



Proceedings of

1st International Conference on

Recent Trends in

Educational Technology

(ICRTET-2026)



September 18 – 19, 2026



Hybrid Mode

Organised by

School of Education

Sri Chandrasekharendra Saraswathi Viswa Mahavidyalaya

(Deemed to be University u/s 3 of UGC Act 1956) (Accredited with 'A' by NAAC)



Enathur, Kanchipuram, Tamilnadu, India – 631561

in association with

Tamil Nadu Teachers Education University



Chennai, Tamilnadu – 600097



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Innovate • Integrate • Inspire
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**School of Education,
SCSVMV, Enathur, Kanchipuram.**

in association with

**Tamil Nadu Teachers Education University
Chennai**

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About SCSVMV

Sri Chandrasekharendra Saraswathi Viswa Mahavidyalaya (SCSVMV) is a Deemed-to-be University located at Enathur, Kanchipuram, Tamil Nadu. Established in 1993 under the aegis of the Sri Kanchi Kamakoti Peetam Charitable Trust, the University was founded with the vision of restoring Kanchipuram's historic identity as a centre of learning. The University was established with the blessings of His Holiness Pujyasri Jayendra Saraswathi Swamigal and His Holiness Pujyasri Sankara Vijayendra Saraswathi Swamigal.

SCSVMV has a distinctive educational philosophy that seeks to integrate traditional knowledge with modern scientific practices, rooted in Indian values and guided by a global outlook. The University is committed to providing quality higher education that promotes academic excellence, holistic development, ethical values, and social responsibility.

The University offers multidisciplinary higher education through its various faculties and departments in areas including Sanskrit and Indian Culture, Management, Human Resources and Commerce, Engineering and Technology, Science, Arts and Humanities, Education, Health Sciences, Allied Health Sciences, and Law. The University also promotes research and doctoral programmes across its academic disciplines.

The School of Education is an integral part of the University's academic ecosystem and contributes to the preparation of competent, professionally committed, and socially responsible teachers. It promotes quality teacher education, pedagogical development, research, and innovative approaches to teaching and learning.

SCSVMV places strong emphasis on research, innovation, creativity, and professional excellence. The University provides an enabling environment for scholarly exchange through conferences, seminars, workshops, research initiatives, and interdisciplinary academic activities. Its commitment to academic quality and value-based education contributes to the development of knowledgeable, skilled, and socially responsible individuals.

With its rich heritage, multidisciplinary academic environment, commitment to research and innovation, and integration of traditional Indian values with contemporary knowledge, SCSVMV continues to contribute to higher education, teacher education, research, and societal development. The University provides a vibrant platform for academic collaboration and scholarly exchange at national and international levels.

About TNTEU

Tamil Nadu Teachers Education University (TNTEU) is a state university established by the Government of Tamil Nadu with the primary objective of promoting excellence in teacher education. The University was established under Tamil Nadu Act No. 33 of 2008, which came into effect on 1 July 2008. Headquartered at Karapakkam, Chennai, TNTEU is an exclusive university dedicated to teacher education and plays a significant role in strengthening the quality, standards, and professional development of teacher educators and teachers in Tamil Nadu.

TNTEU undertakes academic and research activities through areas such as Pedagogical Sciences, Value Education, Educational Psychology, Educational Technology, Curriculum Planning and Evaluation, and Educational Planning and Administration. These areas reflect the University's commitment to addressing contemporary challenges and emerging developments in education.

The University also promotes seminars, conferences, workshops, symposia, research activities, innovative courses, and extension programmes to encourage academic exchange and professional development in teacher education. Its objectives include developing research facilities, promoting innovative approaches in teacher education, enhancing quality, and responding to the changing educational needs of society. Through its academic programmes, research initiatives, affiliated institutions, and professional development activities, Tamil Nadu Teachers Education University continues to contribute to the advancement of teacher education and the preparation of competent, dynamic, and socially responsible educators.

About the Conference

The 1st International Conference on Recent Trends in Educational Technology (ICRTET-2026) focuses on understanding the changing landscape of education in the digital era and examining the meaningful integration of technology into teaching, learning and educational practices. The conference provides a platform for researchers, educators and practitioners to share emerging perspectives, innovative practices and experiences, while critically reflecting on the opportunities and challenges of technological transformation in education. It aims to promote responsible, inclusive, learner-centred and future-ready educational practices through the effective use of technology.

Key Areas of ICRTET 2026

- A. Artificial Intelligence in Education
- B. Curriculum development and innovation
- C. Digital assessment and evaluation
- D. Digital Pedagogy and Teacher Education
- E. Educational Psychology in the Digital Era
- F. Educational Research and Innovation
- G. E-Learning and Virtual Education
- H. Emerging technologies in education
- I. Ethics and Challenges in Educational Technology
- J. Guidance and Counselling in Education
- K. Health, Well-Being, and Education
- L. Inclusive Education and Assistive Technologies
- M. Innovations in Teaching and Learning
- N. Leadership in educational technology
- O. Learner centered approaches in digital education
- P. Smart Classrooms and Future Learning
- Q. Student Engagement and Interactive Learning
- R. Teacher professional development
- S. 21st Century Skills and Digital Literacy



Prof. Vempaty Kutumba Sastry

Chancellor, SCSVMV,
Enathur, Kanchipuram.

Message

It is a matter of great pride and satisfaction to welcome all delegates, researchers, academicians, educationists, and students to the **1st International Conference on Recent Trends in Educational Technology (ICRTET-2026)**.

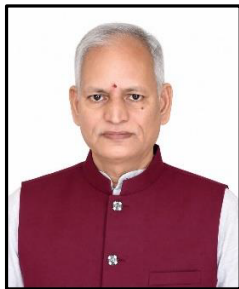
Education is undergoing a profound transformation through technological advancements that enhance teaching, learning, assessment, and research. This conference provides an excellent platform for intellectual exchange, collaboration, and innovation in the field of educational technology.

I congratulate the School of Education, SCSVMV, and Tamil Nadu Teachers Education University for organizing this significant international event. I am confident that the conference will inspire meaningful discussions and generate valuable insights that contribute to the advancement of education globally.

I extend my best wishes to all participants and wish the conference a grand success.

Warm regards,

Prof. Vempaty Kutumba Sastry



Prof. G. Srinivasu
Vice-Chancellor
SCSVMV

Message

It gives me immense pleasure to extend my best wishes to the **1st International Conference on Recent Trends in Educational Technology (ICRTET–2026)**, organized by the School of Education, SCSVMV Deemed University, in association with Tamil Nadu Teachers Education University. With the divine grace of Devi Sri Kamakshi and the benign blessings of our revered Patron, **Pujyashri Shankara Vijayendra Saraswathi Shankaracharya Swamigal** and **Pujyashri Sri Satya Chandrasekarendra Saraswathi Swamiji**, may this conference emerge as a vibrant confluence of wisdom, innovation and technology.

In this age of Artificial Intelligence, digital transformation and emerging educational technologies, I am confident that ICRTET–2026 will foster meaningful knowledge exchange, pedagogic innovation and intellectual cross-pollination among educators, researchers and scholars. May the deliberations inspire a future-ready, learner-centric and value-anchored education ecosystem, harmonising the timeless insights of Bharatiya Jnana Parampara with contemporary technological possibilities. I wish the conference every success and scholarly distinction.

Warm regards,

Prof. G. Srinivasu



Prof.R.Vasanth Kumar Mehta

Pro Vice-Chancellor
SCSVMV

Message

It gives me immense pleasure to extend my warm greetings and best wishes to all the participants of the **1st International Conference on Recent Trends in Educational Technology (ICRTET-2026)**.

The rapid integration of technology into education has transformed the landscape of teaching, learning, research, and innovation, creating new possibilities for enhancing educational practices and outcomes. In this context, conferences such as ICRTET-2026 provide a valuable platform for academicians, researchers, policymakers, and practitioners to exchange ideas, share innovative practices, and foster meaningful collaboration.

I sincerely appreciate the efforts and dedication of the organizers in bringing together experts and professionals from diverse backgrounds for this significant international event. I am confident that the deliberations and scholarly exchanges during the conference will generate valuable insights and contribute meaningfully to the advancement of educational technology.

I wish all the participants engaging and fruitful deliberations and hope that the conference will serve as a catalyst for new ideas, collaborations, and innovations in the field of education.

I wish ICRTET-2026 great success and a memorable and enriching experience for all its participants.

Warm regards,

Prof. R. Vasanth Kumar Mehta



Prof.G.Sriram
Registrar i/c, SCSVMV

Message

It gives me immense pleasure to extend my warm greetings to all the participants, researchers, academicians, industry experts, and students attending the **1st International Conference on Recent Trends in Educational Technology (ICRTET–2026)** organized by the School of Education, Sri Chandrasekharendra Saraswathi Viswa Mahavidyalaya (SCSVMV), in association with Tamil Nadu Teachers Education University.

Educational technology is transforming the way knowledge is created, shared, and experienced. This conference provides a valuable platform for scholars and practitioners from diverse disciplines to exchange innovative ideas, present research findings, and discuss emerging trends that can shape the future of education.

I am confident that the deliberations and interactions during this conference will contribute significantly to advancing teaching, learning, and educational research. I appreciate the efforts of the organizing committee in bringing together distinguished experts and participants from various parts of the world.

I wish the conference great success and hope that all participants have a fruitful and enriching experience.

Warm regards,

Prof. G. Sriram



Prof.K.Rajasekaran
Registrar i/c, TNTEU

Message

I am extremely delighted to know that the School of Education, Sri Chandrasekharendra Saraswathi Viswa Mahavidyalaya (SCSVMV), Enathur, Kanchipuram in association with *Tamil Nadu Teachers Education University (TNTEU), Chennai is organizing the 1st International Conference on Recent Trends in Educational Technology (ICRTET-2026) on 18th & 19th September, 2026 in Hybrid Mode.

In the present era, Educational Technology is not just an accessory but a necessity. The rapid advancements in Artificial Intelligence, Virtual Reality, Learning Management Systems, Digital Assessment, and Personalized Learning have completely transformed the teaching-learning process. NEP 2020 has rightly emphasized the integration of technology at all levels of education to enhance access, equity, quality, affordability and accountability.

As a University exclusively for Teacher Education in Tamil Nadu, TNTEU is committed to preparing future teachers who are technologically empowered and pedagogically competent. This conference focusing on themes such as AI in Education, Digital Pedagogy, Inclusive Education with Assistive Technologies, Smart Classrooms, Ethics in Educational Technology, and Teacher Professional Development is highly timely and purposeful.

I am confident that this conference will bring together eminent academicians, researchers, teacher educators, and scholars from India and abroad on a common platform to exchange innovative ideas, research findings, and best practices. I am sure the proceedings of this conference will be a valuable academic resource for the teaching community.

I congratulate the Conference Chair, Organizing Secretaries, Joint-Organizing Secretaries and the entire Organizing Team of SCSVMV and TNTEU for their concerted efforts in organizing this significant academic event.

I extend my best wishes for the grand success of ICRTET-2026.

Warm regards,

Prof. K. Rajasekaran



Dr.M.Kanmani
Dean & COE i/c,
TNEU

Message

I am pleased to extend my greetings to all participants of the **1st International Conference on Recent Trends in Educational Technology (ICRTET–2026)**.

This conference provides a valuable platform for researchers and educators to discuss innovative approaches, emerging technologies, and best practices that can enrich the educational process. The exchange of ideas and research outcomes will undoubtedly contribute to academic excellence and educational advancement.

I congratulate the organizers for their initiative and wish the conference a successful outcome.

Warm regards,

Dr.M.Kanmani

Conference Chair



Prof.K.Venkatramanan
Dean, Faculty of Education,
SCSVMV



Prof.N.Ramakrishnan
Professor & Head, Dept. of Educational
Technology, TNTEU

Message

On behalf of the organizing committee, we are delighted to welcome you to the **1st International Conference on Recent Trends in Educational Technology (ICRTET–2026)**. The conference aims to provide a vibrant platform for researchers, educators, and professionals to discuss innovative developments and transformative practices in educational technology. Through keynote sessions, research presentations, and scholarly discussions, participants will gain valuable insights into the future of education.

We sincerely thank all contributors, speakers, reviewers, and participants for their support and participation. We wish you an engaging, enriching, and successful conference experience.

Warm regards,

Prof. K. Venkataramanan
Prof. N.Ramakrishnan

Organizing Secretaries



Mrs.J.Jayapriya
Head i/c, School of Education,
SCSVMV



Dr.R.Rajalakshmi
Asst. Professor, TNTEU



Dr.P.N.Lakshmi Shanmugam
Asst. Professor, TNTEU

Message

We are delighted to welcome all participants to the **1st International Conference on Recent Trends in Educational Technology (ICRTET-2026)**.

The conference has been designed to bring together researchers, educators, scholars, and professionals to share innovative ideas and research findings related to educational technology and its applications. We believe that the discussions and collaborations fostered through this event will contribute significantly to the advancement of education and learning.

We express our sincere gratitude to our Chief Patrons, Patrons, Co-Patrons, Advisory Committee Members, Speakers, Authors, Reviewers, and Participants for their valuable support and contributions.

We wish all participants a meaningful, productive, and memorable conference experience.

Warm regards,

Mrs. J. Jayapriya
Dr. R. Rajalakshmi
Dr. P.N. Lakshmi Shanmugam

Key Note Speakers

	<p>Prof. N. Panchanatham, Vice Chancellor, The Gandhigram Rural Institute, Dindigul</p> <p>Chief Guest – Inaugural Address</p>
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Photo	Name of the Speaker	Topic
	<p>Prof. N. Ramakrishnan Professor & Head, Dept. of Educational Technology, TNTEU, India</p>	Reimagining Education in the Age of Artificial Intelligence and Emerging Technologies: Towards Human-Centric Digital Pedagogy
	<p>Prof. A. Tholappan Professor, Department of Education, Bharathidasan University, Trichy, India</p>	Future-Ready Teacher Education: Emerging Technologies, Innovative Pedagogies and Global Perspectives
	<p>Assoc. Prof. Dr. Thachakorn Komol Faculty of Education, Shinawatra University, Thailand</p>	Beyond AI Tools: Transforming Teaching, Research, Professional Standards, and Academic Excellence in the Digital Era
	<p>Assoc. Prof. Dr. Khashayar Yazdani , Director Centre for PG studies, Malaysia University of Science and Technology, KL</p>	Transforming Higher Education through AI and Digital Innovation

Invited Talk

Photo	Name of the Speaker	Topic
	Dr. Doris Ogueri Environmental Scientist, International Relations, Shinawatra University Thailand	Bridging Classroom and Field: A Technology Enhanced Framework for Environmental Education
	Dr. S. Dhilip President of India Awardee GHSS, Sathiyamangalam India	Artificial Intelligence in Education: From Smart Tools to Smart Classroom
	Dr. P. Subramanian Director - Center for National and International Academic Collaborations TNTEU, India	Artificial Intelligence Tools in Research

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Dr. A. Mathini — Asst. Prof. & Head, SCSVMV

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Reimagining Education in the Age of Artificial Intelligence and Emerging Technologies: Towards Human-Centric Digital Pedagogy

Dr. N. Ramakrishnan

Professor & Head, Department of Educational Technology,
TNTEU, Chennai.

If 20th century education was about access to education, 21st century education is about quality, equity and relevance in the digital era.

We have moved from Blackboard to Whiteboard, from Whiteboard to Smart Board, and now from Smart Board to No Board – Learning is everywhere.

Let me share 5 Recent Trends that are redefining our classrooms:

1. From Artificial Intelligence in Education to Education for Artificial Intelligence:

AI is no longer just a tool. It is a co-teacher. Adaptive learning platforms, Intelligent Tutoring Systems, automated assessment and learning analytics are personalizing education. But we must remember – AI can replace teaching, but it can never replace a Teacher. Our focus under NEP 2020 should be Techno-Pedagogical Competency – how to use AI ethically and effectively.

2. From Teacher-Centred to Learner-Centred Digital Pedagogy:

Technology has empowered the learner. Flipped classrooms, gamification, virtual labs and immersive learning through AR/VR have made learning experiential. The role of the teacher is now a facilitator, mentor and designer of learning experiences.

3. Smart Classrooms and Future Learning:

Smart classrooms are not just about expensive gadgets. A truly smart classroom is one that is inclusive, interactive and innovative. With NEP 2020 emphasizing digital infrastructure and NETF, we need low-cost, scalable solutions for rural India.

4. Ethics, Well-being and Digital Citizenship:

With great technology comes great responsibility. Data privacy, digital addiction, cyberbullying, and the digital divide are real challenges. As teacher educators, we must integrate Ethics and Health & Well-being into Educational Technology.

5. Inclusive Education through Assistive Technologies:

Technology is the greatest equalizer. Text-to-speech, speech-to-text, assistive devices and Indian language e-content are making education accessible for Divyangjan learners. This is true social justice.

Research in Educational Technology should not be just about using technology, but about evaluating its impact on learning outcomes. We need more evidence-based research on what works in Indian classrooms.

Before I conclude, I would like to give a 3-point roadmap for all of us:

A – A for Adaptability: Teachers must continuously upskill.

I – I for Integration: Technology and Pedagogy must be seamlessly integrated, not isolated.

E – E for Empathy: Technology must serve humanity, not replace humanity.

Technology without pedagogy is blind, pedagogy without technology is lame.

Future-Ready Teacher Education: Emerging Technologies, Innovative Pedagogies and Global Perspectives

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Keynote Address for the International Conference on ‘Recent Trends in Educational Technology’

Respected Chief Patron, Patron, Co-Patron, Advisory Committee Members, Chairpersons, , Members of Organising Committee, Joint organising committee of School of Education of Sri Chandrasekharendra Viswa Mahavidyalaya, Kancheepuram and Tamil Nadu Teachers Education University, Chennai, Chief Guests, Keynote Speakers, Teacher Educators, Teachers, Researchers, Research Scholars, and Participants from various parts of India and across the world—A warm greeting to all of you. It is indeed an honour and a privilege to address this international gathering on a topic that is revolutionising the very base of education—Recent Trends in Educational Technology. The topic of my keynote address is "Future-Ready Teacher Education: Emerging Technologies, Innovative Pedagogies and Global Perspectives."

We are at an incredible turning point in the history of education. Technology is no longer just a support for education; it belongs to the learning space, the teaching process, the assessment system, the professional ecosystem, and the educational culture. Artificial intelligence, generative AI, learning analytics, extended reality, adaptive learning platforms, mobile learning, cloud technologies, open educational resources, digital assessment, and intelligent tutoring systems are revolutionizing the creation, access, communication, and assessment of knowledge.

There is a caveat to the discussion thus far. Are we preparing teachers to use technology or are we preparing teachers to transform education with technology? The future of education will not be determined by technology alone. It will be determined by the quality of the human beings who design, use, question, and ethically govern that technology. The future of teacher education is not about replacement of teachers by technology. It is about preparation of teachers to work intelligently, creatively, critically, and ethically with technology.

1. From Traditional Teacher Education to Future-Ready Teacher Education

When I entered teacher education, students needed to acquire knowledge of Content, pedagogy, and professional practice. In other words, what to teach, how to teach, learning assessment strategies, and classroom management. Now there is another key question: How to use technology to enhance student learning effectively. The introduction of TPAC (technological pedagogical content knowledge) frameworks has focused attention on the importance of incorporating technological knowledge with pedagogy and subject knowledge. Even TPACK needs to be viewed in a larger context.

A future-ready teacher should have:

- Content knowledge,
- Pedagogical knowledge,
- Technological knowledge,
- Digital literacy,
- AI literacy,
- Data literacy,

- Ethical literacy,
- Emotional Intelligence, and
- Global competence.

In other words, the teacher of the future is much more than a purveyor of content.

The teacher becomes a facilitator, designer, mentor, researcher, learning analyst, digital citizen, innovator, trendsetter and ethical leader. This metamorphosis calls for a transformation of teacher education institutions as well. Teacher education cannot remain oblivious to the rapid integration of intelligent technologies in schools, colleges and universities by relying only on lectures, textbooks and conventional teaching practice. Our teacher education programs themselves need to become a living laboratory of educational innovation.

2. Artificial Intelligence: The Defining Technology of Educational Transformation

AI has undoubtedly created the most significant disruption in education compared to other emerging technologies. Generative AI applications can assist educators in lesson planning, creating learning materials, generating questions, crafting differentiated activities, providing feedback, translating educational resources, creating simulations, supporting learners with disabilities, analysing learning patterns, and developing personalised learning experiences. For researchers, AI can assist with: literature searching, research methodology, data organisation, code generation, language enhancement, citation management, and academic writing. But, remember that AI is supposed to enhance human intelligence, not replace human judgement.

AI should augment human intelligence, not replace human judgement.

As a final cautionary note, I would like to point out the risk of becoming AI-dependent. If a teacher asks AI to design a question or learning activity for every lesson, that teacher may slowly lose the creative urge. Teacher training must transition from "AI use" to "AI literacy." AI literacy includes understanding what AI can and cannot do, how AI creates information, how bias can seep in, how misinformation is generated, how student data should be safeguarded, how copyright laws should be respected, how academic integrity can be maintained, and how human discretion should be exercised. The teacher of the future should be an AI-augmented teacher, not an AI-dependent teacher.

3. Generative AI and the Changing Nature of Knowledge

Generative AI has also challenged our notions of knowledge. Teachers have been teaching—and students have been learning—under the assumption that the teacher knows and the students don't know for hundreds of years. Now, information is omnipresent. It is not a question of can students find information? but can they evaluate it? can they distinguish fact from fabrication? can they interpret it critically? can they use it ethically? The primary role of education should be the development of knowledge and wisdom, not the transmission of information. Teachers need to teach for Critical thinking, Creativity, Problem solving, Collaboration, Communication, Ethical reasoning, Media literacy, Digital citizenship, and Reflective thinking. Future-ready teacher education has to place a greater emphasis on higher-order thinking skills.

If AI can give an answer, the teacher should teach students how to question the answer.

If AI can write an essay, the teacher should teach students how to make an argument.

If AI can create an image, the teacher should teach students how to interpret representations.

If AI can analyse data, the teacher should teach students how to understand what data means (and doesn't mean).

That is the future of pedagogy.

4. Innovative Pedagogies for Future-Ready Teachers

Technology only has educational value when accompanied by appropriate pedagogy. We need to shift from technology-centred teaching to pedagogy-centred technology integration. Many new pedagogies are coming to the fore.

Flipped Learning

In a flipped learning environment, students use instructional materials prior to class, and in-class time is devoted to discussion, application, problem solving, and collaboration. The teacher assumes the role of facilitator rather than lecturer.

Blended Learning

Blended learning is a type of education that combines traditional in-person instruction with online learning. The key advantage of blended learning is its flexibility, allowing students to receive instruction in multiple formats while also enjoying the benefits of face-to-face interaction.

Project-Based Learning

Technology can help authentic projects in which learners address real-world challenges and create solutions.

Problem-Based Learning

Complex challenges for analysing, assessing, and designing can be provided by digital content, simulations, and artificial intelligence applications.

Collaborative Learning

Learners from different classrooms, institutions and countries can be connected through digital media. A student from Tamil Nadu can collaborate with a student from a different part of the world. This opens up the possibility of global classrooms.

Experiential Learning

Virtual laboratories, simulations, augmented reality, and virtual reality can provide those types of experiences that are difficult, costly, or dangerous to implement in the real classroom. In this way, technology can expand the boundaries of experience-based education.

5. Immersive Technologies: AR, VR and Extended Reality

Another significant trend is the increasing use of Augmented Reality, Virtual Reality, and Extended Reality. Picture a student teacher learning about human anatomy without the confines of a textbook. Imagine a student teacher immersed in a virtual setting for history. Consider a science educator illustrating a chemical process using an interactive simulation. Think about a geography student immersing themselves in a virtual ecosystem. These represent some of the things that could help to make learning more tangible and experiential. Technology should not be used solely because it is awe-inspiring. The bottom line is, does this technology improve learning? If the use of technology does not enhance understanding, increase engagement, make something more accessible, or allow for meaningful participation, then the use of technology is a costly diversion. Future teacher educators need to develop pedagogical judgement, not just technological gusto.

6. Learning Analytics and Data-Informed Teaching

Learning analytics is an emerging field in educational technology.

Digital learning environments generate a wealth of data:

- Participation,
- Attendance,
- Assessment performance,
- Learning progress,

- Time spent on learning resources,
- Interaction patterns, and
- Engagement indicators.

This data, when used responsibly, can also help teachers identify students who need support. Transition from: Reactive teaching to proactive teaching. Teachers can look for early warning signs of potential learning difficulties before a student fails. Ethical questions arise, though: Who owns educational data? Who has access to it? For how long is it stored? Can algorithms discriminate against students? Can data be used to unfairly label students? Data literacy and data ethics need to be a vital part of educating teachers.

7. Personalised and Adaptive Learning

The conventional classroom structure is based on the presumption that students of similar ages progress at the same rate.

- Learners vary in their: Prior knowledge,
- Learning speed,
- Motivation,
- Interests,
- Language,
- Abilities,
- Learning preferences, and
- Social backgrounds.

Artificial intelligence and adaptive learning technologies promise to deliver personalized learning paths. But personalized learning should not mean isolated learning. Human interaction is vital. Education is not merely an exercise in information processing. It is also a social, emotional, cultural, and ethical experience. So the future is not about technology versus teacher. It is about technology + teacher + learner + community.

8. Inclusive and Accessible Teacher Education

A future-ready education system must also be an inclusive education system. Technology offers tremendous possibilities for the learner with diverse needs.

Examples include:

- Text-to-speech,
- Speech-to-text,
- Captioning,
- Screen readers,
- Translation tools,
- Assistive technologies,
- Adaptive interfaces, and
- AI-supported accessibility tools.

However, the digital divide remains a major challenge. Not every learner has:

- A personal device,
- Reliable internet,
- Adequate digital skills,
- Appropriate learning resources, or
- A supportive digital environment.

So, the use of educational technology should be guided by the imperative of equity. If technology is used only to benefit those who are already privileged learners, it may increase the digital divide.

9. Digital Well-Being and the Human Dimension

As technology continues to permeate education, digital well-being is another issue that deserves our attention.

Excessive screen time, information overload, incessant alerts, multitasking, and digital distractions have implications for attention and learning. Digital well-being will be an important understanding for future-ready teachers in addition to digital competence.

Students need to learn:

- When to connect,
- When to disconnect,
- How to manage attention,
- How to protect privacy,
- How to behave responsibly online,
- How to recognise misinformation, and
- How to maintain healthy technology habits.

The goal is not to create technology-dependent learners.

The goal is to create technology-empowered human beings.

10. Teacher Educators as Designers of Educational Futures

This is where teacher educators have a critical responsibility. Teacher educators cannot merely teach prospective teachers about how technology works. They need to show how technology can change pedagogy. A teacher educator should become: A role model of lifelong learning. Technology is always changing, which means that professional development cannot be a one-time event.

We need a culture of continuous professional learning. Teacher educators should engage in:

- Professional learning communities,
- Action research,
- Collaborative lesson design,
- Technology experimentation,
- Peer observation,
- Digital scholarship,
- International collaboration, and
- Reflective practice.

In sum, the teacher educator of the future will need to be a pedagogue and an innovator in education.

11. The Changing Role of Research Scholars

Researchers have an equally important role to play.

The future of educational technology requires research that goes beyond asking:

“Is technology effective?”

We need to ask more sophisticated questions:

- For whom is the technology effective?
- Under what conditions?
- For which subjects?
- For which age groups?
- Does it improve deep learning or merely engagement?
- What are its long-term effects?
- What are its ethical implications?
- Does it reduce or increase inequality?
- How does it affect teacher identity?
- How does AI influence creativity and critical thinking?

We thus need more cross-cutting research bridging Education, Psychology, Technology, Sociology, Data Science, and Ethics.

Research scholars should also explore emerging variables such as:

- AI literacy,
- Digital competence,
- Technological self-efficacy,
- Techno-pedagogical skills,
- Digital well-being,
- AI readiness,
- Algorithmic awareness,
- Online teaching competence,
- Digital citizenship, and
- Technology acceptance.

This will enrich the research base of teacher education.

12. Global Perspectives in Teacher Education

The term global in our conference theme is very important. Educational technology has enabled opportunities for worldwide collaboration that we couldn't have imagined before.

- Virtual exchange,
- Collaborative research,
- International webinars,
- Shared digital courses,
- Global classrooms,
- Joint projects, and
- International communities of practice.

This can foster global awareness in teachers and students. Globalisation should not lead to the creation of a global monoculture. Technological interventions should be guided by a sensitivity towards:

- Local languages,
- Indigenous knowledge,
- Cultural traditions,
- Regional contexts, and
- Diverse educational philosophies.

The future of education should therefore be globally connected but locally grounded.

13. NEP 2020 and the Indian Context

In India, teacher education transformation is also influenced by the National Education Policy 2020. NEP 2020 highlights technology, multidisciplinary approach, teacher training, experiential learning, digital content, flexibility, and equitable access. The recent initiatives, viz. SWAYAM, DIKSHA, NPTEL, e-content platforms, and e-learning ecosystems, confirm that India is marching towards tech-oriented education. But, digital transformation cannot be realized based on infrastructure alone.

We need infrastructure, access, digital literacy, pedagogy, leadership ethics, ongoing professional development. A smart classroom without a smart teacher does not equal smart education. Laptops for students without a focus on digital literacy do not create digital learning. Smart artificial intelligence without smart ethical considerations can lead to new risks in education. The human capacity to use technology in meaningful ways is as important as the technology itself.

14. Ethics: The Foundation of Future-Ready Education

Ethics, perhaps, is the biggest question for the future of educational technology. Technology always raises ethical questions. Artificial intelligence raises ethical questions around:

- Bias,
- Privacy,
- Transparency,
- Accountability,
- Copyright,
- Academic integrity,
- Surveillance,
- Data ownership, and
- Human autonomy.

So we need to ask, just because technology can do something, does education need to do it? This question should be central to teacher education. Future teachers need to learn to be ethical users of technology. They need to know that educational technology should serve: Human dignity, equity, inclusion, autonomy, creativity and social responsibility. But technology can never be the goal of education.

15. From Digital Teachers to Future-Ready Teachers

What, then, is a future-ready teacher? A future-ready teacher should be:

Technologically competent

Able to use emerging technologies effectively.

Pedagogically innovative

Able to select appropriate methods for diverse learners.

AI literate

Able to understand and critically use artificial intelligence.

Data literate

Able to interpret educational data responsibly.

Ethically responsible

Able to protect privacy, integrity and human dignity.

Inclusive

Able to support diverse learners.

Creative

Able to design new learning experiences.

Reflective

Able to evaluate and improve professional practice.

Globally competent

Able to engage with international perspectives.

Emotionally intelligent

Able to understand and support the human dimension of learning. This is the teacher we must prepare.

16. A New Framework for Future-Ready Teacher Education

I would like to propose a simple conceptual framework for future-ready teacher education:

The 7C Framework

1. **Competence** – technological and pedagogical competence.
2. **Creativity** – ability to design innovative learning experiences.
3. **Criticality** – ability to question technology and evaluate information.
4. **Collaboration** – ability to work with learners, colleagues and global communities.

5. Communication is ability to communicate effectively across digital and physical environments.

6. Compassion – ability to preserve the human and emotional dimensions of education.

7. Conscience – commitment to ethics, equity, responsibility and social justice.

If teacher education can develop these seven dimensions, we can move towards genuinely future-ready teachers.

17. The Future Is Not Technological; It Is Human

Most important, ladies and gentlemen, as we traverse through Artificial Intelligence, virtual reality, adaptive learning and learning analytics, we must never lose sight of one crucial aspect: Education is a human endeavour. A machine can disseminate data. But, it is the teacher who provides motivation. A machine can develop criticism, but this is nothing compared to the support a teacher can provide. A machine can detect a learning barrier, but it is the teacher who provides empathy. A machine can produce a response, but it is the teacher who motivates the learner to investigate a more profound query. This is why teacher education for the future should not be about creating teachers that can compete with machines, but rather about creating teachers whose capabilities as humans are complemented by machines.

18. A Call to Action

Five pledges to make at this international conference.

Firstly, reform teacher training programs. Teacher education programs must integrate technology, AI skills, digital pedagogy, data literacy, and digital citizenship and ethics.

Secondly, transformation of classroom practice. Teacher education colleges should practice what they preach in terms of innovative pedagogy.

Third: Transform professional development. It is essential that teachers have ongoing opportunities for learning, trying out, reflecting, and collaborating.

Fourth, transform educational research. There is a need for research to investigate not only what is effective technology use but also equitable, ethical, and healthy use that supports teacher identity, and long-term educational research.

Fifth, transform our vision of education. Rather than asking, "How can we put more technology into education?" we should be asking, "How can technology help us create more meaningful, inclusive, creative and human learning?"

Conclusion

Ladies and gentlemen, We are at a fork in the road. One way leads to technology-led schooling where educational decisions are mediated by algorithms, platforms and gadgets. The other path leads to human-centred digital schooling where technology is harmoniously intertwined with pedagogy, ethics, imagination and empathy. I am firmly convinced that the latter is the option we should pursue. The future-ready teacher is not the teacher who knows about every new technological tool. The future-ready teacher is the teacher who knows which technology to use, when to use it, why to use it, how to use it ethically, and when not to use it at all.

The future-ready teacher educator is more than just a technology trainer—she or he is a designer of educational futures. Further, the future-ready teacher education institution is more than just a place to train teachers—it is a centre of innovation, reflection, research, collaboration, and social transformation. Let us prepare teachers who are not afraid of Artificial Intelligence, but understand Artificial Intelligence. Let us prepare teachers who are not controlled by technology, but control technology for educational purposes. Let us prepare teachers who can teach in physical classrooms, virtual environments, and intelligent digital ecosystems.

Let us prepare teachers who link local knowledge with global knowledge. Let us prepare teachers who meld technological competence with human compassion. Most importantly, let us prepare teachers who understand that the purpose of technology is not to make education more technological, but to make education more meaningful, inclusive, accessible, creative, and human. The future of education is being created today. The future of teacher education depends on what we choose to prepare our teachers for today.

Let us choose innovation without losing humanity, technology without losing ethics, globalisation without losing identity, and digital transformation without losing the teacher at the heart of education. Let us build a generation of future-ready teachers, future-ready learners and future-ready educational institutions. With these thoughts, I congratulate the organisers for providing an opportunity to teacher educators, teachers and research scholars from different parts of the world to come together and deliberate on this important and timely theme. I wish this international conference meaningful intellectual exchanges, innovative research collaborations and transformative outcomes.

Thank you, School of Education of Sri Chandrasekharendra Viswa Mahavidyalaya, Kancheepuram and Tamil Nadu Teachers Education University, Chennai,
Thank you very much.

Beyond AI Tools: Transforming Teaching, Research, Professional Standards, and Academic Excellence in the Digital Era

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Abstract

Artificial Intelligence (AI) is rapidly reshaping higher education, yet meaningful transformation requires moving beyond the adoption of individual AI tools toward systematic professional development, responsible practice, and sustainable institutional change. This research aim to a practice-based initiative developed through three phases: **context and needs assessment, curriculum development and training innovation, and monitoring and impact assessment.**

The initial phase involved document and research review, in-depth interviews with key educational and organizational leaders across nine organizations in Thailand, and focus group discussions involving four higher education institutions. The findings highlighted strong demand for practical, hands-on AI training focused on improving work efficiency, teaching and learning, research, academic publication, professional competencies, and the ethical use of AI.

Based on these needs, AI capacity-development programs were designed and implemented during 2025–2026 across institutions in Thailand and internationally. Nine training programs across seven institutions engaged university leaders, lecturers, researchers, staff, graduate students, school administrators, and teachers. The programs integrated approximately **17–28 AI tools** into authentic academic and professional tasks, including research development, instructional design, data analysis, academic writing, assessment, presentation, and publication. Professional development was also connected with **Professional Standards Frameworks (PSF)** to strengthen teaching competencies and academic professionalism.

Monitoring and evaluation indicated particularly strong interest in practical applications such as prompt engineering, AI-assisted research and analysis, presentation development, assessment design, and information synthesis. The research argues that the future of educational technology lies **beyond AI tools themselves**—in developing human capability, professional standards, ethical AI practice, institutional support systems, and sustainable academic ecosystems that transform **teaching, research, professional practice, and academic excellence.**

Keywords: Artificial Intelligence, Educational Technology, Professional Standards Framework, Faculty Development, Teaching and Learning, Research and Publication.

Transforming Higher Education through AI and Digital Innovation

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Abstract:

This presentation explores how higher education institutions can move beyond simply adopting artificial intelligence tools toward becoming truly AI ready universities. It argues that digital transformation is not only a technological challenge, but also an institutional transformation involving research capability, academic skills, governance, infrastructure, and leadership.

The presentation introduces the 5P Framework: Purpose, People, Process, Platforms and Data, and Policy and Governance, as a practical approach for developing sustainable AI research capacity. It also emphasizes that AI should augment rather than replace researchers, with human judgement, intellectual ownership, ethical responsibility, interpretation, and accountability remaining at the centre of academic work.

The session will conclude with a practical pathway for universities to assess AI readiness, develop institutional capabilities, pilot appropriate applications, and scale successful practices while measuring success through research quality, researcher capability, integrity, efficiency, and academic impact.

I hope this topic will be suitable for the conference, and I look forward to contributing to the programme.

Bridging Classroom and Field: A Technology-Enhanced Framework for Environmental Education

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Abstract

Environmental education demands instructional approaches that help learners grasp complex environmental processes and translate knowledge into responsible action. This paper examines the role of educational technology within the Environmental Education Program for International Middle School Students (EEPIMSS), designed to teach wastewater, water pollution, water quality, and the oxidation pond method of wastewater treatment at the LERD Project in Thailand. LERD Project, the King's Royally Initiated Laem Phak Bia Environmental Research and Development Project is a royal initiative in Phetchaburi Province, Thailand, that uses natural systems to treat municipal wastewater and manage solid waste. It was established by His Majesty King Bhumibol Adulyadej. The study was originally planned as a field-based program for international middle school students in Bangkok, however, COVID-19 restrictions prompted a shift to digital and visual resources, including videos, animations, PowerPoint presentations, posters, worksheets, games, and crossword activities.

The study began with a survey of 240 students aged 11–15, followed by an intervention with 50 students and a control group of 10. The four-session program (approximately one hour each) targeted environmental awareness, knowledge, attitudes, skills, and behavior. Results showed substantial improvement among intervention participants, while the control group exhibited minimal change. Students expressed heightened interest in wastewater treatment and environmental protection, and school leaders endorsed integrating environmental education into the curriculum.

While technology was not the sole driver of outcomes, the experience underscores its value in representing complex processes, sustaining learning when field access is limited, and linking scientific understanding to action. The paper proposes a Technology-Enhanced Environmental Education Framework that integrates problem identification, learner assessment, content simplification, curriculum alignment, digital representation, engagement, action, assessment, and sustainability. This framework offers a transferable model for technology integration in environmental education, especially where physical site access is constrained.

Keywords: *environmental education, educational technology, environmental literacy, wastewater education, international students, digital learning, water quality, sustainability*

1. Introduction

Environmental challenges ranging from water pollution to climate change require educational responses that go beyond factual recall to cultivate awareness, skills, responsible attitudes, and sustainable behavior. These issues are scientifically complex yet intimately tied to daily life, demanding pedagogies that help learners understand processes and recognize their roles in environmental stewardship.

Educational technology can represent complex systems through visual, audio, and interactive media, diversifying how content is delivered and enabling interaction and collaboration. However, its effectiveness depends on thoughtful integration with pedagogy, curriculum, and context. UNESCO cautions against treating technology as an end in itself, emphasizing alignment with educational objectives and human interaction (UNESCO, 2023).

Interestingly, the COVID-19 pandemic highlighted both the promise and limits of digital learning. While technology maintained continuity, it also revealed gaps in experiential and social interaction. UNESCO further stresses considerations of access, equity, teacher readiness, and governance in technology adoption (UNESCO, 2023).

Environmental education particularly benefits from direct observation and fieldwork. Yet distance, cost, safety, scheduling, and disruptions often limit site visits. The EEPIMSS program, initially designed around a field trip to the LERD Project in Phetchaburi, pivoted to video and multimodal digital resources when the visit became impossible. This shift transformed technology from a supplementary tool to a core conduit for experiential learning. Existing literature has largely overlooked the role of developing and implementing useful environmental education model through technology and awareness to the classrooms. Therefore, this study serves as the first to do such.

This paper reconceptualizes EEPIMSS through an educational technology lens, addressing three questions:

1. How was technology used to communicate wastewater and water quality concepts to international middle school students?
2. What learning outcomes were associated with the intervention?
3. How can this experience inform a broader framework for technology-enhanced environmental education?

2. Literature Review

2.1 Educational Technology in Contemporary Education

Educational technology has evolved from basic audiovisual aids to immersive digital ecosystems including learning management systems, simulations, virtual experiences, and AI. The 2023 UNESCO Global Education Monitoring Report validates technology's potential to improve content representation, interaction, and collaboration. Nevertheless, it warns against assuming automatic learning gains without purposeful design (UNESCO, 2023).

For environmental education, technology can play an important role but should not replace direct experiences. It enables access to otherwise inaccessible sites and processes. The OECD's 2026 Digital Education Outlook highlights generative AI's potential when guided by clear pedagogical intent, cautioning against outsourcing cognitive work without meaningful learning (OECD, 2026).

2.2 Educational Technology and Environmental Education

Environmental education aims at awareness, knowledge, attitudes, skills, and behavior; dimensions requiring active engagement, not memorization. Technology supports these through simulations, virtual field trips, storytelling, monitoring apps, and collaborative platforms. UNESCO's Education for Sustainable Development

(ESD) framework emphasizes learning that connects knowledge to sustainability action (UNESCO, 2023).

EEPIMSS adapted technology to its audience: international middle schoolers with diverse linguistic and cultural backgrounds. Instruction prioritized simple English, visual scaffolding, and reduced jargon.

2.3 Simplification of Complex Environmental Knowledge

Communicating scientific concepts to younger learners is a central challenge in science and environmental education. Specialized terms, abstract processes, and complex language can make understanding difficult, especially for middle school students and multilingual learners (Buxton et al., 2019; Zeng et al., 2025). For this reason, EEPIMSS simplified the oxidation pond process into digestible concepts: “aerobic” became “needs oxygen,” “anaerobic” became “no oxygen needed,” “influent” became “used water,” and “effluent” became “treated water.” Multimedia tools such as videos, animations, slides, worksheets, and puzzles reinforced understanding, aligning with Mayer’s principles of multimedia learning (Mayer, 2021).

2.4 Digital Representation of Field Experiences

It is known that field experiences offer authentic learning but are often logistically constrained. Therefore, EEPIMSS substituted a video tour of the LERD Project when the field trip was canceled. Accordingly, students expressed interest in visiting physically, indicating digital media complemented but did not fully replicate experiential learning. This, however, underscores technology’s role as an alternative pathway, not a total replacement.

3. Methodology

3.1 Research Context

The study was conducted in Bangkok among international middle school students (Grades 6–8) with the program focusing on wastewater and water quality, emphasizing the LERD Project’s oxidation pond system.

3.2 Participants

The study involved multiple participant groups across the preliminary and intervention phases.

Preliminary Survey. The initial survey included 240 students from selected international middle schools in Bangkok. Participants were between 11 and 15 years of age and were enrolled in Grades 6 to 8. The sample comprised 96 female students and 144 male students.

Intervention Phase. The environmental education intervention involved 50 students in the treatment group and 10 students in the comparison group. Students in the treatment group received the four session instructional program, while students in the comparison group did not receive the intervention during the study period. Post-test surveys were administered to both groups.

Teacher Survey. Ten teachers participated in the teacher survey. These teachers were involved in delivering or supporting the environmental education program within the school.

Principal Interview. An interview was conducted with one school leader, the school principal, to obtain administrative perspectives on the program and its integration into the curriculum.

3.3 Program Design

The program was designed around five core environmental education outcomes: awareness, knowledge, attitudes, skills, and behavior. Content was integrated into existing science curriculum areas rather than presented as a separate subject. This approach enabled wastewater and water quality concepts to be connected with established science topics.

The instructional content was organized into four thematic units:

1. Water pollution and its impacts.
2. Domestic wastewater and drainage systems.
3. The oxidation pond method of wastewater treatment.
4. Individual and collective roles in improving water quality.

The program was delivered over four instructional sessions, with each session lasting approximately one hour. Content was divided into manageable segments to support comprehension and retention.

3.4 Technology and Instructional Resources

Resource	Purpose
Video	Depict environmental problems and processes
LERD Project video	Virtual site access
Animation	Simplify processes
PowerPoint	Organize visual information
Posters	Illustrate causes, effects, solutions
Worksheets	Reinforce concepts
Crossword puzzles	Build terminology
Games	Boost engagement
Discussion	Encourage reflection and questioning

This multimodal approach avoided overreliance on any single tool.

3.5 Data Collection and Evaluation

Data collection included preliminary questionnaires, student pretest and posttest surveys, teacher responses, participant observation, and an interview with the school principal. The evaluation focused on changes in five environmental education outcomes: awareness, knowledge, attitudes, skills, and behavior.

A logic model was used to guide program planning and evaluation. The logic model connected program inputs, activities, outputs, outcomes, and intended impacts. This provided a structured approach for linking instructional resources and activities with the intended environmental learning outcomes.

4. Results

4.1 Environmental Awareness and Knowledge

Students who participated in the intervention demonstrated improvements in their understanding of wastewater, water pollution, water quality, and the oxidation pond method of treatment. The simplification of technical content and the use of real world examples appeared to facilitate comprehension. Consequently, the school principal regarded the program as valuable for developing environmental awareness and knowledge and subsequently discussed the possibility of establishing an environmental club. These findings are consistent with research indicating that simplified language, visual scaffolding, and contextual examples can improve science learning for middle school and multilingual students (Buxton et al., 2019; Zeng et al., 2025; Mayer, 2021).

4.2 Environmental Attitudes and Skills

This study offers new insights that intervention was associated with more positive environmental attitudes and the development of practical skills. On the other hand, students recognized that environmental protection requires individual participation and that they can contribute through informed decisions and responsible actions. The combination of visual resources, discussion, games, and practical environmental examples provided multiple opportunities for students to interpret environmental problems and consider possible responses. This aligns with the view that environmental education should cultivate not only knowledge but also attitudes, skills, and a sense of agency (UNESCO, 2023a; Ardoin et al., 2020).

4.3 Environmental Behavior

Improvements in environmental behavior were observed among students in the treatment group, whereas the comparison group did not demonstrate comparable changes. While technology contributed to these outcomes, the results should not be interpreted as evidence that digital tools independently caused behavioral change. The intervention combined teacher facilitation, discussion, visual resources, games, worksheets, and environmental content. The appropriate conclusion is that the integrated environmental education intervention was associated with positive changes in the measured outcomes. This interpretation is consistent with guidance that technology should support, rather than replace, pedagogical design and human interaction (UNESCO, 2023b; OECD, 2026).

4.4 Student Responses to the Digital Representation of the LERD Project

The video representation of the LERD Project provided students with indirect access to the wastewater treatment site following the cancellation of the planned field visit. Through the video, students were able to observe the oxidation ponds and develop a

visual understanding of the treatment process. Notably, students expressed interest in visiting the site physically, suggesting that the digital representation did not fully replicate the experiential value of an in person field trip. Nevertheless, the video afforded access to a location that students would otherwise have been unable to observe during the intervention. Taken together, these findings illustrate both the potential and the constraints of digital field representation. The results support the position that digital resources can serve as complementary or alternative pathways when direct experiential learning is unavailable, while also underscoring the continued importance of authentic environmental experiences where feasible (UNESCO, 2023b; Mayer, 2021).

4.5 Teacher and School Responses

Teachers and the school principal responded positively to the environmental education program. Their responses indicated interest in continuing environmental education and in promoting an environmental club within the school. The findings also support curriculum integration as a practical approach because environmental content can be connected with existing science education rather than requiring the creation of an entirely separate subject. These responses highlight the importance of school leadership and teacher support in sustaining environmental education initiatives (UNESCO, 2023a; Ardoin et al., 2020)

5. Discussion

The EEPIMSS experience demonstrates how educational technology can support environmental education when it is selected according to the learning needs of students and the characteristics of the subject matter. Four contributions are particularly evident.

Representation: The most significant contribution of technology in the intervention was representation. Wastewater treatment is a process that students cannot easily observe within an ordinary classroom. Through video and animation, students could observe processes that would otherwise remain abstract. PowerPoint presentations and posters provided additional visual organization, while worksheets, games, and crossword activities reinforced learning.

Accessibility: The second contribution was accessibility. The LERD Project was geographically distant from the school, and the physical visit became impossible during the pandemic. Video therefore provided a means of maintaining the intended learning objective despite the loss of physical access.

Simplification: The third contribution was simplification. Technology allowed complex environmental information to be presented through multiple forms. This was particularly relevant to international students because the program had to account for differences in language, educational background, and cultural experience.

Engagement. The fourth contribution was engagement. The use of video, animation, games, posters, and discussion created different opportunities for students to interact with the subject matter. The original study reported that students became interested in the LERD Project and expressed a desire to visit the site.

These findings are in line with UNESCO's position that digital technology can improve instruction by varying how content is represented and by supporting

interaction and engagement (UNESCO, 2023b). However, UNESCO also cautions that technology should not be assumed to produce learning independently of teachers, curriculum, and pedagogical design (UNESCO, 2023b).

The experience also reinforces an important distinction between technology as a tool and technology as a substitute for pedagogy. The EEPIMSS intervention reflects this principle because technology was combined with teacher explanation, discussion, questioning, and observation. Current developments in artificial intelligence further strengthen this argument. The OECD Digital Education Outlook 2026 emphasizes that generative artificial intelligence can support learning when used with clear pedagogical intent, but that simply outsourcing cognitive work to technology does not necessarily result in learning (OECD, 2026). Although artificial intelligence was not used in EEPIMSS, the principle is directly relevant to future development of the program. Digital tools should be selected because they improve a specific learning process, not merely because they are technologically advanced.

6. Proposed Technology-Enhanced Environmental Education Framework

Building on the original EEPIMSS framework, this model makes technology's role explicit:

1. Environmental Problem Identification
2. Learner and Context Assessment
3. Content Simplification
4. Curriculum Integration
5. Digital Representation
6. Learner Engagement
7. Environmental Action
8. Assessment (Awareness → Knowledge → Attitudes → Skills → Behavior → Action)
9. Reflection and Sustainability

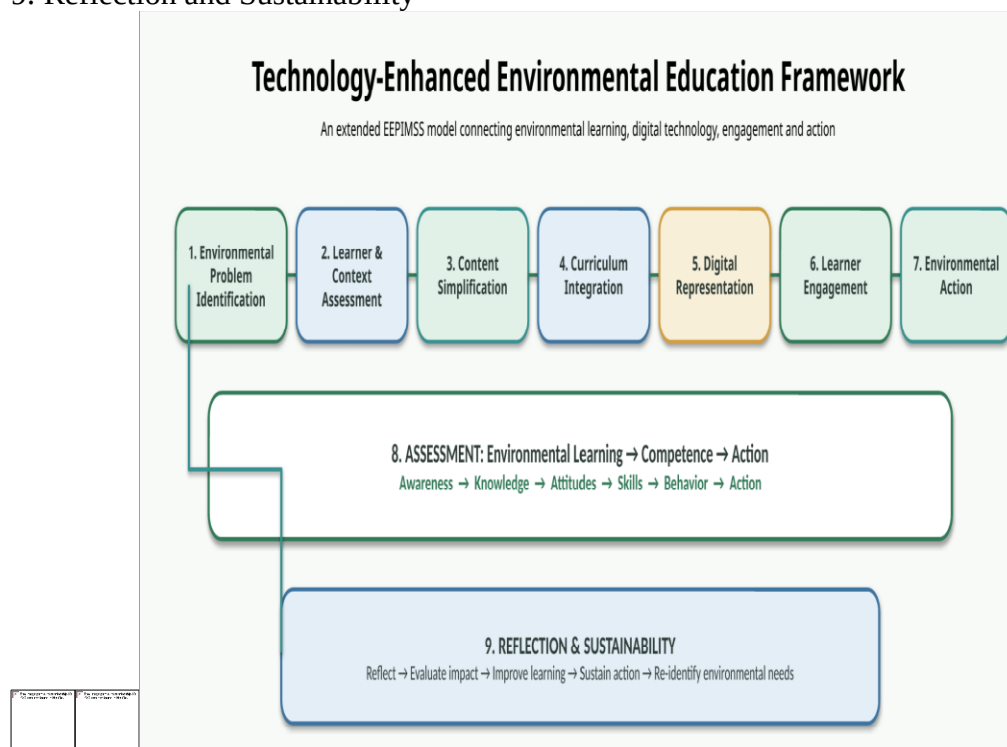


Fig. 1: Technology-Enhanced Environmental Education Framework

This non-linear framework emphasizes interaction among stages, supporting adaptive, context-sensitive design.

7. Implications for Educational Technology

The EEPIMSS experience offers several implications for educational technology research and practice.

First, technology selection should begin with the educational problem rather than the available technology. In this case, the educational problem involved communicating complex wastewater treatment processes and providing access to a field site that students could not physically visit.

Second, technology can improve access to authentic environmental knowledge. A recorded field experience can provide students with exposure to environmental infrastructure, ecological systems, and scientific processes beyond the geographical boundaries of their school.

Third, multimedia resources can support inclusive environmental education. International classrooms frequently contain learners with different language abilities and educational backgrounds. Visual representation can reduce dependence on advanced language proficiency while maintaining access to scientific concepts (Mayer, 2021).

Fourth, educational technology can support continuity during disruption. The COVID 19 experience demonstrated that environmental education programs must be capable of adapting to unexpected interruptions. Digital resources can provide alternative pathways when field visits or classroom activities are disrupted (UNESCO, 2023b).

Fifth, technology should remain connected to human interaction. Teacher guidance, discussion, questioning, and reflection remain essential. This principle is particularly important as schools increasingly adopt artificial intelligence and other advanced technologies (UNESCO, 2023b; OECD, 2026).

Sixth, environmental education provides an important context for developing responsible digital learning. Students can use digital tools not only to consume information but also to investigate environmental issues, communicate findings, and participate in sustainability activities (UNESCO, 2023a).

8. Limitations

The findings should be interpreted with caution due to the underlisted reasons.

First, the original intervention was conducted in one international school after two additional schools withdrew because of pandemic related constraints. The original study had initially planned to involve three international schools but was redesigned because of school closures, restrictions, and limitations on external access.

Second, the intervention involved a relatively small comparative group, with 50 students participating in the second phase and 10 students forming the control group.

Third, the planned physical field experience could not be implemented. Although the video provided valuable visual access to the LERD Project, it could not completely reproduce the sensory and experiential dimensions of a physical field visit.

Fourth, the intervention incorporated multiple instructional strategies. Consequently, it is not possible to attribute the observed learning outcomes exclusively to technology. The findings should instead be understood as evidence associated with an integrated environmental education intervention (UNESCO, 2023b).

Finally, the original program was developed before the widespread adoption of generative artificial intelligence in education. The proposed extension of the framework to artificial intelligence therefore represents a future research direction rather than a finding from the original study (OECD, 2026).

9. Conclusion

EEPIMSS demonstrates how educational technology, when thoughtfully integrated, can extend environmental learning in international school contexts. The program's pivot from field trip to digital representation preserved learning objectives and yielded gains in awareness, knowledge, attitudes, skills, and behavior.

The proposed Technology-Enhanced Environmental Education Framework offers a scalable model for integrating technology into environmental education—particularly where physical access is limited. The goal is not to make environmental education more technological, but to use appropriate tools to make knowledge more accessible, understandable, engaging, and actionable. As schools adopt advanced digital tools and AI, this principle becomes ever more critical.

In conclusion, EEPIMSS shows that purposeful technology can bridge the gap between classroom and field, knowledge and experience, awareness and action.

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Artificial Intelligence in Education: From Smart Tools to Smart Classrooms

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Abstract

Artificial Intelligence is rapidly reshaping education, creating new possibilities for teachers to **teach more effectively, generate richer learning resources, assess continuously, analyse learning data and personalise instruction**. The emergence of Generative AI has made sophisticated educational capabilities accessible to ordinary classrooms, enabling teachers and students to move beyond conventional digital resources towards interactive, creative and learner-centred experiences.

This session, designed from the perspective of a **teacher, textbook author, educational innovator and AI-integrated pedagogy practitioner**, explores practical ways in which AI can be integrated into **secondary schools and higher education**. Rather than presenting AI merely as a content-generation technology, the session proposes a complete **AI-enabled teaching-learning-assessment cycle: Plan → Create → Teach → Interact → Assess → Analyse → Personalise → Improve**.

The session will introduce participants to a range of practical tools and demonstrate how each can address a specific educational purpose. **Google NotebookLM** can transform teacher-selected sources, textbooks and reference materials into interactive learning companions, helping learners summarise, question and explore content. **Claude** can assist educators in developing lesson ideas, differentiated explanations, activities, discussion prompts, project-based tasks and interactive learning materials. **Google Storybook** can bring concepts to life through AI-assisted storytelling, while **Adobe Express** can support the creation of visually engaging posters, presentations, learning materials and multimedia resources.

The session will also focus on **AI-supported assessment and classroom interaction**. **Google Forms** can facilitate structured quizzes, feedback and assessment activities. **Kahoot!** and **Gimkit** can transform revision and formative assessment into engaging gamified experiences, while **Mentimeter** can provide real-time interaction through polls, questions, word clouds and student responses. These platforms can help teachers collect immediate evidence of learning and respond to misconceptions during the lesson rather than waiting until a formal examination.

A further focus will be **learning analytics and data-informed pedagogy**. Tools such as **Julius AI** can assist educators in analysing assessment datasets and identifying patterns, learning gaps and areas requiring intervention. This creates an opportunity to move from simply collecting marks to understanding **what students know, what they struggle with and what pedagogical intervention may be appropriate**.

The session will additionally explore **AI-powered video creation and multimedia learning**, demonstrating how teachers can develop short explanatory videos, digital stories, animated concepts, revision resources and flipped-learning materials. Students can also use AI tools to

create and present their own knowledge products, encouraging creativity, communication, collaboration and digital literacy.

For **secondary education**, these technologies offer significant opportunities for differentiated learning, language development, STEM education, gamified learning, project-based learning and personalised remediation. AI can provide multiple explanations of the same concept, support students with different learning needs and enable teachers to create engaging resources without requiring advanced technical skills. In **higher education**, AI can support research, academic inquiry, data analysis, case-based learning, presentations, interdisciplinary projects and authentic assessment.

However, effective AI integration requires more than technological adoption. The session will address important educational questions concerning **AI literacy, academic integrity, hallucinations and misinformation, data privacy, intellectual property, bias and responsible use**. Teachers and students must learn not only *how to use AI*, but also **when to use it, how to question its output and how to verify it**. Assessment practices must likewise evolve from an emphasis on easily generated answers towards portfolios, projects, demonstrations, presentations, reflections and authentic problem-solving.

The central proposition of this session is that **AI should not replace the teacher; it should amplify teacher expertise**. When routine tasks are supported by AI, educators can devote more time to mentoring, creativity, critical thinking, individual attention and meaningful human interaction. The future of education will therefore not be determined by AI alone, but by **teachers who understand how to combine human intelligence, pedagogical expertise and artificial intelligence**.

This keynote-style session aims to provide educators with a **practical, inspiring and responsible roadmap for moving from experimenting with individual AI tools to designing genuinely AI-enhanced classrooms**—classrooms where technology supports the teacher, empowers the learner and ultimately makes learning more engaging, personalised, creative and meaningful.

Artificial Intelligence Tools in Research

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Abstract

The exponential growth of data and information has made traditional research methods time-consuming and complex. Artificial Intelligence (AI) has emerged as a transformative force in research across all disciplines including education, science, and social science. AI tools are not a replacement for human intelligence and critical thinking, but powerful assistants that augment researcher capability. When used ethically and judiciously, AI tools enhance the quality, efficiency, and impact of research. Researchers, especially in teacher education, must develop AI literacy to use these tools responsibly as per UGC and NCTE guidelines.

Transforming Pedagogy in the AI Era: AI-Driven Teaching, Learning, and Assessment Practices Aligned with NEP 2020

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Abstract

The global educational landscape is undergoing a change driven by Artificial Intelligence (AI). This paper looks at how pedagogical frameworks in the context are shifting and checks how AI-driven teaching, personalized learning and continuous assessment fit with the rules of the National Education Policy (NEP) 2020. Going past old rote-based teaching styles, AI tools such as Generative AI, Intelligent Tutoring Systems (ITS) and Learning Analytics give ways to help students take charge adapt tests and include everyone. This study brings in the AI–Pedagogy–NEP–Quality (APNQ) Framework, a theory that aims to mix AI strengths with teacher-focused, fair and culture-sensitive teaching practices. Based on a look at research from databases like Scopus, Web of Science, ERIC, Google Scholar and policy documents from the Ministry of Education National Council for Teacher Education (NCTE) and the Central Board of Secondary Education (CBSE) this paper shows the need for teachers to learn new skills for algorithmic fairness and for equal access to technology. In the end AI-based teaching is not seen as a way to replace teachers. As a vital path to improve education quality, equity and lifelong learning, in many Indian classrooms.

Introduction: Education in the AI Era

The way people learn today is changing because of the growth of Artificial Intelligence. Artificial Intelligence is making a difference in how schools work. Tools like Large Language Models, machine learning and data analysis are changing how knowledge is created, shared and used in schools (Holmes et al. 2019; Luckin, 2018). In schools AI is not just a helper for paperwork anymore. It is now a part of teaching giving students feedback and helping schools make decisions (Chiu et al. 2023; Selwyn, 2019).

Around the world schools are moving away from ways of teaching that fit everyone the same way. They are now focusing more on each student. What they need (Ayeni et al. 2024). In India this change is happening at the time as big changes in the education system led by the Ministry of Education. These changes are part of the National Education Policy, from 2020 (Ministry of Education 2020). The country wants to help students think better solve problems and use technology well. This means that how teachers teach and how students learn must change a lot (Government of India 2020; NITI Aayog, 2018). Using AI in schools means thinking again about how lessons are planned how students stay interested how tests are fair and what teachers do every day (Panigrahi, 2023; Toppo, 2025).

From Traditional to AI-Driven Pedagogy

For years the old way of teaching in places like India has mostly focused on teachers talking while students just sit and listen. This old way relies a lot on tests that decide everything (Shulman, 1987; UNESCO, 2021). Because this method is so stiff it often fails to help students who learn at speeds or have different ways of thinking. It also does not always work well for students from backgrounds, in large classrooms (Darling-Hammond, 2017; Hattie, 2012).

Moving toward an AI-driven teaching model changes the classroom into a space where everyone interacts and uses data to learn (Celik, 2023; Panigrahi, 2023). AI tools can take over the repetitive jobs. These jobs include testing making different versions of lessons and helping students understand simple ideas (Luckin, 2018). When AI tools do these things teachers get free time. This extra time lets teachers focus on important things like helping students with their feelings teaching right from wrong and leading group projects (Darling-Hammond, 2017; Selwyn, 2019).

AI-Driven Teaching: Transforming Teacher Practices

AI-driven teaching changes how teachers plan lessons adjust curricula and run classes away (Chiu, 2023; Holmes et al., 2019). I see teachers using Generative AI tools and Intelligent Authoring Systems to create lesson plans that fit the class to build worksheets that build on each step and to craft reading passages at levels all in just a few minutes (CBSE, 2023; Harry, 2023).

- **Automated Content Scaffolding:** Teachers use Generative AI to turn ideas into simple, multi-lingual or picture versions that match each student's reading skill (CBSE, 2023; UNESCO, 2024).
- **Predictive Analytics, for Early Intervention:** Machine learning watches past grades finding students who might fall behind or lack skills before final tests (Onesi-Ozigagun et al. 2024; Panigrahi, 2023).
- **Automated Instructional Alignment:** Smart lesson builders help teachers keep each day's work tied to Bloom's Taxonomy and the country's learning goals (NCERT, 2023; Shulman, 1987).

AI-Driven Learning: Personalisation and Learner Agency

AI-driven learning moves away from reading and listening to active learner agency (Ayeni et al. 2024; Luckin, 2018). AI platforms put Vygotsky's idea of the Zone of Proximal Development (ZPD) into practice at a scale by constantly changing the difficulty of exercises when learners interact in real time (Holmes et al., 2019; Onesi-Ozigagun et al., 2024).

- **Adaptive Learning Paths:** Intelligent Tutoring Systems analyze response speed, accuracy and error types to deliver hints, scaffolding or enrichment modules tailored to individual learning styles (Harry, 2023; Luckin, 2018).
- **Adaptive Learning Paths** rely on Intelligent Tutoring Systems that examine how fast a learner answers, how accurate the answers. What kind of mistakes are made. Adaptive Learning Paths then give hints, scaffolding or extra modules that fit each learner's style (Harry, 2023; Luckin, 2018).
- **Autonomous Knowledge Exploration:** Conversational AI agents enable students to pursue inquiry asking iterative questions without fear of peer judgment or social anxiety (Toppo, 2025; UNESCO, 2021).
- **Autonomous Knowledge Exploration** lets students use AI agents to ask questions in a loop exploring topics on their own. Autonomous Knowledge Exploration removes the worry about being judged by classmates or feeling Toppo, 2025; UNESCO, 2021).
- **Universal Accessibility:** powered text-to-speech, real-time closed captioning and predictive text translation assist neurodivergent learners and students with specific learning disabilities (SLDs) (PIB, 2026a; UNESCO, 2024).

- Universal Accessibility brings AI-powered text-to-speech live captioning and predictive text translation to help neurodivergent learners and students with specific learning disabilities (SLDs) (PIB, 2026a; UNESCO, 2024).
- These technologies cultivate motivation by granting learners autonomy over their learning speed, medium and progression path fostering habits of self-regulated lifelong learning (Ayeni et al. 2024; Ministry of Education 2020).
- These technologies build motivation by giving learners control, over how fast they learn what tools they use and how they move forward. These technologies also encourage habits of lifelong learning (Ayeni et al. 2024; Ministry of Education 2020).
- By automating admin work teachers get back the real teaching time they need to work one-on-one with students and help small groups catch up (Hattie, 2012; Panigrahi, 2023).

AI-Driven Assessment: From Testing to Feedback

Assessment paradigms are shifting away from high-stakes end-of-year exams, toward continuous diagnostic and formative evaluation models (Harry, 2023; Ministry of Education 2020). AI-driven assessment works quietly with instruction gathering performance data while students learn (Holmes et al., 2019; Onesio-Ozigagun et al., 2024).

- **Formative Feedback Loops:** Automated essay scoring and code analysis tools give feedback on student work pointing out structural, logical or grammatical errors and allowing students to revise repeatedly (Harry, 2023; Luckin, 2018).
- **Multimodal Assessment:** Natural Language Processing (NLP) and Computer Vision can evaluate presentations, conceptual mind maps and collaborative group problem-solving activities (Chiu et al. 2023; PIB, 2026b).
- **Reduction of Evaluation Bias:** Standardized AI scoring rubrics reduce teacher bias in open-ended evaluations when checked against datasets (Eden et al. 2024; UNESCO, 2021).

Aligning AI-Driven Pedagogy with NEP 2020

I find that the strategic mandates of NEP 2020 India's National Education Policy, line up perfectly with the push to bring AI into schools (Kaur, 2026; Ministry of Education 2020). NEP 2020 calls for a move from rote learning urging us to focus on critical thinking hands-on learning and competency-based education (Government of India 2020; Toppo, 2025).

- **Paragraph 4.25 (Mathematical & Computational Thinking):** NEP 2020 tells us that students in secondary schools must learn computational thinking, coding and get exposed to AI (Ministry of Education 2020; PIB, 2026b). I see AI-driven teaching bring these goals to life in the classroom with games and hands-on projects (NCERT, 2023).
- **Paragraph 23.6 (Technology in Education & NETF):** NEP 2020 recommends setting up the National Educational Technology Forum, NETF to steer how technology is used in schools and colleges (Ministry of Education 2020). I think AI learning analytics fit NETF's aims by using data to help schools make decisions (Kaur, 2026; NITI Aayog, 2018).
- **Paragraph 24.4 (Digital Infrastructure and Multilingualism):** NEP 2020 supports AI-powered translation tools that work with platforms, like DIKSHA and SWAYAM. These tools help deliver top-quality learning material in India's regional languages (Ministry of Education 2020; PIB, 2026a).

Using AI-Driven Pedagogy to Reach Quality Education

The Sustainable Development Goal 4 (SDG 4) says that everyone deserves an fair education (UNESCO, 2021). In places like India where money and tools are often limited it is hard to keep things equal. Problems like having many students in one class different levels of tech and gaps between regions make it tough to give a good education to every child (Panigrahi, 2023; World Bank, 2024). I believe AI-driven pedagogy can act as a tool to help improve education in all these different areas:

- **Sharing Knowledge Everywhere:** High-quality AI-driven instructional content and smart tutors can reach schools in far-off rural areas. This helps close the gap between regions (Panigrahi, 2023; World Bank, 2024).
- **Helping Students Where They Struggle:** Automated tests can quickly find out if kids are struggling with reading or math. This helps teachers step in away to support the NIPUN Bharat mission (Ministry of Education 2020; PIB, 2026b).
- **Better Decisions, for Leaders:** Real-time learning analytics dashboards show school leaders how students are doing. This helps school leaders and administrators make choices based on real facts (Onesi-Ozigun et al. 2024; Toppo, 2025).

Teacher. Human–AI Collaboration

The successful use of AI in classrooms depends on teacher skill and ongoing learning (Celik, 2023; Panigrahi, 2023). As emphasized by the National Council, for Teacher Education (NCTE) technology integration must focus on expanding than replacing, the human dimensions of teaching (NCTE 2021).

- **Reskilling Educator Cadres:** Teacher training programs must incorporate AI literacy, prompt engineering and digital ethics into pre-service B.Ed., Continuous professional learning (CPD) modules (Kaur, 2026; NCTE, 2021; UNESCO, 2024).
- **Technological Pedagogical Content Knowledge (TPACK-AI):** Educators need an updated TPACK framework that includes knowledge of AI tools with subject knowledge and teaching methods (Celik, 2023; Mishra, 2023).
- **Preserving the Human Element:** While AI can process data evaluate assignments. Deliver customized content AI cannot replicate empathy, ethical guidance, cultural background or emotional support (Darling-Hammond, 2017; Selwyn, 2019). Effective teaching relies on Human-AI collaboration, where technology handles tasks while teachers focus on socio-emotional development (Celik, 2023; Panigrahi, 2023).

Ethical, Inclusive and Responsible AI in Education

Using AI in schools brings up ethical, technical and social problems. We need rules to manage these problems (Eden et al., 2024; UNESCO, 2021).

- **Algorithmic. Equity:** Many AI models learn from data from big cities. This can cause AI to be unfair to students in areas or those who speak different Indian languages (Eden et al., 2024; PIB, 2026a). To fix this AI platforms must use datasets that actually represent people (NITI Aayog, 2018; PIB, 2026a).
- **Data. Governance:** When students use these tools they create a lot of data. Educational platforms must follow data protection laws. This is the way to stop companies from selling student data or watching students without permission (Eden et al., 2024; ResearchGate, 2026).

- **Digital Divide and Inclusivity:** Not everyone has internet or good computers. This gap might make the difference, between poor students even bigger (Panigrahi, 2023; Toppo, 2025). When we build AI solutions we should focus on tools that work on phones work offline and do not need much data (Ministry of Education 2020; World Bank, 2024).

The APNQ Framework operates across four interconnected dimensions:

- **AI Technological Layer:** Provides the digital substrate, including Generative AI models, learning analytics engines, adaptive platforms, and local-language NLP modules (Chiu et al., 2023; PIB, 2026a).
- **Pedagogical Layer:** Converts technological capabilities into active, student-centric instructional methods, real-time diagnostic evaluation, and scaffolded self-learning (Ayeni et al., 2024; Luckin, 2018).
- **NEP 2020 Alignment Layer:** Ensures all digital and pedagogical activities comply with national policy mandates, including competency-based evaluation, multilingual accessibility, and continuous teacher professional development (Kaur, 2026; Ministry of Education, 2020; NCTE, 2021).
- **Quality Outcomes Layer:** Evaluates overall system success against SDG 4 goals, focusing on improved learner retention, critical thinking development, equity, and access across diverse learner populations (Panigrahi, 2023; UNESCO, 2021).

The goal of this paper is to turn technology possibilities into classroom work. For that purposes the APNQ Framework is offered. This framework connects tools, teaching ways, policy goals and quality results into one system.

Challenges and Future Directions

Even though AI teaching can change things a lot spreading it throughout India's schools is not easy. Several real problems stand in the way (Panigrahi, 2023; Toppo, 2025):

- **Infrastructure Constraints:** Many rural schools lack computers have spotty electricity and face bad internet. These issues stop use of technology (Panigrahi, 2023; World Bank, 2024).
- **Teacher Adoption Barriers:** Teachers worry that AI might replace them or that it is too hard to use. This fear can make them push back (Celik, 2023; Panigrahi, 2023). Structured change plans must make clear that AI is meant to help teachers not to take their jobs (Kaur, 2026; NCTE, 2021).
- **Pedagogical Superficiality:** Using AI to turn old lecture styles into automated sessions gives little benefit (Selwyn, 2019; Toppo, 2025). Future work must aim for changes in teaching design (Chiu, 2023; Holmes et al., 2019).

Future Directions:

- Developing open-source, light-footprint AI tools that fit low-resource schools (PIB, 2026a; World Bank, 2024).
- Conducting long-term research, in schools to see how AI affects student staying in school and their emotional growth (Kaur, 2026; Panigrahi, 2023).
- Expanding national teacher training, guided by NCTE and NCERT so that AI teaching skills become part of teacher certification (Kaur, 2026; NCTE, 2021).

Conclusion

The fast change happening in Artificial Intelligence is changing the way people learn in schools. This change is moving from ways of teaching to new ways that are special for each student and can change as needed. The way Artificial Intelligence helps teach, learn and test matches the

plans in NEP 2020. This gives a chance to make learning better in all schools in India. When Artificial Intelligence does the things like checking work and finding problems it does not take the job of the teacher. Instead it helps the teacher become a learning designer someone who helps with feelings and relationships and a partner with technology. With feedback smart help and automatic translation, Artificial Intelligence in learning helps fix old problems like students not understanding, not being interested and not having equal chances to learn.

To make the most of this change there needs to be a good balance. Fixing problems like not computers, unfair rules in machines keeping data safe and teachers feeling worried needs more money for better tools clear rules about how to use technology and training for teachers. The APNQ Framework, in this paper gives a plan to make sure technology is used in a way that follows teaching rules government plans and the needs of people. In the end when using Artificial Intelligence with fairness, care and good teaching plans it helps make learning and helps students learn on their own for the whole life.

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A Study on Artificial Intelligence Framework for Predicting Dropout Risk in Rural Higher Education Using Machine Learning

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Abstract

Student dropout in higher education is a major challenge, particularly in rural areas where students often face academic, financial, social, and infrastructural difficulties. Early identification of students who are at risk of dropping out can help educational institutions provide timely support and improve student retention. Traditional approaches for dropout prediction mainly focus on prediction accuracy but often fail to explain the reasons behind the predictions, making them difficult for educators to trust and apply.

Keywords: AI, SHA, XAI, XGBoost

Introduction

This research proposes an Explainable Artificial Intelligence (XAI) framework for predicting dropout risk in rural higher education using Machine Learning techniques. The proposed framework analyses various student-related factors, including academic performance, attendance, financial background, socioeconomic conditions, and learning behaviour. Machine learning algorithms such as Decision Tree, Random Forest, and XGBoost are applied to develop predictive models for identifying students who are likely to discontinue their education. To improve transparency and interpretability, Explainable AI techniques such as SHAP (Shapley Additive explanations) are integrated to identify the major factors influencing each prediction.

The proposed framework aims to provide accurate dropout risk prediction along with meaningful explanations that can assist teachers, administrators, and policymakers in making informed decisions. By identifying high-risk students at an early stage, educational institutions can design personalized interventions such as academic counselling, financial assistance, and mentoring programs. This research contributes to the development of transparent and trustworthy AI solutions for improving student retention and supporting sustainable higher education, especially in rural communities. The study was developed with data from students belonging to educational programmes in Colombia, with a sample of 269 rural students. Using artificial neural networks (ANNs), the study analysed the influence of variables grouped into individual, socioeconomic, academic and institutional determinants on the dropout intentions of rural students in virtual programmes.

Research Objectives

- To develop an Explainable Artificial Intelligence (XAI)-based framework for predicting dropout risk among students in rural higher education institutions.
- To identify the key academic, socio-economic, demographic, and institutional factors that influence student dropout in rural higher education.

- To implement machine learning algorithms for accurate dropout risk prediction and compare their performance.
- To integrate Explainable AI techniques (such as SHAP or LIME) to provide transparent and interpretable predictions for educators and stakeholders.
- To assist educational institutions in identifying at-risk students at an early stage, enabling timely intervention and support.
- To evaluate the effectiveness, accuracy, and interpretability of the proposed XAI framework using appropriate performance metrics.

Research Methodology

This study follows a quantitative and experimental research methodology to develop an Explainable Artificial Intelligence (XAI) framework for predicting student dropout risk in rural higher education.

- **Problem Identification:** Identify the factors contributing to student dropout in rural higher education institutions through literature review and domain knowledge.
- **Data Collection:** Collect student-related data such as academic performance, attendance, demographic information, socio-economic background, and institutional factors from publicly available educational datasets or institutional records.
- **Data Preprocessing:** Clean the collected data by handling missing values, removing duplicate records, encoding categorical variables, and normalizing numerical features.
- **Feature Selection:** Select the most relevant features influencing student dropout using statistical methods or feature importance techniques.
- **Model Development:** Train machine learning models such as Decision Tree, Random Forest, XGBoost, or Logistic Regression to predict dropout risk.
- **Explainability Integration:** Apply Explainable AI (XAI) techniques such as SHAP (Shapley Additive explanations) or LIME (Local Interpretable Model-agnostic Explanations) to explain the model's predictions.
- **Model Evaluation:** Evaluate the predictive performance using metrics such as Accuracy, Precision, Recall, F1-Score, and ROC-AUC. Assess the quality of explanations generated by the XAI techniques.
- **Result Analysis:** Analyse the prediction results and explanations to identify the most influential factors affecting student dropout and discuss how the framework can support early intervention strategies.

From an Explainable AI (XAI) Perspective

The proposed research examines student dropout prediction in rural higher education through the lens of Explainable Artificial Intelligence (XAI). Unlike traditional machine learning models that often function as “black boxes,” XAI provides transparent and interpretable predictions by explaining the factors influencing each prediction. The framework integrates machine learning algorithms with explanation techniques such as SHAP and LIME to identify the key academic, socio-economic, demographic, and institutional factors associated with student dropout. By providing clear explanations for prediction outcomes, the proposed framework supports educators and policymakers in making informed decisions, implementing timely interventions, and improving student retention in rural higher education institutions.

Conclusion

The proposed Explainable AI (XAI) framework provides an effective and transparent approach for predicting student dropout risk in rural higher education. By combining machine learning algorithms with explainability techniques such as SHAP and LIME, the framework not only achieves accurate predictions but also explains the factors influencing each prediction. This transparency helps educators, administrators, and policymakers understand the reasons behind dropout risk and make informed decisions. The study highlights that academic performance, attendance, socio-economic conditions, demographic characteristics, and institutional support are among the key factors affecting student retention. Early identification of at-risk students enables educational institutions to implement timely interventions, provide personalized support, and reduce dropout rates. Overall, the proposed framework contributes to the development of trustworthy and interpretable AI systems in education. It supports data-driven decision-making and has the potential to improve student success and retention in rural higher education institutions. Future research may focus on incorporating real-time educational data, deep learning models, and additional explainability techniques to further enhance the accuracy and practical applicability of the framework.

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Artificial Intelligence Usage in Education and Emotional Maturity among Prospective Teachers

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Abstract

Artificial Intelligence (AI) is increasingly becoming part of contemporary education, influencing teaching, learning, assessment, academic support, and professional preparation. Prospective teachers, as future educators, need to develop the ability to use AI effectively while also maintaining the emotional balance required for responsible teaching. The present study focuses on Artificial Intelligence Usage in Education and Emotional Maturity among prospective teachers. The study aims to examine whether Artificial Intelligence Usage in Education and Emotional Maturity differ significantly with respect to gender, locality, and type of management, and to determine the relationship between the two variables. A descriptive survey method was adopted for the study. The sample consisted of 304 prospective teachers selected from teacher education institutions. Data were collected using standardized tools measuring Artificial Intelligence Usage in Education Scale and Emotional Maturity Scale. A Personal Data Sheet was also created by the investigator. The formulated hypotheses and objectives were tested using appropriate statistical technique t-test and F-Test Analysis of Variance (ANOVA) and Correlation analysis. Recent research indicates that AI literacy and AI readiness are becoming important components of teacher education, while emotional competencies remain essential for effective professional functioning. The study is expected to provide useful insights for teacher educators, institutions, and policymakers in developing balanced teacher preparation programmes that integrate technological competence with emotional development.

Keywords: *Artificial Intelligence, AI Usage, Education, Emotional Maturity, Prospective Teachers, Teacher Education, AI Literacy*

Introduction

Artificial Intelligence (AI) is rapidly becoming an important part of modern education. AI-based applications are being used for teaching, learning, lesson planning, assessment, educational research, and personalized learning. As future teachers, prospective teachers need to develop the knowledge and skills required to use AI effectively, critically, and ethically in educational settings. However, teaching is not only concerned with technological knowledge. It also requires emotional stability, patience, self-control, empathy, and the ability to respond appropriately to students and different classroom situations. Emotional maturity is therefore an important quality for prospective teachers. The effective integration of AI with emotional development can help future teachers use technology while maintaining the human values of education. Hence, the present study focuses on Artificial Intelligence Usage in Education and Emotional Maturity among Prospective Teachers.

Need of the Study

The increasing use of AI in education has created new opportunities as well as challenges for prospective teachers. Future teachers are expected to use AI tools for educational purposes while also exercising professional judgement and ethical responsibility. At the same time, they need emotional maturity to manage classroom situations, maintain positive relationships,

understand students' needs, and deal with professional challenges. Excessive dependence on technology without adequate emotional and professional development may affect the quality of teacher–student interaction. Therefore, it is important to study Artificial Intelligence Usage in Education along with Emotional Maturity among prospective teachers. The findings of the study may help teacher education institutions design programmes that develop both AI competency and emotional maturity, thereby preparing prospective teachers for the changing demands of contemporary education.

Review of the Literature

Zawacki-Richter et al. (2019) highlighted the growing application of AI in higher education and emphasized the need for greater attention to the pedagogical and human dimensions of AI implementation.

Crompton and Burke (2023) reviewed research on AI in higher education and observed the increasing use of AI applications for teaching, learning, assessment, and administration. Such developments demonstrate that future teachers need adequate preparation to work in technology-rich educational environments.

Ayanwale et al. (2024) investigated AI literacy among 529 pre-service teachers and found that knowledge and understanding of AI played an important role in several dimensions of AI literacy. The study also examined AI use, AI detection, ethics, creation, problem-solving, and emotion regulation.

Younis (2024) examined the effectiveness of a professional development programme designed to develop AI literacy among prospective teachers. The findings indicated that the programme improved AI literacy skills, suggesting that structured training can help future teachers develop the competencies needed for AI-supported education.

Zhang et al. (2023) investigated AI acceptance among pre-service teachers using a multigroup approach. Their work demonstrates the importance of understanding future teachers' attitudes and acceptance when designing AI-related teacher education programmes.

Objectives of the Study

The present study has the following objectives:

- To find out the level of Artificial Intelligence Usage in Education among prospective teachers.
- To find out the level of Emotional Maturity among prospective teachers.
- To find out whether there is a significant difference in Artificial Intelligence Usage in Education and Emotional Maturity among prospective teachers with respect to gender, locality, type of management.
- To find out whether there is a significant relationship between Artificial Intelligence Usage in Education and Emotional Maturity among prospective teachers.

Hypotheses of the Study

The following null hypotheses may be formulated:

- There is no significant difference between male and female (Gender) prospective teachers in their Artificial Intelligence Usage in Education and Emotional Maturity.
- There is no significant difference between rural and urban (Locality) prospective teachers in their Artificial Intelligence Usage in Education and Emotional Maturity.
- There is no significant difference among prospective teachers from different types of management (Government, Government-Aided and Self Finance) in their Artificial Intelligence Usage in Education and Emotional Maturity.

- There is no significant relationship between Artificial Intelligence Usage in Education and Emotional Maturity among prospective teachers.

Methodology

The descriptive survey method was adopted for the present study and selected the stratified random sampling technique. 304 prospective teachers were randomly selected from various colleges belongs to government, government-aided and self-financed management. Data were collected using standardized tools measuring Artificial Intelligence Usage in Education Scale and Emotional Maturity Scale. A Personal Data Sheet was also created by the investigator. The formulated hypotheses and objectives were tested using appropriate statistical technique t-test and F-Test Analysis of Variance (ANOVA) and Correlation analysis.

Testing of Hypothesis

Hypothesis – 1

There is no significant difference between male and female (Gender) prospective teachers in their Artificial Intelligence Usage in Education and Emotional Maturity.

Table 1						
Details of t-Test Result for Gender						
Variables	Gender	N	Mean	SD	t-Value	LOS
Artificial Intelligence Usage in Education	Male	100	106.21	9.818	0.997	Not Significant
	Female	204	107.40	9.618		

*LOS- Level of Significance.

Table 1 indicates that the obtained t-value is 0.997. It is less than the table value of 1.96 at 0.05 level of significance. It is inferred from these results ($t = 0.997 < 1.96$), Therefore, the null hypothesis, that there is no significant difference between male and female prospective teachers with respect to their Artificial Intelligence Usage in Education based on gender is accepted.

Table 2						
Details of t-Test Result for Gender						
Variables	Gender	N	Mean	SD	t-Value	LOS
Emotional Maturity	Male	100	63.08	4.084	0.855	Not Significant
	Female	204	63.50	3.746		

*LOS- Level of Significance.

Table 2 indicates that the obtained t-value is 0.855. It is less than the table value of 1.96 at 0.05 level of significance. It is inferred from these results ($t = 0.855 < 1.96$), Therefore, the null hypothesis, that there is no significant difference between male and female prospective teachers with respect to their emotional maturity is accepted.

Hypothesis – 2

There is no significant difference between rural and urban (Locality) prospective teachers in their Artificial Intelligence Usage in Education and Emotional Maturity.

Table 3						
Details of t-Test Result for Locality						
Variables	Locality	N	Mean	SD	t-Value	LOS
Artificial Intelligence Usage in Education	Rural	89	102.90	9.327	4.940	Significant
	Urban	215	108.71	9.332		

***LOS- Level of Significance.**

Table 3 indicates that the obtained t-value is 4.940. It is greater than the table value of 1.96 at 0.05 level of significance. These results suggest that there is significant prospective teachers with respect to their artificial intelligence usage in education between rural and urban areas ($t = 4.940 > 1.96$). Therefore, the null hypothesis is not accepted.

Table 4						
Details of t-Test Result for Locality						
Variables	Locality	N	Mean	SD	t-Value	LOS
Emotional Maturity	Rural	89	63.88	3.460	1.602	Not Significant
	Urban	215	63.14	4.000		

***LOS- Level of Significance.**

Table 4 indicates that the obtained t-value is 1.602. It is less than the table value of 1.96 at 0.05 level of significance. It is inferred from these results ($t = 1.602 < 1.96$), Therefore, the null hypothesis, that there is no significant difference between rural and urban prospective teachers with respect to their emotional maturity is accepted.

Hypothesis – 3

There is no significant difference among prospective teachers from different types of management (Government, Government-Aided and Self Finance) in their Artificial Intelligence Usage in Education and Emotional Maturity.

Table 5						
Details of F-ratio Result for Type of Management						
Variables	Type of Management	N	Mean	SD	F-ratio	LOS
Artificial Intelligence Usage in Education	Government	89	64.81	3.236	21.577	Significant
	Government - Aided	98	64.05	3.047		
	Private	117	61.68	4.279		
	Total	304	63.36	3.859		

***LOS- Level of Significance.**

As shown in the Table 5 indicates that the obtained F-value is 21.577; it is greater than the Table Value of 3.00 at 0.05 level of significant. It is inferred from this result $F = 21.577 > 3.00$. Hence, the formulated null hypothesis that there is significant difference among prospective

teachers belonging to difference type of management (government, government-aided and private) with respect to their artificial intelligence usage in education is not accepted.

Table 6						
Details of F-ratio Result for Type of Management						
Variables	Type of Management	N	Mean	SD	F-ratio	LOS
Emotional Maturity	Government	89	84.98	2.671	1.875	Not Significant
	Government-Aided	98	84.87	2.118		
	Private	117	85.40	1.672		
	Total	304	85.11	2.153		

***LOS- Level of Significance.**

As shown in the Table 6 indicates that the obtained F-value is 1.875; it is less than the Table Value of 3.00 at 0.05 level of significant. It is inferred from this result $F = 1.875 < 3.00$. Hence, the formulated null hypothesis that there is no significant difference among prospective teachers belonging to difference type of management (government, government-aided and private) with respect to their role of emotional maturity is accepted.

Hypothesis – 4

There is no significant relationship between Artificial Intelligence Usage in Education and Emotional Maturity among prospective teachers.

Table 7				
Details of Correlation Coefficient Result for relationship between Artificial Intelligence Usage in Education and Emotional Maturity in Prospective Teachers.				
Variables	N	Correlation Coefficient	‘r’ Value	LOS
Artificial Intelligence Usage in Education and Emotional Maturity	304	0.071	0.217	Not Significant

***LOS- Level of Significance.**

Based on the computed correlation coefficient ‘r’ value in Table 7, and examination of the table above that the correlation ‘r’ value is 0.217 which is significant at the 0.05 level. Therefore, the null hypothesis is accepted. Thus, the prospective teachers with respect to their Artificial Intelligence Usage in Education and Emotional Maturity are positively correlated.

Educational Implications

The study highlights the importance of developing AI competencies and emotional maturity among prospective teachers. Teacher education institutions can provide practical training in AI tools, ethical use of AI, and digital teaching methods. Activities such as group discussions, role-play, mentoring, and stress-management programmes can also strengthen emotional maturity and classroom readiness.

Conclusion

Artificial Intelligence is becoming an important part of modern education. Prospective teachers need both AI knowledge and emotional maturity to use technology effectively and responsibly. Integrating AI training with emotional and professional development in teacher education can help prepare competent, confident, and responsible future teachers.

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AI Literacy and Professional Development among Teachers

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Abstract

The rapid development of Artificial Intelligence (AI), particularly Generative AI, is transforming teaching and learning and creating new competency requirements for teachers. AI literacy has therefore become an important professional competency for understanding, using, evaluating, and applying AI effectively and responsibly in education. This paper examines the importance of AI literacy and professional development among teachers, with particular attention to the competencies required, challenges faced, and strategies for effective AI integration. The paper adopts a thematic review approach based on recent literature on teacher AI literacy and professional development. The review highlights that teachers require not only basic AI knowledge and technical skills but also critical evaluation skills, ethical awareness, pedagogical knowledge, and continuous learning capabilities. Major challenges include limited AI knowledge, inadequate professional development opportunities, unreliable AI-generated information, ethical and privacy concerns, bias, and rapid technological developments. The review further identifies continuous training, hands-on learning, collaborative professional development, classroom-based practice, ethical training, critical evaluation, action research, and regular updating as important strategies for strengthening teachers' AI competencies. Based on these findings, a five-stage model comprising Awareness, Acquisition, Integration, Reflection, and Creation and Continuous Learning is proposed. The paper concludes that sustained, practical, collaborative, and context-sensitive professional development is essential for preparing teachers to integrate AI effectively and responsibly into education.

Keywords: *Artificial Intelligence, AI Literacy, Teacher Professional Development, Teacher Competencies, AI Integration.*

Introduction

Since 2023, the use of Generative Artificial Intelligence (GenAI) chatbots, such as ChatGPT, has grown rapidly in both educational and professional settings. The increasing use of these AI tools highlights the importance of AI literacy as an essential competency for individuals to understand, use, and evaluate AI technologies effectively and responsibly (PwC, 2025). In education, the growing use of AI is changing how teachers plan lessons, prepare learning materials, assess students, provide feedback, and support their own professional learning. However, using AI effectively requires more than basic technical skills. Teachers need to understand how AI works, evaluate AI-generated information, recognize its limitations, and use AI in an ethical and responsible manner. Recent research also highlights the need to provide teachers with appropriate professional development to support effective AI integration in teaching and learning (Ding et al., 2024; Tan et al., 2025) .

Therefore, AI literacy is becoming an important professional competency for teachers. Professional development can help teachers develop the knowledge, skills, confidence, and ethical awareness needed to use AI effectively in their professional practices. UNESCO's *AI Competency*

Framework for Teachers identifies five important areas of teacher AI competency: human-centered mindset, ethics of AI, AI foundations and applications, AI pedagogy, and AI for professional learning. In this context, the present paper focuses on AI literacy and professional development among teachers. It examines the important AI competencies teachers need, the challenges they may face in developing these competencies, and the opportunities that professional development can provide for effective and responsible use of AI in education.

Significance of AI Literacy among Teachers

AI literacy is important for teachers for several reasons. First, teachers need to understand the basic concepts and principles of AI. Without basic knowledge, they may find it difficult to identify reliable AI tools and understand the limitations of AI-generated information. Second, teachers need practical skills to use AI tools effectively. Simply knowing about an AI tool is not enough. Teachers should know how to give suitable prompts, check the generated content, make necessary changes, and use AI appropriately in teaching and learning activities. Third, teachers need critical AI literacy. AI tools can sometimes provide incorrect, misleading, or fabricated information. Therefore, teachers should be able to check and verify AI-generated content before using it. They should also help students develop the habit of critically evaluating information produced by AI. Fourth, ethical awareness is an important part of AI literacy. Teachers should understand issues related to data privacy, copyright, intellectual property, academic integrity, bias, transparency, and human responsibility when using AI in education. Finally, AI literacy requires continuous learning and professional development. Since AI technologies are developing rapidly, teachers cannot develop sufficient AI competencies through a single training programme or workshop. They need continuous opportunities to update their knowledge, skills, and practices (Aravantinos et al., 2026). Recent research also supports this broader understanding of AI literacy. A systematic review of AI literacy in school education identified cognitive, emotional, psychological, and behavioral dimensions and highlighted continuous professional development as an important aspect of teachers' AI literacy (Tan et al., 2025).

Objectives of the Paper

- Explain the concept and importance of AI literacy among teachers.
- Examine the role of professional development in improving teachers' AI literacy.
- Identify the major challenges in AI-focused teacher professional development and suggest suitable strategies to address them.
- Propose a progressive model for developing teachers' AI competencies through continuous professional development.

Concept of AI Literacy

AI literacy is a multidimensional concept that involves more than simply knowing how to use digital tools. In the past, technological literacy mainly focused on the ability to operate digital technologies. However, AI requires additional knowledge and skills because AI systems can create content, provide recommendations, analyze information, and support decision-making (Prilop et al., 2025). For teachers, AI literacy can be understood as the ability to:

- understand the basic concepts of AI
- use AI tools effectively and appropriately
- critically evaluate AI-generated information
- identify the limitations, errors, and biases of AI systems

- use AI in teaching, learning, and assessment
- protect data privacy and intellectual property
- use AI in an ethical and responsible manner and
- continuously update their knowledge and skills as AI technologies develop.

Therefore, AI literacy includes not only knowledge and technical skills, but also attitudes, values, critical thinking, and professional judgement. For teachers, developing these areas is essential for the effective and responsible use of AI in education (Michelle Kelley, 2025).

Teacher Professional Development in the AI Era

Teacher professional development refers to continuous learning opportunities that help teachers improve their knowledge, skills, attitudes, and teaching practices. Traditionally, professional development has focused on areas such as subject knowledge, teaching methods, assessment, classroom management, and the use of digital technologies. However, the rapid development of AI requires teachers to develop new knowledge and skills. In the AI era, professional development should help teachers understand:

- What is AI and how does it work?
- How does Generative AI work at a basic level?
- How can AI tools support teaching and learning?
- How can teachers check the accuracy of AI-generated information?
- How can AI be used without reducing teachers' professional independence?
- What ethical issues should teachers consider when using AI?
- How should teaching and assessment practices change in response to AI?
- How can teachers use AI to support their own professional learning?

UNESCO's teacher competency framework also recognizes AI for professional learning as an important competency area. This shows that AI is not only a tool for classroom teaching but can also support teachers in their continuous professional learning and development (UNESCO, 2024a).

Literature review

Paunanthie & Tholappan, (2025) emphasized that effective techno-pedagogical integration in rural Sri Lanka and Tamil Nadu requires context-specific and continuous teacher professional development. The study highlighted differentiated support, collaborative learning, mentoring, and teacher agency. These findings suggest that AI-focused professional development should also be continuous, collaborative, and responsive to teachers' local educational needs.

Younis, (2024) investigated the effectiveness of an instructional-design-based professional development programme in developing AI literacy skills among pre-service teachers. The study found that structured professional development can contribute significantly to improving teachers' AI literacy and their ability to engage with AI technologies in educational contexts. The findings emphasize the importance of systematic training and practical learning opportunities in preparing teachers for effective and responsible AI integration in education.

Deshen et al., (2026) conducted an exploratory study on teachers' AI literacy and examined their knowledge, understanding, and ability to engage with AI technologies. The study highlighted the importance of developing AI literacy among teachers to support effective and responsible use of AI in education. The findings emphasize the need for appropriate professional development to strengthen teachers' AI-related knowledge and competencies.

Yang & Kong, (2025) highlighted the importance of teacher professional development in developing AI literacy education. The study emphasized strengthening teachers' AI knowledge and pedagogical skills for effective classroom integration.

Ruiz & Yambao, (2026) examined AI literacy and professional development engagement as predictors of mathematics teachers' readiness for AI-enhanced instruction. The study highlighted that teachers' AI literacy and participation in professional development play an important role in their readiness to integrate AI effectively into teaching

Challenges in Developing Teachers' AI Literacy

Although AI offers many opportunities in education, teachers may face several challenges in developing the knowledge and skills needed to use AI effectively and responsibly (Wang & Zhu, 2026).

- **Lack of AI Knowledge and Skills** - Some teachers may have limited knowledge of basic AI concepts and may not have the skills to select and use suitable AI tools for educational purposes.
- **Limited Professional Development Opportunities** - Teachers may not have enough opportunities to participate in AI-related training. Short-term workshops alone may not be sufficient to develop the knowledge and skills needed for effective AI use.
- **Accuracy and Reliability of AI Outputs** - AI tools can sometimes provide incorrect, misleading, or fabricated information. Therefore, teachers need the ability to check and verify AI-generated content before using it in teaching and learning.
- **Ethical and Privacy Concerns** - The use of AI creates concerns related to student data, privacy, copyright, intellectual property, academic integrity, and responsible use. Teachers need appropriate awareness to address these issues.
- **Bias and Lack of Transparency** - AI systems may produce biased or unfair outputs. In some cases, it may also be difficult for teachers to understand how AI systems arrive at particular responses or recommendations.
- **Rapid Changes in AI Technology** - AI technologies are developing rapidly, and new tools and features are introduced regularly. Therefore, teachers cannot depend only on existing knowledge. Continuous professional learning is necessary to keep their AI knowledge and skills up to date.

Strategies for AI-Enabled Teacher Professional Development

Effective professional development can help teachers overcome the challenges of using AI in education. The following strategies can support the development of teachers' AI literacy and professional competencies (Ding et al., 2024; Tan et al., 2025):

- **Continuous Training:** AI-related professional development should be provided regularly rather than as a one-time training programme.
- **Hands-on Learning:** Teachers should have opportunities to practice using AI tools for real teaching tasks, such as lesson planning, content creation, assessment, and feedback.
- **Ethics-Focused Training:** Training should include important issues such as data privacy, copyright, bias, academic integrity, and responsible use of AI.
- **Collaborative Learning:** Teachers can improve their AI skills through professional learning communities, peer support, mentoring, and collaborative activities.
- **Classroom-Based Practice:** Teachers should be encouraged to use AI in actual classroom situations and reflect on its effectiveness and limitations.

- **Critical Evaluation:** Professional development should help teachers develop the ability to check, verify, and critically evaluate AI-generated information.
- **Action Research:** Teachers can conduct small-scale classroom-based research to examine the benefits, challenges, and effectiveness of AI in teaching and learning.
- **Regular Updating:** Professional development programmes should be updated regularly to reflect new developments, tools, and emerging issues in AI.

Overall, AI-enabled professional development should be continuous, practical, collaborative, ethical, and reflective. Such an approach can help teachers develop the confidence and competencies needed to use AI effectively and responsibly.

AI Competency Framework for Teachers

The AI Competency Framework for Teachers, developed by UNESCO, (2026) provides guidance on the knowledge, skills, and values that teachers need to use Artificial Intelligence effectively and responsibly. The framework was developed with a focus on protecting teachers' rights, maintaining human control, and promoting sustainable use of AI. The framework identifies 15 competencies under five major dimensions:

- **Human-centered mindset** – understanding the importance of human judgement and responsibility when using AI.
- **Ethics of AI** – using AI safely, fairly, responsibly, and with respect for privacy and human rights.
- **AI foundations and applications** – developing basic knowledge of AI and learning how to use AI tools appropriately.
- **AI pedagogy** – using AI to support teaching, learning, lesson planning, and assessment.
- **AI for professional learning** – using AI to support teachers' continuous learning and professional development.

These competencies are organized into three levels of development: Acquire, Deepen, and Create. At the Acquire level, teachers develop basic AI knowledge and skills. At the Deepen level, they improve their ability to apply AI in teaching and professional activities. At the Create level, teachers use AI more confidently and creatively to develop new teaching practices and contribute to professional and educational improvement. The framework serves as a global guide for teacher education and professional development. It can help countries and educational institutions design AI training programmes, develop teacher competency standards, and assess teachers' AI-related skills. It also encourages teachers to use AI critically, ethically, and responsibly while continuing to develop their professional knowledge.

Proposed Model for Teacher AI Professional Development

A five-stage model is proposed.

Stage 1: Awareness - Teachers are introduced to:

- AI concepts;
- Generative AI;
- opportunities;
- risks;
- ethical concerns.

Stage 2: Acquisition - Teachers develop:

- basic AI knowledge;
- practical tool skills;
- prompting skills;

- evaluation skills.

Stage 3: Integration - Teachers apply AI to:

- lesson planning;
- learning activities;
- assessment;
- feedback;
- differentiated instruction.

Stage 4: Reflection - Teachers evaluate:

- effectiveness;
- accuracy;
- learner response;
- ethical implications;
- limitations.

Stage 5: Creation and Continuous Learning - Teachers move towards:

- innovative AI-supported pedagogy;
- peer mentoring;
- action research;
- collaborative development;
- continuous professional learning.

This progression is broadly consistent with UNESCO's (2024) Acquire–Deepen–Create progression for teacher AI competencies.

Discussion

The review shows that AI literacy is essential for teachers to use AI effectively and responsibly. Professional development plays an important role in developing teachers' AI knowledge, practical skills, critical thinking, and ethical awareness. The reviewed studies emphasize that AI training should be continuous, practical, collaborative, and connected to classroom needs. Therefore, teachers need ongoing professional support to respond confidently to the rapid development of AI technologies.

Educational Implications

Teacher education institutions and schools should integrate AI literacy into pre-service and in-service professional development programmes. Training should provide hands-on experience in using AI for teaching, assessment, and lesson planning, along with awareness of ethics, privacy, bias, and academic integrity. Professional Learning Communities, mentoring, and continuous training can further support teachers in developing responsible AI practices.

Conclusion

AI literacy has become an important competency for teachers in the changing educational environment. Continuous and well-structured professional development can strengthen teachers' AI knowledge, skills, confidence, and ethical awareness. Therefore, teacher professional development should be practical, collaborative, continuous, and responsive to emerging AI developments to support effective and responsible AI integration in education.

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A Study of Foundational Stage Teachers Approach towards AI Tools

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Abstract

Artificial Intelligence (AI) has emerged as a driving force in the field of education, reshaping teaching-learning processes and learner engagement. In this study researcher conducted questionnaire on a sample of foundational stage teachers to know about their attitude awareness towards AI tools. In this study survey method is used. Sample for the study is selected through convenient sampling method. In this study data collected from 45 foundational stage teachers of Sangli city. The obtained quantitative data analyzed by using percentage.

Key Words: AI tools, foundational stage, teachers, learning, etc.

Introduction

The Foundational Stage is particularly important because it forms the basis for children's future educational development. According to the National Education Policy (NEP) 2020, the Foundational Stage covers children from approximately 3 to 8 years of age, including three years of preschool/Anganwadi education followed by Grades 1 and 2. At this stage, children develop foundational literacy and numeracy, language abilities, cognitive skills, socio-emotional competencies, motor skills, creativity, and positive attitudes towards learning. Teaching at this level therefore requires developmentally appropriate, play-based, activity-based, experiential, and child-centered approaches. In the context of NEP 2020, National Curriculum Framework for Foundational Stage (NCF-FS), it is important to examine how Foundational Stage teachers perceive and approach emerging AI tools. Such a study can provide information about teachers' awareness, familiarity, attitudes, confidence, patterns of use, perceived benefits, perceived challenges, and training needs related to AI.

Statement of the Problem

A STUDY OF FOUNDATIONAL STAGE TEACHERS APPROACH TOWARDS AI TOOLS

Objectives of the study

- To know the awareness of Foundational stage teachers about AI tools.
- To study the Foundational stage teachers approach towards AI tools.

Assumptions:

The present study is based on the following assumptions:

- Foundational Stage teachers have varying levels of awareness and familiarity with AI tools - UNESCO (2024) identifies AI foundations and applications as an important component of teachers' AI competency and notes that teachers require knowledge and skills to understand and use AI effectively.
- Teachers' approaches towards AI tools may differ according to their knowledge, skills, confidence, and previous exposure to technology - UNESCO's AI Competency Framework for

Teachers emphasize that teachers require different levels of AI knowledge, skills, and competencies and identifies progression from Acquire, Deepen, to Create.

- AI tools can support teachers in lesson planning, preparation of teaching-learning materials, activity design, assessment, and professional learning - UNESCO (2024) includes AI pedagogy and AI for professional learning among the five dimensions of teacher AI competency. UNESCO (2023) also discusses the potential of generative AI for curriculum design, teaching, learning, and research activities.
- Teachers may have concerns about AI use related to accuracy, privacy, ethics, bias, safety, and developmental appropriateness - UNESCO (2023) highlights concerns regarding data privacy, ethical issues, human agency, safety, and age-appropriate use of generative AI in education.

Need and Importance of the study

AI tools are increasingly being used for lesson planning, teaching-learning material development, assessment, personalized learning, content generation, and professional development. Although these tools offer considerable opportunities for improving teaching practices, their educational effectiveness depends largely on teachers' awareness, attitudes, confidence, digital competence, and willingness to use them appropriately. The Foundational Stage, covering children from approximately 3 to 8 years of age, is a critical period for developing foundational literacy and numeracy, language, cognitive abilities, creativity, social-emotional skills, and learning habits. Teachers at this stage require appropriate and engaging resources to address children's diverse developmental and learning needs. Teachers may differ in their awareness, acceptance, confidence, frequency of use, perceived usefulness, and concerns regarding AI. It can provide an understanding of teachers' positive or negative perceptions, willingness, confidence, and readiness to adopt AI-supported practices. The findings may help determine how AI can be used to complement play-based, activity-based, experiential, and child-centred learning rather than replacing essential teacher-child interaction.

Delimitations of the study:

- Present research is restricted to only foundational stage teachers.
- This research is limited for Marathi medium teachers.
- This research is limited for Sangli city.

Scope of the study

The present study will be helpful to know more about the attitude of foundational stage teachers towards AI tools

Research Methodology

For the present study to achieve objectives quantitative approach was adopted. For the present study researcher used survey method.

Sample of the study

The sample of the study was foundational stage teachers.

Tool

For the present study researcher have prepared semi structured questionnaire for foundational stage teachers.

Data collection

Researcher was prepared questionnaire for foundational stage teachers by using Google Form. It consists 20 questions for foundational stage teachers to study their approach towards AI tools. The data was collected by the sending questionnaire through Google form to the foundational stage teachers. 45 foundational stage teachers from Sangli city were responded to the questionnaire. Responses were analyzed carefully by using statistical tools.

Data Analysis and interpretation

Quantitative data was collected and analyzed with the help of statistical tool that is percentage.

Table 1 - Awareness about AI tools

Q. No.	Question	Responses from foundational stage teachers	
		Yes	No
1.	Do you know about AI tools?	43 (91%)	4 (9%)
2.	Do you know different AI tools?	40 (89%)	5 (11%)
3.	Do you use regularly different AI tools?	37 (82%)	8 (18%)

From the above table the following observations are noted:

- Forty three (91%) teachers know about AI tools whereas 2 (9%) are unaware of it.
- Forty (90%) teachers said that they know different AI tools whereas 5 (11%) not aware about it.
- Thirty seven (82%) teachers said that they use different AI tools regularly whereas 8 (18%) teachers said that they do not use it.

Table 2 - For what purpose do you use AI tools?

To study concepts deeply	To evaluate	To make teaching Innovative	To complete projects	To get new information
4 (9%)	0 (0%)	22 (49%)	4 (9%)	15 (33%)

From the above table the following observations are noted:

- The data shows that the primary purpose of using AI tools is to make teaching innovative, 22 respondents (49%) selecting this option. This indicates that nearly half of the respondents view AI as a valuable tool for introducing new, creative, and engaging approaches to teaching and learning.
- The second most common purpose is to get new information, selected by 15 respondents (33%).
- A smaller number of respondents use AI tools to study concepts deeply and to complete projects, with 4 respondents (9%) selecting each purpose.
- None of the respondents (0%) reported using AI tools for evaluation. This may suggest that respondents are not yet using AI extensively for assessment or evaluation-related activities.

Table 3 - Approach towards AI tools

Q. No.	Question	Responses from foundational stage teachers	
		Yes	No
1.	Do you think that AI tools help you to understand difficult concepts easily?	43 (96%)	2 (4%)
2.	Do you use AI tools in teaching?	39 (87%)	6 (13%)
3.	Do you think teachers should aware about AI tools?	43 (96%)	2 (4%)
4.	Is it right to give information about AI tools at foundational stage?	38 (84%)	7 (16%)
5.	Can academic problems be solved with the help of AI tools?	38 (84%)	7 (16%)
6.	Does AI helps to increase students interest in learning?	41 (91%)	4 (9%)
7.	Do you think that information about AI tools should be included in school curricula?	39 (87%)	6 (13%)
8.	Can interactive teaching be done with the help of AI tools?	35 (78%)	10 (22%)
9.	Can AI tools be used in activity based teaching?	36 (80%)	9 (20%)
10.	Does AI tools useful for the cognitive development of students?	36 (80%)	9 (20%)
11.	Does AI tools useful for the psychological development of students?	31 (69%)	14 (31%)
12.	Does AI tools useful for the Sociological development of students?	39 (87%)	6 (13%)
13.	Does AI tools useful for the Physical development of students?	18 (40%)	27 (60%)
14.	Does AI tools useful for the Personality development of students?	39 (87%)	6 (13%)
15.	Do you think that use of AI tools in teaching-learning will decrease importance of teachers?	23 (51%)	22 (49%)
16.	Do you think that an overreliance on AI tools is right?	13 (29%)	32 (71%)

From the above table the following observations are noted:

- A very high proportion of teachers, 43 (96%), believe that AI tools help them understand difficult concepts easily and 2 (4%) teachers denied it.
- Similarly, 43 (96%) agree that teachers should be aware of AI tools, showing strong recognition of the importance of AI literacy among teachers.
- A majority of teachers, 39 (87%), reported that they use AI tools in teaching.
- 38 (84%) teachers believe that providing information about AI tools at the foundational stage is appropriate, and the same proportion feel that academic problems can be solved with the help of AI tools. This reflects a considerable level of acceptance of AI as a supportive educational resource.
- As many as 41 (91%) believe that AI increases students' interest in learning. Moreover, 39 (87%) support including information about AI tools in school curricula. Teachers also recognize the potential of AI for interactive teaching (78%) and activity-based teaching (80%), indicating that AI is viewed as a means of making classroom practices more engaging and learner-centred.
- Regarding students' development, 80% of teachers believe that AI tools are useful for cognitive development, while 87% consider them beneficial for sociological development and personality development. A comparatively lower proportion, 69%, believe that AI contributes to psychological development. The lowest positive response in this area is related to physical development, with only 40% of teachers considering AI useful for this purpose, while 60% disagree.
- Fifty one percent teachers believe that it may decrease teachers' importance, whereas 22 (49%) do not.
- Only 13 (29%) teachers believe that overreliance on AI tools is appropriate, whereas 32 (71%) disagree. This suggests that although teachers are positive about using AI, most of them do not support excessive dependence on AI tools.

Objective wise Findings:

Objective 1 : To know the awareness of foundational stage teachers about AI tools.

- The findings indicate that 91% of foundational stage teachers are aware of AI tools, while only 9% are unaware, showing a high level of basic awareness.
- 90% of teachers reported knowing different AI tools, indicating that awareness extends beyond general knowledge to familiarity with various AI applications.
- 82% of teachers use different AI tools regularly, suggesting that a substantial proportion of teachers are not only aware of AI but also actively using it.
- 96% of teachers believe that teachers should be aware of AI tools, reflecting strong recognition of the importance of AI awareness and digital competency among teachers.
- The primary purpose of using AI tools is to make teaching innovative (49%), followed by getting new information (33%). Only 9% each use AI for studying concepts deeply and completing projects, while none use it for evaluation.

Objective 2 : To study the approach of foundational stage teachers towards AI tools.

- The teachers show a highly positive approach towards AI, with 96% believing that AI tools help them understand difficult concepts easily.
- 87% of teachers reported using AI tools in teaching, while 84% believe that information about AI should be provided at the foundational stage.

- 91% believe that AI tools increase students' interest in learning, and 87% support including information about AI tools in the school curriculum.
- Teachers also recognize AI as useful for interactive teaching (78%) and activity-based teaching (80%), indicating its perceived potential to make teaching more engaging and learner-centred.
- AI is considered beneficial for cognitive (80%), sociological (87%), and personality development (87%), while its perceived contribution to psychological development is comparatively lower (69%) and physical development is lowest (40%).
- Teachers have mixed views about whether AI will reduce the importance of teachers, with 51% agreeing and 49% disagreeing.
- A clear majority (71%) do not support overreliance on AI tools, indicating awareness of the need for balanced and responsible use of AI.

Conclusions of the Study

- Majority of the foundational teachers are aware about AI.
- Foundational stage teachers demonstrate a high level of awareness and familiarity with AI tools, and this awareness is reflected in their regular use of AI, particularly for innovative teaching and accessing new information.
- Foundational stage teachers have a positive but cautious approach towards AI tools. They recognize AI as an effective aid for innovative, interactive, and engaging teaching and for supporting students' development.
- Foundational stage concern about overreliance on AI and its possible impact on the role of teachers indicates that they view AI as a supportive tool rather than a replacement for teachers.
- Majority of the teachers are in opinion that to include AI and AI related subjects should be included in school curriculum.
- AI tools significantly enhance learning effectiveness, as most teachers report improved understanding of difficult concepts, instant feedback, and increased interest in their studies.
- Majority of the teachers are in opinion that AI tools impact on their learning process.

Conclusion

The present research concludes that use of AI tools are important part of teaching-learning process to enhance quality of education at foundational stage. Use of different AI tools makes learning process more interesting and effective. Based on the findings of the study, it can be concluded that AI-based learning tools have a significant positive impact on the overall development of students at foundational stage. The majority of respondents reported that use of AI helps to develop cognitive, psychological, sociological, physical aspects of students. The Intellectual use of AI tools makes teaching-learning process superior and improves quality of education at foundational stage

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The Role of Artificial Intelligence in Mathematics Teaching and Research

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Abstract

Artificial Intelligence (AI) is rapidly transforming mathematics education, enabling personalized instruction, automated assessment, and advanced mathematical research. This paper examines the role of AI in mathematics teaching and research, drawing on developments in intelligent tutoring systems, adaptive learning platforms, computer algebra systems, and machine-assisted theorem proving. It reviews how AI-driven tools reshape classroom pedagogy through differentiated instruction and real-time feedback, and explores AI's growing contribution to mathematical research, including automated theorem proving, symbolic computation, and AI-assisted conjecture generation. The paper further discusses a framework for responsible integration, the changing role of teachers, and challenges including algorithmic bias, over-reliance on technology, and equity of access. It argues that AI should function as a complementary cognitive partner rather than a replacement for human mathematical reasoning, and concludes with recommendations for educators, curriculum designers, and policymakers.

Keywords: Artificial Intelligence; Mathematics Education; Intelligent Tutoring Systems; Automated Theorem Proving; Adaptive Learning; Educational Technology; Machine Learning in Research

Introduction

Mathematics education has traditionally relied on structured pedagogy emphasizing procedural fluency, conceptual understanding, and problem-solving ability. The rapid advancement of Artificial Intelligence (AI) — encompassing machine learning, natural language processing, and knowledge-based reasoning — has begun to reshape how mathematics is taught, learned, and researched (Zawacki-Richter, Marín, Bond, & Gouverneur, 2019). AI-powered platforms can diagnose individual learning gaps, generate personalised practice problems, provide instant feedback, and even assist professional mathematicians in exploring conjectures and verifying proofs (Luckin, Holmes, Griffiths, & Forcier, 2016), raising important questions about the changing role of teachers and the pedagogical strategies needed to harness AI without compromising core reasoning skills (UNESCO, 2023). This paper reviews AI applications in mathematics teaching and research, discusses a framework for balanced integration, and examines the associated pedagogical and ethical challenges.

Methodology

This paper adopts a narrative-integrative review methodology. Sources were identified through targeted searches of Scopus, Web of Science, and Google Scholar (2011–2023) using combinations of the terms “artificial intelligence,” “mathematics education,” “intelligent tutoring systems,” “automated theorem proving,” and “adaptive learning.” Priority was given to peer-reviewed journal articles, meta-analyses, and reports from recognised bodies (e.g., UNESCO) published in English. Eleven core sources meeting these criteria were retained and synthesised

thematically across teaching applications, research applications, and integration challenges; the review does not claim exhaustive coverage of the field and is best read as a structured synthesis rather than a systematic review with formal inclusion/exclusion screening.

Review of Literature

Intelligent Tutoring Systems (ITS) such as Carnegie Learning's Mathia and ALEKS demonstrate AI's capacity to model individual student knowledge states and tailor instructional sequences, with meta-analytic evidence suggesting such systems can approach the effectiveness of one-on-one human tutoring under certain conditions (VanLehn, 2011). Adaptive learning platforms consistently show gains in engagement and mastery of procedural skills through immediate, individualised feedback (Roschelle, Feng, Murphy, & Mason, 2016). Computer algebra systems (CAS) such as Mathematica and SageMath have long supported symbolic computation, and recent integration of machine learning has extended their capabilities toward pattern recognition and conjecture generation (Davenport & Sangwin, 2021). In automated reasoning, formal proof assistants such as Lean and Coq increasingly use machine learning to guide proof search, while large language models assist with informal reasoning and solution explanation (Polu & Sutskever, 2020). A widely cited example is the collaboration between DeepMind researchers and mathematicians that used machine learning to identify new relationships in knot theory and representation theory, showing AI can serve as a genuine research collaborator (Davies et al., 2021). Literature on teacher education emphasises professional development that equips teachers to interpret AI analytics and preserve opportunities for productive struggle, which remains essential to mathematical learning (Holstein, McLaren, & Alevan, 2020).

Role of AI in Mathematics Teaching

Intelligent Tutoring, Adaptive Learning, and Assessment

Intelligent tutoring systems use knowledge-tracing algorithms to build a dynamic model of each learner's mastery, adapting the sequence and difficulty of problems so students are neither under-challenged nor overwhelmed (VanLehn, 2011; Roschelle et al., 2016). AI-based assessment tools further evaluate intermediate problem-solving steps, using pattern-matching and natural language processing to detect specific misconceptions such as sign errors or flawed algebraic manipulation, enabling real-time formative feedback that would be difficult for a single teacher to sustain across a large classroom (Wollowski & Selkowitz, 2019).

$$P(L_t) = P(L_{t-1}) + (1 - P(L_{t-1})) \cdot P(T)$$

Equation 1 (Bayesian Knowledge Tracing). Here $P(L_t)$ is the estimated probability that a learner has mastered a skill after the t -th practice opportunity, and $P(T)$ is the probability of transitioning from an unmastered to a mastered state on a single attempt. Most commercial ITS platforms, including those cited above, use a variant of this update rule to decide which item to present next, which is the computational mechanism underlying the “adaptive sequencing” described in the literature (VanLehn, 2011).

Problem-Solving Assistants and Learning Analytics

Tools combining optical character recognition with step-by-step solution engines let students photograph a problem and receive a worked solution; used responsibly they scaffold understanding, though they also raise concerns about answer-copying and reduced productive

struggle (Wollowski & Selkowitz, 2019; Holstein, McLaren, & Aleven, 2020). Separately, predictive-analytics dashboards flag students at risk of falling behind by analysing response time, error frequency, and engagement, supporting differentiated instruction and early intervention (Holstein et al., 2020; Zawacki-Richter et al., 2019).

Inclusive Mathematics Education

AI-driven speech-to-text, text-to-speech, and adaptive interface technologies increasingly support learners with visual, auditory, or cognitive challenges, translating mathematical notation into accessible formats and adjusting pacing to diverse needs, thereby advancing inclusive mathematics education (UNESCO, 2023).

Role of AI in Mathematical Research

Automated Theorem Proving and Symbolic Computation

Formal proof assistants integrated with machine learning models can suggest proof tactics, search proof libraries for relevant lemmas, and autonomously complete portions of formal proofs, reducing the manual burden of formalisation and strengthening confidence in verified results (Polu & Sutskever, 2020). Similarly, AI-enhanced computer algebra systems combine symbolic manipulation with learned heuristics to select efficient strategies for integration, equation solving, and simplification, reducing time spent on complex symbolic derivations (Davenport & Sangwin, 2021).

Pattern Discovery and Data-Driven Modelling

Machine learning models trained on large mathematical datasets can identify subtle patterns that may elude human intuition, generating candidate conjectures for further investigation. A notable case is the collaboration between DeepMind researchers and mathematicians at Oxford and Sydney, who trained supervised learning models on invariants from knot theory to predict algebraic quantities such as the signature, and used gradient-based attribution techniques on the trained models to reveal which invariants were most predictive; this pointed mathematicians toward a previously unrecognised relationship that was subsequently formalised and proved as a new theorem linking geometric and algebraic invariants of knots. A parallel workflow applied the same attribution-driven approach in representation theory, guiding a proof about symmetric group representations. In both cases the machine learning model did not produce a proof itself; rather, it narrowed an intractably large search space of candidate relationships down to a small set that human mathematicians could feasibly test and prove, illustrating a “human-in-the-loop” discovery workflow rather than fully automated theorem generation (Davies et al., 2021). In applied mathematics, neural network-based function approximation is increasingly used to model dynamical systems and solve high-dimensional partial differential equations, opening new avenues for interdisciplinary research.

$$\mathcal{L} = \mathcal{L}_{data} + \lambda \cdot \mathcal{L}_{PDE}, \quad \mathcal{L}_{PDE} = \|\partial u / \partial t - N[u]\|^2$$

Equation 2 (Physics-Informed Neural Network loss). A neural approximation u of the solution is trained by minimising a composite loss: $\mathcal{L}_{data}$ penalises deviation from known data or boundary conditions, while $\mathcal{L}_{PDE}$ penalises violation of the governing differential operator N (e.g., a diffusion or wave operator), with λ weighting the two terms. This formulation, rather than classical finite-difference or finite-element discretisation, is what allows a single trained network to approximate solutions across a continuous domain and generalise to related boundary conditions without re-solving the system from scratch.

Towards a balanced framework for AI Integration

Given the benefits and risks of AI adoption, this paper proposes a balanced framework built on four guiding principles for integrating AI into mathematics teaching and research. These principles extend established educational-technology frameworks such as TPACK (Technological, Pedagogical, and Content Knowledge) and the SAMR model of technology integration (Substitution, Augmentation, Modification, Redefinition) to the specific demands of mathematical reasoning, where preserving productive struggle is a first-order design constraint rather than an incidental concern.

- AI as a cognitive partner: tools should scaffold and extend human reasoning rather than substitute for it, preserving opportunities for productive struggle.
- Teacher-mediated integration: teachers should retain pedagogical agency, using AI analytics as decision-support rather than instructional authority.
- Equity and access: institutions must ensure equitable access to AI tools and infrastructure so integration narrows, not widens, achievement gaps.
- Ethical and transparent use: curricula should build AI literacy alongside mathematical literacy, teaching critical evaluation of AI-generated solutions (UNESCO, 2023).

Challenges and Limitations

AI integration in mathematics education and research faces significant challenges. Algorithmic bias in training data can lead adaptive systems to under-serve learners from underrepresented backgrounds (Zawacki-Richter et al., 2019), while over-reliance on AI-generated solutions risks undermining procedural fluency and independent reasoning (VanLehn, 2011). Infrastructural and financial constraints limit access in under-resourced schools, raising equity concerns (UNESCO, 2023). In research, the opacity of many machine learning models — the black-box problem — complicates verification of AI-generated conjectures, requiring careful human validation (Davies et al., 2021), and data-privacy concerns grow as platforms collect detailed learner profiles (Holstein et al., 2020).

The scale of these effects is worth noting quantitatively. VanLehn's (2011) meta-analysis found human one-on-one tutoring produces effect sizes of roughly 0.79–2.0 standard deviations over no-tutoring instruction, while step-based intelligent tutoring systems achieved approximately 0.76 standard deviations — comparable to, though generally still below, expert human tutors. Roschelle et al. (2016) similarly reported measurable but modest achievement gains from online homework platforms in a large-scale randomised study. Such figures support cautious optimism about ITS effectiveness while underscoring that AI tools currently supplement rather than match the highest-quality human instruction, reinforcing the paper's “cognitive partner” framing rather than a substitution narrative.

Conclusion and Future Directions

Artificial Intelligence is reshaping mathematics teaching and research, from personalised tutoring and automated assessment to theorem-proving assistance and conjecture generation. When integrated thoughtfully, AI can enhance access, personalise instruction, and accelerate discovery as a cognitive partner for learners and researchers, but realising these benefits requires attention to pedagogical design, equity, teacher training, and ethical safeguards. Future research should examine the long-term cognitive impact of AI-assisted learning and explore deeper human-AI collaborative models in mathematical research. The goal should not be to replace human

mathematical thinking but to cultivate a symbiotic relationship in which AI amplifies human creativity and insight.

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Artificial Intelligence Literacy among School Students: A Conceptual Framework for Developing Knowledge, Critical Understanding, and Responsible AI Use

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Abstract

Artificial Intelligence (AI) is rapidly becoming an integral component of contemporary education and everyday life. School students increasingly encounter AI through generative AI applications, intelligent tutoring systems, recommendation algorithms, voice assistants, automated translation, search engines, and other digital platforms. Although these technologies provide significant opportunities for learning, creativity, and problem-solving, they also introduce challenges related to misinformation, algorithmic bias, privacy, academic integrity, overdependence on automated systems, and responsible technology use. Consequently, conventional digital literacy is no longer sufficient to prepare students for an AI-mediated society. This conceptual paper examines the meaning and scope of Artificial Intelligence Literacy (AIL) among school students and proposes a four-dimensional conceptual framework comprising AI Knowledge and Understanding, AI Application and Problem-Solving, Critical Evaluation of AI, and Ethical and Responsible AI Use. The framework integrates cognitive, functional, critical, and ethical dimensions of AI literacy and positions students not merely as consumers of AI-generated outputs but as informed, critical, creative, and responsible participants in an AI-enabled society. The paper discusses the relevance of each dimension for school education and proposes implications for curriculum development, pedagogy, teacher preparation, and assessment. The framework may provide a foundation for future empirical research and the development of age-appropriate AI literacy assessment instruments for school students.

Keywords: *artificial intelligence literacy, school students, AI education, AI literacy framework, critical AI literacy, responsible AI use, digital literacy.*

Introduction

Artificial Intelligence has moved from being a specialized technological field to becoming a visible component of everyday social, educational, and economic life. School students encounter AI through search engines, recommendation systems, social media, digital assistants, adaptive learning platforms, generative AI applications, automated translation systems, and educational software. The rapid expansion of generative AI has further transformed the nature of students' interaction with technology by enabling them to generate text, images, presentations, explanations, computer code, and other forms of content.

The growing presence of AI in students' lives creates both educational opportunities and new responsibilities. AI can support personalized learning, provide immediate feedback, facilitate creativity, assist problem-solving, and provide access to diverse learning resources. At the same time, students may encounter inaccurate AI-generated information, algorithmic bias, privacy risks, inappropriate content, plagiarism, and excessive dependence on automated outputs. Therefore, students need more than the technical ability to operate AI applications. They require the knowledge and judgment necessary to understand what AI is, use it appropriately, evaluate its outputs critically, and make responsible decisions concerning its use.

The concept of Artificial Intelligence Literacy has emerged in response to this need. Long and Magerko (2020) conceptualized AI literacy as a set of competencies that enables individuals to understand, use, evaluate, and engage critically with AI. Similarly, Ng et al. (2021) identified four broad aspects of AI literacy involving understanding AI, applying AI, evaluating AI-related outcomes, and recognizing ethical issues. A later systematic review identified six major constructs: recognizing AI, knowing and understanding AI, using and applying AI, evaluating AI, creating with AI, and navigating AI ethically (Lintner, 2024).

More recent research indicates that AI literacy in school education is expanding beyond technical knowledge and operational skills. A 2025 systematic review of AI literacy programs for children and youth reported that operational competencies continue to dominate existing frameworks, while sociocultural and critical dimensions remain comparatively underdeveloped. The review consequently called for more balanced conceptualizations of AI literacy that address social, ethical, and critical dimensions.

UNESCO's *AI Competency Framework for Students* similarly emphasizes that students should develop the capacity to understand and use AI safely and meaningfully while maintaining human agency. The framework identifies four broad dimensions: a human-centred mindset, ethics of AI, AI techniques and applications, and AI system design. It also organizes competencies progressively around understanding, applying, and creating. Against this background, the present paper proposes a concise four-dimensional framework specifically designed for conceptualizing AI literacy among school students.

Conceptualizing Artificial Intelligence Literacy

AI literacy can be understood as the capacity to acquire and apply knowledge, skills, critical judgment, and ethical awareness necessary to interact effectively and responsibly with AI systems. It involves more than understanding technological terminology or learning how to operate a particular AI application. Because AI systems influence the information students receive, the decisions they make, and the content they create, AI literacy must also include the ability to question, evaluate, and contextualize AI-generated information.

The distinction between digital literacy and AI literacy is particularly important. Digital literacy generally concerns the ability to access, use, evaluate, and communicate information through digital technologies. AI literacy extends these competencies by requiring an understanding of systems that can generate, classify, predict, recommend, or make decisions based on data and algorithms. AI literacy therefore incorporates elements of digital literacy, information literacy, data literacy, computational thinking, critical thinking, and ethical reasoning.

Recent scholarship reinforces this multidimensional interpretation. A 2024 systematic review of AI literacy research identified six major constructs ranging from recognition and understanding to application, evaluation, creation, and ethical navigation. A recent systematic review specifically focused on school education further found that AI literacy involves cognitive, behavioural, psychological, and contextual dimensions and that knowledge, skills, ethics, generative-AI competencies, and psychological factors are increasingly recognized as important components. Therefore, AI literacy among school students should be conceptualized as an integrated competency rather than a single technological skill.

Proposed Four-Dimensional Framework of AI Literacy

The proposed framework consists of four interconnected dimensions:

AI Knowledge and Understanding

The first dimension represents the foundational cognitive component of AI literacy. Students need an age-appropriate understanding of what AI is, how AI systems operate at a basic level, and where AI is used in everyday life. This dimension includes knowledge of concepts such as algorithms, data, machine learning, generative AI, pattern recognition, automation, and intelligent systems. Students should also understand that AI systems are designed by humans and operate within particular technological and social contexts. Importantly, students need to recognize that AI does not necessarily "know" or "understand" information in the same manner as a human being. AI knowledge should also include awareness of the capabilities and limitations of AI. Students should understand that an AI system may produce an apparently convincing response that is inaccurate, incomplete, biased, or unsupported by evidence. Such foundational understanding is essential for preventing uncritical acceptance of AI-generated content. UNESCO's student competency framework emphasizes foundational AI knowledge as an essential element of responsible participation in an AI-enabled society. Thus, AI Knowledge and Understanding forms the cognitive foundation upon which the other dimensions depend.

AI Application and Problem-Solving

The second dimension concerns students' ability to use AI appropriately for learning and problem-solving. AI literacy should not remain purely theoretical. Students need opportunities to interact with AI tools in meaningful and educationally appropriate ways. This dimension includes using AI to search for information, generate ideas, support writing, explore alternative solutions, organize information, develop creative products, obtain explanations, and solve problems. However, effective application should involve purposeful use rather than indiscriminate dependence on AI. Students should learn to select appropriate AI tools for particular purposes, formulate suitable prompts or instructions, interpret responses, revise AI-generated material, and combine AI assistance with their own knowledge and reasoning. In this sense, AI application is closely associated with creativity and problem-solving. Recent research on generative AI literacy identifies "know and understand," "use and apply," "evaluate and incorporate," and ethics among the central competencies required for educational use of generative AI. The educational objective, therefore, should not be to teach students simply how to obtain an answer from AI. Instead, students should learn how AI can function as a supportive cognitive and creative resource while retaining responsibility for the final product.

Critical Evaluation of AI

The third dimension represents the critical component of AI literacy. This dimension is particularly important because AI-generated information may appear authoritative even when it is inaccurate or misleading. Students should develop the capacity to evaluate the quality, accuracy, relevance, reliability, and limitations of AI-generated outputs. They should learn to verify important information through credible sources rather than automatically accepting AI responses. Critical evaluation also involves understanding algorithmic bias, stereotypes, misinformation, fabricated information, and the limitations of AI training data. Students should be encouraged to ask questions such as: Where did this information come from? Is the answer supported by evidence? Could the system be biased? What information might be missing? Should I verify this response using another reliable source? The need for this critical dimension has become increasingly evident in recent literature. A systematic review of AI literacy programs for children

and youth found that critical dimensions have received less attention than operational competencies. Similarly, research on critical AI literacy argues that children require opportunities to understand and question the social and technological consequences of AI rather than simply learning to operate AI systems. Critical evaluation transforms students from passive recipients of AI-generated information into active and reflective users.

Ethical and Responsible AI Use

The fourth dimension concerns students' ability to use AI in ways that respect ethical principles, personal rights, academic integrity, and social responsibility. Students should understand issues such as privacy, data protection, fairness, bias, transparency, accountability, intellectual property, plagiarism, and appropriate attribution. They should also recognize that the use of AI in education involves responsibilities toward other people and society. For example, students should understand why entering another person's private information into an AI system may be inappropriate, why submitting AI-generated work as entirely their own may violate academic integrity, and why AI outputs should not automatically be treated as morally or socially neutral. Ethical AI literacy should also involve human agency. Students should retain responsibility for decisions made with AI assistance rather than transferring responsibility to the technology. UNESCO emphasizes human-centred AI education, responsible use, critical judgment, and students' role as responsible citizens and potential co-creators of AI. Recent research specifically examining K–12 AI ethics education indicates that ethical learning needs to become a more integral component of AI literacy rather than an optional addition. Therefore, ethical and responsible use should constitute one of the central dimensions of school-level AI literacy.

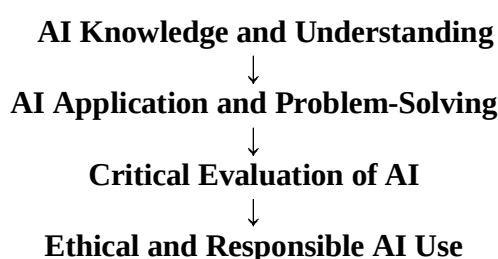
Integrated Conceptual Framework

The four dimensions should not be regarded as isolated competencies. They form a developmental and mutually reinforcing structure.

- **AI Knowledge and Understanding** provides the foundation for understanding the nature and limitations of AI.
- **AI Application and Problem-Solving** enables students to employ AI meaningfully for learning, creativity, and problem-solving.
- **Critical Evaluation of AI** enables students to examine AI outputs, recognize limitations, verify information, and exercise independent judgment.
- **Ethical and Responsible AI Use** guides students in applying AI while respecting privacy, academic integrity, fairness, safety, and human responsibility.

The model can therefore be summarized as:

AI Literacy among School Students



However, the framework should ultimately be viewed as interactive rather than strictly linear. Ethical considerations influence how AI is applied; knowledge influences critical evaluation; and critical evaluation determines whether an application is appropriate and responsible. This conceptualization is consistent with the broader movement in AI education from simple technological exposure toward competency-based and human-centred AI education. The recent competency perspective on AI literacy similarly emphasizes the integration of knowledge, skills, dispositions, and contextual factors rather than treating AI literacy as a narrow technical ability.

Educational Implications

The proposed framework has several implications for school education. First, AI literacy should progressively become part of school curricula rather than being treated exclusively as an extracurricular technology topic. Curriculum designers should provide age-appropriate opportunities for students to understand AI concepts and their applications. Second, classroom pedagogy should emphasize inquiry, problem-solving, project-based learning, discussion, and reflection. Students could compare human-generated and AI-generated answers, identify inaccuracies in AI outputs, investigate algorithmic bias, or examine ethical dilemmas involving AI. Third, teacher preparation is essential. Teachers need sufficient AI literacy to guide students in appropriate use, identify misconceptions, and create meaningful learning experiences. AI literacy education cannot be implemented effectively if teachers themselves lack confidence and conceptual understanding. Fourth, assessment practices need to evolve. Rather than assessing only students' ability to operate AI tools, schools should assess whether students can explain AI concepts, use AI appropriately, evaluate AI-generated information, and demonstrate ethical judgment. Finally, AI literacy should be linked with broader educational aims such as critical thinking, creativity, problem-solving, digital citizenship, information literacy, and responsible citizenship. UNESCO's framework similarly emphasizes that AI education should prepare students to become responsible and creative participants in an AI-enabled society.

Conclusion

Artificial Intelligence is transforming the technological and educational environment in which school students learn and communicate. Consequently, AI literacy has become an important educational competency for the contemporary school learner. The present conceptual paper proposes that AI literacy should extend beyond the ability to operate AI tools and should incorporate foundational knowledge, purposeful application, critical judgment, and ethical responsibility. The proposed four-dimensional framework consists of AI Knowledge and Understanding, AI Application and Problem-Solving, Critical Evaluation of AI, and Ethical and Responsible AI Use. Together, these dimensions provide a balanced conceptualization that combines cognitive, functional, critical, and ethical aspects of AI literacy. The framework responds to the growing concern that AI literacy education may become overly focused on operational skills while neglecting critical and sociocultural dimensions. Recent research indicates the importance of addressing this imbalance, particularly for children and young people. The proposed framework may serve as a foundation for curriculum development, teacher education, classroom pedagogy, and assessment. It can also support future empirical studies examining AI literacy among school students across age groups, school types, geographical regions, and demographic characteristics. Most importantly, AI literacy education should aim to develop

students who do not merely use AI, but who understand it, question it, apply it purposefully, and use it responsibly.

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Right to Education in the Digital Age: A Socio-Legal Analysis of Constitutional Guarantees, Judicial Interpretation and the Emerging Digital Divide

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Abstract

Education is widely regarded as the single most important tool for individual empowerment and national development, and constitutional systems across the world have progressively recognised it as a legally enforceable entitlement rather than a mere policy aspiration. The transition of teaching and learning from the physical classroom to digital platforms accelerated dramatically by the COVID-19 pandemic has, however, exposed serious gaps between the formal guarantee of education and its actual, equal enjoyment. This article examines how the 'right to education' recognised under Article 21 and Article 21A of the Constitution of India has been judicially reinterpreted to respond to the realities of online and technology-mediated learning. Using a doctrinal method, it traces the evolution of the right through landmark decisions and situates these alongside judicial responses to the pandemic-induced 'digital divide'. The article further draws a brief comparative reference to two United States decisions and to international human rights instruments, before identifying the legal and ethical challenges posed by artificial intelligence, algorithmic decision-making and student data in EdTech. It concludes by proposing a rights-based framework for digital education that keeps equity, accessibility and accountability at its core, expressed in language intended to be accessible to policymakers, educators and the general public and not only to legal specialists.

Keywords: *Right to Education; Article 21A; Digital Divide; Right to Internet Access; Educational Technology; Constitutional Law; Data Privacy in Education*

Introduction

Few rights occupy as central a place in the architecture of human dignity as the right to education. It is the right through which most other rights the right to livelihood, the right to political participation, the right to health information become meaningful, because it equips a person with the capacity to understand and exercise them. For this reason, education has been treated in Indian constitutional jurisprudence not as a discretionary welfare scheme but, increasingly, as a facet of the right to life itself under Article 21 of the Constitution, and later as an independent fundamental right under Article 21A. The manner in which education is delivered, however, has changed more in the last decade than in the previous century. Smart classrooms, learning-management systems, massive open online courses, and most recently artificial intelligence-based tutoring tools have moved teaching away from the physical schoolroom and onto screens, servers and search algorithms. The COVID-19 pandemic compressed this transition into a matter of months, forcing an entire generation of learners in India and elsewhere to depend on smartphones, laptops and internet connectivity simply to attend school.

This article asks a simple but pressing question in language that is meant to be accessible to non-lawyers as much as to legal scholars: does the constitutional right to education, as it currently stands, adequately protect a learner's access to the tools of digital education, or has the law simply not caught up with the classroom of the twenty-first century? To answer this, the article traces the judicial journey of the right to education in India, examines how courts have responded

to disputes over internet access and digital exclusion, draws limited comparative lessons from foreign jurisdictions, and identifies the newer legal and ethical questions raised by artificial intelligence and data-driven EdTech platforms.

The Constitutional and International Architecture of the Right to Education

The Constitution of India did not originally list education among the Fundamental Rights contained in Part III. It appeared instead as a Directive Principle of State Policy under Article 45, which, prior to 2002, merely directed the State to endeavour to provide free and compulsory education to children until the age of fourteen. Article 46 additionally obliged the State to promote the educational interests of the weaker sections of society¹. This position altered dramatically through judicial interpretation before it altered through constitutional amendment. The courts read education into the expansive language of Article 21's guarantee of 'life and personal liberty', reasoning that a life without the ability to read, reason and participate in society could not be said to be a life of dignity. This judicial innovation was eventually consolidated by the Eighty-Sixth Constitutional Amendment Act, 2002, which inserted Article 21A, guaranteeing free and compulsory education to all children between six and fourteen years of age². Parliament gave legislative teeth to this guarantee through the Right of Children to Free and Compulsory Education Act, 2009³, which fixes concrete duties on schools and the State, including neighbourhood school norms, the twenty-five per cent reservation for economically weaker sections in private unaided schools, and prohibitions on detention, expulsion and capitation fees at the elementary level.

India's domestic guarantees mirror, and are reinforced by, its international commitments. Article 26 of the Universal Declaration of Human Rights, 1948, recognises education as a right belonging to everyone, directed towards the full development of the human personality⁴. Article 13 of the International Covenant on Economic, Social and Cultural Rights, 1966, elaborates this into State obligations of availability, accessibility, acceptability and adaptability of education⁵ a framework increasingly used by scholars to test whether digital learning arrangements are genuinely accessible to disadvantaged learners. Article 28 of the United Nations Convention on the Rights of the Child, 1989⁶, and Article 24 of the Convention on the Rights of Persons with Disabilities, 2006⁷, extend these obligations specifically to children and to persons with disabilities, both groups disproportionately affected by an unplanned shift to digital-only instruction.

¹INDIA CONST. arts. 14, 15, 19(1)(a), 19(1)(g), 21, 21A, 30, 45, 46.

²The Constitution (Eighty-Sixth Amendment) Act, 2002, INDIA CODE (inserting art. 21A).

³Right of Children to Free and Compulsory Education Act, No. 35 of 2009, INDIA CODE (2009).

⁴Universal Declaration of Human Rights art. 26, G.A. Res. 217 (III) A, U.N. Doc. A/810 (Dec. 10, 1948).

⁵International Covenant on Economic, Social and Cultural Rights art. 13, Dec. 16, 1966, 993 U.N.T.S. 3.

⁶Convention on the Rights of the Child art. 28, Nov. 20, 1989, 1577 U.N.T.S. 3.

⁷Convention on the Rights of Persons with Disabilities art. 24, Dec. 13, 2006, 2515 U.N.T.S. 3.

Judicial Foundations: From Mohini Jain to T.M.A. Pai **Mohini Jain v. State of Karnataka (1992)**

The Supreme Court's foundational statement on the right to education came in *Mohini Jain v. State of Karnataka*⁸, decided in 1992. A Karnataka government notification had permitted private medical colleges to charge a steep 'capitation fee' from students who were not admitted under the government quota. The Supreme Court held that the right to education flows directly from the right to life under Article 21, reasoning that the dignity contemplated by that Article cannot be assured to a citizen unless it is accompanied by a right to education, and struck down the capitation fee regime as arbitrary and violative of Article 14⁹. In plain terms, the Court said that a State cannot allow money to become the only gatekeeper of learning.

Unni Krishnan, J.P. v. State of Andhra Pradesh (1993)

A year later, a larger Constitution Bench in *Unni Krishnan v. State of Andhra Pradesh*¹⁰ partially reconsidered this position. While affirming that the right to education is part of Article 21, the Court held that this fundamental character attaches only to education up to the age of fourteen; beyond that age, and particularly for professional and higher education, the State's obligation was treated as being subject to its economic capacity and developmental priorities rather than being an absolute, immediately enforceable right¹¹. This distinction remains conceptually important when assessing digital-education claims, because much of today's debate over device and internet access concerns exactly the elementary and secondary stage that *Unni Krishnan* treated as non-negotiable.

T.M.A. Pai Foundation v. State of Karnataka (2002)

Nearly a decade later, an eleven-judge Constitution Bench in *T.M.A. Pai Foundation v. State of Karnataka*¹² revisited the regulatory scheme built on *Unni Krishnan*, this time in the context of the autonomy of private and minority unaided educational institutions under Articles 19(1)(g) and 30. The Court held that private unaided institutions enjoy a substantial degree of autonomy in administration, including admissions and fee fixation, subject only to reasonable regulation aimed at preventing profiteering, capitation and maladministration¹³. The judgment confirms an enduring tension in Indian education law between institutional autonomy including, today, the autonomy of EdTech providers and private schools to design their own digital pedagogy and the State's residual duty to ensure that autonomy does not translate into exclusion of students who cannot afford the fees, devices or connectivity that a given mode of instruction demands.

⁸*Mohini Jain v. State of Karnataka*, AIR 1992 SC 1858 (India).

⁹*Id.* at 1859–60.

¹⁰*Unni Krishnan, J.P. v. State of Andhra Pradesh*, AIR 1993 SC 2178 (India).

¹¹*Id.* ¶¶ 168–72 (limiting the fundamental-right character of education to age fourteen, by reference to INDIA CONST. art. 45 as it then read).

¹²*T.M.A. Pai Found. v. State of Karnataka*, (2002) 8 S.C.C. 481 (India).

¹³*Id.* at 537–41 (6:5) (affirming the autonomy of private unaided institutions in administration, subject to reasonable regulation, and overruling in part *Unni Krishnan, J.P. v. State of Andhra Pradesh*, AIR 1993 SC 2178).

The Digital Turn: Recognising Internet Access as Integral to Education

Faheema Shirin R.K. v. State of Kerala (2019)

The first Indian judgment to connect internet access directly with the right to education was delivered by a single judge of the Kerala High Court in *Faheema Shirin R.K. v. State of Kerala*¹⁴. A student residing in a college hostel had been expelled after refusing to comply with hostel rules restricting mobile phone use during certain hours. The High Court held that the right to access the internet forms part of the right to education as well as the right to privacy guaranteed under Article 21, and that a student who has attained the age of majority should ordinarily be free to decide how and when to use technology for study, subject only to rules that do not cause disturbance to others¹⁵. The judgment is a clear judicial recognition years before the pandemic made the point unavoidable that connectivity is no longer a convenience for a student but a condition for meaningful learning.

Anuradha Bhasin v. Union of India (2020)

A broader, though not education-specific, recognition of the constitutional status of internet access followed from the Supreme Court's judgment in *Anuradha Bhasin v. Union of India*¹⁶, arising out of the prolonged internet shutdown imposed in Jammu and Kashmir in 2019. The Court held that the freedom of speech and expression under Article 19(1) (a), and the freedom to carry on trade, business, profession or occupation under Article 19(1) (g), extend to their exercise over the medium of the internet, subject to the tests of legality, necessity and proportionality applicable to restrictions on fundamental rights generally¹⁷. While the Court stopped short of declaring internet access itself to be an independent fundamental right, its reasoning has been widely relied upon by commentators and subsequent litigants to argue that reliable internet access is a necessary precondition for the effective enjoyment of the right to education in an era of online instruction.

COVID-19 and the Digital Divide: Judicial Response

The pandemic converted these doctrinal propositions into an urgent practical crisis. In *Justice for All v. Government of NCT of Delhi*¹⁸, a Division Bench of the Delhi High Court directed government and private unaided schools in Delhi to provide free laptops, tablets or mobile phones, together with an internet package, to students belonging to economically weaker and disadvantaged sections, holding that the cost of such gadgets could not be treated as part of tuition fees and describing the denial of digital access as amounting to a form of 'digital apartheid' within the classroom¹⁹. The Supreme Court subsequently stayed operation of this direction in February

¹⁴*Faheema Shirin R.K. v. State of Kerala*, AIR 2020 Ker 35 (India).

¹⁵*Id.* ¶¶ 20–25 (holding that the right to access the internet forms part of the right to education and the right to privacy under INDIA CONST. art. 21).

¹⁶*Anuradha Bhasin v. Union of India*, (2020) 3 S.C.C. 637 (India).

¹⁷*Id.* ¶¶ 25–32 (holding that freedom of speech and expression under INDIA CONST. art. 19(1)(a), and the freedom to carry on trade or business under art. 19(1)(g), extend to their exercise over the internet, subject to the proportionality standard).

¹⁸*Justice for All v. Gov't of NCT of Delhi*, W.P. (C) No. 5822/2020 (Del. H.C. Sept. 18, 2020) (India).

¹⁹*Id.* (directing schools to supply gadgets and internet packages to economically weaker section students free of cost, and describing the denial of digital access as "digital apartheid" contrary to INDIA CONST. arts. 14, 21 & 21A and the Right of Children to Free and Compulsory Education Act, No. 35 of 2009).

2021 while the matter remained under consideration²⁰, illustrating the genuine difficulty financial and administrative rather than merely legal of translating a rights-based judgment of this kind into workable state policy at scale. Even so, the underlying constitutional concern was not abandoned. In October 2021, hearing a separate matter concerning access to technology for students of unaided schools, the Supreme Court observed that the digital divide exposed by the pandemic had produced ‘stark consequences’, effectively resulting in a denial of the right to education to children from economically weaker sections and disadvantaged groups, and it called upon the Union and State Governments to jointly devise a realistic and lasting solution²¹. Taken together, these developments show a judiciary that recognises digital exclusion as a live constitutional harm, even as it continues to grapple with the practical limits of ordering technological equality into existence through a single writ.

Comparative Perspectives

A brief look beyond India is instructive. In the United States, *Brown v. Board of Education* (1954)²² remains the most celebrated education judgment in comparative constitutional law, in which the U.S. Supreme Court held that racially segregated public schools were inherently unequal and violated the Equal Protection Clause of the Fourteenth Amendment, even where the physical facilities provided to each race were nominally comparable²³. The case's enduring lesson that formal access to a schoolhouse means little if the conditions attached to that access are unequal translates directly to the digital context: a State that permits online schooling while ignoring unequal access to the devices and bandwidth needed to attend it risks recreating, through infrastructure, the very inequality that *Brown* condemned through segregation.

A cautionary contrast comes from *San Antonio Independent School District v. Rodriguez* (1973)²⁴, where the U.S. Supreme Court declined to treat education as a fundamental right under the federal Constitution and upheld a Texas school-funding system based substantially on local property taxes, despite the resulting disparities between wealthy and poor school districts²⁵. Read alongside the Indian position, in which education enjoys express fundamental-right status under Article 21A, the comparison suggests that Indian courts are institutionally better placed than their American counterparts to treat unequal digital access in education as a constitutional wrong rather than a mere policy shortfall provided the right is interpreted with the same purposive generosity that produced *Mohini Jain* and *Faheema Shirin*.

²⁰Gov't of NCT of Delhi v. Justice for All, Diary No. 3813/2021 (S.C. Feb. 10, 2021) (order staying operation of the Delhi High Court's judgment) (India).

²¹Action Comm. Unaided Recognised Priv. Schs. v. Union of India (S.C. Oct. 8, 2021) (oral observations on the pandemic-induced digital divide, as reported) (India).

²²*Brown v. Bd. of Educ.*, 347 U.S. 483 (1954).

²³*Id.* at 493–95.

²⁴*San Antonio Indep. Sch. Dist. v. Rodriguez*, 411 U.S. 1 (1973).

²⁵*Id.* at 35–37, 54–55 (declining to treat education as a fundamental right under the U.S. Constitution and upholding a school-funding scheme based substantially on local property taxes).

Emerging Legal and Ethical Challenges in Educational Technology

Beyond the question of bare access, the growing use of artificial intelligence and data-driven tools in classrooms raises a second generation of legal concerns that existing right-to-education jurisprudence has not yet fully addressed.

Student Data Privacy

Learning-management systems, proctoring software and AI tutors routinely collect sensitive information about children, including performance data, biometric identifiers used for online examination surveillance, and behavioural data. The Digital Personal Data Protection Act, 2023, imposes special obligations on entities processing the personal data of children, including a general requirement of verifiable parental consent and a prohibition on tracking, behavioural monitoring or targeted advertising directed at children²⁶, but its application to everyday EdTech products remains at an early stage. Until such standards are enforced in practice, the constitutional right to privacy recognised in *Justice K.S. Puttaswamy v. Union of India* (2017)²⁷ provides the underlying normative basis on which student data protection claims may eventually be built²⁸.

Algorithmic Bias and Automated Decision-Making

AI-based tools that grade assignments, recommend content, or flag students as ‘at risk’ of dropping out operate on data sets that may embed existing social biases of gender, caste, region or economic background. A right to education that is genuinely equal cannot be indifferent to the possibility that an opaque algorithm silently channels disadvantaged students toward lower-quality resources or lower expectations. While Indian courts have not yet decided a case squarely on algorithmic bias in education, the equality guarantee under Article 14 and the non-discrimination mandate under Article 15 offer an obvious doctrinal foothold for such claims once they arise²⁹.

Accountability of Private EdTech Platforms

Much of India's digital-education ecosystem is now delivered by private companies operating outside the direct regulatory framework of the RTE Act, which was drafted with brick-and-mortar schools in mind. Questions of consumer protection, refund practices, misleading claims about learning outcomes, and grievance redressal for EdTech subscribers increasingly fall into a regulatory gap between education law and consumer law, an area that would benefit from purpose-built oversight rather than piecemeal litigation.

²⁶Digital Personal Data Protection Act, No. 22 of 2023, § 9, INDIA CODE (2023) (imposing verifiable parental consent and anti-tracking obligations in respect of children's personal data).

²⁷*Justice K.S. Puttaswamy (Retd.) v. Union of India*, (2017) 10 S.C.C. 1 (India).

²⁸See id. ¶¶ 3, 21 (J. Chandrachud) (recognising privacy as intrinsic to the right to life and personal liberty under INDIA CONST. art. 21).

²⁹INDIA CONST. arts. 14, 15 (equality before law and prohibition of discrimination).

Towards a Rights-Based Framework for Digital Education

Drawing on the preceding analysis, four modest but concrete recommendations emerge, informed in part by the National Education Policy 2020³⁰ and by UNESCO's global monitoring of pandemic-era school closures³¹. First, statutory recognition of digital access as an essential input to elementary education. The RTE Act should be amended, or supplemented by delegated legislation, to expressly recognise a minimum level of device and connectivity support as part of the State's core obligation under Article 21A, rather than leaving this to be inferred case-by-case through writ litigation as occurred during the pandemic. Second, a statutory or regulatory floor for EdTech data protection tailored to children, covering consent verification, data minimisation, retention limits and a ban on commercial exploitation of children's learning data, would give schools and parents an enforceable standard rather than relying solely on general privacy principles. Third, an obligation of algorithmic transparency for AI tools used in high-stakes educational decisions such as grading, tracking or streaming of students, including a right for a student or parent to seek a human review of any adverse automated decision. Fourth, institutional coordination between the Ministry of Education, the Ministry of Electronics and Information Technology, and State Governments to translate the Supreme Court's 2021 call for a 'realistic and lasting solution' to the digital divide into a costed, time-bound national programme, rather than allowing the obligation to remain a judicial aspiration unmatched by administrative follow-through.

Conclusion

The right to education in India has always evolved through a dialogue between constitutional text and judicial interpretation from the initial recognition of a fundamental right in *Mohini Jain*, through the qualification introduced in *Unni Krishnan*, to the formal constitutional guarantee in Article 21A. The digital transformation of learning represents the next chapter of that dialogue. *Faheema Shirin* and *Anuradha Bhasin* show that Indian courts are willing, in principle, to treat access to technology as constitutionally significant; the pandemic-era litigation on the digital divide shows that courts are equally aware of how far implementation still lags behind principle. What is now required is neither further judicial innovation nor further litigation-by-crisis, but deliberate legislative and administrative action that treats a device, a data connection and a fair, transparent digital classroom as being as indispensable to the right to education today as a school building and a blackboard once were. Only then will the constitutional promise of education reach every child, regardless of which side of the digital divide they happen to be born on.

³⁰Ministry of Education, Gov't of India, National Education Policy 2020, at §§ 4.5–4.42 (2020).

³¹UNESCO, COVID-19 Education Response: Global Monitoring of School Closures (UNESCO 2021).

Academic Integrity and Professional Risk in Pre-Service Teachers' Use of Generative AI: A Conceptual Analysis

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Abstract

Teacher preparation programs are especially poised to encounter an ethical dilemma as GenAI tools enter the realm of higher education: Pre-service teachers should not only use GenAI tools responsibly while in their own education, but they should model and teach their future students how to use them responsibly. This paper draws on the latest empirical and conceptual research on the challenges associated with the risks of GenAI in the teacher preparation context, such as difficulties with academic integrity, moral conflict of pre-service teachers using GenAI for coursework, overreliance on AI-generated content, and uneven institutional preparedness to teach responsible use. The paper is drawn from the self-efficacy theory and the TPACK model and suggests that these risks should not be mitigated exclusively by regulation, but by explicitly addressing ethics lessons and transparency norms, as well as by incorporating reflection as part of the intended curriculum of teacher education courses. A set of principles for programs and priorities for future research conclude the paper.

Keywords: *generative AI, academic integrity, pre-service teachers, teacher education, AI ethics, moral dissonance.*

Introduction

While there has been a great deal of promise for the instructional potential of generative AI in education, there are serious doubts about its potential harm, especially in teacher preparation, where pre-service teachers have a dual role. They are students who are struggling with their own questions of academic honesty, and they are also helping to prepare themselves to be the professionals who will in the future set and enforce the same standards for their own students. This directly, as described by Caling et al. (2025), has been the case in the majority of the literature on AI and academic integrity, which has tended to focus on general student populations and ignored the specific conundrum in which pre-service teachers are placed regarding the clash between their own learning strategies and their professional duties. Structural considerations of this concern are added by Mishra, Warr and Islam (2023), who point out that with GenAI's ability to produce plausible pedagogical content on demand, the “author” and “originality” of coursework are complicated. This paper attempts to (a) review the literature about the risks and ethical issues that GenAI poses to pre-service teachers, (b) provide the framework for considering the risks and ethical issues within self-efficacy and TPACK frameworks, and (c) make proposals for proactively responding to the risks and ethical issues rather than reacting to them in teacher education programs.

Theoretical Framework

Risk-taking and its consequences

According to Bandura's (1997) self-efficacy theory, self-efficacy or self-confidence in one's ability and judgment influence the reactions to tempting shortcuts. Building on this, Khasawneh (2024) conducted a survey of 300 EFL pre-service teachers to assess the direct link between their personal commitment to academic integrity and the influence of ChatGPT's time-saving appeal on making the decision to use it in an inappropriate way and academic tasks, as well as the effect of peer influence on that decision. This implies that integrity here plays a certain role as a disposition, which may be cultivated by training, rather than as a rule to be enforced after the event.

The erosion risk and TPACK

A structural risk of the TPACK model is that pre-service teachers may rely on GenAI to bypass the process of planning and end up not learning the basics of pedagogical reasoning as described by the model (Mishra, Warr, and Islam, 2023). In this articulation, the risk goes beyond transgression in one assignment to a lack of professional formation.

Risks and ethical concerns:

Academic Integrity as an attitude put on trial.

The results of the survey conducted by Khasawneh (2024) suggest that academic integrity is not inherent or fixed but is rather a trait that is shaped by situational pressures, such as time constraints, peer behavior, and striving to look smart, which all have measurable impacts on how pre-service teachers think about using Chat GPT. This implies that situational pressures can be tackled directly in integrity-focused interventions, not just by general honesty appeals.

The daily use of moral dissonance.

These survey results are enriched by qualitative work. In their study, Caling et al. (2025) interviewed 10 pre-service teachers at a teacher education institution in Manila, who reported using ChatGPT on a regular basis for paraphrasing, organizing ideas, and simplifying complex material, as well as feeling a conflict between convenience and conscience, and between innovation and integrity. While highlighting the pressure of academics, workload, and the perceived inefficiencies of classroom methods, participants also articulated how they felt they were now becoming accustomed to relying on AI, and how this normalization of AI use would lead to doubt regarding their ability to effectively manage it when they are one day running their own classroom.

Accuracy, plagiarism and critical engagement.

In a mixed-methods study, Amaranti Pesce and Fernández Blanco (2024) showed that pre-service teachers appreciated the use of ChatGPT due to its conceptual support and the fast feedback it provided, but also voiced concerns about the accuracy of the information it generates and the problem of plagiarism, which, in the authors' opinion, highlights the need to "use ChatGPT critically rather than blindly. The participants in this study also identified their own future role as a teacher, in which they said they would want to help their students learn to use AI in a critical and responsible manner, as opposed to it just happening.

Overreliance and skill formation

Further to the TPACK-based concern raised in Section 2, Mishra, Warr and Islam (2023) warn that the computational fluency of GenAI can hide lack of developing competence on the part of the pre-service teacher, especially when the content is used verbatim in lessons or explanations,

without being developed, modified or revised. This is a pattern observed by Caling et al. (2025) in their interviews.

Uneven institutional readiness.

Students are not the only ones who are at risk in this space. According to Nyaaba and Zhai (2024), the teacher educators, who model and teach the use of GenAI responsibly, are not sure that they are equipped enough to do the same. This poses an equity issue: The quality of ethical teaching that a pre-service teacher receives could depend significantly on the program, or even the individual teacher with which they happen to be learning.

Implications for Teacher Education Programs

- **Address situational pressures, not just personal honesty.**
 - Since Khasawneh (2024) found that time pressure and peer influence measurably shape integrity-related decisions, programs might do more good by addressing workload design and assignment structure than by relying on integrity pledges alone.
- **Make space for moral dissonance rather than assuming it away.**
 - Caling et al.'s (2025) findings suggest pre-service teachers are often aware of the tension in their own AI use rather than oblivious to it. Structured reflection — journaling, case discussion, or peer dialogue about this dissonance — may do more to build durable judgment than policy statements alone.
- **Teach critical evaluation of AI output explicitly.**
 - Following Amaranti Pesce and Fernández Blanco (2024), coursework should build the habit of checking AI-generated content for accuracy and originality as a routine practice, not an occasional caution.
- **Build in transparency and disclosure norms.**
 - Requiring pre-service teachers to disclose GenAI use in their own coursework may serve two purposes at once: reinforcing honest practice now, and modeling the norms they will need to set for their own future students.
- **Invest in teacher educator readiness.**
 - Following Nyaaba and Zhai (2024), addressing risk at the pre-service level likely requires parallel investment in faculty professional development, since instructors cannot model or teach judgment they have not themselves developed.

Conclusion

The risks generative AI introduces into pre-service teacher preparation are not simply technical or logistical; they are ethical and developmental, touching on academic integrity, professional identity formation, and equitable access to guidance. The literature reviewed here — spanning a large-scale integrity survey (Khasawneh, 2024), qualitative interview work (Caling et al., 2025), and mixed-methods perception research (Amaranti Pesce & Fernández Blanco, 2024) converges on a similar conclusion: pre-service teachers are rarely unaware of the ethical tensions in their own AI use, but they need more structured support to translate that awareness into durable professional judgment. Future research should examine whether ethics-focused interventions during pre-service training measurably reduce problematic AI use once these individuals become in-service teachers, and should extend the evidence base beyond the EFL, general education, and Philippine and Latin American contexts where much of the current qualitative and survey work is concentrated.

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Artificial Intelligence in Legal Education: Opportunities, Challenges and the Future of Law Teaching

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Abstract

Artificial Intelligence (AI) is rapidly ¹transforming higher education, including the teaching and learning of law. The emergence of generative AI systems capable of producing text, analysing information, summarising documents, translating materials and responding to complex questions has created both significant opportunities and serious concerns for legal education. Traditionally, legal education has relied upon case-law analysis, statutory interpretation, legal research, classroom discussion, moot courts, clinical education and written assessment. AI does not necessarily replace these pedagogical approaches rather, it has the potential to reshape how they are delivered and evaluated. At the same time, unrestricted dependence on AI may weaken independent legal reasoning, encourage academic dishonesty, reproduce inaccurate or biased information, compromise privacy and create uncertainty regarding authorship and accountability. This paper examines the opportunities, challenges and future implications of Artificial Intelligence in legal education, with particular reference to the Indian context. It adopts a doctrinal and analytical methodology based on policy documents, legal and regulatory materials, institutional developments and emerging academic literature. The paper analyses AI-assisted legal research, personalised learning, interactive pedagogy, assessment, legal writing, clinical education and faculty development. It also examines concerns relating to hallucinations, algorithmic bias, data protection, academic integrity, digital inequality and the changing role of law teachers. The paper argues that the appropriate response of law schools should not be an absolute prohibition or unrestricted adoption of AI. Instead, a human-centred, pedagogically supervised and ethically governed model should be adopted. AI literacy should become part of contemporary legal education, while core competencies such as legal reasoning, critical thinking, ethical judgment, advocacy and independent research must remain human-centred. This paper proposes an institutional framework for responsible AI use in law schools and concludes that the future of legal education lies not in replacing the law teacher with AI, but in developing an effective partnership between teacher, student and technology.

Keywords: Artificial Intelligence, Legal Education, Generative AI, ChatGPT, Legal Pedagogy, Legal Research, Academic Integrity, Legal Technology, AI Ethics, Law Teaching.

¹Fengchun Miao and Wayne Holmes, *Guidance for Generative AI in Education and Research*, UNESCO, Paris, 2023, ISBN 978-92-3-100612-8

Introduction

Education has always evolved alongside technological change. The printing press transformed access to knowledge, computers transformed information processing, the internet transformed communication and research and online learning platforms transformed the geographical boundaries of education. Artificial Intelligence represents another major stage in this technological transformation. Unlike earlier technologies that primarily assisted humans in storing, retrieving or communicating information, contemporary AI systems can analyse information, generate content, identify patterns, interact conversationally and assist with complex intellectual tasks. The impact of AI is particularly significant in legal education because law is fundamentally a knowledge-intensive discipline. Legal education requires students to locate authoritative sources, understand legislation, analyse judicial decisions, interpret legal principles, construct arguments and apply law to factual situations. Generative AI tools can perform some of these activities rapidly, but their capacity to produce plausible yet incorrect legal information creates a corresponding need for verification and human judgment². The National Education Policy (NEP) 2020 recognised the transformative relationship between technology and education. It specifically refers to artificial intelligence and other emerging technologies and states that technological interventions should be rigorously and transparently evaluated before being scaled. The Policy also envisages technology being used to improve teaching, learning, assessment, planning and administration.

Objectives of the Study

The present study has the following objectives:

- To examine the emerging role of Artificial Intelligence in legal education.
- To identify the major opportunities presented by AI for law teaching and learning.
- To analyse the challenges associated with AI-assisted legal education.
- To examine the impact of generative AI on legal research, writing and assessment.
- To examine the relevance of AI literacy for future legal professionals.

Research Questions

The study seeks to answer the following questions:

- How can Artificial Intelligence improve the quality and effectiveness of legal education?
- What are the principal risks associated with the use of generative AI by law students?
- How can law schools protect academic integrity while permitting responsible AI use?
- What competencies should law teachers develop in the AI era?
- What institutional safeguards are necessary for responsible AI adoption in Indian law schools?

Research Methodology

The paper adopts a doctrinal, analytical and exploratory methodology. It relies primarily upon secondary sources, including government policies, regulatory materials, institutional documents, international guidance, judicial and justice-sector developments and academic

² Steve Lorteau and Douglas Sarro, "Artificial Intelligence in Legal Education: A Scoping Review," *The Law Teacher*, Vol. 60, No. 1, 2026, pp. 138–162, DOI: 10.1080/03069400.2025.2592440

literature concerning AI and legal education. The study particularly considers the National Education Policy 2020, UNESCO's guidance concerning generative AI in education, UNESCO's AI Competency Framework for Teachers, UGC materials concerning academic integrity, Indian policy documents on responsible AI, Indian judicial technology initiatives and recent empirical research concerning AI-assisted legal education. The study does not claim to present original statistical findings from a survey of students or teachers. Instead, it synthesises existing developments and proposes a framework for responsible integration of AI into legal education.

Understanding Artificial Intelligence in the Context of Legal Education

Artificial Intelligence refers broadly to computational systems capable of performing tasks that ordinarily require aspects of human intelligence, including learning, pattern recognition, language processing, prediction and decision support.³ For legal education, the most immediately relevant development is generative AI. Generative AI systems can produce new text, summaries, explanations, questions, hypothetical situations and other forms of content in response to user instructions. The educational significance of generative AI lies in its interactive character. A student can ask a system to explain a complicated doctrine, generate hypothetical facts, compare legal concepts or identify possible arguments. However, the fact that an AI system can generate an answer does not establish that the answer is legally correct. This distinction is crucial in legal education. Law students must learn that legal knowledge is not merely information. Law requires:

- identification of the applicable legal rule
- determination of authoritative sources
- interpretation of statutory provisions
- analysis of precedent
- application of law to facts
- evaluation of competing arguments
- ethical judgment and
- persuasive communication.

AI can assist several stages of this process, but it cannot automatically replace the student's responsibility for the final legal conclusion. UNESCO's guidance on generative AI⁴ adopts a human-centred approach and emphasises ethical, safe, equitable and meaningful use of AI in education and research. It also highlights concerns relating to privacy, regulation and institutional preparedness. This human-centred approach is particularly appropriate for legal education because law itself is concerned with human rights, justice, accountability, fairness and institutional responsibility.

³ Prakash Sharma and Rumi Roy, "Artificial Intelligence in Legal Education: Re-evaluating Pedagogy and Ethics to Cultivate Future Legal Professionals," *Asian Journal of Legal Education*, Vol. 13, Issue 2, 2026, pp. 238–252, DOI: 10.1177/23220058261449191

⁴ Evgeny Guglyuvatyy, "Reimagining Legal Education: Navigating the Promise and Perils of Artificial Intelligence," *Asian Journal of Legal Education*, Vol. 13, Issue 2, 2026, DOI: 10.1177/23220058261425878

Artificial Intelligence and the Transformation of Legal Education

AI-Assisted Legal Research

Legal research is one of the areas in which AI can provide substantial assistance. Students frequently spend considerable time locating statutes, cases, articles and secondary materials. AI-assisted tools can help students formulate research questions, identify relevant concepts, summarise lengthy documents and generate preliminary research pathways. The increasing use of AI within the justice system further demonstrates law students should understand these technologies. Government material concerning the Indian judiciary⁵ refers to AI-based Legal Research Analysis Assistant (LegRAA), Digital Courts and the experimental SUPACE initiative. A student trained in contemporary legal education should therefore understand both traditional legal research and technology-assisted legal research.

Personalised Learning

Traditional classroom teaching generally operates on the assumption that a teacher must teach a group of students at approximately the same pace. AI can potentially facilitate a more personalised⁶ learning environment. Students may have different levels of understanding of legal concepts. An AI system can be used to generate:

- simplified explanations;
- additional examples;
- hypothetical problems;
- practice questions;
- revision materials;
- comparative explanations; and
- feedback on preliminary drafts.

However, personalisation must not become intellectual dependency. The teacher must remain responsible for ensuring that students are engaging with authoritative legal materials.

AI and Legal Writing

Legal writing is another area likely to be significantly affected by generative AI. Students can use AI to obtain preliminary assistance with:

- organising ideas
- identifying gaps in an argument
- improving grammatical clarity
- generating hypothetical arguments
- summarising a long passage
- converting complex language into simpler language and
- receiving preliminary feedback

⁵ Anil Balan and Alexander Yu Krouglov, "AI and Legal Education: Ethical and Sustainable Approaches," *International Journal of Law and Information Technology*, Vol. 34, 2026, Article eaaf029, DOI: 10.1093/ijlit/eaaf029

⁶ Tito Rendas, "Using Generative AI to Teach (IP) Law," *Journal of Intellectual Property Law & Practice*, Vol. 21, Issue 4, 2026, pp. 183–184, DOI: 10.1093/jiplp/jpag035

AI in Moot Courts and Clinical Legal Education

Moot courts and clinical legal education are central components⁷ of legal education because they connect theoretical knowledge with practical legal skills. A student preparing for a moot court could use AI to:

- identify potential arguments
- generate counterarguments
- simulate questions from judges
- identify weaknesses in submissions
- practise oral advocacy and
- create hypothetical variations of the problem.

However, students must not rely on AI-generated authorities without independent verification. A fabricated case citation or inaccurate proposition can severely undermine a legal submission.

AI and Assessment in Legal Education

Perhaps the greatest challenge created by generative AI concerns assessment. Research has already demonstrated that AI systems can perform reasonably well on certain law-school assessments, although their performance varies depending on the nature of the task. More recent empirical work has produced a more nuanced picture⁸. Other research involving law students has similarly suggested that generative AI may struggle with detailed legal and critical analysis even when it can produce convincing general answers.

Academic Integrity and AI

Academic integrity is one of the most important challenges associated with generative AI⁹. Generative AI complicates traditional understandings of plagiarism. A conventional plagiarism case may involve copying another person's published words¹⁰. AI-generated text may not correspond directly to a single identifiable source. Nevertheless, submitting AI-generated work as one's own may misrepresent the student's intellectual contribution. Therefore, academic integrity policies should move beyond a narrow focus on text similarity. Law schools should develop explicit rules addressing:

- when AI use is permitted
- when AI use is prohibited
- whether AI assistance must be disclosed

⁷ Sthéfano Bruno Santos Divino, "Hey, ChatGPT: How Should We Teach Law to Generation AI?," *Journal of Applied Learning and Teaching*, Vol. 7, No. 2, 2024, pp. 406–411, DOI: 10.37074/jalt.2024.7.2.6

⁸ Julie L. Kimbrough, "Developing Lawyering Skills in the Age of Artificial Intelligence: A Framework for Legal Education," *Journal of Technology Law & Policy*, Vol. 29, 2025.

⁹ Joan R. M. Bullock, "Teaching Legal Thinking in the Age of AI: Reimagining Legal Education Through Cognitive Science and Deliberate Practice," *University of Baltimore Law Review*, Vol. 55, Issue 3, 2026

¹⁰ UNESCO, *Guidance for Generative AI in Education and Research*, UNESCO, Paris, 2023, noting the need for human-centred, ethical, safe, equitable and meaningful use of generative AI in education

- how AI-generated material should be acknowledged
- whether students may use AI during examinations
- whether AI may be used for grammar correction
- how confidential information should be treated and
- consequences of dishonest AI use

AI Hallucinations and Reliability of Legal Information

One of the most serious risks of generative AI is the production of false or misleading information presented in a confident manner. In legal education, this risk is particularly serious.¹¹

An AI system may generate:

- a nonexistent case
- an incorrect citation
- an inaccurate quotation
- an outdated statutory provision
- an incorrect interpretation of a judgment or
- an invented legal principle.

Data Privacy and Confidentiality

AI systems also create concerns concerning privacy and confidentiality. Law students and teachers may handle:

- client information¹²
- clinical legal aid records
- unpublished research
- examination materials
- student records
- disciplinary information and
- confidential institutional documents

Uploading such information¹³ to an external AI system without appropriate safeguards may create significant privacy risks. India's Digital Personal Data Protection Act, 2023 establishes a statutory framework concerning processing of digital personal data and recognises the importance of protecting individuals' personal data while permitting lawful processing.

¹¹ Steve Lorteau and Douglas Sarro, "Artificial Intelligence in Legal Education: A Scoping Review," *The Law Teacher*, Vol. 60, No. 1, 2026, pp. 138–162, discussing AI as a teaching aid, interactive learning facilitator, legal writing aid and tool for skills development

¹² Prakash Sharma and Rumi Roy, "Artificial Intelligence in Legal Education: Re-evaluating Pedagogy and Ethics to Cultivate Future Legal Professionals," *Asian Journal of Legal Education*, Vol. 13, Issue 2, 2026, pp. 238–252, discussing AI-assisted legal research and drafting, algorithmic bias, data governance and curriculum development.

¹³ UNESCO, *Guidance for Generative AI in Education and Research*, 2023, identifying data privacy, human agency, inclusion, equity and ethical validation as significant considerations in educational use of generative AI.

Algorithmic Bias and the Ethics of AI

AI systems learn from data. If training data contain historical biases, AI outputs may reproduce or amplify those biases. This is especially significant for law because legal education must cultivate sensitivity toward

- equality
- discrimination
- gender justice
- constitutional rights
- social justice and¹⁴
- protection of vulnerable groups

An AI-generated¹⁵ answer may appear neutral while implicitly reproducing assumptions embedded in its underlying data.

The Digital Divide

Technology can promote equality, but it can also reproduce inequality. Not every student has equal access to:

- high-speed internet
- advanced computers
- paid AI tools
- subscription-based legal databases
- digital learning resources ¹⁶or
- technical training.

If AI becomes an unofficial requirement for academic success, students without access to such technologies may be disadvantaged. Therefore, law schools must ensure that AI integration does not create a two-tier educational system.

Institutions should provide:

- common institutional access where appropriate¹⁷
- digital literacy programmes
- training sessions
- access to essential databases
- alternative learning pathways and

¹⁴ Kartina A. Choong and Munira H. Patel, "Assessing Law Students in the Age of GenAI," *Asian Journal of Law and Policy*, 2026, DOI: 10.33093/ajlp.2026.12, discussing academic integrity and the possible effects of GenAI on research, analytical, writing, communication and other professional skills

¹⁵ Anil Balan and Alexander Yu Krouglov, "AI and Legal Education: Ethical and Sustainable Approaches," *International Journal of Law and Information Technology*, Vol. 34, 2026, Article eaaf029, examining the implications of AI for established models and methods of legal education

¹⁶ Steve Lorteau and Douglas Sarro, "Artificial Intelligence in Legal Education: A Scoping Review," *The Law Teacher*, Vol. 60, No. 1, 2026, observing that AI outputs in law-school evaluations may be inadequate without effective prompting and human verification.

¹⁷ Julie L. Kimbrough, "Developing Lawyering Skills in the Age of Artificial Intelligence: A Framework for Legal Education," *Journal of Technology Law & Policy*, Vol. 29, 2025, proposing the integration of technology-driven lawyering competencies into law-school learning outcomes.

- reasonable accommodation for students with limited technological access.

AI adoption must be consistent with the principles of access, equity and inclusion that underpin technology-oriented educational policy.

AI Literacy as a Component of Legal Education

Future lawyers will increasingly encounter AI in law firms, courts, corporate legal departments, government offices, legal technology companies and legal research environments.¹⁸ Consequently, AI literacy should become part of professional legal education. AI literacy for law students should include at least the following competencies. Such integration would make AI education interdisciplinary rather than purely technological.

Responsible AI Framework for Indian Law Schools

Based on the preceding discussion, this paper proposes a Human-Centred Responsible AI Framework for Legal Education consisting of seven principles.¹⁹

- **Principle 1: Human Primacy** - AI should assist learning, not replace human judgment.
- **Principle 2: Academic Integrity** - Students must disclose AI use where institutional policy requires it and must not present AI-generated work as independent intellectual work.
- **Principle 3: Source Verification** - All legal authorities generated or suggested by AI must be independently verified.
- **Principle 4: Privacy and Confidentiality** - Students and teachers should not upload confidential or sensitive information to unauthorised AI systems.
- **Principle 5: Equality and Accessibility** - AI adoption should not disadvantage students who have limited technological access.
- **Principle 6: Teacher²⁰ Supervision** - AI-assisted learning should operate under pedagogical supervision.
- **Principle 7: Continuous Evaluation** - Institutional AI policies should be periodically reviewed because AI technology develops rapidly.

This approach avoids two extremes: technological rejection and technological dependence.

Proposed Guidelines for Students

Law schools may consider adopting the following practical guidelines:

- AI may be used only for purposes permitted by the teacher or institution.

¹⁸ Evgeny Guglyuvatyy, "Reimagining Legal Education: Navigating the Promise and Perils of Artificial Intelligence," *Asian Journal of Legal Education*, Vol. 13, Issue 2, 2026, arguing for interdisciplinary legal education, infrastructure, faculty training and institutional policy alignment in an AI-driven legal environment.

¹⁹ Sthéfano Bruno Santos Divino, "Hey, ChatGPT: How Should We Teach Law to Generation AI?," *Journal of Applied Learning and Teaching*, Vol. 7, No. 2, 2024, pp. 406–411, addressing pedagogical approaches to teaching law students in the age of generative AI.

²⁰ Tito Rendas, "Using Generative AI to Teach (IP) Law," *Journal of Intellectual Property Law & Practice*, Vol. 21, Issue 4, 2026, pp. 183–184, examining the opportunities and concerns associated with the use of generative AI in legal teaching.

- Students must independently verify legal authorities.²¹
- Fabricated citations or authorities must never be included in academic work.
- Confidential information must not be uploaded into unauthorised AI systems.
- AI-generated text should not automatically be treated as the student's own work.
- Students should disclose substantial AI assistance when required.
- AI should be used as a learning assistant rather than a substitute for reading cases and legislation.
- Students should maintain records of significant AI assistance for research projects where appropriate.
- Students should critically evaluate AI-generated arguments.
- Students must remain responsible for the accuracy of their final submissions.

Proposed Guidelines for Law Teachers

Teachers should also receive institutional guidance. They should:

- identify which assessments permit AI²²
- redesign assessments where necessary
- teach AI verification
- demonstrate responsible AI use
- avoid entering confidential student information into public AI systems;
- encourage primary-source research
- use oral questioning where appropriate
- assess reasoning rather than merely polished language
- remain updated about AI developments and
- participate in continuous professional development

Conclusion

Artificial Intelligence²³ represents one of the most significant technological developments affecting contemporary legal education. It offers substantial opportunities for improving legal research, personalised learning, interactive teaching, legal writing, assessment, moot-court preparation and professional development. At the same time, it creates serious concerns relating to academic integrity, hallucinated legal authorities, privacy, algorithmic bias, digital inequality and overdependence on technology. The central argument of this paper is that AI should neither be blindly embraced nor categorically rejected in legal education. The appropriate approach is

²¹ UNESCO, *Guidance for Generative AI in Education and Research*, 2023, recommending institutional consideration of the pedagogical and ethical suitability of generative AI tools before their educational deployment.

²² Prakash Sharma and Rumi Roy, "Artificial Intelligence in Legal Education: Re-evaluating Pedagogy and Ethics to Cultivate Future Legal Professionals," *Asian Journal of Legal Education*, Vol. 13, Issue 2, 2026, pp. 238–252, highlighting the potential of AI for translation, customised learning and simulation-based legal education while noting infrastructure and institutional competency concerns.

²³ Kartina A. Choong and Munira H. Patel, "Assessing Law Students in the Age of GenAI," *Asian Journal of Law and Policy*, 2026, DOI: 10.33093/ajlp.2026.12, discussing the need to reconsider assessment practices in law schools in light of generative AI.

responsible integration. India's National Education Policy 2020 already recognises the importance of technology in transforming education and specifically identifies artificial intelligence among emerging technologies requiring research and thoughtful integration. International guidance from UNESCO similarly emphasises human-centred, ethical, safe²⁴ and meaningful use of generative AI in education.

For law schools, the challenge is therefore not merely technological. It is pedagogical and ethical. A law student must learn that an AI-generated answer is not automatically a legal answer. A citation is not authoritative merely because an AI²⁵ system provides it. A persuasive paragraph is not evidence of legal reasoning. Technology can support legal education, but it cannot eliminate the need for human judgment. The future law teacher should therefore not be viewed as a competitor to Artificial Intelligence. Instead, the teacher should become the person who teaches students when to use AI, how to use it, when not to use it, how to verify it, and how to remain accountable for its use. The future of legal education may consequently be understood through a simple principle, AI should enhance legal education, but human reasoning must remain at its centre. The ultimate objective of legal education is not to produce students who can merely obtain answers quickly. It is to produce future lawyers who can think critically, reason legally, act ethically and serve justice responsibly. If AI is integrated with these objectives rather than allowed to displace them, it can become a powerful educational partner and contribute meaningfully to the transformation of legal education in India.

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²⁴ Steve Lorteau and Douglas Sarro, "Artificial Intelligence in Legal Education: A Scoping Review," *The Law Teacher*, Vol. 60, No. 1, 2026, pp. 138–162, identifying academic integrity, pedagogical innovation, accessibility and the risks of passive AI reliance as important issues for legal education.

²⁵ UNESCO, *Guidance for Generative AI in Education and Research*, UNESCO, Paris, 2023, emphasising that educational institutions should pursue a human-centred approach that protects human agency, privacy, equity and meaningful participation in education.

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Generative AI and Pre-Service Teacher Development: A TPACK-Based Framework for Instructional Opportunity

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Abstract

Generative artificial intelligence (GenAI) tools such as ChatGPT are increasingly present in teacher preparation programs, yet much of the surrounding discussion treats them as either a productivity shortcut or a threat to be managed. This paper takes a narrower, opportunity-focused view: drawing on the Technological Pedagogical Content Knowledge (TPACK) model, self-efficacy theory, and the emerging construct of AI literacy, it examines how GenAI can be used deliberately to strengthen pre-service teachers' lesson design, problem-posing practice, creative confidence, and reflective capacity. Synthesizing recent empirical studies from mathematics, science, and general teacher education contexts, the paper argues that GenAI's instructional value lies less in what it produces and more in what it gives pre-service teachers to critique, revise, and rehearse — and it further shows that accuracy concerns, prompt-literacy gaps, and uneven institutional support recur across this literature as real constraints on that value. The paper concludes with practical principles, and stated limitations, for sequencing GenAI exposure within teacher education coursework.

Keywords: *generative AI, pre-service teachers, TPACK, lesson planning, self-efficacy, AI literacy, teacher education*

Introduction

Generative AI has become part of the everyday toolkit of higher education, and pre-service teachers are no exception. What distinguishes their situation from students in most other disciplines is that they are simultaneously learning to use these tools *and* training to make professional judgments about their place in a future classroom. This paper focuses on the instructional opportunity side of that equation: what does recent empirical research suggest about how GenAI can meaningfully strengthen — rather than shortcut — pre-service teacher development, and what limits does that same research place on how far the opportunity extends? Mishra, Warr, and Islam (2023) argue that GenAI's ability to generate plausible pedagogical content on demand shifts the more urgent skill for teacher candidates from *producing* content to *critically appraising* it — judging whether AI-generated material is accurate, developmentally appropriate, and pedagogically sound. This reframing is the starting point for the present paper: rather than treating GenAI as competing with pedagogical skill-building, we ask how it can be structured to support it, while taking seriously the recurring evidence that pre-service teachers themselves flag accuracy and reliability problems in AI output.

Purpose

This paper aims to (a) synthesize recent empirical literature on GenAI's instructional benefits for pre-service teachers, (b) ground this synthesis in TPACK, self-efficacy, and AI-

literacy perspectives, (c) surface the accuracy and institutional-support concerns that recur across this literature, and (d) propose sequencing principles along with the evidentiary limits of those principles for teacher educators designing GenAI-integrated coursework.

Theoretical Framework

TPACK in an AI-mediated context.

Mishra and Koehler's (2006) TPACK model remains a dominant lens for understanding how teachers integrate technology, content, and pedagogy. Mishra, Warr, and Islam (2023) extend this model by describing GenAI as both continuous with earlier digital technologies (protean, opaque, unstable) and distinct from them (generative and social), and they argue this shift reframes what counts as technological knowledge, pedagogical knowledge, and the intersections between them for a teacher working with AI. Several of the empirical studies reviewed below operationalize this shift directly, either by applying a TPACK-based rubric to AI-assisted lesson plans (Lee & Zhai, 2024) or by tracking self-assessed TPACK growth over a semester of guided GenAI use (Mailizar et al., 2026; Segal & Biton, 2024).

Self-efficacy and anxiety.

Bandura's (1997) self-efficacy theory offers a second lens: a pre-service teacher's confidence in evaluating and adapting AI-generated material plausibly shapes how they engage with it. Empirical support for this comes from Wang, Ruan, Zhang, Fu, and Duan (2024), who surveyed 606 pre-service teachers using the Unified Theory of Acceptance and Use of Technology (UTAUT) model. They found that GenAI-related anxiety, social influence, and performance expectancy significantly predicted teachers' behavioral intention to design GenAI-assisted lessons, while effort expectancy and facilitating conditions did not — suggesting that emotional and social factors, not simply ease of use, drive whether pre-service teachers move toward productive GenAI use.

AI literacy as a bridging construct.

A third, related strand of work treats AI literacy — the combination of technical fluency, critical evaluation skill, and ethical awareness needed to use GenAI responsibly — as distinct from, but built on, both TPACK and general self-efficacy. MacDowell, Moskalyk, Korchinski, and Morrison (2024) propose a Student Artificial Intelligence Literacy (SAIL) framework built around exactly this combination. Consistent with this, Nyaaba and Zhai (2024) found, in a professional-development webinar involving 307 teacher educators and in-service teachers in Ghana, that participants were willing to bring GenAI into their practice but identified gaps in prompt-engineering skill, tool cost, and understanding of transparency and ethics as concrete barriers suggesting that willingness alone does not translate into competence without deliberate instruction, and that the constraints on GenAI's instructional promise are institutional as well as individual.

Instructional Opportunities

Lesson planning as a critique-and-revise exercise.

Lee and Zhai (2024) analyzed lesson plans produced by 29 pre-service elementary teachers in Korea who integrated ChatGPT into science instruction, evaluating the results against a

modified TPACK-based rubric. Participants anticipated that ChatGPT could support high-quality questioning, individualized learning, and formative assessment, but also voiced concerns about the accuracy of its output and the risk of student over-reliance — findings consistent with a critique-and-revise rather than accept-as-given use pattern. Mailizar, Hidayat, Syukri, and Wijayanti's (2026) mixed-methods study of eight pre-service mathematics teachers found a similar pattern over a full academic semester: when GenAI tools were used as a structured "virtual peer mentor" for lesson planning and technology integration, participants' self-assessed TPACK increased, and interviews pointed to enhanced technological confidence and interactive teaching strategies — though participants also had to actively interpret and vet AI-generated responses, and the study's own sample of eight participants limits how far its conclusions generalize.

Problem-posing and iterative refinement.

Segal and Biton (2024) studied 15 pre-service secondary mathematics teachers who used ChatGPT to pose and refine mathematics problems as part of a specialization program. The process increased participants' technological knowledge — particularly their understanding of how to craft prompts that produced usable output — and required them to identify and correct errors in the AI's suggestions before the problems were instructionally sound, again illustrating GenAI's value as a draft to be worked on rather than a finished product. A companion study by the same authors, Biton and Segal (2025), followed a similar group of pre-service mathematics teachers through an extended prompt-crafting cycle and found that the process of writing and critically evaluating successive prompts improved the clarity, difficulty calibration, and real-world grounding of the resulting problems — treating prompt literacy itself as a teachable, TPACK-relevant skill rather than an incidental byproduct of using the tool.

Building AI literacy and creative confidence.

MacDowell, Moskalyk, Korchinski, and Morrison (2024) conducted a self-study of an undergraduate multimedia design course in which 35 pre-service and in-service teachers engaged in scaffolded, hands-on activities — including co-authoring an open-access textbook — to build AI literacy under the authors' SAIL framework. Onbasili's (2026) qualitative study of pre-service primary teachers working through a 14-week GenAI-supported digital storytelling course found that participants used tools such as ChatGPT and Copilot as active collaborators in curriculum-aligned storytelling, adapting AI-generated content to students' developmental needs while attending to ethical concerns such as copyright — pointing to a confidence-building function that runs alongside the purely instructional one.

Movement from awareness to considered adoption.

Bae, Hur, Park, Choi, and Moon (2024) analyzed discussion posts from 54 pre-service teachers in an asynchronous online course, using the Diffusion of Innovations framework to track how their views of ChatGPT changed over the term. Course discussion significantly increased participants' awareness and foundational knowledge of GenAI while reducing their anxiety toward it, with many moving from basic awareness toward a considered willingness to apply the tool to their own instructional design — while still raising genuine concerns about accuracy.

A recurring counterweight: accuracy and over-reliance.

Across nearly every study reviewed here, the same caveat resurfaces in some form. Pre-service teachers in Lee and Zhai (2024) worried about accuracy and student dependency; those in Segal and Biton (2024) had to actively correct AI-generated errors; and Nyaaba and Zhai's (2024) participants named prompt-engineering skill and institutional support, not enthusiasm, as the binding constraint on effective use. This convergence suggests that GenAI's instructional opportunity and its central risk are two sides of the same mechanism: the tool is useful precisely

because its output is imperfect enough to demand critical engagement, but that same imperfection is what limits its value when critical engagement is not explicitly taught.

Implications for Teacher Education Programs

Four principles emerge from this literature, each with a corresponding limitation the evidence base does not yet resolve.

- **Sequence exposure deliberately** - GenAI appears most productive when introduced as a tool for critique and revision after foundational planning skills are established (Lee & Zhai, 2024; Mailizar et al., 2026), not as a substitute for learning to plan from scratch. *Limitation*: no study reviewed here directly compares early versus late introduction within the same program, so this remains an inference from within-study patterns rather than a tested causal claim.
- **Address anxiety, not just access** - Since GenAI-related anxiety — more than ease of use — predicted pre-service teachers' intention to design GenAI-assisted lessons (Wang et al., 2024), coursework should include low-stakes, guided practice that explicitly addresses apprehension, not just instruction in how the tools work.
- **Teach prompt literacy explicitly** - Because the quality of AI-generated pedagogical material depended heavily on how pre-service teachers framed their prompts (Segal & Biton, 2024; Biton & Segal, 2025), programs should treat prompt construction as a discrete, assessable skill within TPACK-aligned coursework rather than assuming it develops incidentally through use.
- **Pair individual practice with institutional support** - Nyaaba and Zhai's (2024) finding that tool cost and lack of structured professional development limited GenAI adoption among teacher educators themselves suggests that pre-service teacher training cannot be separated from the question of what access and support their supervising institutions provide. A pre-service teacher's classroom-readiness for GenAI is shaped by more than their own coursework.
- **Use structured reflection to move from awareness to judgment** - Following Bae et al. (2024), assignments that ask pre-service teachers to track their own shifting perceptions of GenAI over a semester may help convert passive familiarity into professional judgment.

Limitations of the Current Evidence Base

The literature synthesized here has several boundaries worth stating plainly. Sample sizes in the most detailed studies are small (8–35 participants in MacDowell et al., 2024; Mailizar et al., 2026; and Segal & Biton, 2024), and several rely on self-assessed rather than externally validated measures of TPACK growth. Most studies are qualitative, single-institution, and drawn from mathematics and science methods courses, with comparatively little evidence yet from humanities, elementary literacy, or special education contexts. Nearly all data collection occurred within a single semester or shorter, so claims about durable changes in practice or belief remain provisional. These constraints do not undercut the consistency of the patterns reported — particularly the recurring critique-and-revise dynamic and the recurring accuracy concern — but they do mean the sequencing principles proposed above should be read as a synthesis of converging signals rather than as an established causal model.

Conclusion

The literature reviewed here suggests that GenAI's instructional value for pre-service teachers lies primarily in structured, reflective use — as a draft to critique, a problem-posing partner, a prompt-literacy exercise, or a low-stakes space to build creative and technological confidence rather than as an unmediated shortcut. That value is bounded by the same features that produce it: AI-generated material is useful to work on because it is imperfect, but that imperfection also means the benefit disappears without deliberate instruction in prompt literacy, critical evaluation, and institutional support. Future work should test the sequencing principles proposed

here directly, using larger and longitudinal samples, comparing outcomes between programs that introduce GenAI early versus late in the curriculum, and extending this research beyond mathematics, science, and literacy contexts into other subject areas, grade bands, and institutional settings.

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A Study on the Usage of Artificial Intelligence (AI) Tools among B.Ed. Students

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Abstract

Artificial Intelligence (AI) has emerged as an important technological development in the field of education, offering new possibilities for teaching, learning, assessment, content creation, and academic support. Teacher education institutions are increasingly exposed to AI-based tools that can assist student teachers in lesson planning, preparation of teaching materials, generating ideas, improving language, and accessing educational resources. However, the increasing use of AI also raises concerns related to overdependence, accuracy of information, academic integrity, privacy, and the development of independent thinking skills. The present study aims to examine the usage of Artificial Intelligence (AI) tools among B.Ed. students. The study focuses on students' awareness, frequency of AI-tool usage, purposes of use, perceived benefits, challenges, and attitudes towards the integration of AI into teacher education. A descriptive survey method was adopted for the study. Data were collected from 160 B.Ed. students using a questionnaire. The results indicate that although many student teachers have heard about AI tools and occasionally use them for academic purposes, their deeper understanding and pedagogical application remain limited. The study suggests that proper training and guidance should be provided to B.Ed. students to improve their effective and responsible use of AI tools in education.

Keywords: *Artificial Intelligence, AI Tools, B.Ed. Students, Teacher Education, Digital Learning, Teaching and Learning.*

Introduction

Technology has become an important part of education and has changed the way teaching and learning take place. Artificial Intelligence (AI) is one of the recent technologies widely used in education. AI tools help students understand difficult concepts, find information, prepare assignments, improve language skills, and create learning materials. They also help B.Ed. students prepare lesson plans, teaching aids, activities, and assessments. B.Ed. students are future teachers who need both teaching and digital skills. Their knowledge and use of AI may help them use technology effectively. However, AI can also cause problems such as inaccurate information, plagiarism, privacy issues, and overdependence. Therefore, the present study focuses on the usages of AI tools among B.Ed. students.

Statement of the Problem

Artificial Intelligence (AI) tools are increasingly being used by students for various academic and educational activities. These tools provide support in understanding concepts, preparing assignments, generating ideas, developing learning materials, and improving digital learning experiences. B.Ed. students, as future teachers, need to understand and use such technologies effectively as part of their professional development. However, the increasing use of AI may also create challenges such as overdependence on technology, inaccurate information, lack of originality, plagiarism, and reduced independent thinking. It is therefore important to understand

how B.Ed. students use AI tools on their academic and learning activities. Studying their level of usage of AI tools can provide useful information for teacher educators and educational institutions to promote appropriate and responsible use of AI. Hence, the present study is undertaken with the following problem: “A Study on the Usage of Artificial Intelligence (AI) Tools Among B.Ed. Students.”

Objectives of the Study

- To find out the level of usage of Artificial Intelligence (AI) tools among B.Ed. students
- To find out the significance of difference in the use of Artificial Intelligence (AI) tools among B.Ed. students based on their qualification.
- To find out the significance of difference in the use of Artificial Intelligence (AI) tools among B.Ed. students based on their group of study.

Hypotheses of the Study

- The level of usage of Artificial Intelligence (AI) tools among B.Ed. students is moderate.
- There is no significant difference in the usage of Artificial Intelligence (AI) tools among B.Ed. students based on their qualification.
- There is no significant difference in the usage of Artificial Intelligence (AI) tools among B.Ed. students based on their group of study.

Research Method

The present study adopted the survey method to study the usage of Artificial Intelligence (AI) tools among B.Ed. students. A total of 160 B.Ed. student teachers from selected teacher education colleges were chosen as the sample for the study. The respondents were selected using a purposive random sampling technique. Data were collected using a structured questionnaire related to the usage of AI tools. The collected data were analyzed using mean, standard deviation and t-test to interpret the results of the study.

Hypothesis Testing

Hypotheses 1: The level of usage of Artificial Intelligence (AI) tools among B.Ed. students is moderate.

Table-1

Variable	Low		Moderate		High		Total	
	N	%	N	%	N	%	N	%
Usage of AI Tools	23	14.375	112	70	25	15.63	160	100

It is evident from the above table-1 that 14.375% of B.Ed. students falls under low, 70% of B.Ed. students falls under moderate and 15.63% of B.Ed. students falls under high category of AI Tools usage. It was found out the level of usage of Artificial Intelligence (AI) tools among B.Ed. students is moderate. Hence the hypotheses that “The level of usage of Artificial Intelligence (AI) tools among B.Ed. students is moderate” is accepted.

Hypotheses 2: There is no significant difference in the usage of Artificial Intelligence (AI) tools among B.Ed. students based on their qualification.

Table 2 - The usage of AI tools among B.Ed. student teachers based on qualification

Group	N	Mean	SD	't' Value	P Value	Level of significance at 0.05%
UG	71	63.35	13.258	0.082	.935	Not Significant
PG	89	63.49	8.595			

Table-2 shows that the obtained t-value (0.082) is lesser than the critical value (1.975) at 0.05% level of significance. This shows that the difference between the UG and PG B.Ed students in the usage of AI tools is not significant. Therefore, the null hypothesis that there is no significant difference in the usage of Artificial Intelligence (AI) tools among B.Ed. students based on their qualification is accepted.

Hypotheses 3: There is no significant difference in the usage of Artificial Intelligence (AI) tools among B.Ed. students based on their group of study.

Table 3 - The usage of AI tools among B.Ed. student teachers based on their group of study

Group	N	Mean	SD	't' Value	P Value	Level of significance at 0.05%
Arts	61	63.33	10.483	0.094	.925	Not Significant
Science	99	63.49	11.162			

Table-3 shows that the obtained t-value (0.094) is lesser than the critical value (1.975) at 0.05% level of significance. This shows that difference between Arts and Science B.Ed. students in the usage of AI tools is not significant at 0.05% level. Therefore, the null hypothesis that there is no significant difference in the usage of Artificial Intelligence (AI) tools among B.Ed. students based on their group of study is accepted.

Findings of the Study

- The level of usage of Artificial Intelligence (AI) tools among B.Ed. students is moderate.
- There is no significant difference in the usage of AI tools among B.Ed. student teachers with respect to their qualification.
- There is no significant difference in the usage of AI tools among B.Ed. student teachers with respect to their group of study.

Discussion

The findings of the study indicate that B.Ed. student teachers have a moderate level of usage of Artificial Intelligence (AI) tools. This suggests that students are aware of and use AI tools for various academic and learning purposes, but their usage has not reached a high level. The results of the study show that B.Ed. student teachers have a similar level of usage about AI tools with respect to their qualification and group of study. This indicates that qualification and subject group

do not have a major influence on the knowledge of AI tools among B.Ed. student teachers. Therefore, teacher education institutions should provide equal opportunities, training, workshops, and practical guidance on AI tools to all B.Ed. students. This will help them develop better knowledge and use AI tools effectively and responsibly in their future teaching.

Educational Implications of the Study

- Teacher education institutions should provide equal opportunities for UG and PG student teachers to develop their knowledge and skills in using AI tools.
- AI-related training programmes, workshops, and seminars should be organized for both Arts and Science B.Ed. student teachers.
- B.Ed. colleges should provide adequate digital resources and technological support to help student teachers understand and use AI tools effectively.

Conclusion

The present study concludes that Artificial Intelligence (AI) tools have become useful resources in the academic activities of B.Ed. students. The study found that the level of usage of AI tools among B.Ed. students is moderate, indicating that students have started using AI for various educational purposes but there is still scope for greater and more effective use. The findings also show that there is no significant difference in AI tool usage based on qualification (UG and PG) and academic group of study (Arts and Science). This indicates that students from different educational backgrounds use AI tools at a similar level. Therefore, B.Ed. students need proper awareness, training, and guidance to improve their knowledge and effective use of AI tools. Teacher education institutions should provide opportunities for students to develop AI-related skills and understand the responsible use of AI. Overall, the effective integration of AI in teacher education can support better learning and help prepare future teachers for technology-enabled classrooms.

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Role of AI in Scientific Research

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Abstract

Artificial intelligence has evolved from a supplementary computational tool into a fundamental component of scientific research. Advances in processing capacity, data infrastructure, and analytical methods have enabled machine learning, deep learning, natural language processing, and large language models to assist researchers across physics, chemistry, biology, and medicine in analyzing complex datasets, identifying non-obvious patterns, predicting molecular behavior, and optimizing experimental parameters. A significant recent development is the shift of AI from a retrospective analytical role to an active one in experimental design and execution, enabling largely autonomous cycles of design, implementation, and interpretation when coupled with robotic systems. The A-Lab initiative illustrates this paradigm, achieving a 71 percent success rate in synthesizing 41 of 58 target inorganic compounds over 17 days of predominantly autonomous operation. Despite these advances, effective use of AI in research still requires human oversight, including data validation, adherence to ethical standards, and expert review of AI-generated conclusions. This chapter examines key AI tools in scientific research, their applications across disciplines, the rise of automated laboratories, and future directions for data-driven discovery.

Keywords: *artificial intelligence, machine learning, deep learning, scientific discovery, autonomous laboratories, robotics, large language models, data-driven research.*

Introduction

Science has traditionally followed a slow cycle of observation, theory, manual testing, and interpretation, but modern instruments and simulations now generate data far faster than researchers can process it by hand, making human attention and computing capacity the real bottleneck rather than scientific possibility [1]. AI addresses this by recognizing patterns, making predictions, and supporting decisions with minimal supervision, turning raw data into actionable insight. Machine learning identifies statistical patterns in historical data to predict new outcomes [2]. while deep learning uses layered neural networks to automatically extract relevant features from complex data without manual engineering. More recently, generative AI and large language models have expanded this further, enabling literature summarization, hypothesis generation, code writing, and research planning.

Together, these advances have driven the rise of AI for Science (AI4S), where AI acts as an active research partner rather than just a computational tool, helping review literature, propose hypotheses, design multi objective experiments, and flag unexpected results. This is especially valuable in data rich, multidisciplinary fields like materials science, chemistry, structural biology, and medicine. When combined with robotics and lab automation, this creates a closed loop system where scientific research can, in principle, operate autonomously.

AI Methods and Technologies for Scientific Research

Artificial intelligence isn't a single technique it's a family of computational approaches, and which one fits best depends on the size, structure, and complexity of the data a researcher is working with. The methods that matter most for scientific work today include machine learning, deep learning, natural language processing, generative AI, computer vision, and what are now called scientific foundation models. None of these operates in a vacuum; in practice they're combined throughout a research project, covering everything from predicting numerical properties to reading images automatically to reasoning across multiple types of data at once [3].

Machine Learning

Machine learning is the base layer for pulling predictive, statistically grounded relationships out of empirical data without needing someone to hand-write rules for every case. It generally splits into three broad approaches. Supervised learning trains on labeled examples to predict properties or sort data into categories. Unsupervised learning works with unlabeled data, looking for hidden structure, grouping similar high-dimensional observations, and flagging outliers. Reinforcement learning takes a different route, refining decision-making strategies through repeated interaction between an agent and its environment; it's increasingly used to explore chemical possibilities, tune experimental settings, and even control robotic lab equipment [4].

Deep Learning

Deep learning relies on neural networks with many layers to build up hierarchical representations directly from raw, high-dimensional scientific data. Because it skips the step of manually deciding which features matter, deep learning can capture subtle, non-linear phenomena that would otherwise be hard to model. Convolutional neural networks in particular have become a standard tool for structural analysis, they pull spatial patterns out of raw data on their own and speed up the processing of large volumes of experimental output [5].

Natural Language Processing

Natural language processing gives computers the ability to read, understand, and summarize the fast-growing body of published research. Through techniques like text mining, entity recognition, and relationship extraction, NLP tools let researchers automate parts of the literature review process, keep tabs on emerging research directions, and trace conceptual connections that span different fields. This directly addresses a very human problem: there's simply no way to manually keep up with millions of new papers [6].

Generative AI and Large Language Models

Generative AI marks a departure from purely analytical prediction toward active creation producing new data instances that are consistent with patterns learned from historical examples. In a lab setting, generative models help design new molecules from scratch, predict crystal structures, and speed up materials discovery. Large language models act more like collaborators than tools: they give scientists a natural-language way to interact with complicated datasets, automatically generate code for simulations, and help draft research hypotheses. Because these models work probabilistically rather than deterministically, everything they produce still needs to be checked against real experimental evidence.

Computer Vision

Computer vision automates the extraction and analysis of visual data from scientific images and video. It's used across microscopy, clinical imaging, materials characterization, and astronomy, where it handles high-throughput tasks such as spotting nanoscale particles, outlining cellular structures, catching defects in materials, and sorting different types of cosmic objects turning what used to be a qualitative, visual judgment call into a quantifiable measurement [7].

Scientific Foundation Models

Scientific foundation models sit at the leading edge of AI4S. They're large-scale systems pre-trained on enormous, cross-disciplinary collections of data, and unlike models built for one narrow task, they can bring text, molecular graphs, crystal coordinates, astronomical images, and simulation logs into a single shared representation. That kind of multimodal integration makes it possible to transfer knowledge across domains, opening the door to predictions and reasoning that span more than one scientific discipline at a time (Table 1) [8].

Table 1 - AI Methods in Scientific Workflows

AI Approach	Typical Data Used	Main Scientific Role	Illustrative Example
Machine Learning (ML)	Tabular records, property measurements, target values	Property forecasting, classification, tuning of parameters	Estimating a compound's boiling point; fine-tuning synthesis temperature
Deep Learning (DL)	High-dimensional raw signals, structural matrices	Automatic feature discovery, spatial pattern recognition	Interpreting high-volume microscopy output; mapping crystal patterns
Natural Language Processing (NLP)	Research articles, patent filings, metadata	Literature mining, trend detection, semantic linking	Connecting related findings across millions of papers from different fields
Generative AI & LLMs	Prompts, molecular notation (SMILES), programming code	De novo molecule design, code writing, hypothesis drafting	Proposing new drug candidates; writing simulation scripts in Python
Computer Vision (CV)	Images, video streams, multi-spectral scans	Automated segmentation, defect detection, classification	Counting nanoscale particles; spotting hairline fractures in materials
Scientific Foundation Models	Mixed inputs graphs, text, images, logs	System-level modeling, cross-domain reasoning	Combining molecular structure with descriptive text in one model

Put together, these methods complement one another, linking data analysis, physical simulation, and higher-level reasoning into a single toolkit. As they're increasingly combined, they're pushing scientific discovery toward a more automated and more intelligent process overall.

Applications of AI Across Scientific Disciplines

Artificial intelligence's proliferation across scientific disciplines stems largely from its pattern-recognition methods being discipline-agnostic, allowing the same underlying architectures to be transferred across disparate problem domains. This portability has established artificial intelligence as a unifying methodological framework linking theoretical inquiry with automated experimentation.

AI in Physics

Artificial intelligence accelerates simulations, refines signal processing, and manages the substantial data volumes generated by modern detection instruments. Applications include real-time filtering of particle-collision events, automated identification of celestial objects and transient phenomena, and neural-network surrogate models that reduce multi-day computations to seconds [9].

AI in Chemistry

Artificial intelligence models the relationships among molecular structure, electronic configuration, and resultant properties, supporting the prediction of quantum-chemical, toxicological, and thermodynamic properties, the modeling of reaction pathways, and accelerated screening for pharmaceuticals and catalysts. Integrated with automated synthesis, generative models increasingly enable closed-loop discovery pipelines [10].

AI in Materials Science

Given the inherent linkage between composition, structure, processing, and performance in materials data, artificial intelligence can evaluate extensive combinatorial spaces to reduce trial-and-error synthesis, predict electronic, thermal, mechanical, and electrochemical properties in advance, and correlate synthesis conditions with outcomes such as nanomaterial morphology and optical behavior [11].

AI in Biology

Applied to extensive multidimensional datasets spanning genomics, transcriptomics, proteomics, and imaging, artificial intelligence supports protein structure prediction, genetic marker identification, molecular docking, high-throughput cellular classification, and multi-omic integration to reveal pathways and therapeutic targets often undetected by conventional statistical methods [12].

AI in Medical Research

In diagnostic imaging, drug discovery, epidemiological modelling, and personalised treatment planning, computer vision algorithms detect subtle pathological features in radiological and histopathological images, while machine-learning models screen extensive virtual compound libraries before synthesis. Given the clinical stakes involved, sustained human oversight remains essential to identify errors, assess bias, and verify output safety [13].

AI in Environmental Science

Integrating data from satellites, sensors, oceanic buoys, and meteorological stations, artificial intelligence improves climate and weather forecasting, monitors air and water quality, quantifies ecological degradation, and supports early-warning systems for floods, wildfires, and other extreme events [14].

AI in Astronomy and Space Science

Given data volumes generated by sky surveys and deep-space instruments that exceed manual analytical capacity, artificial intelligence pipelines classify galaxies, detect exoplanetary transits and orbital irregularities, and forecast solar flares and geomagnetic disturbances threatening satellite infrastructure [15].

AI-Assisted Scientific Discovery

One of the clearest changes in how science is done today is that AI has stopped being a passive tool for crunching data after an experiment and started acting as an active partner throughout the whole discovery process. The traditional path is linear: pose a question, review what's already known, form a hypothesis, run experiments, analyse what comes out, interpret it, and draw conclusions. AI reworks this pipeline by adding computational support at every step, turning what used to be a straight line into more of a loop — literature review, data integration, hypothesis generation, prediction, experimental design, and automated analysis all feeding back into each other continuously, it's work cycle is shown in (Figure 1). Rather than showing up at one isolated checkpoint, AI stays involved with the researcher the whole way through.

Figure 1. AI Research flow chart

AI-Assisted Literature Analysis

Before starting a project, researchers must review far more papers than any person can realistically manage. NLP and semantic search tools help by mapping existing knowledge, identifying cross field connections, extracting key terminology, grouping related ideas, flagging conflicting claims, and highlighting research gaps. However, these tools can miss experimental context and methodological nuances, so human verification remains necessary [3].

Scientific Data Analysis

AI can quickly process massive scientific datasets using pattern recognition and unsupervised learning to find correlations, anomalies, and hidden relationships. This is especially useful in data heavy fields like materials screening, cryo electron microscopy, spectroscopy, and genomics, where data volume exceeds what humans can analyze manually.

AI Based Prediction

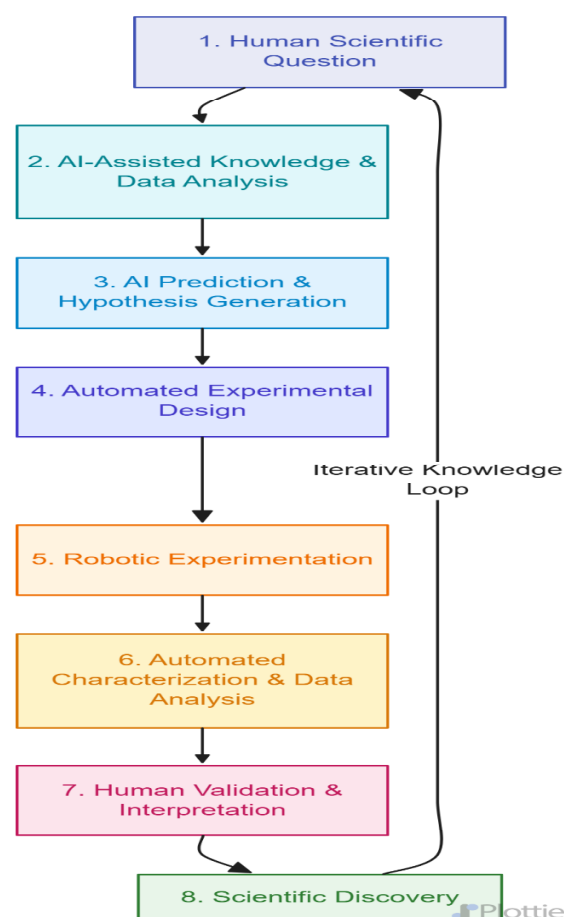
This is AI's most established scientific use. Deep learning models trained on historical data can predict how untested materials or compounds will behave, letting researchers prioritize lab work on the most promising candidates rather than testing everything [16].

Hypothesis Generation

AI can independently generate new scientific hypotheses by analyzing literature and databases, sometimes spotting connections humans might overlook due to existing assumptions. However, these AI generated ideas are only proposals and still require experimental or theoretical validation.

AI Assisted Experimental Design

AI optimizes experiments involving multiple interacting variables (like temperature, pH, and reaction time) by identifying the most promising parameter combinations. This multi objective optimization reduces wasted trials, saves resources, and speeds up experimentation [17].



AI and the Scientific Feedback Loop

AI enables a continuous cycle where predictions guide experiments, results refine the model, and the improved model makes better future predictions. This self-correcting loop is the key mechanism that makes fully autonomous laboratories possible.

Autonomous Laboratories and AI-Driven Research

Autonomous (self-driving) labs combine AI, robotics, and automated instruments to run closed loop research cycles: the AI sets experimental parameters, directs robots to execute them, analyses results, and decides the next trial, while humans oversee goals and validate conclusions rather than doing hands on work [18]. Robots handle repetitive physical tasks such as sample prep, synthesis, and mixing, and they adapt in real time using AI guided computer vision [3]. The core loop of predicting, synthesizing, characterizing, and updating repeats autonomously until a target result or a fully mapped design space is reached. This is especially valuable in materials science, where AI's active learning efficiently navigates complex variable interactions like composition, temperature, and solvents instead of relying on brute force testing [19]. A similar design make test learn cycle accelerates drug discovery, screening virtual compound libraries and refining predictions from biological test data. Despite growing automation, human judgment and contextual expertise remain essential; autonomous labs function as collaborations rather than replacements, shifting research toward a continuous, adaptive, data driven process [20].

Conclusion

Artificial intelligence has gone from being a basic data-processing tool to becoming one of the main drivers of scientific progress today. By bringing machine learning, computer vision, and large language models into fields like physics, chemistry, and medicine, AI is letting researchers work through enormous datasets, predict complicated properties, and come up with new hypotheses far faster than before. Arguably the clearest sign of how far this has come is the emergence of autonomous, closed-loop laboratories. By combining AI with robotics, these self-driving systems can design, run, analyze, and refine experiments continuously — compressing research timelines that used to take years into something much shorter. At its core, AI represents a real shift in how science gets done — from a slow, step-by-step process into something continuous and data-driven. But automation doesn't remove the need for human judgment. Where innovation goes from here still depends on collaboration between people and machines: combining the speed, pattern recognition, and optimization that AI brings with the creativity, ethical judgment, and theoretical insight that only human scientists can provide, in service of solving the bigger problems the world is facing.

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Role of Artificial Intelligence in Education

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Abstract

The digital age is creating a drastic shift in the education world and Artificial Intelligence (AI) is contributing to reforming the education. The strategic importance of AI in the education is discussed in this research paper, and it will explore its use during the entire student lifecycle through data-based learning and development. The study seeks to evaluate the extent to which schools, colleges and Universities are using AI to attain educational excellence, cut down on administrative expenses, and provide a competitive advantage by means of betterment of students. As inferred in this paper, AI could be of great benefit to the students for learning, specifically in speed and accuracy, based on a mixed-method approach. Nevertheless, it throws light on the key issues pertaining to adoption. The conclusion of the paper is that to optimize the positive effects of AI on education, it is better to have a governance structure that is both tech efficient and ethical, one that complements and not substitutes the teachers and at the same time, does not interfere to the learning and education culture of students.

Artificial Intelligence and Education: A Global Bibliometric Analysis of Research Trends and Emerging Themes

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Abstract

AI becomes an inevitable component in each and every field of development in various sectors like medicine, business, education, information science, psychology, and countless others. Even though it arises as a remarkable area of research in education with the expeditious technological advancement that transforms teaching, learning, and assessment practices, thus creating new opportunities and challenges for educators and learners. This study provides a bibliometric analysis of AI in education from 2020 to 2026. The study evaluates 4188 publications gathered from 1317 sources from the selected authenticated bibliometric database. This study undertakes an analysis of publication growth, citation patterns, keywords, influential authors and journals, institutional collaboration, and collaboration patterns to find out the major milestones and emerging themes in the field of study. The results reveal a sudden and steady increase in AI for educational purposes, especially in recent years. Countries like the USA and China contribute more in the scholarly field, while the collaboration among researchers, institutions, and countries fosters the development of the field. The bibliometric analysis recognises ChatGpt, generative AI, and higher education as dominant research areas. The outcome of the research further identifies a transformation of conventional AI to generative AI and the usage of Large Language Models in an educational setting. The integration of AI in the educational environment is contributing to innovation and encouraging further by strengthening the development of a scholarly environment.

Keywords: Artificial Intelligence, ChatGPT, AI, Education, Teaching, Bibliometric Analysis

1. Introduction

Technological advancements in the scientific field make the use of AI more widespread and innovative. AI has been used not only in one field, but in various fields such as medicine, business, agriculture, transportation, and education. The incorporation of AI technologies in education enhances learning outcomes (Madanchian et al., 2025). Nowadays, educational institutions are more dependent on using AI for educational purposes. By adopting AI, contemporary educational institutions are finding solutions to complex queries, enhancing learning outcomes, personalizing instruction, and improving overall learning outcomes (Fortuna et al., 2025). As a result, the combination of AI with education brought enormous changes in the field of education. Advancements and the adoption of digital technologies increase the acceptance of learning models. Researchers explore various possibilities for AI-enabled learning activities, such as adaptive learning systems, automated assessment, virtual learning systems, student performance predictions, and content generation (Kabudi et al., 2021). More than this, the excessive use of generative AI and large language models raises the thoughts of potential and ethical risks of AI use and academic integrity. Gradually, AI has become the center of attraction for scholars, researchers, and academicians from the fields of education, psychology, information technology, and policy studies.

With the increase in scholarly output, it becomes mandatory to evaluate the intellectual structure, emerging trends, patterns of development, and so on. Bibliometric analysis provides quantitative data through authentic databases like Web of Science, Scopus, and Google Scholar for evaluating scientific literature to identify the influential authors, institutions, publication trends, countries, collaboration networks, and thematic evolution. Distinct from traditional literature, the bibliometric method investigates knowledge mapping for the researchers and uncovers hidden relationships of the research topic through citations, keyword analyses, co-citation and co-authorship patterns.

A global bibliometric analysis of research on artificial intelligence and education is important because it helps us to recognize the global understanding across geographical regions and academic communities. Such a bibliometric assessment helps to find out the collaboration patterns, major contributors, dominant and emerging fields of research which make a notable contribution to the future educational innovations. Moreover, understanding of global study determines and identifying knowledge gaps, fostering international collaborations, research dynamics can support policy makers, educators and developing evidence-based strategies for the eminent and efficient use of AI

Thus, it is evident that the study on Artificial Intelligence and Education” can investigate the publication trend, emerging areas, citation impact, collaboration networks, leading search sources, and leading themes. Furthermore, it provides information regarding emerging research areas, thereby pointing out future directions that make global education more impactful. The outcomes mark a remarkable contribution to the researchers, educational institutions, practitioners and to the whole of the world through the innovative usage of AI.

2. Literature Review

Research on Artificial Intelligence in Education (AIED) has developed alongside advances in theories of learning and artificial intelligence. Doroudi (2023) notes that, from its early stages, AIED drew on cognitive information-processing and constructivist approaches to understand and model human and machine learning. Roll and Wylie (2016), in their review of several decades of AIED research, found that early studies largely concentrated on desktop-based, step-by-step problem solving, particularly in STEM education. They argue that the field has gradually moved toward both incremental improvements in classroom applications and broader forms of learning supported by ubiquitous and context-aware technologies.

Feng and Law (2021) examined 1,830 publications using keyword co-occurrence analysis and identified Intelligent Tutoring Systems (ITS) and Massive Open Online Courses (MOOCs) as major components of the field's research structure. Their analysis also showed increasing attention to technologies such as deep learning, neural networks, and eye tracking. More recent work by Kamalov et al. (2023) focuses on deep learning and large language models in education, particularly their applications in personalized learning, automated assessment, and teacher–student interaction. At the same time, the authors identify concerns related to data privacy, algorithmic bias, and academic integrity.

Taken together, these studies indicate a shift in AIED research from task-specific tutoring systems toward broader applications of AI across teaching and learning. Recent research places greater emphasis not only on technological capabilities but also on the practical, ethical, and institutional issues associated with their use in education (Doroudi, 2023; Feng & Law, 2021; Kamalov et al., 2023; Roll & Wylie, 2016).

3. Objectives

The objective of the study is to answer the following questions:

- a) To examine publication trends in research on Artificial Intelligence and Education from 2020 to 2026.
- b) To determine the influential authors, journals, institutions, and countries in this research area.
- c) To examine citation habits and collaboration connections in the field.
- d) To explore the development of themes and discover new research areas through bibliometric visualization methods.

4. Methodology

The study uses a bibliometric approach to evaluate the scholarly landscape of literature related to Artificial Intelligence in Education. The Web of Science database, with its broad coverage and structured data, was used to obtain the dataset for the study. The dataset for the study was sourced from the WoS database through the advanced search feature, applying filters to narrow the results. The details of the search strategy are mentioned below.

Search Query:

“TS=(“artificial intelligence” NEAR/5 education OR “artificial intelligence” NEAR/5 education OR “machine learning” NEAR/5 education OR “generative AI” NEAR/5 education OR “generative artificial intelligence” NEAR/5 education OR “large language model*” NEAR/5 education OR ChatGPT NEAR/5 education)”

Filters

- Publication Period: 2020-2026, Language: English, Document Type: Article
- Database: WoS Database (data retrieved on 21-09-2026)

The search generated 4193 records, which constituted the final dataset for analysis. The search results were downloaded from WoS in BibTeX and Excel format. The BibTeX format is ideal for bibliometric analysis in Biblioshiny (RStudio), available on Windows.

5. Data Analysis

Before starting the analysis, the downloaded file was cleaned and any errors in the data were

carefully corrected. We found one main issue: five records were duplicates. We thoroughly compared all the details and deleted one of the duplicate records to ensure the data is accurate.

5.1 Overview of the Research Landscape

OVERVIEW OF THE DATASET	
Description	Results
Timespan	2020:2026
Sources (Journals, Books, etc)	1317
Documents	4188
Annual Growth Rate %	25.12
Document Average Age	1.83
Average citations per doc	20.71
Document Contents	
Keywords Plus (ID)	1925
Author's Keywords (DE)	8994
Authors and Collaboration	
Authors	15446
Authors of single-authored docs	589
Single-authored docs	636
Co-Authors per Doc	4.51
International co-authorships %	24.36
Document Types	
article	3966
article; data paper	5
article; early access	107
article; early access; retracted publication	7
article; proceedings paper	6
article; publication with expression of concern	1
article; retracted publication	96

Table 1

Table 1 mentions the dataset covering the period 2020–2026 and contains 4,188 documents obtained from 1,317 sources, including journals, books, and other scholarly publications. The research output shows an annual growth rate of 25.12%, indicating a substantial increase in publications during the study period. The documents have an average age of 1.83 years, while the average citation count is 20.71 citations per document, suggesting that a considerable proportion of the recent literature has already received scholarly attention.

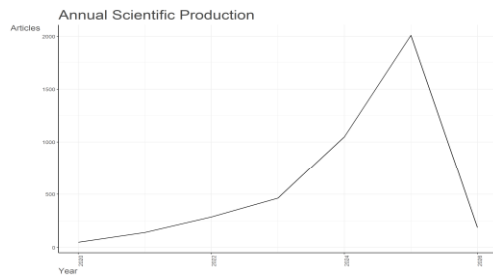
The dataset contains 1,925 Keywords Plus terms and 8,994 author-provided keywords, reflecting a broad range of research themes and terminology. A total of 15,446 authors contributed to the 4,188 documents. Of these, 589 authors produced single-authored publications, accounting for 636 single-authored documents. The average number of co-authors per document is 4.51, indicating that collaborative research is common within the dataset. International collaboration accounts for 24.36% of the publications, showing a measurable level of cross-country research participation.

In terms of document types, research articles dominate the dataset, with 3,966 articles. Other categories include 5 article data papers, 107 articles published as early access, and 6 articles classified as proceedings papers. The dataset also contains 7 early-access articles that were subsequently retracted, 96 retracted publications, and 1 article with an expression of concern. These document-type details are important when interpreting the dataset, as they distinguish the main body of research from early-access, proceedings, and publications affected by post-publication status changes.

5.2 Annual Scientific Production

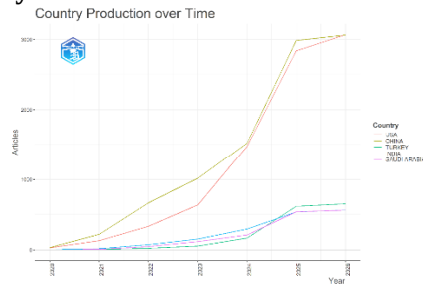
5.2.1 Article-wise Trends in Scientific Production

The annual output of articles (Graph 1) shows a clear upward trend from 2020 to 2025. Publication output increased gradually from around 50 articles in 2020 to about 130 in 2021, nearly 290 in 2022, and around 460 in 2023. The growth significantly accelerated in 2024, surpassing 1,000 articles, and then surged to approximately 2,000 in 2025, marking the peak of the period. The noticeable drop in 2026, with around 190 articles shown in the figure, should be viewed carefully because 2026 is still an ongoing year and the data may not represent the full year. Overall, the figure shows that research activity has expanded considerably, particularly during the last three years of the study period.



Graph 1

5.2.2 Country-wise Trends in Scientific Production



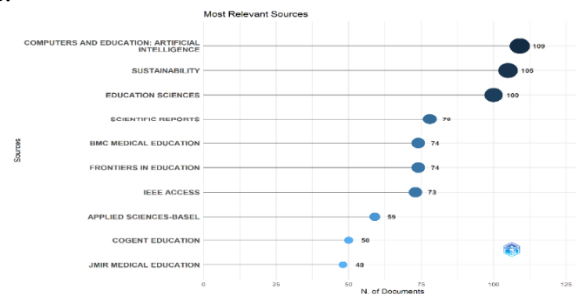
Graph 2

Graph 2 shows a clear increase in research output across all five countries between 2020 and 2026. China and the USA account for the largest share of publications, with both showing strong growth, particularly from 2023 onward; by 2026, their output reaches roughly 3,100 articles each. Turkey also shows a noticeable rise, especially between 2024 and 2025, reaching around 650 articles in 2026. India follows a steady upward pattern throughout the period, increasing from a very small output in 2020 to about 550 articles by 2026. Saudi Arabia shows a trend similar to India's, reaching roughly 550 articles by 2025–2026. Overall, the figure shows that research production remained relatively low in the early years but grew considerably after 2023, with China and the USA showing the strongest expansion in publication output.

5.3 Source (Journal) Analysis

5.3.1 Source Productivity and Relevance

The most relevant sources in the dataset are led by Computers and Education: Artificial Intelligence, with 109 documents, followed closely by Sustainability with 105 documents and Education Sciences with 100 documents (Graph 3). Other important sources include Scientific Reports (78 documents), BMC Medical Education and Frontiers in Education with 74 documents each, and IEEE Access with 73 documents. The remaining sources in the top ten are Applied Sciences-Basel (59), Cogent Education (50), and JMIR Medical Education (48). Overall, the distribution shows that research on the topic is being published across a mix of education, technology, multidisciplinary science, and medical education journals, with education-focused journals making up a substantial part of the publication landscape.

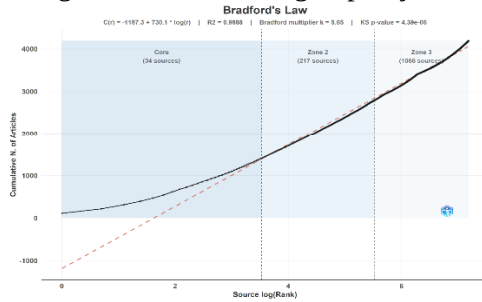


Graph 3

5.3.2 Core Sources based on Bradford's Law

The Bradford's Law analysis divides the 1,317 sources into three zones based on their contribution to the literature. The core zone contains 34 sources, followed by 217 sources in Zone 2 and a much larger 1,066 sources in Zone 3. This pattern in Graph 4 shows that a relatively small group of journals contributes a substantial share of the publications, while the remaining articles are spread across a large number of sources. Overall, the results highlight a concentrated core of important publication

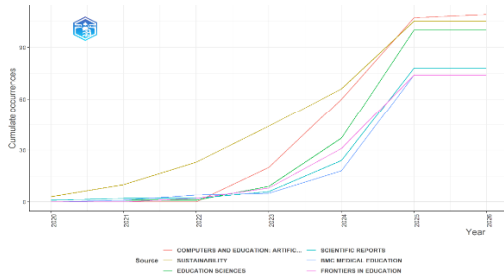
sources alongside a much wider group of journals contributing to the literature.



Graph 4

5.3.3 Publication Trends in Leading Journals

Sources' Production over Time



Graph 5

The source-wise production (Graph 5) shows that publication activity across the major journals increased only gradually during the early years, but the growth became much more noticeable from 2023 onward. Sustainability had the highest cumulative output in the earlier part of the period and continued to grow steadily, reaching about 105 occurrences by 2025–2026. Computers and Education: Artificial Intelligence also saw a strong rise, particularly between 2023 and 2025, reaching around 108 occurrences by 2026. Education Sciences followed a similar pattern and reached about 100 occurrences, while Scientific Reports, BMC Medical Education, and Frontiers in Education also recorded substantial growth, reaching approximately 78, 73, and 74 occurrences, respectively. Overall, the figure shows that most of the leading sources experienced their strongest growth during 2024 and 2025, after which the publication counts remained almost stable through 2026.

5.4 Citation Analysis

5.4.1 Citation Impact and Highly Cited Documents

Year	Average Total Citations Per Article	No. of Publications	Average Total Citations Per Year	Citable Years
2020	34.55	49	4.94	7
2021	32.7	141	5.45	6
2022	23.42	286	4.68	5
2023	61.09	464	15.27	4
2024	25.91	1050	8.64	3
2025	8.61	2010	4.3	2
2026	4.74	188	4.74	1

Table 2

Table 2's citation data show variations in research impact over the years. The average total citations per article were relatively high in the early years, at 34.55 in 2020 and 32.70 in 2021, before falling to 23.42 in 2022. A notable rise occurred in 2023, when the average reached 61.09 citations per article, the highest value in the period, while the number of publications also increased to 464. Publication output then grew sharply to 1,050 articles in 2024, but the average citations per article declined to 25.91, followed by a further decline to 8.61 in 2025 and 4.74 in 2026. The lower citation averages in the most recent years are expected to some extent because these publications have had less time to accumulate citations, as reflected in the declining number of citable years from 7 years in 2020 to just 1 year in 2026.

5.4.2 Most Influential Articles by Citation Count

Table 3 highlights the highly cited publications in the field, with the most cited article being Kung et al. (2023), Performance of ChatGPT on USMLE, which received 2,784 citations and an average of 696 citations per year. This is followed by Gilson et al. (2024) with 1,545 citations, and Alkaissi et al. (2023) with 1,156 citations. Other frequently cited studies focus on ChatGPT in science education, AI ethics, generative AI in higher education, algorithmic bias, and large language models in medical education. The citation pattern shows that ChatGPT, generative AI, medical education, AI ethics, and the broader educational applications of large language models have attracted considerable scholarly attention, particularly in publications from 2023 onward.

Title, Author & Year	Publication	Total Citations	TC per Year
Performance of ChatGPT on USMLE: Potential for AI-assisted medical education using large language models. <i>Tiffany H. Kung, et al. 2023</i>	PLOS Digit Health	2784	696
How Does ChatGPT Perform on the United States Medical Licensing Examination (USMLE)? The Implications of Large Language Models for Medical Education and Knowledge Assessment. <i>Aidan Gilson, et al. 2024</i>	JMIR Medical Education	1545	386.2
Artificial Hallucinations in ChatGPT: Implications in Scientific Writing. <i>Hussam Alkaissi, et al. 2023</i>	Cureus Journal of Medical Science	1156	289
Examining Science Education in ChatGPT: An Exploratory Study of Generative Artificial Intelligence. <i>Grant Cooper, et al., 2023</i>	Journal of Science Education and Technology	774	193.5
Ethics of AI in Education: Towards a Community-Wide Framework. <i>Wayne Holmes, et al., 2021</i>	International Journal of Artificial Intelligence in Education	698	139.6
ChatGPT for Education and Research: Opportunities, Threats, and Strategies. <i>Md. Mostafizer Rahman; Y. Watanobe, 2023</i>	MDPI-Applied Sciences	577	144.2
Challenges and Opportunities of Generative AI for Higher Education as Explained by ChatGPT. <i>Rosario Michel-Villarreal, et al., 2023</i>	MDPI-Education Sciences	495	123.8
Algorithmic Bias in Education. <i>Ryan S. Baker; Aaron Hawn, 2021</i>	International Journal of Artificial Intelligence in Education	482	96.4
Revolutionizing education with AI: Exploring the transformative potential of ChatGPT. <i>Tufan Adiguzel, et al., 2023</i>	Contemporary Educational Technology	479	119.8
Large Language Models in Medical Education: Opportunities, Challenges, and Future Directions. <i>Alaa Abd-alrazaq, et al., 2023</i>	JMIR Medical Education	476	119

Table 3

5.5 Author & Institute Analysis

5.5.1 Author Productivity and Research Contributions

Rank	Author	No. of Publications
1	LI X	30
	WANG J	30
2	WANG Y	29
	ZHANG Y	29
3	LI J	26
4	LI Y	25
	ZHANG J	25
5	CHEN Y	23
	WANG X	23
6	LIU X	21

Table 4

Table 4 shows that a few highly productive researchers dominate publication output. Li X and Wang J share the highest position, with 30 publications each, followed by Wang Y and Zhang Y, who have contributed 29 publications each. Li J has 26 publications, while Li Y and Zhang J have 25 publications each. Chen Y and Wang X have contributed 23 publications each, and Liu X follows with 21 publications. Overall, the leading authors have relatively close publication counts, with the top contributors producing between 21 and 30 publications, indicating active participation by a group of researchers rather than a single dominant author.

5.5.2 Institutional Productivity and Research Output

Rank	Affiliation	Country	Articles
1	The Chinese University of Hong Kong	China	77
2	University of Toronto	Canada	69
3	Education University of Hong Kong	China	68
4	Near East University	Cyprus	64
5	King Saud University	Saudi Arabia	57
6	University of Jordan	Jordan	56
7	King Abdulaziz University	Saudi Arabia	52
	Nanyang Technological University	Singapore	52
8	Zhejiang University	China	50
9	Northwestern University	USA	48

Table 5

Table 5 shows that the research is spread across universities from several countries, with the Chinese University of Hong Kong contributing the highest number of articles (77), followed by the University of Toronto with 69 and the Education University of Hong Kong with 68. Near East University from Cyprus contributed 64 articles, while King Saud University and the University of Jordan produced 57 and 56 articles, respectively. King Abdulaziz University in Saudi Arabia and Nanyang Technological University in Singapore each contributed 52 articles, followed by Zhejiang University in China with 50 and Northwestern University in the USA with 48. The distribution also shows participation from institutions across China, Canada, Cyprus, Saudi Arabia, Jordan, Singapore, and the USA, indicating that research in this area involves a geographically diverse group of universities.

5.6 Conceptual Structure Analysis

5.6.1 Word cloud

The word cloud (Figure 1) highlights main themes in literature, with “Artificial intelligence” as the most prominent term, followed by “education” and “ChatGPT,” indicating a focus on AI and generative AI in education. Keywords like higher education, machine learning, large language models, generative AI, students, technology, learning, and medical education show diverse research interests. Terms such as AI, ethics, experience, assessment, and academic integrity suggest researchers are exploring AI's impact on teaching, learning, and assessment. Overall, the word cloud shows a research landscape centered on AI in education, especially ChatGPT and generative AI in higher education.



Figure 1

5.6.2 Emerging and Trending Research Topics



Figure 2

The trend-topic analysis (Figure 2) shows a clear shift in research interests over time. Earlier

topics such as decision tree, construction, sports, and physical education appear mainly around 2021–2022, while deep learning, big data, and prediction became more visible around 2023. From 2024 onward, the focus moves strongly toward machine learning, students, and performance, followed by a sharp rise in artificial intelligence, ChatGPT, and education by 2025. The larger bubbles for these recent terms also indicate their higher frequency, showing how the research focus has gradually moved from traditional AI and data-driven methods toward generative AI and its applications in education.

5.6.3 Keyword Co-occurrence and Thematic Structure

Figure 3: The co-occurrence network shows three closely connected clusters of research themes, represented by red, blue, and green nodes. The larger nodes indicate terms that occur more frequently, while the numerous connecting lines show strong relationships between the keywords. The red cluster appears to represent the central AI and education-related themes, while the blue and green clusters cover related research areas that are strongly linked to the central group. The dense connections across all three clusters suggest that these themes are not studied in isolation but frequently appear together within the same publications. Overall, the network reflects a well-connected research field, with artificial intelligence and education-related concepts acting as important links between different areas of study.

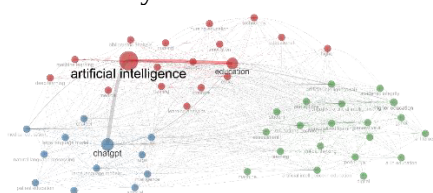


Figure 3

6. Limitation

This study is limited to a single dataset covers publications from 2020-26. Even though the dataset contains 4,188 documents from 1,317 sources, the analysis demonstrates only the records retrieved and indexed within the preferred database, which excludes necessary records from other databases, languages and publication formats. Other than that, the occurrence of duplicate and retracted records requires data cleaning, which indicates the inaccuracy of the database, which affects the bibliometric outcomes. Another limitation comes from the citation-based indicators. Publications from recent years, like 2025-26, takes longer time to get the citation when compared to older ones. In addition to it the study focused on quantitative bibliometric measurement such as publication count, citation, keywords, collaboration pattern without analyzing the quality, methodology and usefulness of the research.

7. Conclusion

The findings indicate a rapid and steady growth in research of AI in education between 2020 and 2026, with publication trends increasing dramatically in recent years. The analysis shows that the strongest contribution is from countries like China and USA. The study also reveals the research collaboration, influential authors, journals, and the institution responsible for shaping this field. The domain themes within the research landscape are ChatGpt, Generative AI, Machine Learning and Higher Education. The citation, keyword, and thematic analyse indicate the shifting of traditional AI to generative AI and the influence of large language models in the education environment. The study also noted that AI-related subjects are expanding across various educational settings, positioning AI as a core theme and focal point for new development and research, thus fostering innovation.

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Artificial Intelligence in Teaching, Learning, and Assessment

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Abstract

Artificial Intelligence (AI) is redefining teaching, learning, and assessment in the 21st century, marking a shift from traditional teacher-centered classrooms to technology-enabled learner-centered ecosystems. This study examines the transformative role of AI in education with special reference to teacher education in India under NEP 2020. The objectives are to understand the concept and evolution of AI in Education (AIEd), to analyze its applications in personalized learning, intelligent tutoring systems, automated assessment, smart content creation, and administrative automation, and to critically evaluate its benefits and ethical challenges. The study is descriptive and based on secondary sources from 2019-2026, including UNESCO reports, UDISE+ data, NEP 2020, and empirical studies by Holmes et al., Luckin, Chen et al., and Indian researchers. Findings reveal that AI enhances learner engagement through adaptive pathways, reduces teacher workload by up to 40% through automated evaluation, and supports data-driven attainment of Programme Learning Outcomes (PLOs) and Course Learning Outcomes (CLOs). It also promotes inclusive education through speech-to-text, bilingual translation (Tamil-English), and remedial support for diverse learners.

However, significant barriers remain: digital divide in rural India where only 38% schools have functional computers, lack of AI training among B.Ed. trainees, data privacy risks, algorithmic bias from Western datasets, high implementation costs, and threat to human values and teacher-student relationships. The paper proposes a three-level competency framework for prospective teachers — (a) operational skill, (b) pedagogical integration, and (c) ethical awareness — and suggests policy, institutional, and teacher-level strategies for human-centered AI integration. It emphasizes that internship performance appraisal of B.Ed. interns should evaluate critical use of AI, not mere technological proficiency. The study concludes that AI should be positioned as an intelligent assistant to teachers, not a replacement, ensuring transparent, robust, time-bound, and value-based teaching-learning and evaluation practices aligned with NAAC quality indicators.

Keywords: *Artificial Intelligence in Education (AIEd), Personalized Learning, Intelligent Tutoring Systems, Teacher Education, NEP 2020, Educational Assessment, Digital Divide, Teaching Competency, Learning Outcomes, Ethics in AI.*

Introduction

Background of AI in Education Artificial Intelligence refers to computer systems that can perform tasks requiring human intelligence, such as learning, reasoning, and decision-making. In education, AI started with simple computer-assisted learning in the 1980s, but with machine learning and generative AI (like ChatGPT, Gemini), it has now become a transformative force. Global investment in AIEd crossed \$6 billion by 2024.

Need and Significance of the Study

Indian classrooms face problems of large student-teacher ratio (30:1), diverse learners, and heavy administrative burden. AI offers solutions through personalization and automation. For B.Ed. students, AI literacy is now a job-readiness skill.

Statement of the Problem

While AI tools are widely available, their pedagogical integration is unplanned. This paper addresses: How can AI be effectively and ethically integrated into teaching-learning without replacing the teacher?

Objectives

Each objective guides the paper to move from concept → application → critical analysis → practical solution for Indian teacher education.

Review of Literature

Holmes et al. (2022) classified AIED into learner-facing (adaptive platforms), teacher-facing (automated grading), and system-facing (admission analytics). Luckin (2021) found ITS improves learning gains by 0.76 SD compared to traditional teaching. Kumar & Singh (2023) in Delhi NCR found positive attitude but only 22% teachers had hands-on training. UNESCO (2024) emphasizes human-centered AI with strict data governance.

Applications in Detail

- **Personalized and Adaptive Learning:** Platforms assess prior knowledge and adjust pace. Example: If a B.Ed. student is weak in assessment concepts, the system gives more practice tests.
- **Intelligent Tutoring Systems:** Provide step-by-step hints, not just answers. Useful for Maths, Science pedagogy.
- **Automated Assessment:** AI checks MCQs instantly and evaluates essays for grammar, coherence. Teachers save 40% time (Chen et al., 2020).
- **Smart Content Creation:** Generates lesson plans mapped to CLOs/PLOs, bilingual question papers (Tamil/English), PPTs in minutes.
- **Administrative Automation:** Facial recognition attendance, timetable optimization, early dropout prediction through learning analytics.
- **Inclusive Education:** Text-to-speech for visually impaired, real-time Tamil translation, simplifying content for slow learners — aligns with remedial support.
- **Bilingual Teaching:** AI translation enables answering bilingually, crucial for TNTEU exams.

Benefits in Detail

- **For Learners:** Self-paced learning, 24x7 doubt clearance, immediate feedback.
- **For Teachers:** Reduced correction burden, data on student performance, better attainment calculation of PLOs/CLOs.
- **For Institutions:** Transparent, time-bound internal evaluation, improved NAAC scores, efficient internship monitoring.

Challenges in Detail

- **Digital Divide:** Only 38% rural schools have functional computers (UDISE+ 2023).
- **Teacher Readiness:** B.Ed. curriculum still focuses on traditional methods.
- **Privacy:** Student data stored on foreign servers poses risk.
- **Bias:** AI trained on Western data may mis-evaluate Indian contexts.
- **Cost:** Premium tools unaffordable for aided colleges.
- **Human Values:** Over use reduces empathy, social skills, teacher-student bond.

AI and teacher education in India

- NEP 2020: Recommends National Educational Technology Forum (NETF) to promote AI.
- Role of B.Ed. Colleges: Must train interns not just to *_use_* AI, but to *_critically evaluate_* AI-generated lesson plans during internship appraisal.
- Competency Framework: Future teacher needs: a) AI operational skill, b) Pedagogical integration, c) Ethical awareness.

Suggestions

- Policy Level: Include AI module in TNTEU B.Ed. syllabus, fund vernacular AI tools.
- Institutional Level: Create AI ethics committee, provide tutorial support for weak students in AI use.
- Teacher Level: Use AI for first draft, but apply own classroom experience; always disclose AI use to students.

Conclusion

AI will not replace teachers, but teachers who use AI will replace those who do not. The goal is comprehensive appraisal of interns — effectiveness in teaching, evaluation competency, regularity, and job readiness — where AI is a tool, not a substitute for professional judgment.

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Artificial Intelligence in Education

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Abstract

Artificial Intelligence (AI) is changing not only how students learn, but also how education itself is delivered. AI can support personalized learning, provide instant feedback and assist students according to their learning needs.¹ This research focuses on the changing relationship between students, teachers and AI, rather than simply discussing the advantages of technology.

Introduction

Traditional education generally follows a common pattern: the teacher teaches, the student listens, and examinations measure learning. AI introduces a new possibility where learning can become more personal, interactive and flexible.² Instead of replacing teachers, AI can act as a digital learning assistant.

Objectives

To study how AI is changing the traditional learning process.

To understand the changing role of teachers and students.

To examine whether AI can support individual learning needs.

To identify the responsible use of AI in education.

Body of the Research

A. The Three-Way Learning Model

AI creates a new relationship between:

Teacher: Provides guidance, values and human understanding.

Student: Learns, questions and thinks independently.

AI: Provides information, explanations and learning support.

B. AI as a “24/7 Study Partner”

AI tools can provide academic assistance whenever students need it. A student can ask for explanations, examples or practice questions and receive immediate responses.

C. From Same Learning to Personal Learning

Traditional classrooms often provide the same lesson to everyone. AI can help provide different explanations and learning materials according to individual needs and progress.

D. The “Human + AI” Classroom

The future classroom does not necessarily mean AI replacing teachers. Instead, teachers can use AI for routine tasks while spending more time on discussion, creativity, guidance and personal interaction.

Findings

The research suggests that AI can make learning more flexible and personalized. However, students still need human guidance, critical thinking and creativity. Therefore, AI is more useful when it supports human teaching rather than replaces it.

Suggestions

Students should use AI to understand concepts, not simply copy answers.

Teachers should guide students in responsible AI use.

AI-generated information should be verified.

Schools should create clear rules for ethical AI use.

Human interaction should remain an important part of education.

Conclusion

AI may not be the future of education by itself; instead, it may become a new partner in education. The important question is not “Can AI replace teachers?” but * “How can teachers and AI work together to help students learn better?”

The classroom of the future may not be “Teacher vs AI”, but “Teacher + AI

Artificial Intelligence in Education: An overview

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ABSTRACT

Artificial Intelligence (AI) is becoming an important part of modern education. It helps students in learning, provides quick feedback and supports teachers in their academic work. AI can make learning easier and more personalized. However, its use also creates challenges such as privacy, incorrect information and overdependence. This research focuses on the role, benefits and challenges of AI in education.

OBJECTIVES

- To understand the meaning of Artificial Intelligence in education.
- To study how AI is used in teaching and learning.
- To identify the benefits of AI for students and teachers.
- To understand the challenges of using AI in education.
- To study the ethical issues related to AI.
- To suggest ways to use AI responsibly in education.

INTRODUCTION

Artificial Intelligence means the ability of computers and machines to perform tasks that normally require human intelligence. In education, AI is used to support students and teachers in different learning activities. It can provide learning assistance, quick answers, feedback and personalized learning. AI is therefore becoming a useful tool in modern education.

BODY OF RESURCH

AI is used in education in several ways. It can help students understand difficult topics and provide learning materials according to their needs. AI-based tools can also help teachers with tasks such as preparing learning materials and assessing students' work.

AI provides many benefits in education. It can save time, give quick feedback, support individual learning and make educational resources easily available. It can also support teachers by helping with some routine academic tasks.

However, AI also has some disadvantages. Sometimes AI may provide incorrect information. Students may become too dependent on AI and reduce their own effort and critical thinking. There are also concerns about privacy, academic dishonesty and misuse of technology.

Therefore, AI should be used carefully. Teachers should guide students, and students should use AI to improve their learning rather than completely depend on it.

FINDINGS

The research finds that Artificial Intelligence can have a positive role in education when it is used properly. It can make learning easier, provide quick support and help students learn according to their needs.

AI can also support teachers by reducing some routine work and providing useful educational assistance. However, AI cannot completely replace teachers because teaching also involves guidance, communication, motivation and human understanding.

The research also finds that responsible use of AI is important. Problems such as incorrect information, excessive dependence, privacy concerns and academic dishonesty need to be addressed.

Overall, AI is most useful when it works together with students and teachers, rather than replacing human involvement.

SUGGESTION

- AI should be used as a supporting tool, not as a replacement for teachers.
- Students should use AI to understand topics instead of simply copying answers.
- Teachers should guide students on the proper use of AI.
- AI-generated information should be checked before using it.
- Student information and privacy should be protected.
- Educational institutions should create clear rules for responsible AI use.
- Students should continue developing their own thinking and problem-solving skills.

CONCLUSION

Artificial Intelligence has an important role in modern education. It can support students, teachers and the learning process in many ways. Although AI has certain challenges, responsible use can make education more effective and accessible. Therefore, AI should be used with proper guidance, ethical care and human involvement.

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Artificial Intelligence in Education: New Perspectives

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Abstract

Artificial Intelligence (AI) is transforming education through personalised learning, automated assessment, academic support, and immediate feedback. It can analyse student performance, recommend learning materials, and assist teachers with routine tasks. However, AI also raises concerns about privacy, bias, academic integrity, unequal access, and overdependence. It should therefore support, not replace, teachers. This research examines the uses, benefits, challenges, and responsible implementation of AI in education.

Objectives of the Research

1. To understand AI in education.
2. To examine its effect on teaching and learning.
3. To identify its major applications.
4. To analyse its benefits and challenges.
5. To examine ethical concerns.
6. To suggest responsible uses.
7. To understand its future role in education.

Introduction

Education has changed significantly with digital technology. AI refers to systems that can analyse information, recognise patterns, understand language, generate content, and provide recommendations.

In education, AI can identify student difficulties, recommend resources, answer questions, assist with grading, and support teachers. Its importance has grown with online learning, digital classrooms, and generative AI.

However, technology must be used ethically while preserving students' independent thinking, creativity, communication, and problem-solving skills. AI should support teachers rather than replace them.

Body of the Research

1. AI-Powered Personalised Learning

AI analyses student performance and recommends materials based on individual needs. This makes learning more flexible and student-centred.

2. Intelligent Tutoring Systems

AI tutoring systems explain concepts, ask questions, provide hints, and offer feedback. They can supplement teachers but cannot replace their emotional support and judgement.

3. AI in Assessment

AI can grade objective questions, identify common mistakes, analyse performance, and provide quick feedback. However, results must be monitored for errors and bias.

4. Generative AI and Academic Learning

Generative AI can create explanations, summaries, questions, and study plans. Students should use it for support and brainstorming, not to replace their own effort or submit unoriginal work.

5. AI as a Teaching Assistant

AI can help teachers prepare lessons, create quizzes, organise materials, and analyse performance, allowing more time for teaching and mentoring.

6. Accessibility and Inclusive Education

Speech-to-text, text-to-speech, translation, and captioning tools can improve access for students with language or learning barriers.

7. Major Benefits

- Personalised learning
- Faster feedback
- Reduced administrative work
- Greater accessibility
- Support for teachers and students
- Identification of learning difficulties
- Flexible learning
- Assistance with research and content creation

8. Challenges and Ethical Concerns

- Privacy: Student data must be protected.
- Bias: Incomplete data can produce unfair results.
- Academic Integrity: Students may misuse generative AI.
- Digital Divide: Unequal access limits benefits.
- Overdependence: Excessive use may weaken independent thinking.
- Accuracy: AI can provide incorrect information and requires human verification.

Key Findings

1. AI can improve personalised and flexible learning.
2. It can reduce repetitive work.
3. AI feedback can identify weaknesses quickly.
4. It can improve accessibility.
5. AI cannot replace teachers.
6. Privacy, bias, integrity, and unequal access remain concerns.
7. AI literacy is necessary.
8. Human supervision is essential for important decisions.

FOUR KEY STEPS FOR RESPONSIBLE AI

Step 1 – Understand

Learn what AI can do and its limitations.

Step 2 – Verify

Check AI-generated information against reliable sources.

Step 3 – Use Responsibly

Use AI to support, not replace, independent thinking and research.

Step 4 – Protect

Safeguard student data and follow ethical guidelines.

SUGGESTIONS

1. Provide AI literacy programmes.
2. Establish clear rules for generative AI.
3. Encourage verification of AI-generated information.
4. Protect confidential student data.
5. Keep teachers involved in important decisions.
6. Evaluate AI tools for accuracy and fairness.
7. Improve access to devices and internet.
8. Promote critical thinking and original work.
9. Train teachers to use AI effectively.
10. Use AI as a human-centred tool, not a replacement for teaching.

CONCLUSION

AI offers important opportunities to personalise learning, provide feedback, support teachers, improve accessibility, and analyse educational data. However, privacy, bias, academic integrity, unequal access, and accuracy must be addressed.

The future of education should combine human and artificial intelligence. Teachers should continue guiding and mentoring students, while AI provides support. Successful implementation should improve learning while protecting equality, integrity, human values, and independent thinking.

Artificial Intelligence in Education: The Emerging Trends

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Abstract

Artificial Intelligence (AI) is transforming modern education by making learning faster, easier and more personalized. AI can help students understand difficult concepts, receive instant feedback and access learning materials according to their needs. It can also assist teachers in preparing educational content and managing routine tasks. This research focuses on the role of AI in improving the teaching and learning process.

Objectives

1. To understand the role of AI in education.
2. To identify how AI supports students and teachers.
3. To examine the benefits and challenges of AI in learning.
4. To suggest responsible use of AI in education.

Introduction

Artificial Intelligence is a technology that enables computers to perform tasks that normally require human intelligence. In education, AI is increasingly used as a tool for teaching, learning and assessment.¹ It provides students with quick access to explanations, practice and feedback.

Body of the Research

AI is used in education in several ways. It can provide personalized learning based on a student's needs and progress. It can act as a virtual tutor by explaining concepts and answering questions. AI can also support language learning, assessment and educational content creation.²

For teachers, AI can reduce certain repetitive tasks and provide useful learning information. For students, it can make learning more flexible and accessible.

However, AI also has challenges. Students may become dependent on AI or use it to complete academic work without learning. AI-generated information can also be inaccurate. Privacy and responsible use are therefore important considerations.³

Findings

- Make learning more personalized.
- Provide quick feedback.
- Support teachers and students.
- Improve access to educational resources.
- Create challenges related to accuracy and academic honesty.

Suggestions

- Use AI as a learning tool, not a replacement for learning.
- Verify AI-generated information.
- Develop clear rules for AI use in educational institutions.
- Protect students' privacy.
- Encourage independent thinking along with AI-assisted learning.

Conclusion

Artificial Intelligence has the potential to make education more personalized, accessible and effective. Its benefits can be achieved when it is used responsibly. AI should support the educational process while teachers and students remain at the centre of learning.

Artificial Intelligence Integration and 21st - Century Teaching Competencies among Student Teachers

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Abstract

Artificial Intelligence (AI) is increasingly transforming teaching learning assessment and teacher education. Generative AI provides new opportunities for student teachers to develop innovative teaching practices while creating concerns related to ethics privacy academic integrity bias and responsible technology use. This study examines the relationship between AI awareness and 21st century teaching competencies among B.Ed. and M.Ed. student teachers. A descriptive survey design is proposed with an illustrative sample of 200 student teachers, comprising 150 B.Ed. and 50 M.Ed. students. Data are proposed to be collected through a structured questionnaire covering AI awareness, AI application skills, digital pedagogy, critical thinking, creativity, communication, collaboration, problemsolving and ethical awareness. Percentage, mean, standard deviation, t-test, ANOVA and correlation analysis are proposed for data analysis. The illustrative findings suggest that student teachers may demonstrate higher AI awareness and digital teaching competency, while ethical understanding and advanced AI pedagogical skills require further development. The study recommends integrating AI literacy responsible AI use AI supported lesson planning, assessment and practical technology-based training into B.Ed. and M.Ed. programmes.

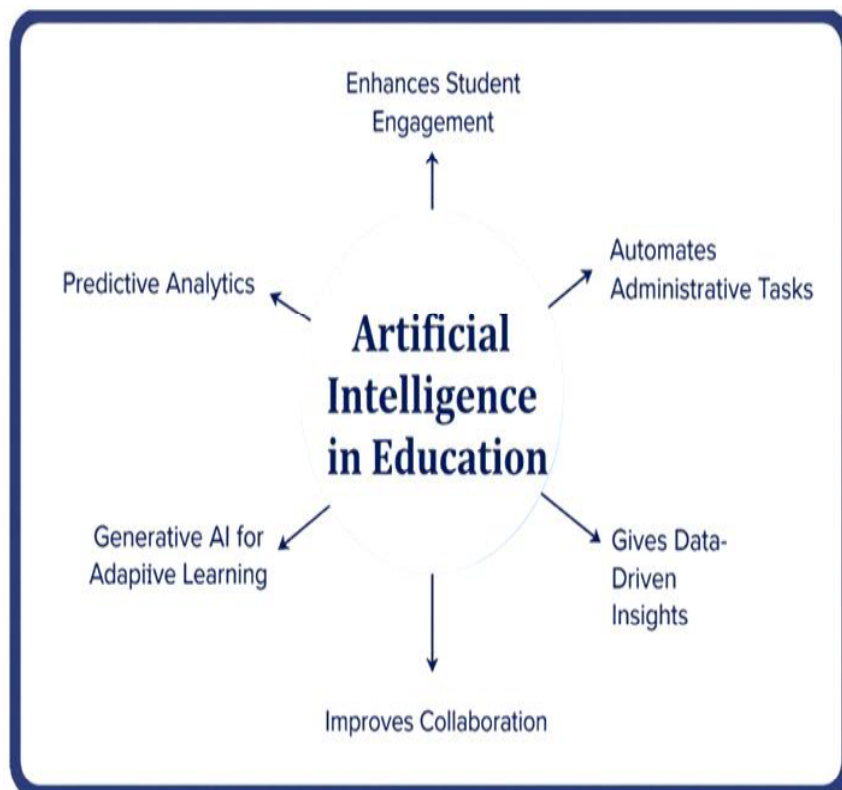
Keywords: Artificial Intelligence, Generative AI, Student Teachers, B.Ed., M.Ed., Teacher Education, 21st Century Skills, AI Literacy, Teaching Competency.

Introduction

Artificial Intelligence (AI) is becoming an important component of modern education, supporting lesson planning, content creation, personalised learning, assessment, feedback and professional development. The growth of generative AI has created new possibilities for innovative teaching while also highlighting concerns about ethics, privacy, academic integrity bias and responsible technology use. Teacher education must therefore prepare student teachers with both pedagogical and technological competencies. In addition to subject and teaching knowledge, future teachers require digital literacy, critical thinking, creativity, communication, collaboration, problemsolving and ethical awareness. In this context, B.Ed. and M.Ed. programmes have an important role in developing student teachers who can use AI effectively, critically and responsibly. The present study therefore focuses on AI awareness and its relationship with 21st century teaching competencies among student teachers.

Statement of the Problem

The rapid development of AI tools has created both opportunities and challenges for teacher education. Student teachers may use AI applications for lesson planning assignment preparation content creation and academic research but their level of AI literacy critical evaluation and ethical understanding may vary.



Objectives of the Study

- Assess the level of AI awareness among B.Ed. and M.Ed. student teachers.
- Examine the AI application skills of student teachers.
- Assess the level of 21st-century teaching competencies among student teachers.
- Determine whether AI competency differs between B.Ed. and M.Ed. student teachers.
- Determine whether 21st century teaching competency differs between B.Ed. and M.Ed. student teachers.
- Examine the relationship between AI competency and 21st century teaching competency.
- Identify the major challenges faced by student teachers in using AI for educational purposes.
- Suggest strategies for strengthening AI integrated teacher education.

Hypotheses of the Study

- ❖ There is no significant difference in AI competency between B.Ed. and M.Ed. student teachers.
- ❖ There is no significant difference in 21st century teaching competency between B.Ed. and M.Ed. student teacher's competency among student teachers.
- ❖ There is no significant relationship between AI competency and 21st century teaching competency among student teachers.

Review of Literature

- **Biswal, S. P., Gorain, R., & Pallai, P. (2026)** examined students' perceptions of AI in education. The study reported generally positive attitudes towards AI while highlighting concerns about privacy bias employment and the importance of human teachers.

- **Dua, B., & Gupta, A. (2026)** proposed an integrated AI pedagogical framework for pre-service teachers focusing on teacher competencies ethical AI and culturally responsive pedagogy.
- **Kundu, A., Bej, T., & Mondal, R. (2026)** investigated AI literacy among Indian school teachers and identified cognitive pedagogical ethical and contextual dimensions. The study also reported challenges related to training, infrastructure privacy bias and misinformation.
- **Saxena, P. (2026)** proposed a competencybased and ethically grounded model for AI in teacher education, emphasising AI literacy humanAI collaboration ethical responsibility and institutional support.
- **Singh, V., & Ram, S. (2024)** examined the impact of AI on teacher education including personalised learning, AIsupported content creation teacher training and ethical considerations.
- **Suresh, G. (2024)** studied the use of AI among 72 B.Ed. student teachers in Pune India. The survey examined their use of AI for educational purposes and their perceptions of AI in education.

Research Methodology and Design

The study adopts a descriptive survey research design to examine AI competency and 21st century teaching competencies among student teachers.

Population

The population comprises B.Ed. and M.Ed. student teachers enrolled in teacher education institutions.

Sampling Technique

A stratified sampling technique may be used to ensure representation of B.Ed. and M.Ed. student teachers.

Sample

For the illustrative statistical analysis a sample of 200 student teachers is considered, comprising 150 B.Ed. students and 50 M.Ed. students.

Analysis and Interpretation

Table 1 Programme-wise AI Competency

Programme	N	Mean	SD
B.Ed.	150	3.55	0.69
M.Ed.	50	3.79	0.61
Total	200	3.61	0.68

Interpretation: The illustrative findings indicate that M.Ed. student teachers have a higher mean AI competency score than B.Ed. student teachers in the simulated dataset. However statistical significance should be determined through an independent samples *t*-test using actual respondent level data.

Table 2 Programme-wise 21st-Century Teaching Competency

Programme	N	Mean	SD
B.Ed.	150	3.67	0.65
M.Ed.	50	3.91	0.57
Total	200	3.73	0.64

Interpretation: The illustrative findings indicate that M.Ed. student teachers have a higher mean score in 21st century teaching competency than B.Ed. student teachers.

Table 3 Gender-wise Distribution of Respondents

Gender	Frequency	Percentage
Male	78	39.0
Female	122	61.0
Total	200	100.0

Interpretation: The illustrative data show that 61% of the respondents are female while 39% are male. Thus, female student teachers constitute the larger proportion of the sample.

Table 4 AI Awareness among Student Teachers

AI Awareness Level	Frequency	Percentage
Low	24	12.0
Moderate	82	41.0
High	94	47.0
Total	200	100.0

Interpretation: The illustrative findings indicate that 47% of student teachers have a high level of AI awareness, followed by 41% with moderate awareness and 12% with low awareness. Overall, the findings suggest that most respondents possess moderate to high awareness of Artificial Intelligence.

Table 5 Mean Scores of AI Competency Dimensions

AI Competency Dimension	Mean	SD	Level
AI Awareness	3.78	0.72	High
AI Knowledge	3.52	0.81	Moderate
AI Application Skills	3.61	0.76	High
Generative AI Usage	3.69	0.84	High
AI Ethics	3.38	0.79	Moderate
AI-Assisted Pedagogy	3.55	0.77	Moderate
AI Professional Learning	3.73	0.71	High
Overall AI Competency	3.61	0.68	High

Interpretation: The illustrative results indicate an overall high level of AI competency among student teachers with a mean score of 3.61. AI awareness recorded the highest mean (3.78), while AI ethics recorded the lowest mean (3.38). The findings suggest that student teachers demonstrate good awareness and practical engagement with AI, but further development in AI ethics and AI-assisted pedagogy may be beneficial.

Table 6 Major Challenges in Using AI

Challenge	Frequency	Percentage
Lack of formal AI training	136	68
Ethical/privacy concerns	118	59
Lack of institutional support	104	52
Difficulty evaluating AI-generated information	98	49
Limited access to appropriate tools	86	43
Lack of confidence	79	39.5

Interpretation: The illustrative findings indicate that lack of formal AI training is the most commonly reported challenge followed by ethical and privacy concerns and limited institutional support.

Discussion

The illustrative findings suggest that AI competency is an important component of contemporary teacher education. Student teachers require both knowledge of AI tools and the ability to apply them effectively in teaching and learning. Although AI awareness appears relatively high, comparatively lower levels of AI ethics and AI assisted pedagogy indicate the need for

greater emphasis on privacy bias copyright misinformation academic integrity and responsible AI use. The positive illustrative relationship between AI competency and 21st century teaching competency suggests a possible association between AI skills and broader teaching capabilities. However, correlation does not imply causation and actual respondent level data are required to establish statistical significance.

Overall teacher education programmes should integrate AI literacy ethical awareness digital pedagogy and practical AI based teaching activities to prepare student teachers for technology enabled education.

Conclusion

Artificial Intelligence is transforming teacher education and creating new competency requirements for future teachers. B.Ed. and M.Ed. programmes should therefore develop not only AI and digital skills but also pedagogical knowledge critical thinking creativity communication collaboration and ethical awareness. The illustrative findings suggest a positive relationship between AI competency and 21st century teaching competencies. However, the data used in this paper are simulated for demonstration purposes and should be replaced with actual data and verified statistical results before publication or presentation. Effective AI integrated teacher education should promote responsible AI use human judgement creativity ethical practice and professional competence ensuring that technology supports rather than replaces the essential human dimensions of teaching.

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Artificial Intelligence Literacy and 21st Century Skills: Preparing Students for an AI-Driven World

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Abstract

Artificial Intelligence (AI) is rapidly transforming education, employment, communication, healthcare, business, science and everyday life. The emergence of generative AI tools has created new possibilities for teaching and learning while simultaneously raising concerns about misinformation, privacy, academic integrity, bias, overdependence on technology and the changing nature of human work. In this context, preparing students merely to operate digital devices is no longer sufficient. Students need Artificial Intelligence Literacy (AI Literacy) the knowledge, skills, attitudes and ethical understanding required to understand, evaluate and responsibly use AI systems.

The present paper explores the relationship between AI literacy and essential 21st-century skills, including critical thinking, creativity, communication, collaboration, problem-solving, digital literacy, information literacy, adaptability and ethical decision-making. AI literacy enables students to understand how AI systems function, recognize their strengths and limitations, evaluate AI-generated information, formulate effective prompts, protect personal data and use AI as a tool for learning and creative problem-solving.

The paper argues that AI should not replace human intelligence, creativity or teachers; instead, it should be used to augment human capabilities. Schools and higher education institutions therefore need to integrate AI literacy across the curriculum, strengthen teacher capacity, develop responsible-use policies and provide equitable access to AI-enabled learning opportunities. The paper concludes that combining AI literacy with 21st-century skills can help students become critical thinkers, responsible digital citizens, innovative problem-solvers and lifelong learners who are prepared to participate meaningfully in an AI-driven world.

Keywords: Artificial Intelligence, AI Literacy, 21st-Century Skills, Digital Literacy, Critical Thinking, Generative AI, Education, Creativity, Ethical AI, Students

Introduction

The twenty-first century is characterized by rapid technological transformation. Among the technologies influencing contemporary society, Artificial Intelligence has emerged as one of the most significant. AI systems are now capable of generating text, images, audio and video, analyzing large amounts of information, translating languages, providing recommendations, supporting decision-making and assisting people in solving complex problems.

The introduction of generative AI has accelerated this transformation. Students can now interact with AI systems to obtain explanations, generate ideas, receive feedback, translate information, create presentations and support research activities. These developments provide considerable opportunities for education.

Therefore, education systems must move beyond the traditional concept of digital literacy. Students need to understand not only **how to use technology but also how technology works, how it influences decisions and how it should be used responsibly**. Thus, AI literacy should become an important component of contemporary education.

Understanding Artificial Intelligence Literacy

Meaning of Artificial Intelligence Literacy

Artificial Intelligence Literacy refers to the ability of individuals to **understand, interact with, evaluate and use AI systems effectively, critically, creatively and ethically.**

An AI-literate student should be able to:

- Explain basic concepts of Artificial Intelligence.
- Understand that AI systems operate using data, algorithms and models.
- Identify common applications of AI.
- Recognize the strengths and limitations of AI.
- Evaluate AI-generated information critically.
- Use AI tools appropriately for learning.
- Formulate effective prompts and instructions.
- Recognize bias and misinformation.
- Protect personal information and privacy.
- Understand ethical implications of AI.
- Take responsibility for decisions involving AI.
- Use AI creatively without becoming completely dependent on it.

Why AI Literacy is Important for Students

❖ AI is Becoming Part of Everyday Life

AI is increasingly present in search engines, social media, online learning platforms, mobile applications, recommendation systems, banking, healthcare and employment. Students are therefore likely to encounter AI both inside and outside the classroom. Education should prepare them to understand and interact with these systems responsibly.

❖ Changing Nature of Employment

The workplace of the future will increasingly require individuals who can work with AI rather than simply compete against AI.

❖ Combating Misinformation

AI can generate convincing but inaccurate information. Students who accept AI-generated responses without verification may develop misconceptions. AI literacy therefore requires critical evaluation and information verification.

❖ Promoting Responsible Technology Use

Students must understand that technological capability does not automatically mean ethical appropriateness.

AI Literacy and 21st-Century Skills

The relationship between AI literacy and 21st-century skills is particularly important because AI changes how students learn, think, communicate and solve problems.

❖ Critical Thinking

Critical thinking is perhaps the most important skill in an AI-driven world. AI can produce fluent and convincing answers, but fluency does not guarantee accuracy.

Creativity and Innovation

AI tools can generate ideas, stories, images, designs and alternative solutions. However, human creativity remains essential for determining whether an idea is meaningful, original and appropriate.

Communication Skills

AI is changing the way people communicate. Students increasingly interact with AI through natural-language instructions or prompts. However, students must not lose the ability to communicate with human beings.

Collaboration and Teamwork

AI can support collaborative learning by providing ideas, explanations and feedback. However, students still need human collaboration to negotiate meaning, resolve disagreements and make collective decisions.

Problem-Solving and Decision-Making

AI can analyze information and suggest possible solutions, but students must learn to determine whether those solutions are appropriate. AI literacy can strengthen problem-solving through a process such as:

Problem Identification → Data Collection → AI Assistance → Critical Evaluation → Human Decision → Implementation → Reflection

Digital and Information Literacy

AI literacy is closely connected with digital and information literacy. The European Commission's DigComp 2.2 framework includes examples relating to emerging technologies such as AI and emphasizes the knowledge, skills and attitudes needed to engage with digital technologies confidently, critically and safely.

Ethical Literacy in the Age of AI

AI brings significant ethical questions into education and society.

- **Privacy:** Students need to understand the risks of entering personal, academic or sensitive information into AI systems.
- **Bias:** AI systems can reproduce or amplify biases present in their training data or design.
- **Academic Integrity:** Generative AI creates new challenges concerning and educational institutions need clear policies that distinguish productive AI assistance from academic dishonesty.
- **Human Responsibility:** AI can provide recommendations, but human beings remain responsible for important decisions.

UNESCO's AI Competency Framework for Students

One of the most important developments in AI education is UNESCO's AI Competency Framework for Students (2024).

The framework identifies four major dimensions:

- **Human-Centred Mindset:** Students should understand human agency and the relationship between humans and AI.
- **Ethics of AI:** Students should understand responsible AI use, safety, accountability and ethical principles.
- **AI Techniques and Applications:** Students should develop foundational knowledge about AI and learn how AI applications work.
- **AI System Design:** Students should develop problem-scoping, design and iterative problem-solving capabilities.

Role of Teachers in Developing AI Literacy

Teachers are central to developing responsible AI users. The teacher's role is changing from being primarily a provider of information to becoming a:

- facilitator of learning;

- learning designer;
- critical-thinking mentor;
- ethical guide;
- technology evaluator;
- researcher; and
- lifelong learner.

Teachers therefore require continuous professional development in AI literacy.

Integrating AI Literacy into the Curriculum

AI literacy should not necessarily be taught only as a separate subject. It can be integrated across existing subjects.

Pedagogical Strategies for Developing AI Literacy

- **Project-Based Learning:** Students can work on authentic problems using AI as one of several resources.
- **Inquiry-Based Learning:** Students can investigate AI-generated claims and determine whether they are supported by evidence.
- **Problem-Based Learning:** Students can use AI to explore solutions to real-world problems such as environmental protection, education, health awareness and community development.
- **Debate and Discussion:** Students can debate questions and discuss the questions related to AI.
- **AI Output Evaluation:** Teachers can intentionally provide students with AI-generated responses containing errors and ask them to identify, verify and correct those errors. This is an excellent method for developing critical thinking.

Challenges in Developing AI Literacy

- **Digital Divide:** Not all students have equal access to devices, reliable internet connections or AI tools. Therefore, AI education must be inclusive.
- **Lack of Teacher Preparation:** Many teachers require professional development to use AI confidently and responsibly.
- **Privacy and Data Protection:** Schools need appropriate policies for protecting student information.
- **Overdependence on AI:** Excessive dependence may reduce independent thinking, writing and problem-solving abilities.
- **Misinformation:** AI-generated content can be inaccurate or misleading.
- **Academic Integrity:** Institutions need clear and practical guidelines regarding appropriate AI use.
- **Rapid Technological Change:** AI technologies change faster than traditional curriculum revision cycles. Therefore, AI education should focus on transferable principles rather than particular tools.

Strategies for Preparing Students for an AI-Driven World

Educational institutions can adopt the following strategies:

- ✓ **Develop AI Literacy Policies:** Schools and colleges should establish clear guidelines for appropriate AI use.
- ✓ **Integrate AI Across Subjects:** AI literacy should become interdisciplinary.
- ✓ **Train Teachers:** Continuous professional development should be provided.

- ✓ **Promote Critical Thinking:** Students should be taught to verify rather than blindly accept AI-generated information.
- ✓ **Teach AI Ethics:** Privacy, fairness, transparency, bias and accountability should be discussed.
- ✓ **Encourage Creativity:** Students should use AI to extend their creativity rather than replace it.
- ✓ **Protect Academic Integrity:** Assessment methods should increasingly focus on reasoning, application, reflection and authentic performance.
- ✓ **Ensure Inclusion:** AI learning opportunities should be available to students from different socioeconomic and educational backgrounds.
- ✓ **Encourage Lifelong Learning:** Students should understand that AI technologies will continue to change and that continuous learning will be necessary.

Educational Implications

The development of AI literacy has several important implications for the education.

- ✓ **For Students:** Students should develop the ability to use AI independently, critically and responsibly.
- ✓ **For Teachers:** Teachers need continuous AI professional development.
- ✓ **For Curriculum Designers:** Curricula should incorporate AI-related knowledge, skills and ethical values.
- ✓ **For Educational Institutions:** Institutions should establish clear policies regarding responsible AI use.
- ✓ **For Policymakers:** Policies should promote equitable access, ethical AI use, privacy protection and teacher preparedness.
- ✓ **For Parents:** Parents should understand AI technologies and guide children in responsible digital behaviour.

Conclusion

Artificial Intelligence is transforming the educational landscape and changing the knowledge, skills and competencies students need for the future. In this context, AI literacy is no longer an optional technological skill; it is becoming an essential component of contemporary education. AI literacy must go beyond teaching students how to operate AI applications. It should enable them to understand AI, question its outputs, recognize its limitations, identify bias, protect privacy, make ethical decisions and use AI creatively.

At the same time, AI literacy must be connected with the broader 21st-century skills of critical thinking, creativity, communication, collaboration, problem-solving, adaptability, digital literacy and ethical decision-making. AI should enhance human intelligence, not replace human thinking. The responsibility of education is therefore to prepare students not simply to become users of AI, but to become critical thinkers, responsible digital citizens, creative innovators and ethical co-creators of the AI-enabled future.

Thus, the future of education should not be “AI versus humans”, but rather “AI with human intelligence, values and creativity.” Preparing students for this partnership is one of the most important responsibilities of education in the twenty-first century.

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Artificial Intelligence in Higher Education: Examining the Relationship between AI Adoption and Learning Effectiveness

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AI has increasingly become common in university learning. Students employ generative AI for a range of tasks, including explaining, writing support, and feedback. Learning takes place through mobile, analytics, immersive, and personalized platforms. Yet, merely utilizing AI won't lead to enhanced learning outcomes. New evidence suggests that the outcome of something actually depends on its purpose and design, as well as students' intellectual engagement. This paper looks at the adoption of AI and the effectiveness of learning with the understanding that engagement, efficiency, critical thinking, and self-directed learning studies have shown that AI-supported learning, which is well structured, can enhance academic performance and participation. At the same time, cognitive offloading and shallow task engagement can be the result of use that is poorly structured or over-reliant. We need a human-centered model in which AI extends the capabilities of students but doesn't replace reasoning, judgement, and responsibility.

Keywords: Artificial Intelligence, Higher Education, Generative AI, Learning Effectiveness, Student Engagement

Introduction

Due to the immediate access that students have to generative AI, the transformation of university teaching, which was previously going slowly with digital technology, is being accelerated. Artificial intelligence is being utilized to simplify complex material, review drafts, produce examples, structure ideas, and receive instant feedback. In a broader digital ecosystem that encompasses online learning, mobile access, collaborative tools, analytics, and virtual learning environments [1], [3]. Using something a lot doesn't mean we learned anything from it. A student may generate a stronger answer or finish work faster while learning little from the experience. Recent literature distinguishes now between task performance and durable learning and emphasizes pedagogical purpose, learner activity, and assessment design [4], [5], [11]. This study investigates the correlation between the use of AI and learning effectiveness rather than assuming greater usage to be beneficial.

Significance of the Study

The issue matters because AI is being used in normal academic practice and institutions are working out their expectations. It is not whether students use AI, but whether the use of AI strengthens understanding, engagement, independence, and the ability to evaluate information. According to research on student engagement, there are good things as well as bad things. A clearer account of this relationship could help inform decision-making around assessment, AI literacy, teaching practice, and institutional policy. This can also enable educators to distinguish useful assistance from that which removes the intellectual work the assessment is designed to measure [10] [12].

Literature Review

The use of artificial intelligence-based technology and systems in the academic creations of students is known as AI adoption in higher education. The accessibility, usefulness, trust, institutional support, and task type impact adoption (Technology Acceptance Model). Recent research has indicated that mere usage frequency is not the key determinant of an ICT tool's educational value. Rather, it is the extent to which the ICT tool is integrated into the pedagogical process that matters most [3], [10].

There is growing evidence of learning outcomes. The 2025 meta-analyses indicate that generative AI interventions have a generally positive impact on academic achievement, motivation, higher-order thinking, engagement, and self-regulation, although effects vary by subject, education level, intervention design, and measures. Therefore, AI can help with learning but not always.

Engagement takes a similar approach. Conversational systems provide students with the ability to put forth questions and test out ideas while leveraging rapid feedback. Still, engagement may turn superficial when AI is used chiefly for finished answers. A systematic review analysed ChatGPT and found engagement and disengagement across the three dimensions: behaviour, emotion, and cognition [2].

Artificial Intelligences can also encourage self-directed learning by helping students identify objectives and organize resources, and monitor progress, co-construct examples, collect feedback, etc. Despite the significant findings in the review, experts stressed that learner agency must remain at the centre [6][7]. Students however, need to be able to choose, monitor understanding and reflect on results.

Now more than ever we need you to think critically. A review of 67 empirical studies conducted in 2026 showed that when the activities are inquiry-based (and scaffolded) ChatGPT can aid critical and creative thinking, but unstructured use can encourage cognitive offloading [8]. Research in academic skills and AI literacy is also focusing on questioning output, checking evidence, considering limitations, and using AI responsibly [9] [10].

Methodology

This study employs a conceptual literature review. It basically originates from studies published during 2023–2026 and/or systematic reviews and meta-analyses, peer reviews as well as recent UNESCO and OECD guidance. The sources that were selected were relevant in the context of higher education, adoption of A.I, engagement, learning outcomes, self-regulated learning, critical thinking, A.I literacy, and governance. No data were collected directly.

Discussion

According to the literature, AI adoption and learning effectiveness are related conditional upon certain factors. AI has the potential to be an effective tutor, feedback giver, brainstorming partner, and more. It is not as educationally valuable when it just does the work for the student. The OECD believes that when the technology use improves task performance, that is not the same as a learning gain.

There are direct implications for assessment. Assignments that can be generated directly are likely to allocate emphasis on reasoning, documentation of the process, oral explanation, application, reflection or comparison between sources. To ensure that we do not eliminate the role of AI in learning, the idea is to make visible what the student's understanding is comprising.

Recent policy work by the OECD focuses on responsible use, data protection, reliability, equity, and AI competences [12].

Digital infrastructure may enlarge the settings where AI-supported learning takes place. IIT Madras showcased a wireless link of 6.39 Gbps using the Bharat 6G THz Testbed in Aug 2026 [14]. Improvements with this technology could ultimately facilitate richer extended-reality learning, remote labs and real-time collaboration, but faster connectivity doesn't equal better learning.

Challenges and Concerns

The basic problem is that fluency does not equal accuracy, nor does it mean correctness, completeness, or conciseness. Consequently, students require knowledge of the subject in order to verify and judge. Another issue of overdependence arises when the writing, reasoning, or problem-solving that students should do is taken over by AI. Both privacy and fairness require due consideration, and so does academic integrity. Ontario universities need to find out what kinds of AI help are acceptable, how student data may be used, and whether students have comparable access to those tools. According to the standards adopted by UNESCO and OECD, human oversight, fairness, safety, transparency, and safeguarding of the interest of the learner are a must [12], [13]. We should improve AI literacy instead of putting a ban on it. Students must be instructed to check what an AI can do, what it can get wrong, how to check for other possibilities, and when to work with little or no input from the AI. Teachers need clear guidance from the institutes about the evaluation processes for meaningful engagement.

Conclusion

AI is slowly becoming a regular part of higher education, but just because it is broadly represented doesn't suggest it's educationally effective. The latest research shows use of generative AI, tied to a specific learning purpose, can be supportive of achievement, engagement, self-regulation, and feedback [4] [9]. Removal of productive cognitive effort is the principal danger. Students must rethink, interrogate, validate, solve, and elucidate. Because of these institutions need policies and teaching practice which enables intentional use; while safeguarding academic integrity, privacy, fairness, and learner agency [11] [13]. Ultimately, AI may be more valuable to higher education by enlarging rather than substituting the great thinking through which learning occurs.

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Pedagogically-Aware Adaptive Retrieval-Augmented Generation for Curriculum-Safe Intelligent Tutoring

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Abstract-Large language models are now used as on-demand tutors, and retrieval-augmented generation (RAG) is the usual method for grounding their answers in textbooks, lecture notes and learning-management-system files. The common assumption is that better retrieval yields safer teaching. That assumption is incomplete. An answer can be factually fluent and still pedagogically harmful: it may cite the wrong syllabus version, respond at the wrong cognitive level, leak an assessment key, or settle a curriculum disagreement in favour of the model's parametric memory rather than the teacher's source. This paper isolates that educational problem-curriculum-safe tutoring-and proposes PACE-RAG (Pedagogically-Aware Curriculum-scoped Educational RAG). The objectives are to name education-specific RAG failures and to specify a teacher-auditable control plane. Four gates surround a standard retrieve-then-generate pipeline: a curriculum-scope filter, a pedagogical-intent classifier, a Bloom-aligned scaffolding policy, and a teacher override log. The paper is conceptual and methodological. It specifies the architecture, works through tutoring vignettes, and defines an evaluation protocol based on curriculum alignment, pedagogical appropriateness, hint integrity and signed accuracy versus a no-retrieval baseline. A later factorial study is expected to raise curriculum alignment and reduce assessment-key leaks relative to naive RAG. The framework supports human-centric digital pedagogy in which the teacher remains the authority over syllabus, assessment and inclusion.

Keywords-artificial intelligence in education, retrieval-augmented generation, intelligent tutoring systems, digital pedagogy, curriculum alignment, assessment integrity.

I. INTRODUCTION

Students now ask conversational models to explain a concept, debug code or check an assignment, often outside a human tutor's timetable [2], [3]. Intelligent tutoring systems already showed that well-designed computer support can approach one-to-one tutoring [5]. Generative models change the engineering route: institutions index course artefacts and let a language model compose an answer [6], [17], [21]. Retrieval-augmented generation attaches external evidence to a parametric model to reduce hallucination [1]. Educational systems follow that pattern. LPITutor personalises LLM tutoring with RAG [6]; KG-RAG adds a course knowledge graph [7]; KITE pairs course retrieval with Socratic scaffolding [8]; RAG-CoVe verifies claims against a textbook [9]. These designs improve factual grounding. They do not guarantee that the assistant behaves as a teacher should.

Published studies already show that retrieval can degrade generation: mixed corpora dilute vector search, long contexts bury mid-ranked evidence, contradictory snippets can override correct parametric knowledge, and RAG can fail even with gold documents [10]-[12]. Those results come from open-domain question answering, not from teaching. This paper asks a narrower question, aligned with human-centric digital pedagogy [16], [20]: when the task is tutoring, which failures are invisible to a factual metric, and how should the pipeline be gated so that an AI assistant

remains curriculum-safe? The novel claim is that educational RAG can fail pedagogically after it has succeeded factually. We name four modes-curriculum-scope mismatch, cognitive-level mismatch, assessment-integrity leakage, and pedagogical knowledge conflict-and wrap a conventional retriever with four corresponding gates.

II. RELATED WORK

Reviews of AI in higher education note that technical papers still outnumber designs that keep the educator in the loop [4], [20]. Holmes et al. argue that AI should amplify teacher judgement [16]. UNESCO places human agency, curriculum integrity and assessment fairness at the centre of generative-AI adoption [3]. Kasneci et al. list gains in personalised explanation together with risks of bias, over-reliance and unverifiable content [2]. Classical ITS work adds two constraints: step-level feedback produces large gains relative to unguided practice [5], and the assistance dilemma warns that too much help turns a task into a demonstration [19]. Vygotsky's zone of proximal development names the same trade-off [15]. Revised Bloom's taxonomy adds a second axis: remember, understand, apply, analyse, evaluate and create are not interchangeable response styles [14]. A system that always emits a complete worked solution is an answer engine, not a tutor.

Recent educational RAG systems treat retrieval as the default grounding layer. LPITutor reports better accuracy and difficulty alignment than an LLM-only baseline [6]. KG-RAG reports a 35% assessment-score gain ($n = 76$) [7]. KITE shows that intent-aware Socratic strategies plus course retrieval can improve simulated tracing follow-ups, and notes that strong retrieval does not by itself yield instructional responses [8]. RAG-CoVe raises factual correctness of formative feedback by verifying claims against a textbook [9]. Lee describes a practical GAI+RAG pipeline [17]. Knowledge tracing can supply a learner-state signal that these systems still treat lightly [18]. Self-RAG decides whether a query needs evidence at all [13]; position-bias studies show under-use of mid-context evidence [11]; conflict-aware prompting addresses parametric versus contextual disagreement [12]. RAG benchmarks document retrieval, assembly, conflict and generation failures [10]. They do not encode educational policy: syllabus version, intended cognitive level, examination integrity, and the teacher as final authority. Existing tutors each cover a slice [6]-[9] but do not jointly gate retrieval on curriculum metadata, help type, Bloom band and assessment leakage. That joint gating is the increment of this paper.

III. PROBLEM FORMULATION AND NOVEL CONTRIBUTION

Let a tutoring episode be a tuple (q, p, C, S, a) , where q is the student query, p is a compact learner profile, C is retrieved context, S is the institutional syllabus graph, and a is the tutor utterance. Conventional RAG maximises factual overlap between a and a gold span in C . That proxy is necessary and insufficient. An educationally admissible answer must also satisfy source admissibility with respect to S ; cognitive-level fit with the intended learning outcome and the learner's ZPD; assessment non-leakage in a graded setting; and conflict handling that prefers the teacher-endorsed artefact. Fig. 1 places the new pedagogical layer beside generic RAG failures reported in the literature [10]. Table I defines the four education-specific modes.

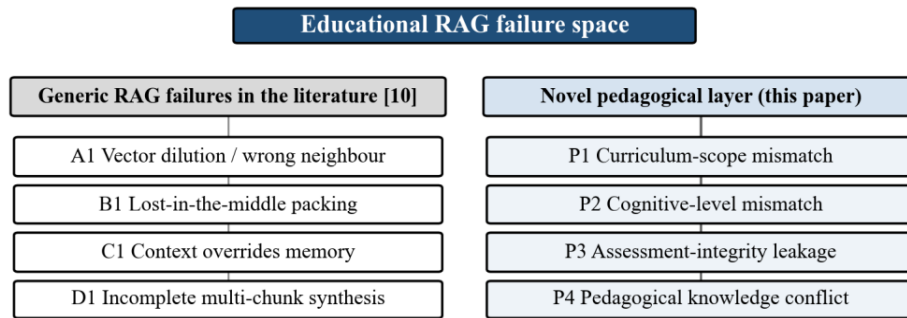


Fig. 1. Generic RAG failures [10] and the proposed pedagogical layer (P1-P4).

TABLE I PEDAGOGICAL FAILURE MODES OF EDUCATIONAL RAG

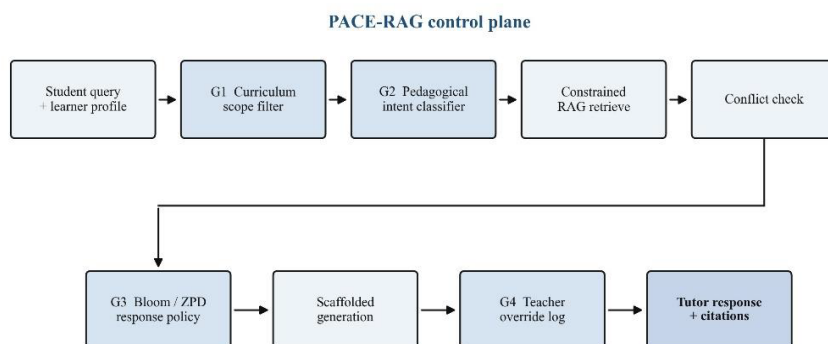
Code	Failure mode	What remains true	What goes wrong
P1	Curriculum-scope mismatch	Retrieved text is topically similar	Wrong board, grade, regulation year, or elective stream
P2	Cognitive-level mismatch	The statement is factually correct	Hint requested but a full solution is given, or vice versa
P3	Assessment-integrity leakage	The key is present in the corpus	A graded item is answered as if it were a practice query
P4	Pedagogical knowledge conflict	Multiple sources are relevant	LLM memory or an outdated note overrules the live syllabus

P1 specialises document-level mismatch: the embedding neighbour may be last year's regulation or a postgraduate treatment of an undergraduate topic. P2 is the assistance dilemma as a generation failure. P3 is almost invisible on open-domain QA benchmarks. P4 extends knowledge conflict [12] from "which fact is true?" to "which fact is this class accountable for?" Research questions follow. RQ1: Which tutoring harms remain after factual RAG metrics are satisfied? RQ2: Can curriculum metadata, pedagogical intent and Bloom policy be inserted as explicit gates without discarding the benefits of retrieval? RQ3: How should such a system be evaluated so that teachers, not only retrieval scores, can judge classroom fitness?

IV. PROPOSED METHODOLOGY: PACE-RAG

PACE-RAG is a gated retrieve-then-generate architecture. It reuses a dense or hybrid retriever and a frozen instruction-tuned LLM. Novelty sits in the control plane, not in a new backbone (Fig. 2).

Course artefacts are chunked with section-aware windows and stored with mandatory metadata: programme, course code, regulation year, unit, intended learning outcome, Bloom band, artefact type and a teacher-set assessment flag. A lightweight curriculum graph $G = (V, E)$ links outcomes to prerequisites and to allowed artefacts. Edges are authored once per course offering. This is cheaper than a fully expert-validated knowledge graph [7] and is sufficient for scope control.



Gates G1–G4 sit around a standard retrieve-then-generate backbone. Arrows do not cross boxes.

Fig. 2. PACE-RAG control plane around a standard RAG backbone.

Gate G1 (curriculum-scope) restricts similarity search to nodes reachable from the learner's current course node. Hard filters drop other regulation years and programmes; soft filters down-weight postgraduate treatments for undergraduate profiles. G1 targets P1 and also reduces vector dilution [10] by shrinking the search space. Gate G2 (pedagogical intent) maps q to {define, explain-why, worked-example, hint, debug, assess-me, off-task}. Intent-aware decoding has already been shown to help tracing support [8]. We couple it to artefact type: hint or debug queries never retrieve examination papers or model-answer folders, even if those files are the nearest neighbours. An assess-me query may retrieve a rubric but not a completed solution for the same item. G2 is the primary control for P3.

Retrieval is hybrid dense-sparse search over the filtered pool, followed by reranking. The retrieved set is inspected for redundancy, positional spread and pairwise contradiction [10], [11]. If contradiction is detected, the generator must surface the conflict rather than silently prefer parametric memory [9], [12]. Where the live syllabus node and an older note disagree, the syllabus node is marked authoritative (P4). Gate G3 (Bloom policy) converts intent and estimated mastery into a lookup, not a second LLM. Mastery may come from a moving average of recent scores or from knowledge tracing [18]. Low-mastery remember/understand items yield a short explanation plus a check question; apply/analyse items yield a Socratic hint; create/evaluate tasks never receive a full artefact. This is ZPD scaffolding [15] and the assistance dilemma [19] in executable form, and it is the control for P2. Adaptive retrieval [13] is reused pedagogically: worked solutions may be withheld even when they would maximise short-term accuracy.

Gate G4 writes every blocked retrieval, leaked-key refusal and conflict decision to an audit log. The teacher can pin an artefact, blacklist a document, or relax G3 in revision week. This is the human-centric loop [3], [16], [22] and a source of training labels for G2: teachers correct the intent tag, not the entire dialogue. The generator then receives $(q, p, C^*, \text{policy}, \text{conflict flags})$. The prompt requires artefact citations, a one-line Bloom-band statement and a closing check question. If G3 selected hint, a complete procedure is forbidden. If G1 returns an empty pool, the model

must say so and point to the teacher-endorsed reading rather than fall back to unconstrained parametric teaching.

V. ILLUSTRATIVE COMPUTER-SCIENCE TUTORING CASES

The following walkthroughs are design cases, not reported student trials. Case 1 (P1). A second-year student asks for the insertion complexity of a B-tree. Naive RAG may retrieve a graduate chapter on B+ tree concurrency. G1 keeps only the current-regulation undergraduate notes, cites the lecture identifier, and asks the student to instantiate the bound on a three-level tree. Case 2 (P2). The student pastes a failing binary-search implementation and writes “just tell me the bug.” G3 permits a localisation hint and a request for a trace of low, high and mid [8], [19]; a full rewrite is withheld. Case 3 (P3). During an online internal test the student asks the course bot for “the output of question 4.” G2 tags assess-me and blocks artefacts with `assessment_flag = true`. The tutor offers textbook SQL semantics, logs the attempt, and notifies the teacher. Case 4 (P4). Lecture slides and an older LMS note disagree on process-state names. The conflict check marks the slide as authoritative, exposes the naming mismatch, and asks the student to map terms onto the syllabus diagram rather than averaging the two accounts.

VI. EVALUATION PROTOCOL AND EXPECTED OUTCOMES

This is a methodological proposal, so we specify how a later empirical study should be run rather than invent classroom scores. Table II lists teacher-scorable metrics that match digital assessment and learner-centred design.

TABLE II EVALUATION METRICS FOR CURRICULUM-SAFE TUTORING

Metric	Definition	Primary gate tested
Curriculum alignment	Share of answers whose cited artefacts sit inside G	G1 / P1
Pedagogical appropriateness	Teacher rubric: hint vs. solution vs. explanation fit	G3 / P2
Hint integrity	Rate of withheld keys on flagged assessment items	G2 / P3
Conflict honesty	Rate of explicit source comparison on planted disagreements	P4
Signed Δ vs. no-RAG	Accuracy minus no-retrieval baseline (can be negative)	overall
Teacher override load	Overrides per 100 queries; target is low but non-zero	G4

A factorial design is recommended: retrieval condition (none, naive RAG, PACE-RAG) $\times$ query type (define, hint, assess-me) $\times$ planted conflict (absent, present). Two teacher-educators score Table II with Cohen's kappa. Simulated-student pipelines [8] suit a first software iteration but cannot replace an in-class study with informed consent, because over-reliance is a human phenomenon [2], [21]. Expected directional outcomes, derived from the cited literature rather than new data, are higher curriculum alignment, fewer hint-integrity violations, a possible drop in "complete-answer accuracy" on hint items (desirable), and a modest teacher-override load after G2 is calibrated.

VII. DISCUSSION AND LIMITATIONS

PACE-RAG is conservative: it will sometimes refuse to answer. In educational technology that refusal is a pedagogical act. It protects assessment validity, keeps the learner in the intended cognitive band, and leaves controversy visible for the teacher [3], [16], [20]. Student queries can reveal misconceptions and personal circumstances, so logs must be purpose-limited, access-controlled and excluded from commercial model training. Bias in the corpus will still propagate; G1 cannot repair a textbook that marginalises some learners. The same gates can, however, serve a slower Socratic mode for inclusive use without changing the syllabus graph. Curriculum graphs and assessment flags should be taught as lesson-planning work, analogous to writing intended learning outcomes, not as a programming chore [4].

The paper does not report a randomised classroom trial. Classifier error in G2 can still leak a key or over-scaffold. Low-resource languages and multimodal laboratories are out of scope, although the gate logic is modality-agnostic. Institutions without stable regulation-year metadata will gain less from G1. These limits keep the novelty claim exact: a pedagogical control plane for educational RAG, grounded in RAG reliability studies [10] and in tutoring theory [5], [14], [15], [19].

VIII. CONCLUSION

This paper narrowed a computer-science line of work on RAG failure modes to a problem that fits current educational-technology research: how to keep an AI tutor curriculum-safe. Factual retrieval success can coexist with pedagogical failure through scope mismatch, cognitive-level mismatch, assessment leakage and syllabus-level knowledge conflict. PACE-RAG addresses those modes with four explicit gates and a teacher audit loop. Future work is an empirical factorial classroom study using the metrics in Table II, beginning with undergraduate computing laboratories and then transferring the same control plane to other disciplines.

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From Smart to Smart Classrooms

A Thematic Review of AI Applications, Pedagogical Opportunities, Risks and Ethical Practices in K–12 and Higher Education

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Abstract

Artificial intelligence (AI) is becoming a general-purpose educational layer supporting planning, teaching, assessment, feedback, research, accessibility and learning. This thematic review synthesizes recent research and policy literature, with emphasis on K–12 teachers and university lecturers. Applications are organized into instructional design, personalization and tutoring, assessment and feedback, language and communication, research productivity, and creative/multimodal learning. Recent evidence reports positive average effects, but substantial variation across subjects, learners and implementation conditions. A 2025 meta-analysis of 29 empirical studies ($n=2,657$) reported Hedges' $g=0.924$, while another meta-analysis of 68 experimental/quasi-experimental studies reported $SMD=0.45$ with very high heterogeneity ($I^2=95\%$). Thus, AI availability alone does not ensure learning gains. The paper proposes a human-in-the-loop approach in which educators retain pedagogical authority, verify outputs, protect learner data, redesign assessment and develop students' critical AI literacy. Benefits, risks, subject applications and practical ethical principles are summarized.

Keywords: *Artificial Intelligence in Education; Generative AI; K–12; Higher Education; AI Literacy; Personalized Learning; Assessment; Academic Integrity; Ethical AI; Teacher Competency.*

1. Introduction

Artificial intelligence in education (AIED) includes intelligent tutoring, learning analytics, natural-language processing, speech recognition, computer vision, recommender systems, automated assessment and generative AI. The rapid spread of large language models has shifted the educational question from whether AI exists to how it can be used deliberately, critically and ethically.

UNESCO's AI Competency Framework for Teachers identifies 15 competencies across five dimensions: human-centred mindset, ethics, AI foundations and applications, AI pedagogy, and AI for professional learning, progressing through Acquire, Deepen and Create. OECD TALIS 2024 reported that about one in three lower-secondary teachers across OECD systems had used AI; among users, 68% used it to learn or summarize a topic and 64% to generate lesson plans or activities, while three in four teachers reported lacking the knowledge or skills to teach using AI.



2. Objectives

- Identify major AI applications for K–12 teachers and university lecturers.
- Synthesize recent empirical and systematic-review evidence on AI-supported learning.
- Examine pedagogical benefits and limitations.
- Show applications across school and university subjects.

- Formulate practical ethical principles for responsible AI use.
- Propose a human-in-the-loop implementation model.

3. Methodology: Thematic Review

A thematic narrative-review approach was used. Recent peer-reviewed systematic reviews, meta-analyses, international policy frameworks and large-scale education surveys were examined, prioritizing evidence reporting samples, effect sizes, review methods or institutional/teacher survey data. The synthesis is interpretive rather than a new statistical meta-analysis. Seven themes were coded: instructional design; personalization and tutoring; assessment and feedback; language and communication; research productivity; multimodal/creative learning; and ethics, governance and AI literacy.

4. What Research Says: Selected Evidence

Evidence source	Evidence base	Key finding	Interpretation
AI academic achievement meta-analysis (2025)	29 studies; n=2,657	$g=0.924$; $I^2=93\%$	Positive average effect; high heterogeneity.
GenAI learning outcomes meta-analysis (2025)	68 experimental/quasi-experimental studies	$SMD=0.45$; $I^2=95\%$	Moderate effect; context matters.
K–12 intelligent tutoring review (2025)	28 studies; n=4,597	Generally positive effects	Benefits reduced relative to non-intelligent tutoring.
Language-learning meta-analysis (2024/25)	Multiple AI interventions	Positive effects; context-dependent	Practice, feedback and speaking are promising.
OECD TALIS 2024	International teacher survey	~1 in 3 used AI	Use is expanding; capacity gaps remain.
UNESCO higher-education survey	400 respondents; 90 countries	90% used AI professionally; ~half in teaching	Governance and AI literacy are urgent.

The evidence is encouraging but does not establish that every AI tool improves learning. High I^2 values indicate substantial differences across learners, disciplines, instructional designs and implementation conditions. Pedagogy, teacher expertise, task quality and verification are therefore as important as the technology.

5. AI Tools for K–12 Teachers

5.1 Lesson Planning and Differentiation

ChatGPT, Gemini, Microsoft Copilot, MagicSchool, Diffit and Brisk Teaching can support lesson outlines, objectives, differentiated texts, examples, discussion questions, exit tickets and scaffolds. Teachers should specify curriculum standards, learner level, language, misconceptions, time and assessment criteria, then verify outputs.

5.2 Language and Literacy

AI can support vocabulary, reading-level adaptation, conversation, pronunciation feedback, grammar explanations, translation, story generation and writing revision. Tools such as ChatGPT, Gemini, Copilot, Google Read Along and speech-enabled applications are best used for guided practice alongside teacher-led interaction.

5.3 Assessment and Feedback

AI can generate question banks, distractors, rubrics, formative feedback and item variations. Quiz-generation platforms can reduce preparation time, but automated feedback should remain draft feedback because AI may misread student intent or produce factual errors.

5.4 Visual, Creative Learning and AI Literacy

Canva AI, Adobe Express, image-generation and text-to-video tools can support posters, storyboards, concept illustrations, historical scenes, science visualizations and multimedia projects. Learning value increases when students explain, critique, edit or cite AI-generated artefacts. Students should also learn about bias, hallucination, privacy, verification, disclosure and the difference between assistance and substitution.

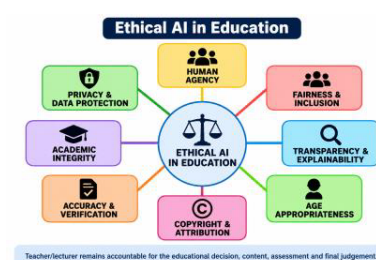
6. AI Tools for University Lecturers

Academic task	Representative tools	Use	Key control
Course design	ChatGPT, Claude, Gemini, Copilot	Outcomes, plans, cases, prompts	Map to outcomes; verify.
Research discovery	Perplexity, Elicit, Consensus, Scite, ResearchRabbit	Literature discovery and evidence mapping	Read original papers; AI is not the evidence.
Document-grounded study	NotebookLM and similar systems	Q&A and synthesis from provided sources	Check citations and source boundaries.
Data / STEM	Wolfram Alpha, coding copilots, Python	Worked examples, reasoning, coding	Verify calculations, code and assumptions.

Assessment	Gradescope, rubric AI, quiz generators	Draft rubrics, feedback, items	Human moderation; protect data.
Writing / editing	ChatGPT, Claude, Grammarly-type tools	Language, structure, clarity	Preserve authorship; disclose substantive use.
Presentation / media	Canva, Adobe Express, Gamma	Slides, diagrams, visual explanations	Check accessibility, copyright and facts.

7. AI Tool Ecosystem

Figure 1. Representative AI ecosystem. Institutions should check current age, privacy and licensing conditions before adoption.



8. How AI Helps Different Subjects

Subject	AI-supported activities	Example outputs	Teacher role
English / Languages	Conversation, pronunciation, vocabulary, grammar, reading, writing	Dialogue practice, differentiated texts	Model language; verify; build communication.
Mathematics	Worked examples, hints, alternatives, error analysis	Stepwise solutions, variants, visuals	Require reasoning; verify validity.
Science	Concepts, simulations, questions, data interpretation	Lab scenarios, diagrams, hypotheses	Validate claims and evidence.
Social Science / History	Source comparison, debate, timelines, role-play	Multiple perspectives, inquiry questions	Teach source criticism.

Geography / Environmental Studies	Maps, climate explanations, modelling, summaries	Case studies, infographics, scenarios	Check data, scale and context.
Computer Science	Code explanation, debugging, algorithms, scaffolding	Code samples, tests, explanations	Teach computational thinking and authorship.
Arts / Music	Ideation, visual composition, music exploration, critique	Storyboards, image prompts, musical ideas	Emphasize originality and copyright.
Commerce / Economics	Cases, spreadsheet logic, scenario analysis	Business cases, scenarios, data questions	Verify assumptions and real data.

9. Human-in-the-Loop AI Teaching Model

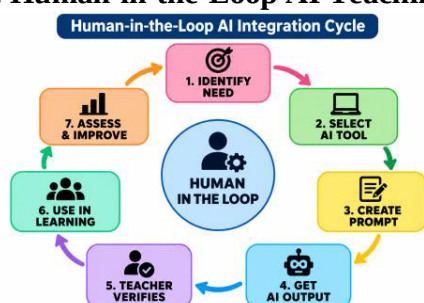


Figure 2. Human-in-the-loop cycle with educator verification, reflection and disclosure.

The central principle is augmentation, not substitution. AI can accelerate tasks where it adds value, while educators retain responsibility for learning objectives, relationships, inclusion, assessment decisions and professional judgement.

10. Benefits of AI in Education

- Personalization: content and practice can be adapted to readiness levels.
- Immediate formative feedback: rapid explanations and revision suggestions.
- Teacher productivity: faster drafting, resource generation and preparation.
- Accessibility: simplification, speech, translation and multimodal representation.
- Engagement: dialogue, simulations and creative production expand practice.
- Research productivity: literature discovery, organization, coding and editing.
- Data-informed support: governed analytics can identify patterns requiring attention.
- Professional learning: AI can act as a rehearsal and lesson-design partner.

11. Limitations and Risks

- Hallucination and factual error: fluent outputs may be unsupported.
- Bias and representation: outputs may reproduce biases in data or system design.
- Privacy and data protection: student or sensitive information may create risks.
- Academic integrity: AI-generated submissions may not demonstrate intended learning.
- Overreliance: excessive delegation may weaken retrieval, writing, problem solving and metacognition.
- Digital inequity: unequal devices, connectivity, models and AI literacy can widen gaps.
- Copyright and attribution: ownership, licensing and acknowledgement may be uncertain.
- Age and safety: younger learners need stronger safeguards and supervision.
- Assessment validity: unrestricted AI can weaken take-home assignments as measures of individual capability.
- Environmental cost: large-scale AI computation consumes energy and other resources.

12. Ethical Use of AI: Practical Framework

Principle	Teacher / Lecturer	Student
Human agency	Use AI to augment judgement; retain responsibility.	Use AI as a learning partner, not a substitute for thinking.
Privacy	Avoid unnecessary personal/confidential data; use approved systems.	Do not disclose personal, family, school or account information.
Accuracy	Verify facts, calculations, citations and feedback.	Cross-check important claims with teachers, textbooks and authoritative sources.
Transparency	Disclose substantial AI assistance where policy requires.	Acknowledge AI assistance according to rules.
Academic integrity	Use process evidence, oral explanation and authentic performance.	Submit work that genuinely represents learning.
Fairness & inclusion	Check stereotypes, language bias and accessibility.	Question biased or exclusionary outputs.
Copyright	Use permitted material and attribute where required.	Respect copyright; do not present others' work as original.
Age appropriateness	Follow institutional, national and platform requirements.	Use teacher-approved tools and accounts.

13. AI and Assessment: From Product to Process

Generative AI requires assessment redesign. Alongside examinations, educators can collect topic proposals, source logs, drafts, prompt-and-response critiques, oral defence, demonstrations, version histories, peer feedback and reflective commentary. A practical rule is: if AI is permitted, assess how students use, critique, verify and improve it; if it is not permitted, state the restriction and provide an appropriate assessment setting. University policy should distinguish permitted assistance from substitution of the student's intellectual work.

14. AI Competency for Teachers and Lecturers

Stage 1 – Awareness: understand AI capabilities, limitations, hallucination, bias and privacy.

Stage 2 – Assisted practice: use AI for low-risk planning, brainstorming and formative resources.

Stage 3 – Pedagogical integration: design AI-supported learning and assessment.

Stage 4 – Critical innovation: evaluate evidence, support policy, conduct classroom research and co-design context-specific solutions.

This progression aligns with UNESCO's teacher competency framework: human-centred mindset, ethics, AI foundations, AI pedagogy and professional learning.

15. Discussion

The literature supports a nuanced interpretation. AI can improve access to feedback, personalization, content generation and learning support, yet positive average effects coexist with high heterogeneity. The same technology may support deep learning in one design and superficial task completion in another. Teachers therefore become designers of learning experiences, evidence curators, AI-output validators, dialogue facilitators and guardians of ethical practice.

AI literacy should be cross-curricular, with domain-specific verification of evidence, reasoning, experiments, code and authorship.

16. Implications for K–12 Schools

K–12 schools should establish age-appropriate AI-use rules, provide professional development in AI, pedagogy and ethics, use approved systems for student data, teach AI literacy progressively (understand → question → verify → create), retain teacher moderation, redesign assessment around reasoning and process, and engage parents and communities.

17. Implications for Universities

Universities should provide faculty development, publish transparent rules for acceptable and restricted AI use, embed AI literacy across disciplines, govern privacy, procurement, intellectual property and academic integrity, research learning outcomes, and provide institutional AI environments with appropriate privacy and source controls.

18. Proposed Institutional AI Adoption Cycle

An institutional adoption cycle can be summarized as: identify the educational problem → define the learning outcome → select the minimum-risk AI capability → pilot → collect learning/usability evidence → audit accuracy, bias, privacy and accessibility → revise → scale only when evidence supports continuation.

19. Conclusion

AI is becoming an important part of education, but its value depends on pedagogy, evidence and governance rather than novelty. Research indicates positive average effects while showing

considerable variation. AI can support planning, personalization, resource creation, feedback, language practice, research and multimodal learning.

A human-centred, human-in-the-loop model is therefore appropriate: educators remain accountable for teaching, assessment and learner-data protection, while students develop verification, critical thinking, ethical reasoning, source evaluation and responsible creation. The transition from smart tools to smart classrooms depends on using intelligent technology to strengthen human learning, relationships and agency.

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Rethinking Assessment in Higher Education in the Age of Generative AI: The 5R Model

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Abstract

Generative artificial intelligence (GenAI) is changing how assessment is designed, completed, and interpreted in higher education. GenAI tools can rapidly produce fluent essays, explanations, code, summaries, and other academic outputs, making it increasingly difficult to infer students' learning from final products alone. This conceptual paper argues that assessment should move beyond dependence on AI detection and focus on the quality of evidence of learning. Drawing on recent scholarship on GenAI, assessment, authentic learning, academic integrity, and AI competency, the paper proposes the 5R Model of AI-Aware Assessment: Recall, Reason, Respond, Reflect, and Responsible AI Use. The model views assessment as the deliberate collection of multiple forms of evidence rather than inspection of a single final product. It distinguishes between learning outcomes and the tools used to achieve them, allowing AI where appropriate while preserving human judgement where it is essential. The paper illustrates the model through a teacher-education example and discusses implications for assessment design, academic integrity, equity, and teacher practice. The model is conceptual and requires empirical validation. The paper concludes that assessment in the GenAI era should focus less on detecting AI use and more on demonstrating understanding, judgement, application, reflection, and responsible human-AI collaboration.

Keywords: generative artificial intelligence; higher education; assessment; authentic assessment; AI literacy; academic integrity; 5R model

Introduction

Assessment is central to higher education because it determines what counts as evidence of learning. Conventional assessment includes examinations, multiple-choice questions, short-answer questions, assignments, reports, presentations, and other products intended to demonstrate students' knowledge and skills. The emergence of GenAI has altered the relationship between the learner, the task, and the submitted product. Because contemporary GenAI systems can generate coherent text, explanations, examples, and code rapidly, a final product is no longer always a transparent indicator of the learner's cognitive work.

The issue is broader than academic misconduct. GenAI can support feedback, self-assessment, learning, and new forms of assessment, while also raising concerns about authenticity, equity, academic integrity, and higher-order thinking (Kizilcec et al., 2024; Xia et al., 2024). Research also indicates that assessment can be redesigned to incorporate GenAI while developing students' judgement about when and how digital tools should be used (Foung et al., 2024).

Accordingly, the central question is not simply how institutions can prevent students from using AI, but how assessment can remain meaningful when AI is available. This paper proposes that assessment should capture a broader range of evidence, including foundational knowledge, reasoning, application, reflection, and responsible AI use. The purpose is not to encourage dependence on AI, but to ensure that assessment remains valid when AI tools are part of the learning environment.

Generative AI and the Changing Assessment Landscape

GenAI has made the relationship between a submitted product and student learning less straightforward. A polished response may be generated or substantially improved with AI assistance.

AI use is not necessarily dishonest; however, the final product alone may provide limited evidence of what the student understands or can do independently.

Xia et al. (2024) argue that assessment in higher education needs to respond to the changing relationship between GenAI and learning, with greater attention to responsible learning, self-regulation, and academic integrity. Fount et al. (2024) similarly demonstrated that assessment can explicitly incorporate GenAI and other digital tools when students are required to use and reflect on them. Their study suggests that assessment can develop students' judgement in selecting and evaluating digital tools rather than treating technology only as a threat. At the institutional level, Moorhouse et al. (2023) found that university guidance on GenAI commonly addresses academic integrity, assessment design, and communication with students. This highlights the need for generative AI assessment literacy, referring to educators' capacity to understand how GenAI affects assessment and to redesign tasks accordingly. The challenge is therefore both technological and pedagogical.

Why Traditional Assessment Needs to Be Rethought

Traditional assessment remains useful, but some formats may provide weak evidence when AI can easily complete the task. Three concerns are particularly important: authenticity, process visibility, and responsible AI literacy. First, a generic task that can be completed convincingly by an AI system may provide limited evidence of individual understanding. Second, a final answer may not reveal the student's reasoning, decisions, revisions, or problem-solving process. Third, students increasingly need to evaluate AI outputs, recognise limitations, protect privacy, acknowledge AI assistance, and exercise human judgement. UNESCO (2023) advocates human-centred, safe, equitable, and meaningful use of GenAI in education. The UNESCO AI competency frameworks further emphasise human agency, ethics, critical judgement, and responsible use in AI-related educational development (Miao & Cukurova, 2024; Miao et al., 2024). These developments suggest that assessment should move beyond checking only the final product and instead generate interpretable evidence of learning.

From Answer-Oriented to AI-Aware Assessment

AI-aware assessment does not mean assessment about AI. It means designing assessment with the understanding that AI is part of the learning environment. The design begins with the intended learning outcome and identifies the evidence needed to demonstrate that outcome. AI may be permitted where it supports the intended learning, while controlled or supervised components may be used when independent performance is essential. For example, if the learning outcome is to analyse an educational problem, students may use AI to generate possible alternatives but should still evaluate those alternatives, justify a final decision, and explain their reasoning. If the outcome is foundational recall, a short individual quiz or oral check may be more appropriate. Thus, AI-aware assessment is not a single format. It is the alignment of learning outcomes, permitted AI use, task design, and evidence requirements.

Table 1. From Traditional Assessment to AI-Aware Assessment

Traditional emphasis	AI-aware emphasis
Reproduction	Application and judgement
Recall as main evidence	Recall with reasoning and interpretation
Single final product	Multiple forms of evidence
AI avoidance	Responsible and transparent AI use
One-time submission	Iterative development and feedback
Product-focused	Process and product
Teacher as evaluator	Teacher as designer, facilitator, and evaluator

Authentic and Process-Oriented Assessment

Authentic assessment provides a strong basis for redesign because it asks students to apply knowledge in meaningful situations rather than merely reproduce information. A systematic review by Vlachopoulos and Makri (2024) found that authentic assessment can support critical thinking, problem-solving, collaboration, and other skills relevant to professional contexts.

In the GenAI era, authentic tasks can be strengthened through context-specific decisions, evidence-based justification, local or professional application, and selected forms of process evidence. For example, students may analyse a case, propose an intervention, justify it with evidence, identify limitations, and reflect on their use of AI. Process evidence may include drafts, annotations, feedback, revision notes, oral explanations, or short reflections. However, such evidence should be used selectively when it improves the validity of the assessment rather than becoming unnecessary paperwork.

Proposed 5R Model of AI-Aware Assessment

The 5R Model of AI-Aware Assessment is proposed as a conceptual framework for designing and reviewing assessment tasks in the GenAI era. It is a synthesis developed by the author and is not presented as an established measurement instrument. Its purpose is to provide a practical design lens for determining whether an assessment captures learning beyond an AI-generated answer.

R1 – Recall

Recall represents the foundational knowledge required for the task. Evidence may include short-answer questions, quizzes, or oral questioning to establish essential concepts and terminology.

R2 – Reason

Reason represents higher-order thinking, including analysing information, comparing alternatives, interpreting evidence, and explaining why a conclusion is justified.

R3 – Respond

Respond represents the application of knowledge to a problem, case, design challenge, performance, or authentic situation. The emphasis is on doing, deciding, creating, or solving.

R4 – Reflect

Reflect represents the learner's ability to examine the learning process, identify changes in understanding, evaluate decisions, and articulate what was learned. Reflection makes aspects of metacognition visible.

R5 – Responsible AI Use

Responsible AI Use represents the ability to use AI critically, ethically, transparently, and purposefully. Evidence may include acknowledgement of AI assistance, evaluation of AI outputs, verification of information, protection of sensitive information, and explanation of human decisions.

The five dimensions are not a fixed sequence. A single assessment may address several dimensions, and not every task needs equal weight across all five. The appropriate dimensions should be selected according to the intended learning outcome and the evidence required to demonstrate it.

Figure 1. Proposed 5R Model of AI-Aware Assessment

Recall → Reason → Respond → Reflect → Responsible AI Use

Note. The model is a conceptual synthesis proposed by the author and requires future empirical validation.

Illustrating the 5R Model in Practice

Consider a teacher-education task on inclusive education. Instead of asking students only to define inclusive education, the assessment can include a short knowledge check (Recall), analysis of a case

involving barriers to participation (Reason), development of a classroom intervention (Respond), reflection after feedback (Reflect), and disclosure and evaluation of GenAI use (Responsible AI Use). This design creates multiple points at which learning becomes visible. Students may use AI to generate possible intervention ideas, but they must judge the relevance of those ideas, adapt them to the case, justify their final decision, and reflect on the process. The assessment therefore focuses on professional judgement and problem-solving rather than simply producing a polished answer.

Assessment Strategies for the GenAI Era

A practical AI-aware assessment system can combine several strategies. Teachers can use authentic, context-rich tasks; oral explanations or demonstrations; staged submissions with feedback and revision; and activities in which students critique AI-generated answers, identify inaccuracies, and improve them using credible evidence.

These approaches position AI as a supporting tool or an object of critical analysis rather than a substitute for student thinking. Fount et al. (2024) found that when students were given opportunities to use and reflect on digital and GenAI tools, they developed judgement in selecting appropriate tools. The study also identified concerns about differences between free and premium tools, reinforcing the importance of equitable assessment design. Assessment design should therefore consider differences in students' access to AI tools, internet connectivity, and AI literacy.

From AI Detection to Assessment Design

AI detection may be useful as one institutional strategy, but detection alone does not solve the underlying assessment problem. Even when AI-generated text is identified, a poorly designed task may still provide weak evidence of learning.

A stronger approach is to design tasks that require context-specific reasoning, explanation, application, and appropriate process evidence. Academic integrity should continue to be supported through clear expectations, transparent policies, acknowledgement of AI assistance, and assessment designs that make authentic participation visible.

Moorhouse et al. (2023) found that institutional guidance commonly addresses academic integrity, assessment design, and communication with students. These should therefore be treated as complementary responses rather than relying on detection alone.

Changing Role of the Teacher

AI-aware assessment increases rather than reduces the importance of teacher judgement. Teachers must decide the learning outcomes, permitted AI use, evidence requirements, fairness, task difficulty, and feedback processes. UNESCO's AI Competency Framework for Teachers identifies five dimensions: human-centred mindset, ethics of AI, AI foundations and applications, AI pedagogy, and AI for professional learning (Miao & Cukurova, 2024).

The teacher's role can therefore be reframed from "AI gatekeeper" to "assessment architect." The assessment architect anticipates AI affordances, identifies where human judgement is essential, designs evidence-rich tasks, communicates expectations, and uses feedback to support deeper learning.

Academic Integrity, Equity, and Responsible AI Use

Responsible AI use should be treated as an educational competency rather than only a compliance issue. Students need to understand that AI outputs can contain errors and that AI use raises questions about privacy, copyright, transparency, and the limits of delegating judgement to automated systems. UNESCO's guidance advocates ethical, safe, equitable, and meaningful use of GenAI in education (UNESCO, 2023). Its AI Competency Framework for Students identifies four dimensions: human-

centred mindset, ethics of AI, AI techniques and applications, and AI system design, with progression through understanding, applying, and creating (Miao et al., 2024).

Equity also requires attention. If AI use is permitted, institutions should consider whether students have comparable access to appropriate tools. If AI use is restricted, the educational purpose of the restriction should be clear and feasible assessment conditions should be provided.

Implications for Higher Education

The 5R Model has implications at three levels.

At the classroom level, teachers can review assessment tasks and identify which forms of evidence are missing.

At the programme level, departments can map assessment methods across courses to ensure an appropriate balance of knowledge checks, authentic application, reflection, and responsible technology use.

At the institutional level, policies can provide clearer guidance on acceptable AI use, disclosure, verification, and assessment design.

Assessment reform should remain purposeful. Not every examination needs to become a complex project, and not every assignment needs an AI component. Where independent recall is the intended outcome, controlled assessment remains appropriate. Where professional judgement, creativity, problem-solving, or critical analysis is intended, richer evidence may be necessary.

Discussion

The central contribution of this paper is a shift in the unit of attention from the presence or absence of AI to the quality of evidence of learning. GenAI can weaken assessment when a task can be completed through generic generation without meaningful human judgement. At the same time, it can become a learning resource when students are required to evaluate outputs, verify information, compare alternatives, make decisions, and reflect.

The 5R Model provides a compact framework for this shift. Recall preserves foundational knowledge; Reason and Respond foreground higher-order thinking and application; Reflect makes aspects of metacognition visible; and Responsible AI Use addresses the competencies required for human–AI collaboration.

The model therefore supports a broader conception of assessment validity in which teachers gather multiple forms of evidence before making judgements about learning. This position is consistent with research calling for assessment that supports self-regulation, responsible learning, integrity, authentic application, and critical engagement with AI (Xia et al., 2024; Vlachopoulos & Makri, 2024; Kizilcec et al., 2024).

The broader implication is that assessment reform should be understood as a pedagogical transformation, rather than merely a technical response to a new category of software.

Conclusion

Generative AI has not made assessment impossible; it has made some traditional assumptions about assessment less defensible. When AI can generate answers, assessment needs to become better at revealing learning. The future of assessment therefore lies not in abandoning traditional methods, but in using them selectively alongside authentic, process-oriented, reflective, and AI-aware approaches. The proposed 5R Model—Recall, Reason, Respond, Reflect, and Responsible AI Use offers a practical conceptual lens for this transition. It encourages educators to assess what students know, how they think, how they apply knowledge, how they learn from experience, and how responsibly they work with AI.

The model is intentionally conceptual and requires empirical examination across disciplines, learner groups, and assessment contexts. Future research can develop assessment indicators for each dimension

and test the model's validity and reliability in different higher-education settings. Ultimately, the goal is not to make assessment AI-proof, but to make it valid, human-centred, authentic, and future-ready.

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Techno – Pedagogical Skills of B.Ed. Student Teachers with respect to certain selected variables

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Abstract

The emergence of new technology has influenced every aspect of human life. In order to prepare students to navigate the 21st-century world, they must be exposed to technology-based instruction in the classroom. Teachers need to acquire knowledge and skills in technology. Today, techno-pedagogical skills are essential for teachers in the teaching and learning process, as they facilitate effective teaching and learning. Every teacher trainee should know how to use technology, pedagogy and content effectively in their daily classroom teaching. Student teachers are the teachers of the future generation. To respond to the challenges, student teachers are required to have competencies such as efficient problem-solving skills, thinking skills and creativity. These are the key features in the teaching profession. The present study examined the techno-pedagogical skills of B.Ed. student teachers and their relationship with cognitive correlates. A descriptive survey method was employed. A sample of 204 B.Ed. student teachers was selected from two teacher education colleges in and around Villupuram District using purposive random sampling technique. The tools used for the study were Techno-pedagogical Skills Scale constructed by D.Anand and R.Rajalakshmi (2024). The data were analyzed using mean, standard deviation, t-test, F-test and correlation. The findings revealed that there is no significant difference in the techno-pedagogical skills of B.Ed. student teachers with respect to gender, educational qualification and locality. However, PG student teachers (M=131.03) scored slightly higher than UG student teachers (M=129.62). The study concludes that the level of techno-pedagogical skills among B.Ed. student teachers is moderate. The study recommends that teachers should be trained to use technology effectively in classroom teaching.

Keywords: *Techno-pedagogical skills, B.Ed. student teachers, Teacher education, Technology integration, Digital teaching skills, teaching competencies.*

Introduction

The emergence of new Technology has influenced every aspect of human life. In order to prepare students to navigate the 21st century world they must be exposed to technology-based instruction in the classroom. Teachers need to acquire knowledge and skills in technology. Today, techno-pedagogical skills are essential for teachers in teaching and learning process, as they facilitate effective teaching and learning. Every teacher trainee should know how to use Technology, pedagogy and content effectively in their daily classroom teaching. Student teachers are the teachers of the future generation. To be able to respond to the challenges, student teachers are required to have competencies such as efficient problem-solving skills, thinking skills and creativity. These are the key features in the teaching profession.

Statement of the Problem

The advent and swift development of Techno-pedagogical skills and tools and their use is increasing in learning and teaching activities among students and teachers in all educational

systems across the world including India. Personal communication and interaction with others and also for improving their Academic performance. The efficacy of learning and teaching in digital atmosphere largely depends on the techno-pedagogical skills of B.Ed. student teachers. At the same time, there is no detailed and analytical study pertaining to confirmation on Techno pedagogical skills B.Ed. student teachers. Furthermore, there is no empirical study of B.Ed. student teachers on their techno-pedagogical skills and the influence of profile variables. Hence, it is imperative to study, “Techno pedagogical skills of B.Ed. student teachers with respect to certain selected variables”.

Objectives of the Study

- To find out the significance of difference in the Techno-pedagogical skills of the Male and Female B.Ed. student teachers.
- To find out the significance of difference in the Techno-pedagogical skills of the UG and PG B.Ed student teachers.
- To find out the significance of difference in the Techno-pedagogical skills of the rural and urban B.Ed student teachers.

Methodology

The identified problem is studied by following descriptive survey method of research. The researcher has diagnosed the B.Ed., student teachers keenly and thoroughly in relates with the topic entitled “Techno-pedagogical skills of B.Ed. student teachers”. The investigator used a validated tool “Techno-pedagogical skills scale” constructed by Mr. D.Anand and R.Rajalakshmi (2024). The reliability value 0.84 of the tool reveals that the tool is reliable enough for data collection. A purposive random sampling technique was used in the present study for collecting the data. The investigator randomly selected two colleges in and around Villupuram District and tested 204 samples. The tool was administered personally by the investigator. The data thus collected were put into appropriate statistical analysis: Mean, standard deviation, t-test, f-test and correlation.

Hypotheses of the Study

- There is no significant difference in the Techno-pedagogical skills of the Male and female B.Ed. student teachers.
- There is no significant difference in the Techno-pedagogical skills of the UG and PG B.Ed. student teachers.
- There is no significant difference in the Techno-pedagogical skills of the rural and urban B.Ed. student teachers.

Hypothesis 1: There is no significant difference in the Techno - pedagogical of the Male and female B. Ed student teachers

Table 1 - Techno Pedagogical scores between male and female B.Ed student teachers

Gender	N	Mean	SD	't-Value'	Level of Significance at 0.05%
Male	102	128.92	5.861	1.96	NS
Female	102	130.72	6.452		

NS - Not Significant

From **Table 1**, it is evident that the mean Techno - pedagogical skills score of the Male and Female B. Ed student teachers is 128.92 and 130.72 respectively. Further, it can be noted that the obtained 't' value is 1.96 (DF=298) at 0.05 level of significance which is lower than the critical value 3.323. Hence, the null hypothesis, "There is no significant difference in the techno-pedagogical of the Male and female B. Ed student teachers" is accepted.

Hypothesis 2: There is no significant difference in the Techno-pedagogical skills of the UG and PG B.Ed. student teachers.

Table 2 - Techno Pedagogical scores between UG and PG B.Ed student teachers

QULIFICATION	N	Mean	SD	't-Value	Level of Significance at 0.05%
UG	175	129.62	6.020	1.138	NS
PG	29	131.03	7.278		

NS - Not Significant

From **Table 2**, it is evident that the mean Techno-pedagogical skills score of the educational qualification of B.Ed. student teachers is 129.62 and 131.03 obtained 't' value is 1.138 (df=202) at 0.05 level of significance which is lower than the critical value 3.323. Hence, the null hypothesis, "There is no significant difference in the Techno- pedagogical of the UG and PG B.Ed. student teachers" is accepted. This shows that there is no significant difference in the techno -pedagogical skills of the UG and PG B.Ed. student teachers. Further it is found that the mean scores of PG student teachers are slightly higher than the UG B.Ed. student teachers

Hypothesis 3:

There is no significant difference in the Techno-pedagogical skills of the rural and urban B.Ed. student teachers.

Table 3 - Techno Pedagogical scores between urban and rural B.Ed student teachers

Locality of Institution	N	Mean	SD	't-Value	Level of Significance at 0.05%
Urban	160	129.95	6.091	0.397	NS
Rural	44	129.34	6.692		

NS - Not Significant

From **Table 3**, it is evident that the mean Techno - pedagogical skills score of the rural and urban B.Ed. student teachers is 129.95 and 129.34 respectively. Further, it can be noted that the obtained 't' value is 0.397 (df=202) at 0.05 level of significance which is lower than the critical value 3.323. Hence, the null hypothesis, "There is no significant difference in the Techno- pedagogical skills of the rural and urban B. Ed student teachers" is accepted. This indicates that there is no significant difference in the Techno- pedagogical skills of the rural and urban B. Ed student teachers

Findings of the Study

- There is no significant difference in the Techno-pedagogical skills of the Male and female B.Ed. student teachers.
- There is no significant difference in the Techno-pedagogical skills of the UG and PG B.Ed. student teachers. Further it is found that the mean scores of PG student (M=131.03) are slightly higher than the UG B.Ed. student teachers (M=129.62).
- There is no significant difference in the Techno-pedagogical skills of the rural and urban B.Ed. student teachers.

Discussion of the Study

The present study reveals that the level of techno-pedagogical skills of B.Ed. student teachers is moderate as studied by (2018). There is no significant difference in the Techno-pedagogical skills of the B.Ed. student teachers with respect to gender, educational qualification, and locality. Today's students expect a smart way of learning due to the evolution of smartphones and technology devices. In learning, everything they expect concrete knowledge. When they are taught through the traditional method of learning, they feel bored. Technology content enables the students to learn in faster and better way. It could improve education skill of the test scores in the post-test than the pre-test significantly. Moreover it reaches all irrespective of different variables selected. Hence the researcher recommends all the teachers to use smart classroom.

Conclusion

The rise of Technology learning and an electronic content is a new paradigm for education and training in the knowledge society. It is empowered by Technological advancements which gives the modern instructional Technology. The development of Technology content in the changing times has become major responsibility of the modern teacher who has to face a new learner in a new environment. The role of qualitative Technology learning material like e-content assumes critical necessity and value to boost and spread modern instructional Technology. However, the development of digital learning material like e-content is not an easy task. We should keep an eye on the various stages of the technology learning material development to ensure whether the developed content is valid and suits to the needs of the learner.

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Influence of profile variables on the Techno Pedagogical Competency of Prospective Teacher Education

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Abstract

The integration of digital technologies into education has created a growing need for teachers to develop effective techno-pedagogical competencies. The present study was undertaken to determine the level of Techno Pedagogical Competency of Prospective Teacher Educators and to examine the influence of selected profile variables on their competency. A survey method was adopted, and a sample of 825 Prospective Teacher Educators was selected randomly from 13 Government, Government-aided and Private Colleges of Education in Chennai, Tiruvallur, Kanchipuram and Chengalpattu districts of Tamil Nadu, India. Data were collected using the Techno Pedagogical Competency Scale developed and validated by Dr. S. Rajasekhar and K. Sathiyaraj (2013). The data were analysed using Mean, Standard Deviation, 't' test, ANOVA, Tukey post hoc test and Regression Analysis with the support of SPSS. The findings revealed that 50.30% of the respondents possessed a moderate level of Techno Pedagogical Competency, 30.91% possessed a high level and 18.79% possessed a low level. Regression analysis showed that Gender, Subject Group, Type of College, Locality of College, Medium of Study, Father's Education, Mother's Education, Monthly Family Income and Residential Area had a positive and significant influence on Techno Pedagogical Competency. The regression model explained 53% of the variance ($R^2 = 0.53$; Adjusted $R^2 = 0.51$) and was statistically significant. The study emphasizes the importance of strengthening techno-pedagogical practices through curriculum enrichment, professional development programmes, workshops and institutional support for Prospective Teacher Educators.

Keywords: *Techno Pedagogical Competency; Prospective Teacher Educators; Profile Variables; Digital Technology; Teacher Education; ICT.*

Introduction

Techno Pedagogical Competency is implicit knowledge, depending on use of pedagogical methods and strategies of teachers and students in combination with information and communication technologies in their exclusive educational activity. Techno Pedagogical Competency is useful for enhancement of effectiveness and efficacy of learning process among students for their professional and personal development through integrating technologies (Archambault and Crippen, 2009). Techno Pedagogical Competency is the capability to apply ICTs in a pedagogical circumstance, and it consists of planning, execution, instructional methods, learning and assessment through information and communication technology. Techno Pedagogical Competency is highly helping the students for increasing their learning capabilities and interest by proper utilization of ICTs.

Need and Significance of the Study

Techno Pedagogical Competency is essential for Prospective Teacher Educators to adopt different technological oriented teaching methods to enhance their subject knowledge, teaching

efficacies and competencies. Prospective Teacher Educators who are Techno Pedagogically Competent can use technology effectively to create a simple and successful learning environment and it is also highly useful them to develop skills to address changes and uncertainty situations in their teaching. Techno Pedagogical Competency of Prospective Teacher Educators allows them to weave teaching techniques into the learning environment, which can increase the information available to their students, and it is also supporting their professional development. Therefore, it is important to study the Techno Pedagogical Competency of Prospective Teacher Educators.

Statement of the Problem

The advent and swift development of digital technologies and tools and their use is increasing in learning and teaching activities among students and teachers in all educational systems across the world including India. In the present day digital teaching and learning atmospheres, it is highly necessary for Prospective Teacher Educators to have adequate Digital Literacy to be efficient in existing digitalized era because they are interestingly and carefully using an array of digital technologies and tools for their learning, personal communication and interaction with others and teaching to their students and also for improving their Techno Pedagogical Competency. The efficacy of learning and teaching in digital atmosphere is largely deepening on Digital Literacy of Prospective Teacher Educators and it is also related with their Techno Pedagogical Competency. Hence, it is imperative to study, **“Influence of profile variables on the Techno Pedagogical Competency of Prospective Teacher Educators”**.

Objectives of the study

- To find out the level of Techno Pedagogical Competency of Prospective Teacher Educators.
- To find out whether there is any significant influence of profile variables on Techno Pedagogical Competency of Prospective Teacher Educators.

Hypotheses of the Study

- The level of Techno Pedagogical Competency of Prospective Teacher Educators is high.
- There is no significant influence of profile variables on Techno Pedagogical Competency of Prospective Teacher Educators.

Methodology

For the present study, the investigator has adopted survey method. A total sample of 825 Prospective Teacher Educators was collected from a Government, Government-aided and Private Colleges of Education in Chennai, Thiruvallur, Kancheepuram and Chengalpattu districts are chosen randomly from 13 Colleges of Education in the study area. Techno Pedagogical Competency Scale (TPCS) developed and validated by **Dr: S. Rajasekhar and K. Sathyaraj** (2013) was used for this study. The reliability of Techno Pedagogical Competency Scale by split-half technique is 0.82. The validity for Techno Pedagogical Competency Scale is 0.91 and so it is highly reliable to conduct the study. The collected data were statistically analyzed using Mean, Standard Deviation, 't' test, ANOVA test, Tukey post hoc test and Regression analysis with the support of SPSS.

Delimitations of the Study

- The study is conducted only among Prospective Teacher Educators in Chennai, Thiruvallur, Kanchipuram and Chengalpattu districts of Tamil Nadu, India only.

- The profile of Prospective Teacher Educators namely Gender, Subject Group, Type of College, Locality of College, Medium of Study, Father's Education, Mother's Education, Monthly Family Income, Type of Family and Residential Area are considered in the study.
- The Prospective Teacher Educators are selected of Education in located in Chennai, Thiruvallur, Kanchipuram and Chengalpattu districts

Hypothesis (1)

“The level of Techno Pedagogical Competency of Prospective Teacher Educators is high”.

One of the objectives of the present study is to examine the level of Techno Pedagogical Competency of Prospective Teacher Educators. The means and standard deviations for the Techno Pedagogical Competency scores for the entire sample are disclosed in the Table 1.

Table 1 - Mean and standard deviation for techno pedagogical competency scores for entire sample and its sub-samples

Variables	N	Mean	S.D
Techno Pedagogical Competency	825	109.85	19.69

The mean and standard deviation for the Techno Pedagogical Competency score for the entire sample is 109.85 and 19.69 sequentially. Based on criterion of Mean $\pm$ SD, Prospective Teacher Educators having score of higher than 130 are in high level, having score between 90 and 130 are in moderate level and having score lower than 90 are in low level of Techno Pedagogical Competency

Table 2 - Levels of techno pedagogical competency for entire sample and its sub- samples

Variables	N	Low	Moderate	High
Techno Pedagogical Competency	825	255 30.91%	415 50.30%	155 18.79%

Regarding to the entire sample of Prospective Teacher Educators, 50.30% of them are having moderate level, 30.91% of them are having high level and 18.79% of them are having low level of Techno Pedagogical Competency. The similar trend is seen among sub-samples also. This finding implies that majority of Prospective Teacher Educators are having moderate level of Techno Pedagogical Competency. Thus, the null hypothesis is not accepted and it is concluded that the Techno Pedagogical Competency of Prospective Teacher Educators is in moderate level.

Hypothesis (2)

“There is no significant influence of profile variables on Techno Pedagogical Competency of Prospective Teacher Educators”.

Table 3 - Influence of profile variables on techno pedagogical competency of prospective teacher educators

Profile Variables	Regression Coefficient	Standard Error	t-value	Significance
Constant	102.977	5.923	17.385	.000
Gender	8.612	1.250	6.890	.000
Subject Group	4.806	1.435	3.349	.001
Type of College	3.053	.897	3.404	.001
Locality of College	10.776	3.737	2.884	.002
Medium of Study	7.393	1.345	5.496	.000

Father's Education	5.227	1.051	4.971	.000
Mother's Education	2.430	.941	2.584	.010
Monthly Family Income	4.959	.759	6.534	.000
Type of Family	2.618	1.380	1.897	.058
Residential Area	15.193	4.671	3.252	.001
R ²	0.53	-	-	-
Adjusted R ²	0.51	-	-	-
F-Value	25.224	-	-	.000

Regression analysis through enter method is applied to find influence of profile variables on Techno Pedagogical Competency of Prospective Teacher Educators. R² and Adjusted R² are 0.53 and 0.51 in sequence showing that the regression model is having moderate fit and F-value is 25.224 indicating that the model is significant. It is seen that Gender, Subject Group, Type of College, Locality of College, Medium of Study, Father's Education, Mother's Education, Monthly Family Income and Residential Area are positively and significantly influencing Techno Pedagogical Competency of Prospective Teacher Educators.

Discussion

The findings of the study reveals that Techno Pedagogical Competency of Prospective Teacher Educators is in moderate level. This is supported by the findings of Sameer Nayak and Priyanka Choudhury (2024), Birender Kaur (2024), Rajalakshmi (2022), Thirunavukkarasu, M. (2021) and Sathya (2017) and it is opposed by finding of Sanjukta Bhuyan and Maruti Kumar Tripathy (2020) as it is high. The finding also shows that Gender, Subject Group, Type of College, Locality of College, Medium of Study, Father's Education, Mother's Education, Monthly Family Income and Residential Area are positively and significantly influencing Techno Pedagogical Competency of Prospective Teacher Educators.

Summary of the Findings

Among the entire sample of Prospective Teacher Educators, 50.30% of them are having moderate level, 30.91% of them are having high level and 18.79% of them are having low level of Techno Pedagogical Competency. Gender, Subject Group, Type of College, Locality of College, Medium of Study, Father's Education, Mother's Education, Monthly Family Income and Residential Area are positively and significantly influencing Techno Pedagogical Competency of Prospective Teacher Educators.

Educational Implications of the Study

- Universities offering M.Ed. courses must include Techno Pedagogical methods and practices in the curriculum for Prospective Teacher Educators.
- Ministry of Higher Education, Government of Tamil Nadu must organize workshops and conferences at state and national levels on Techno Pedagogical Competency for improving Techno Pedagogical Competency of Prospective Teacher Educators for their effective learning and teaching activities.
- Colleges of Education should encourage their Prospective Teacher Educators for using efficient Techno Pedagogical methods for improving their Techno Pedagogical Competency and effectiveness of teaching and learning.

- Colleges of Education must provide counselling to their Prospective Teacher Educators for enhancing their Techno Pedagogical Competency and using Techno Pedagogical methods efficiently for their learning and teaching practices.

Conclusion

The current research is made to study, “Influence of profile variables on the Techno Pedagogical Competency of Prospective Teacher Educators”. The present study explicates that majority of Prospective Teacher Educators are having moderate level of Techno Pedagogical Competency which reveals that the Techno Pedagogical Competency is very essential for the teachers in this current technological era. Techno Pedagogical Competency of Prospective Teacher Educators are positively, significantly and substantially interrelated with each other. The development of Technology content in the changing times has become major responsibility of the modern teacher who has to face a new learner in a new environment.

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Enhancement of Teacher's Cognition and Science Teaching Competency

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Abstract

Effective science teaching requires more than mastery of subject content. A science teacher needs to understand the subject matter, anticipate learners' difficulties and misconceptions, select appropriate pedagogical strategies, organize learning experiences, and use technology meaningfully to support conceptual understanding. In teacher education, these interconnected forms of knowledge are particularly important because teacher trainees enter classrooms with varying levels of subject knowledge, pedagogical understanding and technological competence. The present theoretical paper examines the role of Science Teachers' Knowledge, Pedagogical Content Knowledge (PCK), and Technological Pedagogical Content Knowledge (TPCK/TPACK) in enhancing the cognition and teaching competency of teacher trainees. The conceptual basis of the paper is derived from a doctoral research framework concerning the development of a Science Teachers Knowledge Programme for enhancing teacher trainees' cognition. The source study emphasizes content enrichment, PCK, TPCK, lesson planning and classroom teaching performance as interconnected dimensions of teacher development. It also identifies misconceptions and difficulties in comprehending biological concepts as important challenges in science teaching.

This paper argues that teacher knowledge should be developed as an integrated system rather than as isolated components. Content knowledge provides the foundation, PCK transforms subject knowledge into teachable forms, and TPCK/TPACK enables teachers to integrate appropriate technologies with content and pedagogy. Teacher cognition acts as an important mediating dimension through which teachers perceive concepts, plan instruction and perform classroom teaching. The paper proposes a conceptual framework in which content enrichment, PCK and TPCK interact to strengthen conceptual understanding, lesson planning and classroom teaching competency. The framework has implications for pre-service teacher education, professional development, curriculum design and technology-integrated science teaching.

Keywords: *Science Education, Teacher Knowledge, Teacher Cognition, PCK, TPCK, TPACK, Science Teacher Education, Conceptual Understanding, Teacher Competency*

Introduction

Science education plays an important role in developing learners' ability to observe, question, reason, investigate and interpret the natural world. However, effective science education depends considerably on the quality of science teaching. A teacher may possess considerable subject knowledge but may not necessarily be able to transform that knowledge into meaningful learning experiences for students. Consequently, teacher education must address not only what teachers know but also how they understand, organize, represent and teach knowledge. This theoretical paper is based identifies science as a discipline grounded in evidence, inquiry, procedures and products of knowledge. It also emphasizes the importance of well-trained teachers, adequate learning resources and continuous access to developments in pedagogy and subject content.

At the school level, science teaching may be affected by inadequate laboratory experiences, limited opportunities for experiential learning, difficulties in simplifying subject content and misconceptions among teachers. These issues indicate that improving science teaching requires a systematic approach to teacher knowledge development. Teacher knowledge is multidimensional. It includes knowledge of subject matter, pedagogy, curriculum, learners and the ways in which particular concepts can be represented and explained. Shulman's concept of Pedagogical Content Knowledge provides an important theoretical basis for understanding this integration. The development of Technological Pedagogical Content Knowledge further expands the framework by emphasizing the meaningful integration of technology with content and pedagogy. The present paper therefore explores the theoretical relationship among Science Teachers' Knowledge, PCK, TPCK /TPACK and teacher cognition and proposes an integrated framework for teacher education.

Rationale of the Paper

The need for this theoretical examination emerges from three interconnected challenges. First, teacher trainees may possess uneven levels of conceptual understanding. The source study identified difficulties involving the meaning of scientific terms, relationships among concepts, processes, cause-and-effect relationships and the interpretation of biological structures and phenomena. Second, knowing a scientific concept does not automatically imply knowing how to teach it. Teachers must determine appropriate examples, explanations, representations, activities and assessments. Third, contemporary classrooms increasingly require teachers to use digital and technological resources. Technology becomes educationally valuable only when it is connected appropriately with the content and pedagogy of the lesson. The source research consequently developed three related programmes: a content enrichment programme, a specific PCK programme and a TPCK programme for lesson planning and classroom teaching using ICT. These elements provide the conceptual foundation for the present theoretical paper.

Objectives of the Paper

The objectives are:

- To find out the level of Science Teachers' Knowledge among teacher trainees
- To explain the relationship between subject knowledge and Pedagogical Content Knowledge.
- To find out the effect of TPCK/TPACK in technology-integrated science teaching.
- To analyse teacher cognition as a link between teacher knowledge, lesson planning and classroom performance.
- To propose an integrated theoretical framework for enhancing science teacher competency.
- To identify implications of the framework for teacher education and professional development.

Concept of Science Teachers' Knowledge

Science Teachers' Knowledge may be understood as the integrated knowledge required by a teacher to understand science concepts and transform them into effective learning experiences. The source study operationalizes Science Teachers' Knowledge in terms of the knowledge required for teaching science, particularly biology, through the perspective of PCK. For the purpose of this theoretical paper, Science Teachers' Knowledge can be represented through five interconnected dimensions:

- **Subject Matter Knowledge** - This concerns accurate and sufficiently deep understanding of scientific concepts, principles, processes and relationships.

- **General Pedagogical Knowledge** - this includes knowledge of teaching methods, classroom management, assessment, learning activities and instructional organization.
- **Curriculum Knowledge** - Teachers need to understand what concepts are prescribed, their sequence, their relationship with previous and subsequent learning and the expected learning outcomes.
- **Pedagogical Content Knowledge** - PCK concerns the transformation of subject knowledge into forms that learners can understand. It includes appropriate explanations, analogies, demonstrations, representations, questions and learning activities.
- **Technological Pedagogical Content Knowledge** - TPCK/TPACK adds technological knowledge to the interaction among content and pedagogy. The objective is not simply to use technology but to select and integrate technology that contributes meaningfully to learning.

Pedagogical Content Knowledge as a Core of Science Teacher Education

Pedagogical Content Knowledge is particularly important in science because many scientific concepts are abstract and may be difficult for learners to observe directly. A teacher with PCK considers questions such as:

- What prior knowledge is required?
- What misconceptions might learners possess?
- Which examples will make the concept understandable?
- Which representation is appropriate?
- What activity can provide meaningful experience?
- How can student understanding be assessed?

The source presentation identifies PCK through components including subject matter knowledge, general pedagogical knowledge, pedagogical content knowledge and curricular knowledge. Therefore, PCK can be viewed as the bridge between knowing science and teaching science.

Misconceptions and Teacher Cognition

Teacher cognition is an important theoretical dimension because teachers do not enter classrooms as neutral transmitters of information. Their existing beliefs, perceptions, conceptual structures and experiences influence their instructional decisions. The source study identified misconceptions among teacher trainees as an important issue and treated cognition in relation to perception, planning and performance of selected concepts. A teacher who has an incomplete understanding of a scientific concept may unintentionally reproduce that misunderstanding during instruction. Thus, improving teacher cognition requires opportunities for teachers to examine their existing understanding, identify conceptual gaps, encounter scientifically accurate explanations and apply the improved understanding in teaching situations. Teacher cognition may therefore be conceptualized as a mediating process:

Teacher Knowledge → Teacher Cognition → Lesson Planning → Classroom Performance

This relationship suggests that professional development should address teachers' thinking and understanding rather than focus exclusively on teaching techniques.

TPCK/TPACK and Technology-Integrated Science Teaching

Technological Pedagogical Content Knowledge provides a useful framework for understanding effective technology integration. Technology by itself does not guarantee effective learning. A digital presentation, simulation, video or interactive application becomes educationally meaningful when it is selected according to the learning objective, scientific content and pedagogical requirement. For example, technology can support:

- visualization of microscopic and invisible processes;
- simulation of scientific phenomena;
- multimedia representation of complex concepts;
- interactive learning activities;
- collaborative learning;
- assessment and feedback;
- access to supplementary learning resources.

The source study specifically included the use of multimedia, MS Office, social media, software, new technologies, student activities, group work and technology in teaching-learning as components associated with TPCK development. Thus, TPCK should be understood not as technological skill in isolation but as pedagogically purposeful technological knowledge connected with particular subject content.

Content Enrichment as the Foundation

Content enrichment is a prerequisite for effective science teaching. The source programme included the meaning and need for content enrichment, ways of enrichment and the use of ICT for content enrichment. Content enrichment can include:

- consulting multiple reliable sources
- relating concepts to everyday experiences;
- using scientific models and representations;
- observing natural phenomena;
- using laboratory and demonstration activities;
- connecting concepts with current scientific developments;
- using multimedia and digital resources.

The theoretical proposition is that teachers cannot effectively develop PCK or TPCK without an adequate foundation of content knowledge. Hence:

Content Knowledge → PCK Development → TPCK Integration → Improved Teaching Practice

Lesson planning as a Connecting Mechanism

Lesson planning provides a practical connection between teacher knowledge and classroom performance. A scientifically informed lesson plan requires the teacher to determine:

- learning outcomes;
- prerequisite knowledge;
- content sequence;
- possible misconceptions;
- teaching-learning activities;
- representations and examples;

- technological resources;
- assessment strategies

The source study reports that teacher trainees in the experimental groups included content knowledge, PCK and technological components in their lesson plans following programme implementation.

This supports the theoretical position that lesson planning is not merely an administrative activity. It is an expression of teacher cognition and integrated professional knowledge.

Proposed Theoretical Framework

The proposed framework consists of four major levels:

Level I – Knowledge Foundation

Subject Matter Knowledge + Curriculum Knowledge



Level II – Pedagogical Transformation

Pedagogical Content Knowledge



Level III – Technological Integration

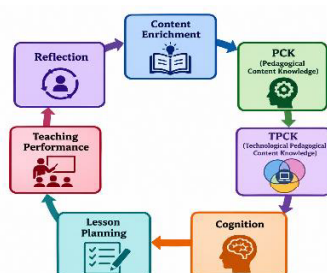
Technological Pedagogical Content Knowledge



Level IV – Professional Practice

Teacher Cognition → Lesson Planning → Classroom Teaching → Reflection

The framework is cyclical rather than strictly linear. Classroom experience generates feedback that can modify teacher cognition and subsequently improve knowledge, planning and practice. Thus, the complete conceptual cycle may be represented as:



This cyclical structure provides a theoretical basis for continuous professional development.

Theoretical Propositions

Based on the conceptual analysis, the following propositions are advanced:

- Proposition 1: Adequate subject matter knowledge is a necessary foundation for effective science teaching.

- Proposition 2: Subject matter knowledge alone is insufficient for effective classroom teaching; it needs to be transformed through PCK.
- Proposition 3: PCK enables teachers to anticipate learners' difficulties and select appropriate representations and instructional strategies.
- Proposition 4: TPCK/TPACK strengthens science teaching when technology is selected according to content and pedagogical requirements.
- Proposition 5: Teacher cognition mediates the relationship between teacher knowledge and classroom practice.
- Proposition 6: Lesson planning provides an observable mechanism through which integrated teacher knowledge is converted into teaching action.
- Proposition 7: Continuous reflection on classroom practice can contribute to further development of teacher knowledge.

Implications for Teacher Education

The framework has several implications for teacher education.

Curriculum Design

Teacher education curricula should integrate subject knowledge, pedagogy and technology rather than treating them as completely separate areas.

Conceptual Enrichment

Teacher trainees should receive opportunities to identify and correct misconceptions before entering actual classrooms.

PCK-Based Training

Teacher educators should provide subject-specific pedagogical experiences rather than relying only on general teaching methods.

Technology Integration

Technology training should be connected to particular concepts, learning objectives and pedagogical situations.

Lesson Planning

Teacher trainees should repeatedly design, implement, evaluate and revise technology-integrated lesson plans.

Practice and Reflection

Microteaching, simulated teaching, peer feedback and real classroom practice should form part of teacher preparation. The source study itself recommends workshops on technology-integrated lesson planning and emphasizes the importance of PCK programmes for teachers.

Conclusion

Science teaching is a complex professional activity that requires the integration of subject knowledge, pedagogy, curriculum understanding and technology. The theoretical analysis presented in this paper establishes that Science Teachers' Knowledge can be strengthened through systematic development of content knowledge, PCK and TPCK/TPACK. Teacher cognition

provides a critical link between knowledge and practice because teachers interpret content, make instructional decisions, plan lessons and perform teaching on the basis of their existing knowledge and beliefs. Lesson planning consequently becomes an important mechanism through which integrated teacher knowledge is translated into classroom practice. The proposed framework—Content Enrichment → PCK → TPCK → Teacher Cognition → Lesson Planning → Classroom Performance → Reflection—provides a theoretically grounded model for strengthening science teacher education.

The central argument of this paper is that technology should not be viewed as an additional component attached to teaching. Rather, technology should be integrated with content and pedagogy in ways that promote conceptual understanding and meaningful learning. A teacher who understands the content deeply, knows how learners understand it, recognizes their possible difficulties, and can select appropriate technological and pedagogical strategies is better positioned to create effective science-learning experiences.

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Transforming Teacher Education Through Digital Pedagogy and the Education of Things (EOT): Synthesizing TPCK Frameworks and Intelligent Learning Spaces

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Abstract

Instructional technologies have evolved to a quick pace which has moved the norm of standard education from merely using ICTs to an integrated approach of Digital Pedagogy and the Education of Things (EoT). This paper focuses on the challenges smart learning spaces, with interconnected hardware, intelligent software and data-driven feedback loops, are creating in the context of the Technological Pedagogical Content Knowledge (TPCK/TPACK) paradigm, which impacts the roles of teachers in the teacher training environment. Based on the context of the educational evolution and the empirical context of the demographical variation, this study examines the impact of factors on stakeholders' attitudes toward digital transformation. The SWOT analysis identifies important opportunities for personalized, adaptive learning as well as challenges such as digital divides and pedagogical resistance. Finally, this paper proposes concrete suggestions for transferring pre-service and in-service teacher training from the “technology acquisition” to the “techno-pedagogical competence.”

Keywords: *Digital Pedagogy, Education of Things (EoT), TPCK Framework, Teacher Education, Intelligent Learning Spaces, Demographic Variables.*

Introduction & Historical Context

The education system has changed throughout history to satisfy the changing needs of society. Oral tradition and apprenticeships were used to prepare people for the modern workforce, as were the standardized public education systems that emerged during the Industrial Revolution. The progressive theorists of the 20th century such as John Dewey, championed experiential learning, and a student-centered approach. The 21st Century requires a paradigm shift from traditional teaching/learning models to more flexible and technology-led models. The world of today's Education 21st century demands a paradigm shift from traditional teaching/learning models to more flexible and technology-led models.

Modern education is not limited to the use of digital tools in teaching and learning but is a way of moving beyond traditional education. Rather, it combines cutting-edge digital learning strategies with the Education of Things (EoT) which refers to the smooth interweaving of networked devices, cloud applications, interactive displays, and artificial intelligence in the context of learning environments. Technology should not be considered a thing; teacher education programs should be designed to produce teachers who can navigate through this smart learning environment.

Theoretical Background & Conceptual Framework

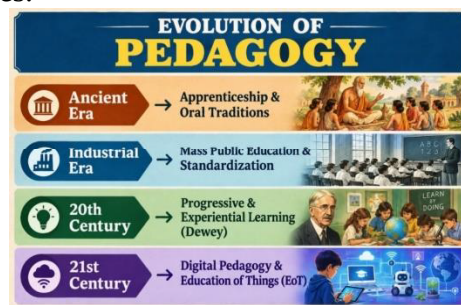
Use of technology in instruction is not easy without being superficial in application, so there must be a strong theoretical foundation.

The TPCK/TPACK Framework

As described by Koehler and Mishra (2005), three key domains of knowledge—content, language, and context—must have dynamic and transactional relationships in order to be effective teachers.

- **Content Knowledge (C):** The knowledge or content of a subject being taught.
- **Pedagogical Knowledge (P):** teaching and assessment practices, processes, methods and strategies.
- **Technological Knowledge (T):** The technological knowledge, which includes basic tools, advanced digital systems, virtual labs, and integration with AI-IoT.

Digital pedagogy arises at the intersection of these fields of TPCK (Technological Pedagogical Content Knowledge) that means technology directly contributes to specific learning goals and pedagogies.

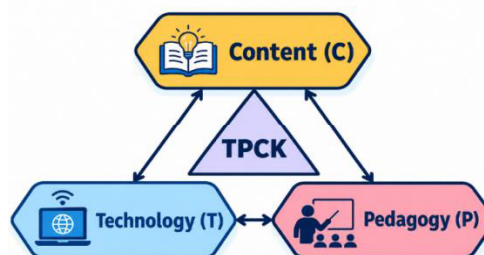


Complementary Learning Theories

The Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) and Technology-Enhanced Learning Acceptance Model (TELAM) suggest that teachers and students are more likely to accept digital tools if they believe the tools will be helpful in their jobs, if they feel they will invest effort in the tools, and if they feel they will have control over how the tools are used. Socio-Constructivist & Information Processing Models: Using Suchman's Inquiry Training and Ausubel's Advance Organizers in EoT-enabled spaces enables learners to dynamically explore concepts as they gain social-emotional competencies (SEL) in a collaborative learning environment.

Education of Things (EoT) and Intelligent Learning Spaces

The Education of Things (EoT) is an infrastructure of software analytics, IoT sensors, interactive displays, and AI platforms that create responsive environments.



Key Pillars of Intelligent Learning Environments

- **Personalized Learning Pathways:** Adaptive systems modify the difficulty of tasks in real-time as a function of student performance, facilitating self-paced learning.
- **Data-Driven Decision Making:** Real-time analytics provide immediate feedback, allowing teachers to adjust instruction based on evidence of student needs.

- **Improved Collaboration:** Virtual learning environments and cloud computing systems bring people together from different geographic regions to provide collaborative problem-solving opportunities.

Social-Emotional Learning (SEL) Support

Devices can track engagement, fostering self-regulation, empathy and collaborative teamwork. Operationalization and Approaches to Digital Integration focuses on the operationalization process and approaches to digital integration. There are four stages of digital pedagogy integration that institutions need to go through in order to be successful:

- **ICT Skills Development Approach:** Emphasis on the essential technical literacy for pre-service teachers in terms of essential software and hardware operational skills.
- **ICT as Pedagogy Approach:** Helps student-teachers create lessons plans on the basis of constructivist approach with digital media.
- **Subject-Specific Approach:** Integrates subject-specific digital tools into subject areas (e.g., virtual chemistry lab, dynamic geometry software).
- **Practical / Experiential Approach:** Gives pre-service teachers chances to practice conducting techno-mediated lessons and to manage interactive classrooms.

Rationale, Demographic Variables and SWOT Analysis section outlines the rationale for the project, demographic variables, and SWOT Analysis.

Role of Demographic Variables

Digital pedagogic and EoT use among stakeholders is not homogenous. Studies show that acceptance rates differ by important demographic factors:

- **Age & Teaching Experience:** Senior educators may be more comfortable with traditional approaches, while early career teachers may be more comfortable with digital approaches.
- **Locality & Socioeconomic Status:** Urban institutions may have strong digital infrastructure while rural or under-resourced institutions may not have access.
- **Gender and Specialization:** Confidence in technology and domain requirements for the different disciplines of Science, Arts and Humanities affect tool usage.

SWOT Analysis of Digital Integration

Category	Factors
Strengths	Personalized learning paths; automated data analytics; heightened student engagement; flexible access to instructional materials.
Weaknesses	Resistance to pedagogical change; inadequate faculty training; high initial infrastructure costs; potential over-reliance on technology.
Opportunities	Expanded continuous professional growth; global collaborative projects; inclusion of immersive technologies (AR/VR/Metaverse).
Threats	Digital divide across socio-economic strata; data privacy and security vulnerabilities; risk of exacerbating educational inequities.

Recommendations for Teacher Education Programs

To bridge the gap between technological access and effective instruction, teacher education frameworks should implement the following structural updates:

- **Shift from Isolated Courses to Embedded Pedagogy:** Replace standalone computer literacy courses with integrated techno-pedagogical modules throughout subject-methodology training.

- **Prioritize Hands-on Practice:** Provide pre-service teachers with direct experience designing, delivering, and evaluating lessons in smart classrooms.
- **Establish Targeted Professional Development:** Offer continuous training programs tailored to different educator career stages and comfort levels.
- **Ensure Equitable Access:** Develop policies that address infrastructure disparities, ensuring low-resource institutions receive adequate hardware, software and connectivity.

Conclusion

Transforming teacher education requires moving beyond viewing technology as an optional addition to traditional teaching. By combining Digital Pedagogy with the Education of Things (EoT) within a structured TPCK framework, educational institutions can establish responsive, data-informed and collaborative learning environments. Accounting for demographic variations and addressing structural challenges enables teacher education programs to prepare educators capable of guiding 21st-century learners effectively.

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Examining Pre-Service Teachers Technological, Pedagogical and Content Knowledge (TPACK)

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ABSTRACT

The present study is focused on examining the pre-service teacher's technological, pedagogical and content knowledge (TPACK). The investigator used normative survey method for the study. The sample consists of 300 pre-service teachers' and stratified random sampling technique has been used for the selection of sample. The investigator used Technological Pedagogical and Content Knowledge (TPACK) Scale, constructed and validated by Schmidt et al. in 2009 was used to measure the pre-service teacher's level of Technological, Pedagogical and Content Knowledge (TPACK). The data were analysed using 't' test and ANOVA. The major findings of the study revealed that Technology knowledge (TK) was the highest among the seven domains of TPACK whereas Technological Content Knowledge (TCK) was the least among the seven domains of TPACK. The study also revealed that the female pre-service teachers are high in TK than male pre-service teachers.

INTRODUCTION

Research on the instructional uses of technology, however, has revealed that teachers often lack the knowledge to successfully integrate technology in their teaching and their attempts tend to be limited in scope, variety, and depth. Thus, technology is used more as "efficiency aids and extension devices" rather than as tools that can "transform the nature of a subject at the most fundamental level". One way in which researchers have tried to better understand how teachers may better use technology in their classrooms has focused on the kinds of knowledge that teachers require in order to use technology more effectively. Shulman (1986) proposed that effective teaching requires a special type of knowledge, pedagogical content knowledge (or PCK), that represents "the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction". The central idea of PCK is that learning to teach a particular subject matter requires not only understanding the content itself but also developing appropriate instructional strategies and skills that are appropriate for learners.

TECHNOLOGICAL, PEDAGOGICAL AND CONTENT KNOWLEDGE (TPACK)

The Technological Pedagogical Content Knowledge (TPACK) framework describes the type of teacher knowledge required to teach effectively with technology. Describing what teachers need to know can be difficult because teaching is an inherently complex, multifaceted activity which occurs in varied settings. By its nature, teaching is an ill-structured problem requiring reasoning about a wide range of interrelated variables such as the background knowledge that students bring into the classroom, teacher and student expectations about the content to be covered, and school and classroom guidelines and rules. The use of technology in the classroom introduces

a new set of variables into the teaching context, and adds complexity due to its rapidly-changing nature (Koehler & Mishra, 2008).

The TPACK framework identifies a unifying structure that not only respects this complexity, but also provides guidance for appropriate technology integration. The TPACK framework describes the kinds of knowledge that teachers need in order to teach with technology, and the complex ways in which these bodies of knowledge interact with one another. This builds on the approach used by Shulman's (1986) pedagogical content knowledge (PCK), describing how and why teacher knowledge of pedagogy and content cannot be considered solely in isolation. Teachers, according to Shulman, need to master the interaction between pedagogy and content in order to implement strategies that help students to fully understand content. The TPACK framework extends Shulman's notion of PCK by including knowledge of technology. Teachers must understand how technology, pedagogy, and content interrelate, and create a form of knowledge that goes beyond the three separate knowledge bases. Teaching with technology requires a flexible framework that explains how rapidly-changing, protean technologies may be effectively integrated with a range of pedagogical approaches and content areas.

NEED FOR THE STUDY

Complicating teaching with technology is an understanding that technologies are neither neutral nor unbiased. Rather, particular technologies have their own propensities, potentials, affordances, and constraints that make them more suitable for certain tasks than others. Understanding how these affordances and constraints of specific technologies influence what teachers do in their classrooms is not straightforward and may require rethinking teacher education and teacher professional development. Social and institutional contexts are often unsupportive of teachers' efforts to integrate technology use into their work.

OPERATIONAL DEFINITIONS OF THE STUDY

TPACK: - TPACK stands for Technological Pedagogical Content Knowledge. It is a theory that was developed to explain the set of knowledge that teachers need to teach their students a subject, teach effectively, and use technology.

Pre-service Teachers: - Graduate students who are pursuing teacher education and training programme before they undertake any formal teaching. They belong to the age group of 20 years and above.

OBJECTIVES OF THE STUDY

The present study has the following objectives;

1. To study the level of pre-service teacher's technological, pedagogical and content knowledge.
2. To study the significant mean difference between pre-service teacher's (i) technology knowledge (TK), (ii) content knowledge (CK), (iii) pedagogical knowledge (PK), (iv) pedagogical content knowledge (PCK), (v) technological content knowledge (TCK), (vi), technological pedagogical knowledge (TPK) and (vii) technological pedagogical content knowledge (TPACK) with respect to their gender.
3. To study the significant mean difference between pre-service teacher's (i) technology knowledge (TK), (ii) content knowledge (CK), (iii) pedagogical knowledge (PK), (iv) pedagogical content knowledge (PCK), (v) technological content knowledge (TCK), (vi),

technological pedagogical knowledge (TPK) and (vii) technological pedagogical content knowledge (TPACK) with respect to their locality.

HYPOTHESES OF THE STUDY

Based on the above objectives the following null hypotheses were framed;

1. There is no significant mean difference between pre-service teacher's (i) technology knowledge (TK), (ii) content knowledge (CK), (iii) pedagogical knowledge (PK), (iv) pedagogical content knowledge (PCK), (v) technological content knowledge (TCK), (vi), technological pedagogical knowledge (TPK) and (vii) technological pedagogical content knowledge (TPACK) with respect to their gender.
2. There is no significant mean difference between pre-service teacher's (i) technology knowledge (TK), (ii) content knowledge (CK), (iii) pedagogical knowledge (PK), (iv) pedagogical content knowledge (PCK), (v) technological content knowledge (TCK), (vi), technological pedagogical knowledge (TPK) and (vii) technological pedagogical content knowledge (TPACK) with respect to their locality.

METHOD ADOPTED FOR PRESENT STUDY

The investigator has used normative survey method to study the pre-service teacher's technological, pedagogical and content knowledge in Kancheepuram District.

POPULATION AND SAMPLE OF THE STUDY

In the present study, the investigator used Stratified Random Sampling technique. The investigator has randomly selected 300 pre-service teachers from 4 B.Ed colleges in Kancheepuram District, Tamil Nadu.

TOOLS USED FOR THE STUDY

The most important and crucial aspect of any research is data collection, which provides answers to the questions under the study. Data collection relies on instruments/tools. The following tools were used for the present study.

1. Technological Pedagogical and Content Knowledge (TPACK) Scale was constructed and validated by Schmidt et al. in 2009.

DESCRIPTIVE ANALYSIS

Table - 1
Level of Pre-service Teacher's on TPACK

S. No	TPACK	N	%
1.	TPK	300	15.7
2.	Content Knowledge (CK)	300	14.1
3.	Pedagogy Knowledge (PK)	300	14.2
4.	Pedagogical Content Knowledge (PCK)	300	14.3
5.	Technological Content Knowledge (TCK)	300	13.0
6.	Technological Pedagogical Knowledge (TPK)	300	14.0
7.	Technological Pedagogical Content Knowledge (TPACK)	300	14.7

The above table –1 shows that, out of 300 pre-service teachers, 15.7% have technology knowledge, 14.4 % have content knowledge, 14.2% have pedagogical knowledge, 14.3 % have pedagogical content knowledge, 13% have technological content knowledge, 14% have technological pedagogical knowledge and 14.7% of pre-service teachers have technological pedagogical and content knowledge.

DIFFERENTIAL ANALYSIS

The differential analysis was employed to find the significant difference in the mean scores of selected variables. t- test were applied in the present study.

Hypothesis – 1 (H1)

There is no significant mean difference between pre-service teacher's (i) technology knowledge (TK), (ii) content knowledge (CK), (iii) pedagogical knowledge (PK), (iv) pedagogical content knowledge (PCK), (v) technological content knowledge (TCK), (vi), technological pedagogical knowledge (TPK) and (vii) technological pedagogical content knowledge (TPACK) with respect to their gender.

Table – 2

Significance of mean difference between pre-service teacher's (i) TK, (ii) CK, (iii) PK, (iv) PCK, (v) TCK, (vi), TPK and (vii) TPACK with respect to their gender.

Dimensions	Gender	N	Mean	SD	t-Value	Sig
TK	Male	24	21.46	2.766	2.04	S*
	Female	276	22.93	3.423		
CK	Male	24	42.08	0.584	0.30	NS
	Female	276	41.78	4.898		
PK	Male	24	24.71	1.197	0.27	NS
	Female	276	24.53	3.225		
PCK	Male	24	14.33	0.963	0.33	NS
	Female	276	14.18	2.234		
TPK	Male	24	15.17	1.308	3.90	S*
	Female	276	12.50	3.317		
TCK	Male	24	31.92	0.584	1.03	NS
	Female	276	31.05	4.082		
TPACK	Male	24	14.08	0.654	1.16	NS
	Female	276	14.59	2.114		

(*significance at 0.05 level)

The above table – 2 reveals that the calculated 't' value for TK (2.04) and TPK (3.90) of pre-service teacher's are greater than the table value (1.98) and the observed mean difference is statistically significant. Hence, the formulated null hypothesis – H1 (i) and (v) are rejected and there is a significant difference in the mean scores of TK and TPK of pre-service teacher's with respect to their gender.

The above table also explains that the calculated 't' value for CK (0.30), PK (0.27), PCK (0.33), TCK (1.03) and TPACK (1.16) of pre-service teacher's are lesser than the table value (1.98) and the observed mean difference is not statistically significant. Hence, the formulated null hypothesis – H1 (ii), (iii), (iv), (vi) and (vii) are accepted and there is no significant difference in the mean scores of CK, PK, PCK, TCK and TPACK of pre-service teacher's with respect to their gender.

Hypothesis – 2 (H2)

There is no significant mean difference between pre-service teacher's (i) technology knowledge (TK), (ii) content knowledge (CK), (iii) pedagogical knowledge (PK), (iv) pedagogical content knowledge (PCK), (v) technological content knowledge (TCK), (vi), technological pedagogical knowledge (TPK) and (vii) technological pedagogical content knowledge (TPACK) with respect to their locality

Table – 3

Significance of mean difference between pre-service teacher's (i) TK, (ii) CK, (iii) PK, (iv) PCK, (v) TCK, (vi), TPK and (vii) TPACK with respect to their locality.

Dimensions	Locality	N	Mean	SD	t-Value	Sig
TK	Rural	173	23.20	3.262	2.35	S*
	Urban	127	22.28	3.511		
CK	Rural	173	41.62	4.998	0.75	NS
	Urban	127	42.04	4.271		
PK	Rural	173	24.53	3.232	0.07	NS
	Urban	127	24.56	2.951		
PCK	Rural	173	14.19	2.064	0.02	NS
	Urban	127	14.20	2.292		
TPK	Rural	173	12.80	3.117	0.53	NS
	Urban	127	12.60	3.503		
TCK	Rural	173	31.03	4.139	0.46	NS
	Urban	127	31.24	3.627		
TPACK	Rural	173	14.53	2.117	0.20	NS
	Urban	127	14.57	1.938		

(*significance at 0.05 level)

The above table – 3 reveals that the calculated 't' value for TK (2.35) of pre-service teacher's are greater than the table value (1.98) and the observed mean difference is statistically significant. Hence, the formulated null hypothesis – H2 (i) is rejected and there is a significant difference in the mean scores of TK of pre-service teacher's with respect to their locality.

The above table also explains that the calculated 't' value for CK (0.75), PK (0.07), PCK (0.02), TPK (0.53), TCK (0.46) and TPACK (0.20) of pre-service teacher's are lesser than the table value (1.98) and the observed mean difference is not statistically significant. Hence, the formulated null hypothesis – H2 (ii), (iii), (iv), (v), (vi) and (vii) are accepted and there is no significant difference in the mean scores of CK, PK, PCK, TPK, TCK and TPACK of pre-service teacher's with respect to their locality.

MAJOR FINDINGS

1. Out of 300 pre-service teachers, 15.7% have technology knowledge, 14.4 % have content knowledge, 14.2% have pedagogical knowledge, 14.3 % have pedagogical content knowledge, 13% have technological content knowledge, 14% have technological pedagogical knowledge and 14.7% of pre-service teachers have technological pedagogical and content knowledge.
2. There is a significant difference in the mean scores of TK and TPK of pre-service teacher's with respect to their gender. But, there is no significant difference in the mean scores of CK, PK, PCK, TCK and TPACK of pre-service teacher's with respect to their gender.

3. Female pre-service teachers are high in TK than male pre-service teachers whereas male pre-service teachers are high in TPK than female pre-service teachers.
4. There is a significant difference in the mean scores of TK of pre-service teacher's with respect to their locality. But, there is no significant difference in the mean scores of CK, PK, PCK, TPK, TCK and TPACK of pre-service teacher's with respect to their locality.
5. Rural pre-service teachers are high in TK than urban pre-service teachers.

DISCUSSION OF THE STUDY

From the present study, it is clear that the Technology knowledge (TK) was the highest among the seven domains of TPACK; results indicated that the pre-service teachers do have a certain level of technology knowledge. For example, they can keep up with the important new technologies and they can learn to use new software easily, technology knowledge they thought would be adequate enough to enable them to use ICT during their field experience. Technological Content Knowledge (TCK) was the least among the seven domains of TPACK; indicated that they have the confidence in integrating technology into their lesson plans, however, when it comes to the actual implementation, they faced issues, such as a lack of time and difficulties in reserving technology for their class.

The study also reveals that female pre-service teachers are high in TK than male pre-service teachers. This may be due to the female pre-service teachers have favourable attitude towards digital technologies than male pre-service teachers. The result of the study is in contradictory with Abubakir & Alshaboul (2023) where male teachers showed a greater level of technological knowledge than female teachers.

EDUCATIONAL IMPLICATIONS OF THE STUDY

- Promoting the integration of technology in the teaching and learning of subject domains should be concerned with pre-service teacher educators.
- Professional development to foster TPACK growth among teacher educators is essential.
- The use of technological pedagogical and content knowledge in classrooms by the teachers will go a long way to manage any form of attitude or behaviour that could emanate in the course of teaching from the learners.

CONCLUSION

The result of the present study indicated that in spite of attempts by teacher educational programs, the participants showed deficiency in knowledge of using technology for instructional purposes. It is believe it may be the result of teaching technology in an isolated way in teacher educational programs. It appears that although teacher education programs are making strides to prepare teachers for using technology in their teaching, their progress still seems slow for equipping teachers with the special knowledge of how to effectively use technology in their teaching.

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From Anganwadi to School Readiness: A Mobile Technology Intervention for Foundational Literacy and Numeracy in Rural India

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Abstract

Background: India is grappling with an acute learning crisis, wherein 50 million elementary students are devoid of foundational literacy and numeracy (FLN) competencies. Anganwadi Centres (AWCs), which constitute the largest grassroots delivery platform for Early Childhood Care and Education (ECCE), face major hurdles such as weak pedagogical frameworks, poorly trained functionaries, and lack of any system for tracking progress. Objective: This paper describes an app-based remedial learning program for rural Anganwadis using visual aids for instruction, provides child-specific progress monitoring, and identifies learning gaps for FLN through automation: "AWW Tracker".

Theoretical framework: The study adopts technology acceptance model (TAM) as theoretical underpinnings to integration of stimulus-organism-response (SOR) framework.

Methods: This study is a sequential explanatory mixed-method approach and includes 100 children (aged 3-6 years) and 50 Anganwadi Workers from 10 Anganwadi centers in North Karnataka. Quantitative data were subjected to regression models, and the qualitative data were analyzed thematically.

Results: The results showed that the positive impacts on pre-literacy ($\beta=0.384$, $p<0.01$) and pre-numeracy skills ($\beta=0.412$, $p<0.001$) were statistically significant. The AWWs reported 78% increased confidence (Cohen's $d=1.26-1.44$). Overall, the 3-color rating system attained 89% inter-rater reliability ($\kappa=0.89$), while automated gap detection reduced remediation planning time by 65%. Qualitative data suggested increased child involvement, diminished paperwork and better school readiness. Perceived usefulness was the strongest predictor of adoption ($\beta=0.412$, $p<0.001$).

Keywords: Foundational Literacy and Numeracy; Anganwadi Workers; Mobile Learning; Early Childhood Care and Education; Technology Acceptance Model; Mixed-Methods Research

1. Introduction

Indian rural education system is facing an existential challenge that may undo years of work signifying towards universal enrolment. The Annual Status of Education Report (ASER) regularly exposes the severity of the learning crisis, with a significant number of children in primary grades not being able to read or do basic arithmetic (ASER Centre, 2023). The ASER 2023 'Beyond Basics' assessment was undertaken in 28 districts and amongst 34,745 youth (14-18 years) revealing that although 73.6 per cent could read text at Class 2-level, this is a decline from 76.6 per cent in 2017. More worrying, only 43.3 per cent of students even attempted basic division at all, which the report describes as a marginal increase from 39.5% in 2017 (ASER Centre, 2023). More than 50 million elementary school children have missed acquiring age-appropriate foundational literacy and numeracy (FLN) skills, resulting building cumulative learning deficits

that intensify as children move further along the education pipeline (Ministry of Education, 2022). This learning crisis is not just an educational misstep, but threatens to destabilize India's human capital formation and therefore future economic growth since foundation skills are the ground on which all future learning is based.

The survey also highlights what is on the cards for the next stage of the education system. The 2021 National Achievement Survey (NAS) is an indicator of this alarming situation as it states that the number of Class 3 students qualifying to grade level competencies has declined by 10%, with similar deficits for Class 5 (49%), Class 8 (41.9%), and Class 10 (37.8%) (Ministry of Education, 2021). Social group-wise performance disparities continue to plague the system, with students belonging to Scheduled Tribe, Scheduled Caste, and Other Backward Class categories lagging behind general category students in performance consistently (Ministry of Education, 2021). These deficiencies are due to insufficient Early Childhood Care and Education (ECCE), a lacuna that the National Education Policy (NEP) 2020 aimed to plug by mainstreaming three years of preschool education within the formal 5+3+3+4 framework (Ministry of Education, 2020). The NEP 2020 clearly states that quality ECCE is the most critical factor that determines educational success, and it takes into account the fact that the highest returns on investments in early childhood can be obtained in human development outcomes.

At the village level, the delivery system for ECCE in rural India urban centres and diminution of AWCs in rural areas is through Anganwadi Centres (AWCs), which function under the umbrella of the Integrated Child Development Services (ICDS) programme. It is a network of more than 13.9 lakh centers catering to nearly 80 million children below the age of six, 60% of whom live in rural areas and this is the World's largest grassroots platform for early childhood development (Ministry of Women and Child Development, 2022; Balaji & Pyari, 2023). The system's reach is enormous, but it is plagued by chronic problems: poor infrastructure, inadequate frontline worker training, lack of standardized curricula, and weak monitoring systems (NIPCCD, 2021). The enormity of the ICDS system lends itself to both opportunity and challenge – on the one hand it holds potential for reaching into the most isolated rural communities, on the other the multiplicity of operating environmental contexts and limited resources make ensuring uniform quality an unattainable goal.

The impact of these failures at every level of the system is debilitating. Children who start primary school lacking basic literacy and numeracy skills are unable to follow the grade-level syllabus, so they get caught in a failure and disengagement trap that consolidates educational disadvantage. Studies have shown that early learning gaps are more likely to grow than regress, a phenomenon known as the “Matthew effect” in education (Shonkoff & Phillips, 2000) This is defined as “the rich getting richer and the poor getting poorer” in terms of skills within education. The Bracken compounding effect of learning deficits indicates that essential interventions have to be implemented at the earliest time point in development to have the greatest impact. In addition, the COVID-19 pandemic has intensified the inequalities, as extended school closures have most impacted children from marginalized communities who did not have access to online learning tools (ASER Centre, 2023). The pandemic has highlighted the pressing requirement for creative, scalable solutions that can deliver quality educational material to children, irrespective of whether they are in a rural area or an urban slum.

In this scenario, mobile-technology provides a new option for dealing with the systemic problems of Anganwadi-centric ECCE delivery. With mobile phone penetration in rural India at 63.5%, m-learning interventions hold potential for delivering structured pedagogical content, ongoing professional development and systematic monitoring of progress to the scale (Deloitte, 2023). Yet achieving the multi-level techno-social contextual factors sensitive convergence of technology, designing for limited digital literacy at the frontline, infrastructural challenges, and developing culturally and linguistically appropriate content (Li, Bonk, & Zhu, 2024) for Anganwadi education is a different matter altogether. The AWW Tracker intervention attempts to engage these competing issues by presenting a mobile-based answer that is both contextually solid and pedagogically viable. This study bridges this important gap by assessing the potential of the AWW Tracker mobile application for enhancing FLN outcomes for children attending rural Anganwadi centres. Using a rigorous mixed-methods design, this study seeks to contribute to the empirical knowledge on the extent to which technology-led interventions can revolutionize the delivery of early childhood education in resource-poor environments. The results hold great promise for implications in policy and practice with respect to national priorities as stated in NEP 2020 and the NIPUN Bharat Mission (Ministry of Education, 2020, 2021).

1.1 The Scale of the Crisis

FLN disparities are exacerbated as children progress through the school system, if they are not remedied during early childhood. The ASER report 2023 makes a mention of how learners who settle for a quick completion of assessment tasks will faintly feel ‘missing out’ when they are asked to ‘read between the lines’ by teachers assuming they have taken up grade-level competencies. After the rudiments of reading and arithmetic, the test assessed the practical application of those skills: Of those 85% who measured the length of an object at the “0 mark” of the ruler, less than 40% gave the right answer when the object was moved away from the starting point. Only 45 per cent could evaluate how long they sleep, using bedtime and time to wake up (ASER Centre, 2023). These results suggest that applied skills are dismal, even among the basically literate and numerate. The National Mission on Proficiency in Reading with Understanding and Numeracy (NIPUN Bharat), which was started in 2021, focuses on the attainment of grade-level competencies by the end of Grade 3 (Ministry of Education, 2021). The NCERT's Foundational Learning Study (FLS) that was conducted in March 2022 to examine the learning outcomes of students of Grade 3 also highlights the significance of early intervention (NCERT, 2022).

1.2 Contextual Challenges in Anganwadis

Anganwadi Workers (AWWs) the frontline providers of ICDS are burdened with multiple constraints in reconceptualising the ECCE mandate in the context of generating substantial learning outcomes. John and Singh (2020) highlighted challenges such as absence of planned pedagogic approaches, non-utilization of existing TLCs, rare refresher training on new curriculum, and non-availability of visual aids or demonstration materials. The infrastructure problems are widespread. A survey of 22 Anganwadi centers found that half were incomplete; 77% had leaking roofs; 50% had no food storage facility, 77% had no indoor play facility and half were without power (Balaji & Pyari, 2023). Data from Ministry of Women and Child Development

from June 2024 showed that 35 per cent of AWCs did not have toilets and 36 per cent were without supply of drinking water (Ministry of Women and Child Development, 2024). Human resource concerns are no less pressing. The primary priorities of the AWWs were to: receive fair pay and improved working conditions (54%) and reduce the amount of paperwork (24%) (Balaji & Pyari, 2023). This dual burden leaves AWWs burdened with administrative responsibilities and having little space to work directly with children. For instance, NITI Aayog Release (2020) brought out that only a minute proportion of AWWs were provided induction training.

A randomized controlled trial of a technology-aided preschool program in 1,000 Anganwadi centers in Maharashtra demonstrated that while such programs can effectively engage parents and bring them content, the learning gains are dependent on the amount of "program voltage"—the amount of engagement (Keskar, Romero, Singh, & Muralidharan, 2024). The more intensive version increased children's learning by about 0.12σ at a total cost of \$1.17 per (Approx. 105Rs) child, providing evidence that thoughtfully designed technology interventions can have substantial positive effects (Kaur & Sharma, 2021; Sharma & Gupta, 2022).

1.3 Research Gap

Although a number of mLearning interventions have been conducted in Indian education contexts, there exist critical gaps in research on mLearning interventions in Anganwadi settings: (1) none of the existing mLearning interventions has been subject to systematic investigation combining FLN delivery through a mobile platform tailored for Anganwadi workers (AWW), visual teaching aids, progress monitoring, and automated identification of learning gaps; (2) the processes by which mobile learning impacts on AWWs capacity and child outcomes are unknown; (3) potential moderators of intervention effects concerning contextual variables have not been systematically investigated; and (4) in the area of mobile FLN interventions specific to ICDS, mixed-method evidence is weak. Recent systematic reviews point to these lacunae. In their meta-analysis Reddy and Krishnan (2023) report that only 12% of the studies that examined interventions in a preschool-context, none of them in Anganwadi set up. In a similar vein, Arora and Singh's (2024) review of systematic reviews pinpointed the absence of context based applications as a major lacuna in translation and scale up.

1.4 Theoretical Framework

The theoretical model of the present study is based on the Technology Acceptance Model (TAM) (Davis, 1989; Davis et al., 1989) and Stimulus-Organism-Response (SOR) model (Mehrabian & Russell, 1974). This combination considers cognitive (technology perception) and behavioral factors (actual changes in teaching and learning) in the success of technology intervention (Chen, 2022; Li, Bonk, & Zhu, 2024). Based on Teece's (2007) dynamic capabilities framework, the research explores the processes through which IT-based initiatives enhance organizational capabilities in sensing (identifying gaps in knowledge), seizing (delivering targeted remediation), and transforming (continuous improvement via feedback). Adner (2017) stressed that value creation depends on complementary human and institutional resources.

1.5 Contribution Statement

This paper makes the following three contributions to the literature: (1) impact evaluation employing rigorous mixed-methods of mobile FLN interventions in Anganwadi settings; (2)

identification and testing of mediating mechanisms through which technology-based platforms influence children's learning outcomes; and (3) analysis of contextual moderators to give implementation guidance for rural, resource-constrained areas.

1.6 Research Questions and Hypotheses

This study addresses three research questions:

- RQ1: Is the AWW Tracker mobile app effective in improving children's foundational literacy and numeracy outcomes?
- RQ2: How does the platform impact AWWs' ability to deliver structured ECCE?
- RQ3: Which contextual factors moderate the success of technology-implemented FLN interventions?

Based on the theoretical framework, six hypotheses are posited:

- H1: Children's foundational literacy outcomes will be significantly better among those using the AWW Tracker.
- H2: Children's foundational numeracy outcomes will be significantly positively affected by the AWW Tracker.
- H3: The AWW Tracker significantly improves AWW pedagogy and teaching practices.
- H4: Perceived usefulness and ease of use positively influence AWW adoption.
- H5: Improved pedagogical knowledge and teaching practices mediate the impact of platform adoption on child learning outcomes.
- H6: Environmental characteristics moderate the impact of the AWW Tracker on learning outcomes.

2. Literature Review

2.1 Early Childhood Care and Education in India

The lasting effect of ECCE on lifelong learning has long been recognized in the study of human development and in research on education. The first six years of life represent a sensitive period for development in cognition, language, social and emotional domains as they with foundational neural pathways and learning experiences during this time period have long-term effects on further educational achievement (Shonkoff & Phillips, 2000). Reflecting this developmental necessity, NEP 2020 accords top priority to universal access to quality ECCE by bringing three years of preschool education under the ambit of the formal system, and establishing FLN as the ultimate educational goal (Ministry of Education, 2020). The Anganwadi, systemized introduced under ICDS in 1975, is the largest institutional network through which ECCE is provided to rural homes. The ICDS covers around 14 lakh Anganwadi Centres registered in the whole country with approximately 15.8 million beneficiaries (Ministry of Women and Child Development, 2022). Nevertheless, between the poor infrastructure, lack of training among frontline workers, dearth of structured curricula, and weak monitoring systems, the mandate to realize quality learning outcomes in ECCE has remained elusive (NIPCCD, 2021).

Anganwadi workers are neither easy to define, nor simple to describe. As non-professionals and members of the community who receive modest honoraria instead of salaries, Anganwadi workers (AWWs) navigate complex demands as lay providers of nutrition, health, and education services (John & Chatterjee, 2021). Means and Motives (2021) distinguish three types of factors affecting service provision: means (capacity), motives (willingness), and opportunities (opportunity to

perform). In terms of education, AWWs face challenges such as lack of structured instructional system, inadequate teaching-learning material, and rare refresher training (Kaur, 2020). The Aadharshila ECCE framework was a landmark policy initiative, but it has been compromised by ineffective training, paucity of resources, and lack of systematic monitoring mechanisms (NIPCCD, 2022).

2.2 Digital Transformation and Mobile Learning in ECCE

The introduction of digital systems within education led to the excitement to employ technological means to enhance the quality of teaching and learning (Hilmy, Boedisantoso, Lindawati, & Mori, 2021). Mobile-based technologies are being increasingly utilized as a medium to provide education content, assessments and to inform personalized learning (Verhoef, Kannan, & Inman, 2015). In the context of developing countries, mobile learning platforms have a potential to narrow the access gap and to enable most unfortunate members of society to receive quality learning materials (Lee, Padmanabhan, & Whang, 1997). Previous research on technology integration in early childhood education has identified a few key principles for success. Pedagogical purposes should drive technology use, teachers need to be adequately trained and the young children using the technology must be considered developmentally appropriate users (Mishra & Koehler, 2006; Hirsh-Pasek, Zosh, Golinkoff, Gray, Robb, & Kaufman, 2015). Digital learning platforms have added features such as interactive content delivery, adaptive learning paths, and progress tracking (Budde, Hänggi, Laglia, & Friedli, 2024). Modifying these technologies to suit the needs of the underserved communities involves developing offline-first solutions while also focusing on the local contexts (Li, Bonk, & Zhu, 2024). The evidence base for mobile technologies in FLN teaching-learning is also expanding. The systematic review of the OECD (2022) highlighted that m-learning approaches may bring about significant positive outcomes in emergent literacy and numeracy. Effectiveness is a function of delivery system, teacher training, and context (UNESCO, 2023). The Poshan Bhi Padhai Bhi programme in India has integrated technology features such as digital content delivery and progress tracking (Ministry of Women and Child Development, 2022).

2.2.1 Digital Divide and Educational Technology in Rural Settings

India's digital divide appears along access as well as capability aspects. With a mobile phone penetration of 63.5% in rural India in 2023, only 38.2% of the rural Indians are using smartphones (Deloitte, 2023). Rural Karnataka has average data speeds of 4.8 MBPS, well below the national average, requiring offline-first applications (TRAI, 2023). Only 31.4% of rural AWWs have been trained in basic digital literacy, according to Kumar and Gupta (2022). A systematic review of 47 mobile learning research (Wilson & Brown, 2023) noted four success factors: developmental appropriateness, teacher professional development, parent involvement, and contextualization. Full-sample studies that implemented all four components showed substantially greater effect sizes ($d = 0.78$) compared to studies that only partially implemented ($d = 0.34$). Offline-first and localized content-based solutions had 42% higher engagement, according to the study by Dahiya and Sharma (2023).

2.3 Theoretical Framework and Hypothesis Development

The proposed theoretical model has been formed based on TAM, SOR and dynamic capabilities theory. TAM says that both perceived usefulness and perceived ease of use influence behavioral

intention. SOR offers a useful lens through which to investigate the effects of technological interventions (stimuli) on cognitive and affective states of users (organism), which in turn are reflected in users' behavioural outcomes (response). Dynamic capabilities theory deals with how initiatives co-ordinately facilitate sensing, seizing and transforming activities to enhance organizational capabilities. H1 and H2 are based on the SOR theory and predict that the platform's visual instruction modules would increase children's engagement and learning. Hirsh-Pasek et al. (2015) revealed that early literacy outcomes are heavily influenced by multimedia content. Wilson and Brown (2023) report large effects of video-based literacy instruction (pooled $d=0.72$). Moderate effect sizes for numeracy interventions ($d=0.48-0.65$). (UNESCO, 2023) H3 is based on Mishra and Koehler's (2006) TPACK model which argues that technology integration enhance teacher knowledge given sufficient content and pedagogy exist. H4 is a natural extension to TAM (Davis, 1989). In kumer and singh (2024) study, 42% variance in adoption of technology by the rural Indian teachers was explained by perceived usefulness. H5 is an extension of SOR theory, suggesting that platform effects are channelled via greater AWW ability. H6 is informed by Adner's (2017) ecosystem logic asserting that the effectiveness of technology is reliant on complementary resources.

3. Methodology

3.1 Research Design

The study utilizing a sequential explanatory mixed-methods design (Creswell & Plano Clark, 2017) in which quantitative findings were validated and expanded upon with qualitative findings. The two-phase design consisted of two sequential parts: Part 1 (quantitative) consisted of a pre-post intervention survey of 50 AWWs and an assessment of FLN skills of 100 children; Part 2 (qualitative) included interviews and focus group discussions (Braun & Clark, 2006; Clark, 2024).

3.2 Research Context and Participants

This study was taken up in 10 Anganwadi Centres (AWCs) in the rural district of Dharwad, Karnataka, India, which was chosen as a representative of rural Karnataka (NIPCCD, 2021). Sample size was calculated performing power analysis with G*Power 3.1 (Faul, Erdfelder, Buchner, & Lang, 2007), showing that 42 participants were needed to observe an effect size of medium magnitude with a power of 80%. Fifty participants were enrolled to allow for 15% attrition. The participants for the quantitative phase were 50 AWWs ($M=34.2$ years, $SD=6.8$; mean years of working as an AWW= 8.5 years, $SD=4.2$) and a 100 children (aged 3-6 years, 52 male, 48 female). Education of AWW varied from 10th standard to a graduate degree (John & Singh, 2020). Children were recruited through stratified random sampling with informed consent of their parents (Shonkoff & Phillips, 2000).

3.3 Intervention Description: The AWW Tracker Platform

The AWW Tracker mobile application utilizes the offline-first and synchronizes with Firebase cloud using SQLite local storage (Lee, Padmanabhan, & Whang, 1997). Some of the features are: (1) video library of 40 animated videos in Kannada, (2) child registration with unique IDs, (3) 3 color assessment system (based on Aadharshila FLN milestones)(NIPCCD, 2022), (4) automated gap detection, and (5) PDF report generation (Sharma & Gupta, 2022). The platform was installed

on feature phones given to AWWs, who were trained for 2 days (Kaur, 2020). All the materials were pre-downloaded, and a WhatsApp support group was formed for ongoing support (Li, Bonk, & Zhu, 2024). The intervention duration was 6 months.

3.4 Quantitative Measures and Procedures

3.4.1 AWW Questionnaire

Background knowledge, novice day-to-day teaching behaviours, attitudes towards technology and the effectiveness of the platform used were adapted from previously validated questionnaires. Development of the instrument was a five-stage process with expert evaluation (Content Validity Index=0.89) and piloting (Cronbach's $\alpha=0.82-0.88$). Major components were: pedagogical knowledge (20 items, $\alpha=0.82$); teaching practices (15 items, $\alpha=0.78$); technology attitudes (12-item TAM-based scale, $\alpha=0.85$); and platform experience (18 items, $\alpha=0.88$).

3.4.2 Child FLN Assessment

The evaluation consisted of 25 questions in four areas: Letter Recognition ($\alpha=0.79$), Phonemic Awareness ($\alpha=0.76$), Number Recognition ($\alpha=0.81$), and Quantitative Reasoning ($\alpha=0.74$). A 3-point scale was used for each item. Trained research assistants (Clark, 2024) administered the assessments and the inter-rater reliability was $\kappa=0.85$.

3.4.3 Quantitative Data Analysis

The data were analyzed with SPSS v28. Pre-post scores were analysed by means of paired t-tests. Platform effectiveness was predicted via multiple linear regressions. The assumptions for parametric tests were met, and missing data (2.1%) were handled by multiple imputation. Statistical significance was set at $p<0.05$.

3.5 Qualitative Measures and Procedures

3.5.1 Child Interviews

After the intervention, 100 children took part in semi-structured interviews exploring their experiences with the AWW Tracker activities (Clark, 2024). The interviews were conducted in Kannada, audio recorded and transcribed verbatim.

3.5.2 Focus Group Discussions

There were four FGDs, two with AWWs and two with parents (Braun & Clarke, 2022). Topics were platform benefits, teaching impact, contextual matters, and scalability (Adner, 2017).

3.5.3 Qualitative Data Analysis

The process of thematic analysis followed the six steps described by Braun and Clarke (2006, 2022). The data were double coded independently ($\kappa=0.81$) with organization facilitated using NVivo 12.

3.6 Data Integration and Ethical Considerations

Integration of both types of data was conducted with a joint display (Creswell & Plano Clark, 2017). The study was approved by the Institutional Review Board (No. KLE/IRB/2024/08), and informed consent was obtained from all the participants (Clark, 2024).

4. Findings

4.1 Quantitative Findings

4.1.1 Descriptive Statistics

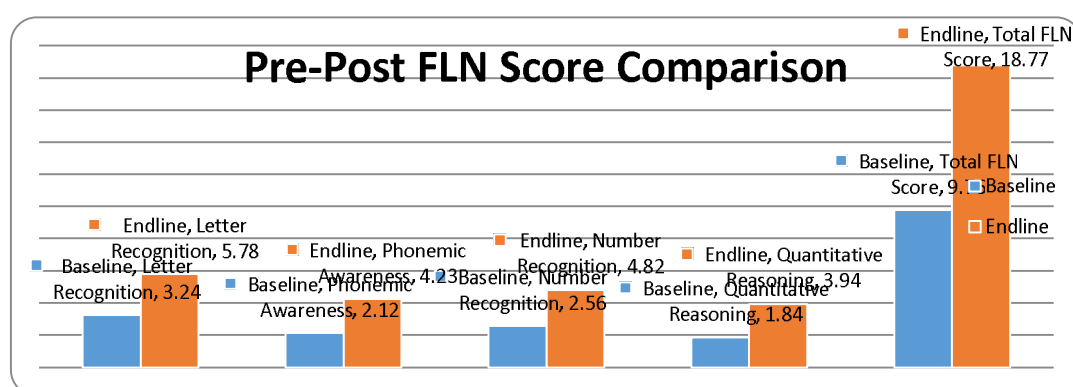
At baseline, AWWs demonstrated moderate pedagogical knowledge ($M=3.12$, $SD=0.78$) and infrequent structured ECCE activities ($M=2.54$, $SD=0.82$). Technology attitudes were favourable, with perceived usefulness ($M=3.82$, $SD=0.74$) slightly higher than ease of use ($M=3.41$, $SD=0.82$).

Table 1: Descriptive Statistics with Effect Sizes (N=50 AWWs; N=100 Children)

Variable	Baseline Mean (SD)	Endline Mean (SD)	Change	95% CI	t(df)	Cohen's d
AWW Outcomes						
Pedagogical Knowledge	3.12 (0.78)	4.21 (0.56)	+1.09****	[0.88, 1.30]	8.94 (49)	1.26
Teaching Practices	2.54 (0.82)	3.98 (0.64)	+1.44****	[1.18, 1.70]	10.12 (49)	1.44
Perceived Usefulness	3.82 (0.74)	4.45 (0.51)	+0.63**	[0.32, 0.94]	3.86 (49)	0.98
Perceived Ease of Use	3.41 (0.82)	4.38 (0.48)	+0.97****	[0.74, 1.20]	8.24 (49)	1.18
Child FLN Outcomes						
Letter Recognition (0-8)	3.24 (2.18)	5.78 (1.92)	+2.54****	[2.12, 2.96]	11.23 (99)	1.12
Phonemic Awareness (0-6)	2.12 (1.76)	4.23 (1.54)	+2.11****	[1.74, 2.48]	9.87(99)	1.08
Number Recognition (0-6)	2.56 (1.82)	4.82 (1.34)	+2.26****	[1.86, 2.66]	10.08 (99)	1.01

Variable	Baseline Mean (SD)	Endline Mean (SD)	Change	95% CI	t(df)	Cohen's d
Quantitative Reasoning (0-5)	1.84 (1.58)	3.94 (1.22)	+2.10***	[1.72, 2.48]	9.52 (99)	1.04
Total FLN Score (0-25)	9.76 (5.82)	18.77 (4.96)	+9.01***	[7.82, 10.20]	14.82 (99)	1.49

Note: *** $p < 0.001$, ** $p < 0.01$

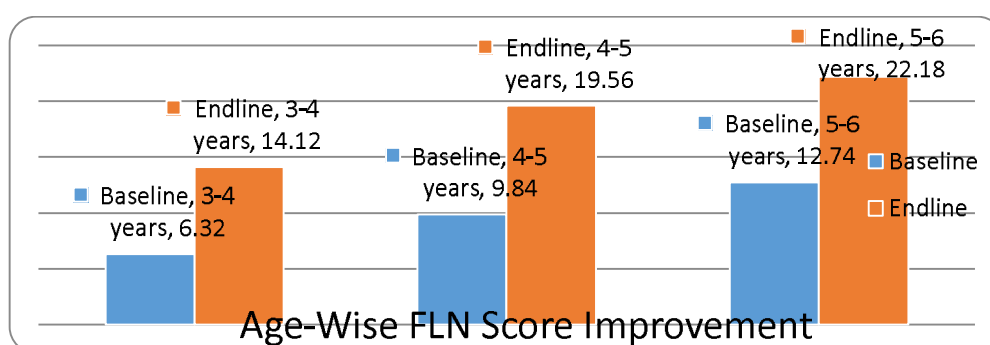


Children's baseline FLN competencies were low ($M=9.76/25$, $SD=5.82$), consistent with national findings. Significant improvements were observed across all domains.

Table 2: Child FLN Outcomes by Age Group

Age Group	Baseline Total (SD)	Endline Total (SD)	Change	95% CI	Cohen's d
3-4 years (n=32)	6.32 (4.18)	14.12 (4.64)	+7.80***	[6.18, 9.42]	1.42
4-5 years (n=34)	9.84 (5.14)	19.56 (4.26)	+9.72***	[7.84, 11.60]	1.56

Age Group	Baseline Total (SD)	Endline Total (SD)	Change	95% CI	Cohen's d
5-6 years (n=34)	12.74 (5.76)	22.18 (3.48)	+9.44***	[7.82, 11.06]	1.38



All age groups showed significant improvements, with the 4-5 year group demonstrating largest gains ($d=1.56$).

4.1.2 Hypothesis Testing Results

H1 (Literacy Outcomes): Letter recognition significantly improved from $M=3.24$ to $M=5.78$, $t(99)=11.23$, $p<0.001$, $d=1.12$. Phonemic awareness significantly increased from $M=2.12$ to $M=4.23$, $t(99)=9.87$, $p<0.001$, $d=1.08$. **H1 supported.**

H2 (Numeracy Outcomes): Number recognition increased from $M=2.56$ to $M=4.82$, $t(99)=10.08$, $p<0.001$, $d=1.01$. Quantitative reasoning improved from $M=1.84$ to $M=3.94$, $t(99)=9.52$, $p<0.001$, $d=1.04$. **H2 supported.**

H3 (AWW Capacity): Pedagogical knowledge significantly increased from $M=3.12$ to $M=4.21$, $t(49)=8.94$, $p<0.001$, $d=1.26$. Teaching practices improved from $M=2.54$ to $M=3.98$, $t(49)=10.12$, $p<0.001$, $d=1.44$. **H3 supported.**

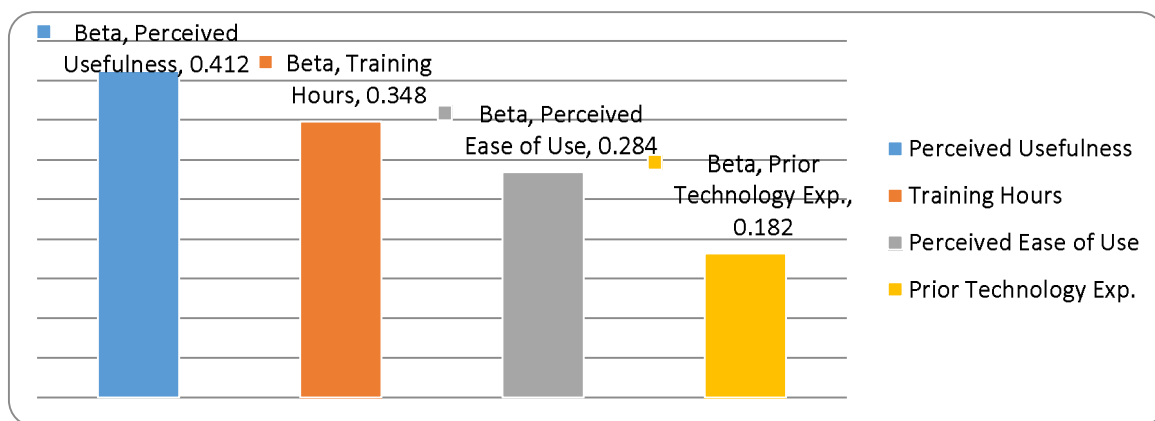
H4 (Technology Acceptance):

Table 3: Regression Analysis for H4 - Predictors of Platform Adoption

Predictor	B	SE	t	p-value
Perceived Usefulness	0.412	0.074	5.57	<0.001
Perceived Ease of Use	0.284	0.078	3.64	<0.01

Predictor	B	SE	t	p-value
Prior Technology Experience	0.182	0.081	2.25	<0.05
Training Hours	0.348	0.068	5.12	<0.001

Note: $R^2=0.612$, Adjusted $R^2=0.584$, $F(4,45)=17.82$, $p<0.001$



Both perceived usefulness ($\beta=0.412$, $p<0.001$) and ease of use ($\beta=0.284$, $p<0.01$) significantly predicted platform adoption. **H4 supported.**

H5 (Mediation Analysis): Bootstrapping mediation analysis (5,000 resamples) revealed significant indirect effects: Perceived Usefulness $\rightarrow$ Pedagogy $\rightarrow$ Child FLN (indirect effect=0.142, 34.5% mediation); Perceived Usefulness $\rightarrow$ Practices $\rightarrow$ Child FLN (indirect effect=0.168, 40.8% mediation); Perceived Ease of Use $\rightarrow$ Pedagogy $\rightarrow$ Child FLN (indirect effect=0.094, 33.1% mediation). **H5 supported.**

H6 (Moderation Analysis):

Table 4: Moderation Analysis for H6

Moderator	Interaction β	SE	t	p-value
Prior Technology Exposure	0.218	0.084	2.59	<0.05
Infrastructure Availability	0.284	0.076	3.74	<0.001
AWW Experience	0.092	0.081	1.14	0.258

Prior technology exposure and infrastructure availability significantly moderated platform effectiveness. AWW experience did not significantly moderate effectiveness. **H6 partially supported.**

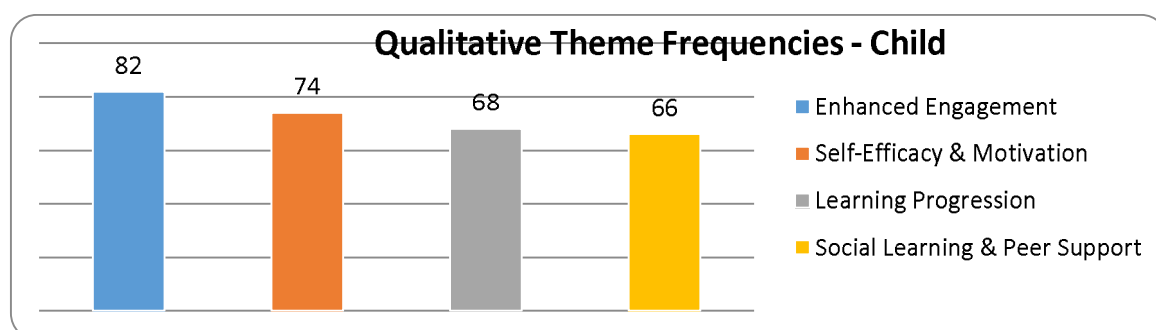
4.2 Qualitative Findings

4.2.1 Thematic Analysis of Child Interviews

Thematic analysis of 100 child interviews revealed four themes.

Table 5: Thematic Analysis of Child Interviews (N=100)

Theme	Definition	Supporting Quotes	Frequency
Enhanced Engagement through Visual Content	Children's positive response to video-based learning	"The letters dance in the video... I remember them better"	82%
Increased Self-Efficacy and Motivation	Children's confidence toward assessment	"I want to get all green... Then Aunty says I am ready for big school"	74%
Social Learning and Peer Support	Collaborative learning experiences	"We watch the video together and then show each other"	66%
Clear Learning Progression	Awareness of competencies acquired	"I know my name now... I can see the letters"	68%



Theme 1: Enhanced Engagement through Visual Content: Children favoured video-based learning, with 82% mentioning videos as their favourite activity. "The letters dance in the video. When they dance, I remember them" (Boy, 4 years).

Theme 2: Enhanced Self-Efficacy and Motivation: 74% reported positive self-perceptions. "I feel bright. I can show my mom the letters that I know" (Boy, 6 years). The 3-color assessment scheme functioned as a motivational source.

Theme 3: Social Learning and Peer Support: 66% reported collaborative learning. "We watch the video together and then help each other" (Girl, 5 years).

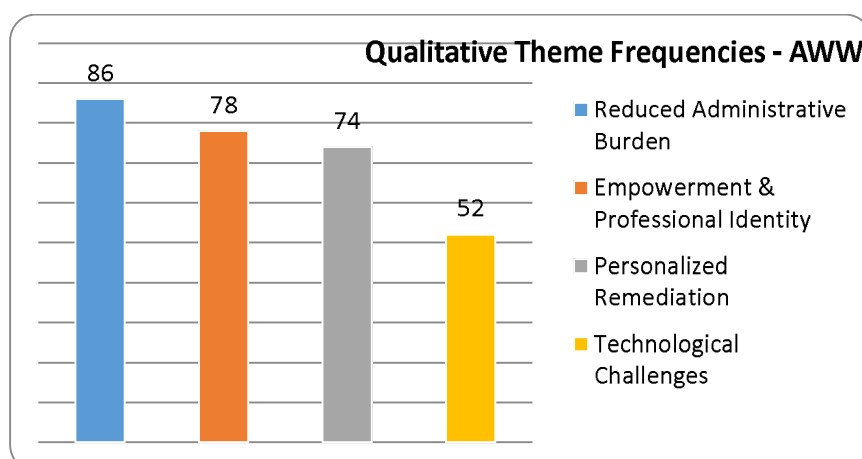
Theme 4: Clear Learning Progression: Children expressed awareness of achievements. "I can count to 10 now, but not all the way to 20 yet" (Boy, 6 years).

4.2.2 Thematic Analysis of AWW Focus Group Discussions

Analysis of AWW FGDs revealed four themes.

Table 6: Thematic Analysis of AWW Focus Group Discussions (N=50)

Theme	Definition	Supporting Quotes	Frequency
Empowerment and Professional Identity	Enhanced confidence and professional role	"Previously I felt like I was just managing children. Now I feel like I am teaching"	78%
Reduced Administrative Burden	Efficiency gains from automated tracking	"My register is now on the phone... I don't need to maintain separate paper records"	86%
Personalized Remediation	Capacity differentiated instruction for	"I can give different children different activities based on what the app tells me"	74%
Technological Challenges	Implementation difficulties and adaptations	"Sometimes the phone battery dies... Charging is not always available"	52%



Theme 5: Empowerment and Professional Identity: AWWs described increased confidence. "Previously I felt like I was just managing children. Now I feel like I am teaching" (AWW-14).

Theme 6: Reduced Administrative Burden: AWWs noted decreased record-keeping. "My register is now on the phone... I don't need to maintain separate paper records" (AWW-19).

Theme 7: Personalized Remediation: AWWs valued gap identification. "The colors make it simple. Green is good, yellow means needs practice, red means needs help" (AWW-09).

Theme 8: Technological Challenges: Some difficulties emerged. "Sometimes the phone battery dies... Charging is not always available" (AWW-31).

4.3 Integrated Findings

Mixed methods integration with joint display shows a coherent story of platform effectiveness. Quantitative findings show significant improvement in both outcomes for AWW and child FLN skills. Qualitative results account for these improvements in terms of increased engagement, professional identity development, decreased administrative burden, and potential for individualized remediation.

5. Discussion

5.1 Summary of Hypothesis Testing

Hypothesis	Statement	Result
H1	Literacy outcomes improve	Supported (d=1.08-1.12, p<0.001)
H2	Numeracy outcomes improve	Supported (d=1.01-1.04, p<0.001)
H3	AWW capacity enhances	Supported (d=1.26-1.44, p<0.001)

Hypothesis	Statement	Result
H4	TAM predicts adoption	Supported ($\beta=0.284-0.412$, $p<0.01$)
H5	Mediation by AWW capacity	Supported (34.5-40.8% mediation)
H6	Contextual moderation	Partially Supported

5.2 Theoretical Contributions

5.2.1 Technology Acceptance Model Extension

This study makes a contribution to the TAM research in three aspects. To begin with, it validates TAM in the context of rural Anganwadi education. Secondly, it shows that perceived usefulness ($\beta=0.412$, $p<0.001$) has more significant impact than perceived ease of use ($\beta=0.284$, $p<0.01$), which implies that value perceptions related to utility are the fundament of continuous participation. Third, this study combines TAM with dynamic capabilities (Teece, 2007), showing that technology adoption can generate organizational change via sensing, seizing and reconfiguration capabilities.

5.2.2 Stimulus-Organism-Response Framework Extension

The mediation findings support SOR theory within the educational technology field. The sizable indirect effects of 34.5-40.8% indicate technology intervention as a stimulus exerts its influence on learning outcomes through organismic changes in pedagogical knowledge and teaching practices.

5.2.3 Dynamic Capabilities Contribution

Gap detection and personalized remediation functionalities of the platform facilitated sensing, seizing, and transforming capabilities, which was especially important given AWWs limited formal training of in assessment and differentiated instruction (John & Singh, 2020).

5.3 Practical Implications

5.3.1 Implementation Recommendations

An underpowered analysis would have been unable to detect all subcategory effects of training and the strong impact of hours training ($\beta=0.348$, $p<0.001$) recommends training be lengthened to 5 days delivered in stages: (1) 2-day initial training, (2) 1-day refresher at 3 months, (3) 1-day advanced training at 6 months, and (4) continuous WhatsApp assistance. In terms of scaling up, the 3-colour assessment model appears optimal due to high reliability (89%). Infrastructure solutions include solar chargers for remote centres and a “light version” for low-memory handsets.

5.3.2 Stakeholder Engagement

Importance of perceived usefulness indicates that it is essential to involve all of the stakeholders. AWWs valued the platform as it met articulated needs for regularised pedagogic support,

monitoring of progress, and relief from administrative burden (Kaur, 2020; Sharma & Gupta, 2022).

5.4 Policy Implications

The intervention is in accordance with the NEP 2020, NIPUN Bharat Mission, and Poshan Bhi Padhai Bhi. For scaling, we suggest a tiered approach to delivery: Tier 1 (full version), Tier 2 (lite version), and Tier 3 (film-based version). The affordable price (₹1,00,000 for 8-10 centres) shows promise for CSR collaboration. The systemic implications are to include the platform in ICDS reporting and carve out a distinct budget head for Anganwadi education technology.

5.5 Limitations and Future Research

5.5.1 Methodological Limitations

The use of pre-post measurements in a single group does not allow for strong causal conclusions (Shadish, Cook, & Campbell, 2002). The generalizability of the single-state design was limited. The 6-month intervention was brief for assessing maintenance over the long term. There may have been novelty effects on assessment.

5.5.2 Future Research Directions

Areas for future research include: (1) quasi-experimental designs with control groups; (2) cost-effectiveness evaluations; (3) longitudinal designs to examine sustainability; (4) investigation of individual differences among children; (5) research on parent and community involvement models; and (6) replication efforts across states.

6. Conclusion

This study evaluated the effectiveness of the adaptive learning platform, AWW Tracker, delivered via a mobile app for FLN support in rural Anganwadi centres. The study provides robust evidence that technology customization can address systemic gaps in delivering early childhood education with a sequential explanatory mixed-methods design involving 50 AWWs and 100 children across 10 centres in Karnataka. Results show to what extent carefully designed contextually embedded technological interventions can overcome the chronic challenges of poor pedagogical frameworks, under-trained frontline workers, and lack of systematic progress monitoring in the ICDS system. Quantitative results show positive impacts on AWW pedagogical knowledge, teaching practices and child FLN skills. The six hypotheses were supported at a statistically significant level, confirming that (a) the platform boosts literacy and numeracy performance, (b) adoption of the platform is predicted by TAM constructs, (c) adoption enhances AWW capacity, (d) the impacts are mediated through AWW capacity, and that (e) the effects are moderated by contextual elements. Mediation analysis confirmed platform effects through enhanced pedagogical knowledge and teaching practices, which corroborates the idea that effectiveness of technology depends on its ability to transform capabilities of practitioners and not simply delivering content passively.

Visualisation led to higher child engagement (82 %) and motivation and self-efficacy, supported social learning and made learning progress transparent from the qualitative results.

AWWs experienced increased professional identity, less paperwork, more opportunities for individualized remediation, and positive reactions to the color-coded assessment system. These qualitative findings highlight the need to design technology that meets the day-to-day realities of frontline workers and delivers meaningful learning opportunities for children. Theoretically, the study advances educational technology theory by confirming TAM in the Anganwadi context, extending SOR in the development of practitioners' capacity, and demonstrating dynamic capabilities in educational settings. Results are useful for practice in terms of implementation, scale-up, and integration into policy. The intervention is consistent with policy goals outlined in the NEP 2020, the NIPUN Bharat Mission and the Poshan Bhi Padhai Bhi. Regarding successful scaling, a three-level implementation architecture, CSR sponsorship, and ICDS reporting mode convergence are proposed. The significance of this project stretches beyond short-term learning gains. By equipping Anganwadi Workers—who have historically been the most marginalized at every level in the ECCE workforce—with concrete pedagogical tools alongside reducing their administrative workload, the intervention tackles systemic labor challenges that have historically ravaged ECCE quality. The project shows that providing technology to frontline workers to enhance their professional development can produce major returns — in terms of both worker satisfaction and child outcomes? In addition, the small financial cost of the intervention (₹1,00,000 for 8-10 centres) allows for wide coverage, especially when in conjunction with corporate social responsibility funding and government support.

Government enabling environment Powerplay: The infrastructure or premise of providing support from government at all levels, is vital to facilitating scale-up across the 14 lakh Anganwadi Centres in India. The Ministry of Women and Child Development in partnership with the state governments, would have to give institutional backing in the form of policy provisions and appropriate budgetary support along with the facilitation of requisite technical infrastructure. Specific government action needs to be taken: (1) adoption of the AWW Tracker as a part of the national ICDS monitoring architecture; (2) setting up a separate budget line for Anganwadi technology interventions; (3) establishing state-level technical support cells for widespread and sustainable upkeep, including trouble-shooting; (4) linking the real-time progress reporting of the platform to the govt.'s reporting system already in place; and (5) creating public-private partnerships around resource mobilization for device distribution and content development. The Ministry of Education and NCERT are to coordinate to ensure coherence with national FLN curricula and assessment frameworks, as well. As India moves toward full coverage of high-quality ECCE in its anganwadi centers, technology adaptation is a promising way to improve the quality of delivery of anganwadi education at scale. The AWW Tracker is a testimony that technology can, with moderate investment, good design and adequate support, empower frontline workers to provide better learning outcomes and gear children towards a successful school transition. The task in front of us is to turn promising pilot results into a sustained, large scale impact at the national level – in over 14 lakh Anganwadi Centres across India, through continuous research, policy commitment, and strengthening of institutions. With unwavering government support and multi-stakeholder engagement, AWW Tracker intervention has the potential to make a positive impact on realizing the ambitious targets set forth in NEP 2020 and NIPUN Bharat Mission and consequently, leaving no child behind in quality early childhood education in India.

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Digital parenting education in the Indian context: Impact of a self-directed e-book on parents' knowledge of parenting and adolescent Behaviour

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Abstract

Parenting during adolescence requires parents to renegotiate control, communication, emotional support and autonomy at a stage marked by rapid developmental change. Although parents increasingly seek parenting information online, structured, culturally relevant and self-directed digital parenting education remains limited in the Indian context. The present study examined the impact of a culturally contextualised electronic book (e-book), “Parenting Together: A Guide for Parents”, on parents’ knowledge of parenting styles and adolescent behaviour. A one-group pre-test–post-test design was used with 600 parents of adolescents drawn through purposive sampling from twenty English-medium senior secondary schools across Haryana, Delhi and Chandigarh. The intervention was embedded within a mixed-methods CIPP evaluation framework; however, the present paper focuses specifically on the Product Evaluation of parents’ knowledge. Parenting knowledge was assessed before and after approximately six months of self-directed e-book exposure using a 50-item Knowledge Assessment Schedule covering conceptual knowledge, authoritarian parenting, permissive parenting, authoritative parenting and adolescent behaviour. Paired-samples t-tests and Cohen’s d were used to examine change. The findings showed a marked improvement in overall parenting knowledge, with the mean score increasing from 118.00 (SD=28.64) at pre-test to 203.34 (SD=32.61) at post-test, a mean gain of 85.34 points, $t(599)=58.30$, $p<.001$, $d=2.38$. Significant gains were observed across all five knowledge domains, with particularly strong improvement in conceptual knowledge and authoritative parenting. The proportion of parents in the Low knowledge category fell from 64.5% to zero, while 77.7% reached the High category at post-test. The findings indicate that a self-directed, culturally grounded e-book can function as a scalable parent-learning intervention and may contribute to strengthening evidence-informed parenting knowledge in the digital era. Given the limitations of a one-group pre-experimental design, the findings are interpreted as strong evidence of pre–post improvement rather than definitive causal proof.

Keywords: *digital parenting education; e-book intervention; parenting knowledge; authoritative parenting; adolescents; educational psychology; India*

Introduction

Parenting is a continuous process in which parents guide, support, discipline and socialise their children. This becomes more challenging during adolescence because young people seek greater independence while still needing emotional support, clear boundaries and guidance. Research distinguishes authoritative parenting, which combines warmth and appropriate control, from authoritarian, permissive and neglectful approaches (Baumrind, 1966, 1991; Maccoby & Martin, 1983). In India, changing family structures, academic pressure, digital media and changing

social expectations have created new challenges for parents. The present study highlights that parents may want to support their adolescents but may lack clear and structured knowledge about adolescent development and effective parenting approaches. Thus, the problem may be more related to a knowledge gap than a lack of parental concern. Digital resources such as self-directed e-books can provide a practical way to address this gap because parents can access, read and revisit the content at their convenience. The e-book developed in the study was designed for joint parent–adolescent reading, using simple language, practical guidance and Indian family situations. The study was guided by the CIPP Evaluation Model (Stufflebeam, 2000), which includes Context, Input, Process and Product Evaluation. Although the wider thesis examined all four components, the present paper focuses mainly on Product Evaluation, specifically the change in parents' parenting knowledge after exposure to the digital e-book.

Rationale of the study

Parenting knowledge refers to parents' understanding of adolescent development, parenting approaches, communication, discipline and the effects of different parental responses. Although knowledge does not automatically lead to changes in parenting behaviour, it provides an important basis for informed decision-making. Belsky's (1984) process model explains parenting through the interaction of parent, child and contextual factors, suggesting that better knowledge can strengthen parents' ability to respond to developmental challenges. Understanding the difference between authoritarian and authoritative parenting is particularly important during adolescence, as authoritative parenting combines rules and expectations with warmth, explanation and responsiveness (Baumrind, 1991). Digital parenting interventions can extend family education beyond face-to-face programmes. Technology-based approaches, including SMS interventions, have shown the feasibility of providing parenting support with limited direct contact (Chu et al., 2019), while parenting education research suggests that improved knowledge and understanding may precede changes in attitudes and practices (Benzies et al., 2021). The present e-book was therefore designed as a self-directed learning resource for parents and adolescents, using accessible content and developmentally relevant examples.

The study addresses gaps identified in the thesis literature review, particularly the limited availability of culturally relevant digital parenting resources for Indian families, the predominance of parent-only approaches, the limited use of systematic pre–post evaluation in Indian parenting education and the limited research on e-books for parents of adolescents. The e-book represents an intersection of family education, educational psychology and digital pedagogy. Its intended educational pathway is from improved understanding to informed attitudes and, potentially, better parenting practices. However, the present paper focuses specifically on the first and most directly measurable stage of this pathway change in parents' parenting knowledge without claiming that knowledge gain alone proves behavioural change.

Objective

To examine the impact of a culturally contextualised, self-directed e-book on parents' knowledge regarding parenting styles and adolescent behaviour.

Method

The wider thesis used a mixed-methods, one-group pre-experimental design embedded in the CIPP framework. For the present paper, the analytical focus is restricted to the parent pre-test and post-test knowledge scores. The sample comprised 600 matched parents participating with adolescents in twenty English-medium senior secondary schools across Haryana, Delhi and

Chandigarh. The regional distribution comprised 200 parent–adolescent dyads from each of the three regions. Participants were selected through purposive sampling. Data collection occurred in three broad phases: pre assessment, e-book exposure and post-intervention assessment. The e-book exposure period extended for approximately six months and was self-directed. The design intentionally allowed parents to engage with the material in their own time rather than through a facilitator-led programme.

Intervention

The intervention was the electronic book titled *Parenting Together: A Guide for Parents and Teens to Grow, Understand and Thrive*. It addressed the four major parenting styles, adolescent development, communication, discipline, emotional and mental-health awareness and practical parent–adolescent issues. Content was presented through an accessible, visually oriented digital format and grounded in Indian family situations. The central educational innovation was the possibility of joint parent–adolescent reading, although the present paper reports only the parent knowledge outcome. The development and standardisation processes were undertaken before the main outcome assessment. For transparency, the thesis reports that expert evaluation, readability assessment and pilot testing supported the suitability of the resource. These procedures are treated here as quality-assurance steps rather than as primary findings, because the purpose of this paper is to foreground educational impact.

Tool for measurement of parenting knowledge

Parents' knowledge was assessed using the 50-item Knowledge Assessment Schedule developed for the study. The schedule covered five domains: conceptual knowledge, authoritarian parenting, permissive parenting, authoritative parenting and adolescent behaviour. The maximum possible grand-total score was 250. The same knowledge assessment was administered at pre-test and post-test, permitting within-person comparison. The study used a researcher-developed, content-aligned knowledge measure. This is important when interpreting the magnitude of the observed effect because the assessment directly represented content addressed by the intervention. Accordingly, the findings are most appropriately interpreted as evidence of substantial learning on the targeted knowledge domain rather than as evidence that all aspects of parenting competence changed.

Statistical analysis

Descriptive statistics were used to summarise pre-test and post-test performance. Paired-samples t-tests were used because the same parents contributed scores at both time points. Cohen's *d* was reported as an effect-size indicator to complement statistical significance. Knowledge categories were also compared descriptively to show the practical distributional shift from Low, Moderate and High levels. Statistical significance was evaluated at the .05 level. The thesis reports one-tailed *p*-values because the hypothesis specified directional knowledge gain.

Results

Overall change in parenting knowledge

A pronounced increase was observed in parents' overall knowledge following the intervention. The grand-total mean increased from 118.00 (*SD*=28.64) at pre-test to 203.34 (*SD*=32.61) at post-test, producing a mean gain of 85.34 points. The paired-samples t-test showed that this change was statistically significant, $t(599)=58.30$, $p<.001$, with a large effect size (Cohen's $d=2.38$). Thus, the post-test distribution was not merely statistically higher; it represented

a substantial shift in the level of demonstrated knowledge. The magnitude of change is especially noteworthy because the baseline profile indicated considerable room for educational improvement. At pre-test, 64.5% of parents were classified in the Low knowledge category and 35.5% in the Moderate category; none were classified as High. Following the intervention, no parent remained in the Low category, 22.3% were Moderate and 77.7% were High. This categorical movement provides an intuitive complement to the inferential statistic and demonstrates that the improvement was distributed across the sample rather than being driven only by a small group of high-performing participants.

Table 1 - Pre-post comparison of parents' knowledge following e-book exposure

Knowledge domain	Pre M (SD)	Post M (SD)	Gain	t(599)	P value	Cohen's d value
Conceptual Knowledge	18.62 (6.86)	39.11 (6.85)	20.49	60.36	<.001	2.46
Authoritarian Parenting	26.38 (5.21)	38.36 (4.97)	11.98	46.73	<.001	1.91
Permissive Parenting	24.48 (5.20)	34.12 (4.70)	9.65	38.85	<.001	1.59
Authoritative Parenting	23.02 (9.22)	52.88 (11.46)	29.86	59.11	<.001	2.41
Adolescent Behaviour	25.50 (5.50)	38.87 (7.11)	13.36	42.31	<.001	1.73
Grand Total	118.00 (28.64)	203.34 (32.61)	85.34	58.30	<.001	2.38

Domain-wise pattern of learning

The domain-level results strengthen the interpretation of the overall gain. All five knowledge domains showed statistically significant improvement, with effect sizes ranging from $d=1.59$ to $d=2.46$. Conceptual knowledge showed a mean gain of 20.49 points and the largest effect size ($d=2.46$). Authoritative parenting knowledge showed the second-largest effect ($d=2.41$) and the largest absolute domain gain, 29.86 points. This pattern is educationally meaningful because authoritative parenting represented one of the most pronounced baseline knowledge deficits identified in the thesis.

The gains in authoritarian and permissive parenting knowledge were also substantial ($d=1.91$ and $d=1.59$ respectively). Improvement in these domains suggests that the intervention did more than promote a single preferred parenting label; it helped parents differentiate among contrasting parenting patterns. Knowledge concerning adolescent behaviour increased significantly as well ($d=1.73$), indicating that the intervention's content on the adolescent developmental context was incorporated into the post-test knowledge profile. An important feature of the results is the alignment between baseline deficit and magnitude of learning. The strongest effects occurred in conceptual and authoritative-parenting knowledge, the areas where parents had comparatively greater need for clarification. This pattern is more informative than a simple

statement that the total score increased: it suggests that the intervention was particularly effective where the educational gap was most pronounced.

Distributional transformation

The categorical results provide the clearest practical illustration of the educational change. Before exposure, nearly two-thirds of the parent sample was in the Low category and no parent reached the High category. After exposure, the Low category disappeared completely and more than three-quarters of parents entered the High category. The shift was therefore not a marginal movement around a cut-off; it represented a broad restructuring of the sample's knowledge profile. Such a distributional transformation is important for educational interpretation. Statistical significance can become almost inevitable in large samples, but the disappearance of the Low group and emergence of a dominant High group indicate that the observed change was also substantively large within the study's scoring framework. Nevertheless, because the instrument was developed specifically for the intervention content, these results should be interpreted as strong evidence of learning in the targeted curriculum rather than as a general measure of parenting competence.

Discussion

The findings show a substantial improvement in parents' parenting knowledge after exposure to the self-directed e-book. The overall mean gain was 85.34 points, with a Cohen's d of 2.38, indicating a large learning effect. Improvement was observed across all assessed domains, suggesting that the gain was not limited to a single topic. The strongest improvement was found in conceptual knowledge, which is consistent with the e-book's educational purpose. This was also supported by qualitative findings, with 33% of parents identifying understanding parenting styles as their most important learning outcome. A particularly important finding was the large improvement in knowledge of authoritative parenting, highlighting better understanding of how clear expectations can be combined with warmth, explanation and responsiveness. The findings also suggest a possible pathway from knowledge to parenting intentions. 35% of parents reported plans to adopt more authoritative practices, 28% to improve communication and 19% to reduce harsh discipline. These findings do not prove sustained behavioural change but indicate that increased knowledge may encourage parents to reconsider their parenting responses. The results are consistent with previous evidence on technology-supported parenting education (Chu et al., 2019; Benzie et al., 2021) and demonstrate the potential of a self-directed e-book for parent education in the Indian context. However, the large effect size ($d=2.38$) should be interpreted cautiously because the knowledge assessment was closely aligned with the intervention content. Therefore, the findings demonstrate a strong learning effect within the targeted knowledge domain, rather than proving that the e-book alone transformed parenting behaviour.

Educational and Practical Implications

The findings of the study show that digital resources can be useful not only for students but also for parents as part of lifelong learning. Since parents play an important role in the educational and emotional development of adolescents, providing them with reliable and easy-to-understand parenting information can strengthen the home learning environment. Schools and counsellors can use digital parenting resources such as e-books as additional material for parent orientation, counselling and adolescent wellbeing programmes, especially where regular counselling support is limited. Such resources should support, not replace, professional

counselling when individual help is required. The study also highlights the importance of Home Science in converting knowledge about human development, family relationships and parenting into simple and useful digital learning materials. The improvement in parents' knowledge suggests that well-planned and relevant digital content can be an effective alternative to only face-to-face education. The self-directed e-book can also be shared widely at a low cost; however, the findings cannot be applied to all parents in India because the study mainly included parents from English-medium urban and semi-urban schools. Therefore, translation, cultural adaptation and further testing would be needed before using the e-book on a larger scale.

Conclusion

The present study provides a strong and focused message: a culturally contextualised, self-directed e-book can be a powerful vehicle for parenting education. Across 600 parents, knowledge increased from a mean of 118.00 to 203.34, with a gain of 85.34 points, $t(599)=58.30$, $p<.001$ and $d=2.38$. Every assessed knowledge domain improved significantly, while the proportion of parents in the Low category fell from 64.5% to zero and 77.7% reached the High category. The most compelling educational insight is that the greatest gains occurred in conceptual and authoritative-parenting knowledge—the very areas in which parents initially showed substantial need. This suggests that the e-book did not merely increase exposure to information; it helped organise previously fragmented ideas into a more coherent framework for understanding parenting during adolescence. The findings position digital parenting education within the broader field of educational psychology in the digital era. A smartphone-accessible learning resource can extend education beyond classrooms and into the family system, where adolescents' everyday developmental experiences unfold. Future research should test the intervention against a control group, examine longer-term retention and parenting behaviour and adapt the resource for regional languages and more diverse populations. The current evidence nevertheless establishes a promising foundation: when digital learning is culturally grounded, developmentally relevant and designed around the learner's real-life context, parenting knowledge can become an attainable and measurable educational outcome.

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Educational Psychology in the Digital Era

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ABSTRACT:

Educational psychology is the study of how students learn, think, behave and develop in an educational environment. In the digital era, technology has become an important part of education. Online classes, digital classrooms, educational applications, videos and artificial intelligence have changed traditional learning methods. Digital technology provides students with easy access to information and allows them to learn at their own pace. However, excessive use of technology may lead to distraction, lack of concentration, excessive screen time and reduced personal interaction. This paper discusses the role of educational psychology in the digital era, the impact of technology on students' learning, its benefits and challenges, and the role of teachers in creating an effective digital learning environment.

Keywords: Educational Psychology, Digital Learning, Technology, Students, Artificial Intelligence

1. INTRODUCTION:

Education has changed greatly with the development of digital technology. Earlier, students mainly depended on teachers, textbooks and classroom teaching. Today, students can learn through computers, smartphones, online classes, educational applications and various digital platforms. Educational psychology helps us understand how students learn and how factors such as motivation, attention, memory, emotions and individual differences affect learning. In the digital era, it is important to understand how technology influences students' learning and behaviour. Digital technology has made education more flexible and accessible. At the same time, it has also created certain challenges. Therefore, educational psychology plays an important role in understanding the proper use of technology in education.

2. OBJECTIVES OF THE STUDY:

The main objectives of this paper are:

1. To understand the meaning and importance of educational psychology in the digital era.
2. To study the impact of digital technology on students' learning.
3. To examine the effect of digital learning on students' motivation and concentration.
4. To identify the psychological benefits of technology in education.
5. To identify the challenges faced by students in digital learning.
6. To understand the changing role of teachers in the digital era.

1. UNESCO, *Global Education Monitoring Report 2023: Technology in Education—A Tool on Whose Terms?* (Paris: UNESCO, 2023).

2. Anita Woolfolk, *Educational Psychology*, 14th ed. (Pearson, 2019); UNESCO, *Global Education Monitoring Report 2023: Technology in Education—A Tool on Whose Terms?* (Paris: UNESCO, 2023).

7. To examine the role of artificial intelligence in education.
8. To suggest ways to use digital technology effectively and responsibly.

3. DIGITAL ERA AND EDUCATION:

The digital era refers to the period in which digital technology is widely used in different areas of life, including education.

Digital education includes:

- Online classes
- Digital classrooms
- Educational websites
- Learning applications
- Online examinations
- Educational videos
- E-books and digital notes
- Artificial intelligence-based learning tools

These technologies have made it possible for students to access educational materials from different places and at different times.

4. PSYCHOLOGICAL BENEFITS OF DIGITAL: LEARNING

Digital technology can provide several benefits to students.

- Increased Interest in Learning
Interactive digital content can make lessons more interesting and encourage students to participate in learning.
- Learning at Individual Pace
Students can repeat recorded lessons and study difficult topics according to their own pace.
- Better Understanding
Videos, images and animations can help students understand concepts more easily.
- Immediate Feedback
Some digital learning platforms provide immediate feedback, helping students understand their mistakes.
- Independent Learning
Digital resources allow students to explore topics independently and develop their learning skills

5. PSYCHOLOGICAL CHALLENGES OF DIGITAL LEARNING:

Although digital learning has many advantages, it also has certain challenges.

3.UNESCO, *Global Education Monitoring Report 2023: Technology in Education—A Tool on Whose Terms?* (Paris: UNESCO, 2023).

4.OECD, *Digital Education Outlook 2021: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots* (Paris: OECD Publishing, 2021).

5.UNESCO, *Global Education Monitoring Report 2023: Technology in Education—A Tool on Whose Terms?* (Paris: UNESCO, 2023).

➤ **Lack of Concentration**

Notifications, social media and entertainment applications can distract students while studying.

➤ **Excessive Screen Time**

Spending too much time using digital devices may affect students' study habits and daily routine.

➤ **Reduced Personal Interaction**

Online learning may reduce direct communication between students and teachers and interaction among classmates.

➤ **Information Overload**

Students can access a very large amount of information online. Sometimes, this can make it difficult to identify useful and reliable information.

➤ **Dependence on Technology**

Excessive dependence on digital tools may reduce opportunities for students to develop independent thinking and problem-solving skills.

FINDINGS:

The major findings of this paper are:

1. Digital technology has changed traditional methods of teaching and learning.
2. Online learning provides students with greater flexibility.
3. Digital learning materials can make learning more interactive and interesting.
4. Technology can support personalised learning according to individual needs.
5. Excessive use of digital devices can cause distraction and reduce concentration.
6. Too much dependence on technology may affect independent learning.

SUGGESTIONS:

The following suggestions can help in making digital learning more effective:

1. Students should maintain a balance between online and offline learning.
2. Unnecessary digital distractions should be avoided during study time.
3. Educational websites and applications should be used properly.
4. Students should take regular breaks while using digital devices.
5. Teachers should encourage classroom interaction and group activities.
6. Students should develop critical thinking instead of depending completely on technology.
7. Schools and colleges should provide proper guidance on responsible use of technology

CONCLUSION:

Digital technology has brought major changes to education and the learning process. It has made education more flexible, interactive and accessible. Digital tools can help students understand lessons, access information and learn according to their own pace.

However, excessive use of technology can create problems such as distraction, lack of concentration, excessive screen time and reduced personal interaction. Educational psychology helps teachers understand how these changes affect students' learning and behaviour.

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“Student engagement in the digital era: a conceptual framework for learner-centred and interactive learning”

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Abstract

The rapid development of digital technology has transformed contemporary educational practices and created new possibilities for teaching, learning, communication, and student participation. Digital platforms, learning management systems, virtual classrooms, multimedia resources, educational applications, collaborative tools, and emerging technologies have increasingly become part of formal learning environments. Within this changing educational landscape, student engagement has gained considerable importance because meaningful learning depends not only on access to educational resources but also on learners' active involvement in the learning process. Student engagement is multidimensional and encompasses behavioural, cognitive, emotional, and agentic dimensions. Although digital technologies can facilitate participation, interaction, collaboration, flexibility, and access to learning resources, the mere presence of technology does not necessarily result in meaningful engagement. The pedagogical approaches through which technology is integrated into learning are equally important. Learner-centred and interactive approaches can provide opportunities for students to exercise autonomy, collaborate with peers, communicate with teachers, participate actively, solve problems, and take greater responsibility for their learning. The present conceptual paper examines student engagement in the digital era and explores the relationship among digital technology, learner-centred pedagogy, interactive learning, and student engagement. The paper is based on a review and synthesis of existing scholarly literature on student engagement, educational technology, learner-centred learning, digital pedagogy, interaction, and digital literacy. Based on the synthesis, a conceptual framework is proposed in which digital technology functions as an enabling component, while learner-centred pedagogy and interactive learning act as important pedagogical mechanisms through which technology may contribute to meaningful engagement. The framework incorporates learner autonomy, interactivity, collaboration, personalisation, meaningful teacher support, and digital learning resources as supporting conditions for behavioural, cognitive, emotional, and agentic engagement. The paper also identifies challenges including unequal access to technology, limited digital competence, teacher preparedness, digital distraction, information overload, reduced social interaction, and concerns associated with emerging technologies. The paper concludes that technology alone cannot guarantee student engagement; meaningful engagement requires the purposeful integration of technology with learner-centred and interactive pedagogical practices.

Keywords: Student Engagement; Digital Learning; Learner-Centred Learning; Interactive Learning; Educational Technology; Digital Pedagogy; Digital Literacy.

1. Introduction

The rapid advancement of digital technology has brought significant changes to education. Digital devices, online learning platforms, learning management systems, virtual classrooms, multimedia resources, educational applications, collaborative technologies, and artificial intelligence-supported tools have increasingly influenced teaching and learning. These developments have expanded learning beyond the traditional classroom by enabling students to access educational

resources, communicate with teachers and peers, collaborate on academic tasks, and participate in learning activities across different locations and times. Consequently, digital education has become an important component of contemporary educational practice.

The increasing use of technology has also contributed to a shift from teacher-dominated approaches towards more flexible and learner-centred learning environments. While conventional instruction often positions teachers as the primary source of knowledge and students as receivers of information, digital environments can provide learners with opportunities to explore content independently, search for information, participate in discussions, complete interactive activities, collaborate with peers, receive feedback, and create digital products. These opportunities can support more active forms of learning and participation. However, technology alone does not guarantee meaningful learning or engagement. Its educational value depends largely on how it is integrated with appropriate pedagogy and learning objectives.

Student engagement is therefore a central consideration in digital education. Engagement broadly refers to students' active and meaningful participation in learning. Fredricks, Blumenfeld, and Paris (2004) conceptualised engagement as a multidimensional construct comprising behavioural, emotional, and cognitive dimensions. Behavioural engagement includes participation, effort, attention, and persistence; cognitive engagement involves psychological investment, strategic learning, self-regulation, and willingness to undertake challenging tasks; and emotional engagement includes students' interest, enjoyment, sense of belonging, and attitudes towards learning. Reeve and Tseng (2011) further identified agentic engagement, referring to students' constructive contribution to the learning process, such as asking questions, expressing preferences, and influencing instructional activities.

Digital technology has expanded the ways in which these dimensions of engagement can be expressed. Behavioural engagement may be reflected through participation in online classes, submission of digital assignments, interactive quizzes, and online discussions. Cognitive engagement may involve researching information, solving problems, evaluating online sources, using simulations, and reflecting on learning. Emotional engagement may be supported through interactive resources and students' sense of connection with teachers and peers, while agentic engagement can be demonstrated when learners ask questions, seek clarification, suggest ideas, or actively contribute to the learning process.

Digital technology can also facilitate learner-centred learning, which emphasises active participation and recognises differences in students' needs, experiences, abilities, interests, and learning preferences. Rather than treating students as passive recipients of information, learner-centred approaches encourage inquiry, problem-solving, collaboration, reflection, decision-making, and greater learner autonomy. Digital environments can support these principles by allowing students to access resources at different times, select learning materials, communicate through different channels, and participate in activities according to their learning needs.

Interactive learning is another important dimension of digital education. Learning is shaped not only by receiving information but also by interactions among learners, teachers, peers, and learning content. Moore (1989) identified three important forms of interaction in distance education: learner-content, learner-instructor, and learner-learner interaction. Digital technologies can

facilitate these forms through multimedia resources and simulations, online discussions and video conferencing, and collaborative platforms and shared digital spaces.

The relationship between technology, pedagogy, and engagement is therefore complex. Digital technology creates opportunities for participation, but these opportunities require appropriate instructional design. Learner-centred pedagogy can promote autonomy and responsibility, while interactive learning can strengthen communication, collaboration, and social connection. When appropriately integrated, these elements may create richer opportunities for meaningful student engagement.

Nevertheless, digital education also presents challenges, including unequal access to devices and reliable internet connectivity, differences in digital competence, and varying levels of teacher preparedness. Digital environments may also contribute to distraction, information overload, social isolation, and excessive dependence on technology. The development of artificial intelligence has created additional opportunities while raising concerns related to academic integrity, independent thinking, privacy, and responsible technology use.

Against this background, the present conceptual paper examines student engagement in the digital era, with particular attention to learner-centred and interactive learning. It brings together major concepts from the literature and proposes a conceptual framework explaining how digital technology, learner-centred pedagogy, and interactive learning may contribute to different dimensions of student engagement. The framework provides a theoretical basis for understanding digital engagement and may guide future empirical research.

2. Objectives of the Study

The present conceptual paper is guided by the following objectives:

1. To understand the concept and dimensions of student engagement in the digital era.
2. To examine the role of digital technology in promoting student engagement.
3. To understand the importance of learner-centred and interactive learning approaches in digital education.
4. To propose a conceptual framework explaining the relationship among digital technology, learner-centred pedagogy, interactive learning, and student engagement.

3. Methodology

The study adopts a conceptual research design based on a review and synthesis of secondary literature. No primary data, research instruments, or experiments were used. Relevant peer-reviewed articles, systematic reviews, books, and theoretical publications were reviewed on student engagement, educational technology, learner-centred and interactive learning, digital pedagogy, digital literacy, and 21st-century skills.

The literature was thematically synthesised to identify key concepts, relationships, opportunities, and challenges in digital learning. Based on this synthesis, a conceptual framework was developed linking digital technology, learner-centred and interactive pedagogy, and the behavioural, cognitive, emotional, and agentic dimensions of student engagement. The framework is theoretical and provides a basis for understanding digital engagement and guiding future empirical research.

4. Review of Literature

4.1 Student Engagement in the Digital Era

Fredricks et al. (2004) Student engagement is widely recognised as an important concept in understanding educational participation and learning outcomes. Described engagement as a multidimensional construct comprising behavioural, emotional, and cognitive dimensions. These dimensions provide a useful basis for understanding how students participate in educational activities and respond to learning environments.

Behavioural engagement is associated with students' participation, effort, attention, persistence, attendance, and involvement in academic activities. In digital environments, behavioural engagement may be observed through students' participation in online classes, completion of digital assignments, attendance in virtual sessions, contributions to online discussions, and interaction with digital learning materials.

Cognitive engagement concerns the mental effort and psychological investment students devote to learning. It involves deep learning, strategic thinking, self-regulation, problem-solving, critical thinking, and the willingness to engage with challenging tasks. Digital environments can potentially support cognitive engagement by providing students with access to diverse information, interactive simulations, problem-solving activities, digital research resources, and opportunities for independent exploration.

Emotional engagement refers to students' feelings and attitudes towards learning, teachers, peers, and the educational environment. Interest, enjoyment, belonging, confidence, and positive attitudes can influence the extent to which students remain involved in learning activities. In digital education, emotional engagement may be strengthened through meaningful teacher interaction, collaborative learning, supportive online communities, and learning activities that are relevant to students' interests and experiences.

Reeve and Tseng (2011) extended the understanding of engagement by introducing agentic engagement. Agentic engagement reflects students' constructive contribution to instruction, including asking questions, communicating preferences, requesting clarification, expressing needs, and contributing ideas that influence the learning process. This dimension is particularly relevant to learner-centred digital environments because technology can provide multiple channels through which learners can communicate their needs and participate in shaping learning activities.

The digital era has therefore expanded both the opportunities and complexities associated with student engagement. Students can participate through multiple platforms and modes, but digital participation should not be equated automatically with meaningful engagement. A student may spend considerable time online without engaging deeply with educational content. Consequently, the quality, purpose, and nature of digital participation are important considerations.

Nkomo et.al (2021), in their systematic review of student engagement with digital technologies, highlighted considerable variation in the conceptualisation and measurement of engagement. Their findings indicate that engagement with digital technologies is a complex phenomenon that requires attention to different dimensions and forms of participation. This suggests the need for broader conceptualisations of engagement that consider not only observable online activity but also cognitive, emotional, and agentic involvement.

4.2 Digital Technology and Student Engagement

Digital technology has the potential to transform the learning environment by providing students with increased access to educational content, communication tools, collaborative spaces, and interactive resources. Learning management systems, virtual classrooms, educational applications, online discussion forums, multimedia resources, digital assessment tools, and collaborative platforms can facilitate different forms of participation.

One important contribution of digital technology is increased flexibility. Students can often access learning materials at different times and locations, allowing them to review content according to their individual learning needs. Recorded lectures, digital notes, online readings, instructional videos, and interactive resources can support self-paced learning.

Digital technologies can also strengthen communication. Online discussion boards, messaging systems, video conferencing, and collaborative platforms provide opportunities for students to communicate with teachers and peers. Such communication may be particularly important in learning environments where physical interaction is limited.

Another important feature is interactivity. Interactive quizzes, simulations, educational games, virtual laboratories, and multimedia activities can require students to respond, make decisions, solve problems, and receive feedback. Such activities can move learning beyond passive information consumption.

Bedenlier et al. (2020) highlighted the role of educational technologies in facilitating student engagement in higher education and emphasised the importance of understanding technology as part of a broader educational process. Similarly, Bond and Bedenlier (2019) proposed that educational technology can facilitate engagement through different mechanisms, but its effects depend on how technologies are incorporated into educational practice.

Digital technology can also support collaboration. Students may work together through shared documents, discussion forums, digital project spaces, and online communication platforms. Collaborative learning can promote the exchange of ideas and provide students with opportunities to construct knowledge together.

However, technology does not inherently guarantee engagement. Excessive reliance on digital tools may result in passive consumption of content. Poorly designed online courses may overwhelm learners with information without providing sufficient interaction or guidance. Therefore, the educational impact of technology depends on instructional design, teacher support, learner characteristics, and the quality of interaction.

The role of technology should consequently be understood as enabling rather than determining engagement. Technology creates opportunities, while pedagogy determines how those opportunities are transformed into meaningful learning experiences.

4.3 Learner-Centred Learning

Learner-centred learning represents a shift from teacher-dominated instruction towards approaches that recognise students as active participants in the educational process. It emphasises learners' needs, experiences, interests, autonomy, participation, and responsibility.

Learner-centred pedagogy encourages students to participate actively in learning rather than simply receive information. Students may engage in inquiry, discussion, problem-solving, collaboration, project-based learning, reflection, and independent exploration. Such approaches can contribute to deeper learning by requiring students to apply and construct knowledge.

The digital environment provides several opportunities for implementing learner-centred principles. Students may access different resources, choose learning materials, complete self-paced

activities, participate in collaborative projects, and receive personalised feedback. Digital platforms can also provide opportunities for students to communicate their preferences and learning needs.

Bremner, et.al (2022), through their systematic review of learner-centred pedagogy, identified important features including active participation, adaptation to learners' needs, learner autonomy, development of relevant skills, shared responsibility, and formative assessment. These elements are closely connected with the requirements of digital learning environments.

Learner autonomy is particularly important. Digital education can allow students to manage aspects of their learning, including when they access resources, how they practise particular skills, and which additional resources they consult. However, autonomy should not be interpreted as complete independence from teachers. Effective learner-centred education requires appropriate guidance, scaffolding, feedback, and support.

Learner-centred learning also recognises differences among learners. Students may vary in their prior knowledge, learning pace, digital competence, interests, and access to technology. Digital environments can potentially accommodate some of these differences through differentiated resources, flexible learning pathways, and personalised activities.

Nevertheless, learner-centred approaches require careful instructional planning. Simply providing students with freedom or access to digital resources does not automatically make learning learner-centred. Teachers need to design meaningful learning experiences that provide appropriate choices while maintaining clear learning objectives and academic support.

4.4 Interactive Learning in Digital Education

Interaction is a fundamental element of meaningful learning. Moore (1989) identified three major types of interaction in distance education: learner-content interaction, learner-instructor interaction, and learner-learner interaction. These forms remain relevant in contemporary digital learning environments.

Learner-content interaction occurs when students engage directly with educational materials. In digital learning, this may involve reading electronic texts, watching instructional videos, completing interactive quizzes, exploring simulations, solving digital problems, or using multimedia resources.

Learner-instructor interaction involves communication between students and teachers. This may take place through virtual classrooms, discussion boards, email, digital feedback, messaging systems, or video conferencing. Teacher interaction can provide clarification, guidance, feedback, encouragement, and motivation.

Learner-learner interaction occurs when students communicate and collaborate with their peers. Digital platforms can facilitate group discussions, collaborative projects, peer assessment, shared documents, online communities, and virtual group activities.

Interactive learning can contribute to engagement because students are required to respond and participate rather than merely receive information. It can also support social learning by providing opportunities to exchange perspectives and construct understanding collectively.

The quality of interaction is particularly important. An online discussion consisting of brief or superficial responses may provide less educational value than a carefully designed discussion requiring students to analyse information, justify arguments, respond to peers, and reflect on

different perspectives. Therefore, interactive learning should be purposeful and connected with learning outcomes.

Digital learning environments should consequently provide a balanced combination of learner-content, learner-instructor, and learner-learner interaction. Such balance can help address both the academic and social dimensions of student engagement.

4.5 Digital Pedagogy and Teaching Practices

Digital pedagogy refers broadly to the purposeful integration of digital technologies into teaching and learning. It goes beyond the technical use of devices and platforms and focuses on how technology can support instructional objectives, learning processes, assessment, communication, and interaction.

Effective digital pedagogy requires teachers to make informed decisions about when, why, and how particular technologies should be used. The technological pedagogical content knowledge framework developed by Mishra and Koehler (2006) emphasises the relationship among technological knowledge, pedagogical knowledge, and content knowledge. The framework suggests that effective technology integration requires teachers to understand the interaction between technology, pedagogy, and subject matter.

Koehler, et.al (2013) further explained the importance of technological pedagogical content knowledge in supporting effective technology-integrated teaching. This perspective is particularly relevant to student engagement because the same technology may produce different learning experiences depending on how it is used.

For example, an instructional video may be used simply as a replacement for a lecture, resulting in relatively passive learning. Alternatively, the same video may be combined with reflective questions, group discussion, problem-solving activities, and formative assessment, creating a more interactive experience.

Digital pedagogy can therefore support engagement when teaching practices are deliberately designed around active participation. Teachers can use digital technologies to facilitate inquiry, collaborative learning, project-based learning, formative assessment, personalised feedback, and reflective learning.

Digital assessment is another important component. Online quizzes, polls, digital portfolios, peer assessment, and immediate feedback can provide information about students' progress and allow teachers to adjust instruction. Formative assessment can also encourage students to monitor their own learning.

Effective digital pedagogy consequently requires both technological competence and pedagogical understanding. Teachers need professional development that helps them integrate technology meaningfully rather than simply learn how to operate digital tools.

4.6 Digital Literacy and 21st-Century Skills

Digital literacy is increasingly important in contemporary education because students are required not only to consume digital information but also to evaluate, communicate, create, and use information responsibly. Digital competence includes knowledge, skills, and attitudes necessary for confident, critical, and responsible engagement with digital technologies.

Vuorikari et al., (2022) The framework developed by the European Commission provides a comprehensive framework for digital competence and includes areas such as information and data literacy, communication and collaboration, digital content creation, safety, and problem-solving. Digital literacy is directly connected with student engagement because students need sufficient digital competence to participate effectively in technology-supported learning. A student who cannot navigate an online platform, evaluate the reliability of information, or communicate appropriately in digital spaces may experience barriers to participation.

Digital learning can also contribute to the development of broader 21st-century skills. These include critical thinking, creativity, communication, collaboration, problem-solving, self-regulation, adaptability, and responsible digital citizenship.

Student engagement should therefore not be understood solely as participation in digital activities. Meaningful engagement should also contribute to students' ability to think critically, collaborate with others, solve authentic problems, communicate ideas, and use digital technologies responsibly.

The development of digital literacy consequently represents both a condition for and an outcome of effective digital learning. Students require digital competence to participate meaningfully, while appropriately designed digital learning environments can provide opportunities for students to strengthen these competencies.

5. Research Gap

The review of literature indicates that student engagement has become an important area of educational research, particularly with the increasing integration of digital technologies into teaching and learning. Earlier conceptualisations focused primarily on behavioural, emotional, and cognitive dimensions, while later scholarship expanded the concept to include agentic engagement. The emergence of digital learning environments has further broadened the ways in which students can participate in educational activities. However, several gaps remain in understanding the relationship between digital technology and meaningful student engagement.

First, there is a lack of consistency in the conceptualisation and measurement of student engagement in digital learning environments. Nkomo et al. (2021) identified considerable variation in how engagement with digital technologies has been conceptualised and measured. Their review also highlighted the frequent reliance on students' self-reported perceptions. This indicates the need for more comprehensive approaches that consider behavioural, cognitive, emotional, and agentic dimensions together.

Second, existing research often examines educational technology independently from pedagogy. While digital technologies can provide opportunities for interaction, flexibility, collaboration, and access to information, technology itself does not determine whether meaningful engagement will occur. The pedagogical purpose and instructional design surrounding technology are equally important. There is therefore a need for frameworks that examine technology and pedagogy as interconnected components rather than treating technology as an independent solution.

Third, although learner-centred pedagogy has received considerable attention, its relationship with digital student engagement requires further conceptual and empirical examination. Learner-centred approaches emphasise active participation, autonomy, adaptation to learner needs, relevant skills, shared responsibility, and formative assessment. However, the effectiveness of such

approaches may vary according to educational context, teacher preparedness, learner characteristics, and technological conditions.

Fourth, interaction requires greater attention in digital engagement research. Digital environments can support learner-content, learner-instructor, and learner-learner interaction, but these forms of interaction are not always equally available or effectively designed. There is a need to understand how different forms of interaction contribute to different dimensions of engagement.

Fifth, digital literacy and teacher digital competence are sometimes treated as separate issues rather than as important conditions supporting meaningful engagement. Students need digital skills to participate effectively, while teachers need both technological and pedagogical competence to design engaging digital learning experiences.

6. Proposed Conceptual Framework

The proposed conceptual framework is developed from the synthesis of the reviewed literature. The central assumption of the framework is that student engagement in digital learning does not emerge automatically from the availability of technology. Instead, meaningful engagement is likely to develop when digital technologies are deliberately integrated with learner-centred pedagogy and interactive learning practices.

The framework consists of five interconnected components: digital technology, learner-centred pedagogy, interactive learning, supporting learning conditions, and student engagement.

6.1 Digital Technology

Digital technology represents the enabling environment within which digital learning takes place. It includes learning management systems, online learning platforms, virtual classrooms, multimedia resources, educational applications, collaborative platforms, digital assessment tools, simulations, educational games, and artificial intelligence-supported technologies.

These technologies can increase access to educational resources, provide flexible learning opportunities, facilitate communication, support collaboration, and provide opportunities for immediate feedback.

However, technology is positioned as an enabling factor rather than a direct determinant of engagement. Its contribution depends on how it is integrated into teaching and learning.

6.2 Learner-Centred Pedagogy

Learner-centred pedagogy represents the first major pedagogical component of the framework. It places learners at the centre of the learning process and emphasises active participation, autonomy, individual needs, collaboration, reflection, problem-solving, and responsibility.

In digital environments, learner-centred pedagogy may involve self-paced learning, learner choice, inquiry-based tasks, project-based activities, personalised learning pathways, reflective activities, and opportunities for students to communicate their learning needs.

6.3 Interactive Learning

Interactive learning represents the second major pedagogical component. It creates opportunities for students to interact with content, teachers, and peers.

The framework draws on Moore's (1989) three forms of interaction:

- Learner-content interaction
- Learner-instructor interaction

➤ Learner-learner interaction

These forms of interaction can occur through online discussions, collaborative projects, digital simulations, video conferencing, interactive quizzes, peer feedback, digital assignments, and virtual group activities.

6.4 Supporting Conditions

The framework proposes that learner-centred pedagogy and interactive learning create several supporting conditions:

- Learner autonomy
- Interactivity
- Collaboration
- Personalisation
- Meaningful teacher support
- Access to appropriate digital learning resources
- Digital competence
- Opportunities for feedback and reflection

These conditions provide the immediate learning environment through which technology and pedagogy can influence engagement.

6.5 Student Engagement

The central outcome of the framework is student engagement. Engagement is conceptualised as multidimensional and includes four dimensions.

Behavioural engagement involves participation, effort, attention, persistence, attendance, and involvement in learning activities.

Cognitive engagement involves mental investment, deep learning, critical thinking, problem-solving, self-regulation, and strategic learning.

Emotional engagement includes interest, enjoyment, belonging, confidence, and positive attitudes towards learning.

Agentic engagement involves students' constructive contribution to instruction, including asking questions, expressing preferences, seeking clarification, communicating needs, and contributing ideas.

6.6 Development of 21st-Century Skills

The framework further proposes that meaningful engagement can contribute to broader educational outcomes, particularly the development of 21st-century skills such as critical thinking, creativity, communication, collaboration, problem-solving, self-regulation, digital literacy, and responsible digital citizenship.

Conceptual Relationship

The proposed framework can be represented as follows:

Digital Technology

Learner-Centred Pedagogy + Interactive Learning

Learner Autonomy + Interactivity + Collaboration + Personalisation + Teacher Support + Digital Competence

Student Engagement

Behavioural + Cognitive + Emotional + Agentic Engagement

Meaningful Learning + 21st-Century Skills

The framework should not be interpreted as a rigid or universally linear causal model. Rather, it represents a conceptual relationship among the major elements identified in the literature. Contextual factors such as students' characteristics, teacher competence, institutional support, technological access, and educational policies may influence the strength and nature of these relationships.

The central proposition of the framework is that digital technology creates opportunities for engagement, but learner-centred and interactive pedagogical practices determine how those opportunities are transformed into meaningful learning experiences.

7. Challenges in Promoting Student Engagement in Digital Learning

Although digital learning provides considerable opportunities for student participation, maintaining meaningful and sustained engagement presents several challenges.

7.1 Unequal Access to Technology

The digital divide remains a significant challenge. Students may differ in their access to smartphones, computers, tablets, reliable internet connectivity, electricity, and suitable learning environments. Such inequalities can directly affect participation in digital learning.

Students who experience limited access may be unable to attend virtual classes regularly, download learning resources, participate in interactive activities, or complete digital assignments. Consequently, technological expansion without adequate attention to equity may reproduce existing educational inequalities.

7.2 Limited Digital Competence

Students require appropriate digital skills to participate effectively in technology-supported learning. Limited ability to navigate platforms, evaluate online information, communicate digitally, create content, or solve technical problems may reduce participation.

Digital competence is therefore an important prerequisite for meaningful engagement. Educational institutions need to provide opportunities for students to develop these skills rather than assuming that all learners possess sufficient digital knowledge.

7.3 Inadequate Teacher Preparedness

Teachers play a central role in designing digital learning experiences. However, teachers may differ in their technological knowledge, confidence, training, and pedagogical understanding.

Learning how to operate a digital platform is not sufficient. Teachers also need to understand how technology can support interaction, collaboration, assessment, learner autonomy, and active learning. Inadequate teacher preparation can result in technology being used primarily for content delivery rather than meaningful engagement.

7.4 Digital Distraction

Digital devices provide access to educational resources but also expose students to social media, entertainment, games, advertisements, and other distractions. Students may therefore find it difficult to maintain attention during digital learning.

Purposeful instructional design, clear expectations, interactive activities, and appropriate digital habits are necessary to reduce distraction.

7.5 Information Overload

The abundance of information available online can create difficulties for learners. Students may encounter large quantities of information without knowing which sources are reliable or relevant. Information overload can affect cognitive engagement and make learning more difficult. Students therefore require information and media literacy to evaluate sources and identify credible evidence.

7.6 Reduced Social Interaction

Excessive reliance on online learning may reduce face-to-face communication and contribute to feelings of isolation. Students may experience weaker social connections when digital learning is primarily individual and asynchronous.

Learner-learner and learner-instructor interaction should therefore be deliberately incorporated into digital learning environments.

7.7 Lack of Motivation and Self-Regulation

Digital learning often requires students to manage their own time, attention, and learning activities. Students with limited self-regulation may struggle to maintain regular participation.

Learner autonomy should therefore be accompanied by appropriate structure, teacher guidance, feedback, deadlines, and opportunities for reflection.

7.8 Concerns Regarding Emerging Technologies

Artificial intelligence and other emerging technologies provide opportunities for personalised learning, automated feedback, and academic support. At the same time, excessive dependence on such tools may affect independent thinking, creativity, academic integrity, and students' ability to complete tasks independently.

Responsible integration of emerging technologies requires clear educational purposes, ethical guidance, digital literacy, and teacher supervision.

8. Strategies for Improving Student Engagement

Improving student engagement in digital learning requires a balanced combination of technology, pedagogy, interaction, teacher support, and learner development.

8.1 Purposeful Integration of Technology

Teachers should select digital technologies according to learning objectives rather than using technology simply because it is available. Digital tools should be employed when they provide clear educational value, such as facilitating interaction, collaboration, feedback, practice, inquiry, or access to resources.

8.2 Active Learning

Digital learning should encourage students to think, create, discuss, apply, solve problems, and reflect. Interactive quizzes, case studies, simulations, projects, problem-solving tasks, and digital presentations can encourage active participation.

8.3 Promotion of Learner Autonomy

Students should be given appropriate opportunities to make choices about aspects of their learning. Self-paced resources, independent projects, learner-selected topics, and flexible learning activities can support autonomy and responsibility.

8.4 Meaningful Teacher Support

Teacher presence remains important in digital education. Teachers should provide regular feedback, clarification, encouragement, guidance, and opportunities for communication. Digital technology should therefore complement rather than replace meaningful teacher-student relationships.

8.5 Collaborative Learning

Collaborative digital activities can strengthen peer interaction and social engagement. Group projects, online discussions, peer assessment, shared documents, and virtual collaborative tasks can encourage students to exchange ideas and learn from one another.

8.6 Use of Interactive Multimedia

Videos, animations, simulations, educational games, interactive presentations, and digital quizzes can provide diverse learning experiences. However, multimedia should be linked to learning objectives and accompanied by activities requiring students to process and apply information.

8.7 Personalised Learning

Digital environments can provide opportunities for differentiated instruction and personalised learning. Students may receive different resources, feedback, or levels of difficulty according to their learning needs and progress. Personalisation should be supported by teacher guidance to prevent students from becoming overwhelmed.

8.8 Formative Digital Assessment

Digital assessment tools can provide immediate feedback and help teachers monitor student progress. Online quizzes, polls, digital portfolios, peer assessment, and feedback systems can support continuous assessment and self-regulation.

8.9 Development of Digital Literacy

Students should be taught how to search for information, evaluate sources, communicate responsibly, create digital content, protect personal information, and use emerging technologies ethically. Digital literacy should be integrated into regular learning rather than treated as an isolated skill.

8.10 Continuous Professional Development for Teachers

Teachers require continuous professional development in digital pedagogy. Training should address technology integration, digital instructional design, online interaction, digital assessment, learner-centred approaches, collaborative learning, digital safety, and responsible use of artificial intelligence.

8.11 Creating Inclusive Digital Learning Environments

Educational institutions should consider accessibility and equity when designing digital learning. Learning resources should be available in appropriate formats, platforms should be accessible to diverse learners, and alternative arrangements should be considered for students with limited technological access.

Overall, the literature supports a shift from a technology-centred view of digital education towards a pedagogically centred perspective. The important question is not simply whether technology is

being used but whether technology is being used to create opportunities for active participation, meaningful interaction, autonomy, collaboration, reflection, and deeper learning.

Yes. Here is a more concise, academically written version of the Discussion, designed to fit approximately one page, while retaining the key theories, citations, framework relationships, digital competence, and contextual factors.

9. Discussion

The synthesis of literature indicates that student engagement in the digital era is a complex and multidimensional phenomenon extending beyond visible participation in online activities. It includes behavioural, cognitive, emotional, and agentic dimensions. Fredricks et al. (2004) identified behavioural, cognitive, and emotional engagement, while Reeve and Tseng (2011) further recognised agentic engagement, emphasising students' active contribution to the learning process.

Digital technologies provide opportunities for participation, communication, collaboration, information access, feedback, and interactive learning. However, technology alone does not guarantee meaningful engagement. Nkomo et al. (2021) highlighted variations in the conceptualisation and measurement of digital engagement, indicating the need to distinguish technological activity from genuine cognitive and emotional involvement in learning.

The proposed framework therefore positions learner-centred pedagogy and interactive learning between digital technology and student engagement. Technology creates learning opportunities, whereas pedagogy determines how these opportunities are utilised. Learner-centred approaches promote autonomy, active participation, choice, collaboration, and responsibility, consistent with the findings of Bremner et al. (2022).

Interaction is also central to meaningful digital engagement. Moore's (1989) framework identifies learner-content, learner-instructor, and learner-learner interaction. These forms support independent exploration, teacher guidance and feedback, and peer collaboration respectively. A balanced combination of these interactions can contribute to a more engaging and socially connected learning environment.

The framework further emphasises teacher and student digital competence. The TPACK perspective of Mishra and Koehler (2006) highlights the integration of technology, pedagogy, and content, indicating that effective digital teaching requires more than technical skills. Similarly, student digital competence involves the ability to access, evaluate, create, communicate, and use digital information responsibly, as reflected in the DigComp 2.2 framework. Thus, digital competence and engagement have a reciprocal relationship: digital competence supports effective participation, while meaningful digital learning can further develop such competence.

The effectiveness of digital learning also depends on contextual conditions, including technology access, teacher preparedness, institutional support, learner characteristics, digital competence, and educational policies. Therefore, the proposed relationships may differ across educational contexts. Overall, the literature supports a shift from a technology-centred to a pedagogically centred approach. The value of digital technology lies not simply in its use, but in its capacity to support active participation, meaningful interaction, autonomy, collaboration, reflection, and deeper learning. The proposed framework integrates these elements to provide a comprehensive basis for understanding student engagement in digital learning environments.

This version keeps the important academic points without the repetition, making it more suitable for a one-page research paper section.

10. Educational Implications

The proposed conceptual framework has implications for teachers, teacher educators, educational institutions, curriculum planners, researchers, and policymakers.

Teachers should use digital technologies purposefully and align them with learning objectives. Digital activities should promote participation, discussion, collaboration, problem-solving, creativity, reflection, and communication rather than simply replace traditional teaching.

Educational institutions should provide adequate digital infrastructure, reliable connectivity, technical support, and learning resources, along with appropriate pedagogy and professional development.

Teacher education programmes should develop digital pedagogical competence and prepare teachers to integrate technology with learner-centred, interactive, collaborative, and formative learning practices.

Curriculum planners should include digital literacy and 21st-century skills such as critical thinking, creativity, communication, collaboration, problem-solving, self-regulation, and responsible digital citizenship.

The digital divide should also be addressed, as providing devices alone is insufficient without internet access, technical support, digital competence, and suitable learning environments. Digital learning should also maintain meaningful teacher–student and peer relationships by strengthening communication, collaboration, and feedback.

Finally, policymakers should support sustained digital transformation through infrastructure, teacher development, curriculum reform, digital literacy, accessibility, and appropriate guidelines for emerging technologies.

11. Future Research Directions

The proposed conceptual framework provides several directions for future research. Empirical studies can examine the relationships among digital technology, learner-centred pedagogy, interactive learning, and the behavioural, cognitive, emotional, and agentic dimensions of student engagement. Longitudinal research is also needed to determine whether digital learning supports sustained engagement and meaningful learning.

Future studies should use multiple methods, including questionnaires, interviews, observations, learning analytics, digital activity data, and academic performance measures. Research should also examine the role of artificial intelligence in personalised learning and feedback, while considering its effects on independent thinking, self-regulation, academic integrity, and learner autonomy.

Comparative studies could explore digital engagement across educational levels, subjects, geographical settings, socioeconomic backgrounds, and learning environments. Further research should examine the influence of teacher digital competence, including technological and pedagogical knowledge, training, confidence, and attitudes, on student engagement.

Finally, future research should investigate the relationship between digital engagement and 21st-century skills such as critical thinking, creativity, collaboration, communication, problem-solving, self-regulation, and digital citizenship. Empirical testing of the proposed framework could also examine mediating and moderating factors such as digital competence, teacher support, learner autonomy, technological access, motivation, socioeconomic background, and institutional support.

12. Conclusion

Digital technology has transformed education by expanding opportunities for teaching, learning, communication, collaboration, and participation. However, technology alone does not ensure meaningful student engagement.

The literature shows that engagement is multidimensional, comprising behavioural, cognitive, emotional, and agentic dimensions. The proposed framework connects digital technology with learner-centred pedagogy and interactive learning, highlighting autonomy, collaboration, interaction, teacher support, digital competence, and formative feedback as important conditions for meaningful engagement.

Students should therefore be viewed as active participants who contribute to and construct their learning. At the same time, challenges such as unequal access, limited digital competence, inadequate teacher preparedness, distraction, information overload, and self-regulation difficulties require appropriate pedagogical, institutional, and policy support.

Overall, the educational value of technology depends on its meaningful integration with pedagogy, interaction, and learner participation. The proposed framework provides a theoretical basis for understanding these relationships and supports future empirical research on sustained and meaningful student engagement in digital learning environments.

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Educational Research and Innovation: Catalysts for Systemic Pedagogical Transformation

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Abstract

Educational research and innovation constitute the primary catalysts for modernizing teaching and learning paradigms across global educational landscapes. As societies navigate rapid digital transformation, economic shifts, and changing cognitive demands, traditional instructional frameworks prove insufficient. This paper examines the intrinsic relationship between systematic educational research and localized pedagogical innovation. By evaluating international benchmarks such as those promoted by the OECD Centre for Educational Research and Innovation (CERI) and regional structural reforms like India's National Education Policy 2020, this study explores how institutional research cultures can be systematically cultivated to drive sustainable, equitable, and evidence-based educational practices (OECD, 2023).

Keywords: *educational innovation, educational research, pedagogy, systemic reform, policy integration*

Introduction

The twenty-first century has introduced complex challenges to formal and informal education systems, demanding an urgent transition from static knowledge transmission to dynamic capability building (Fullan, 2016). Historically, educational research operated in academic isolation, producing theoretical treatises that rarely translated into operational classroom improvements. Concurrently, educational innovation often occurred as unvetted, gadget-driven experimentation without empirical backing (Hargreaves, 2003). Bridging this historical divide requires an integrated approach where rigorous scientific inquiry informs innovative practice, and grassroots innovations feed back into empirical research models. This symbiosis is essential for cultivating educational institutions capable of fostering critical thinking, adaptability, and lifelong learning.

Theoretical Dimensions of Educational Innovation

Educational innovation is not merely the introduction of novel technological artifacts or administrative reshuffling; it represents a fundamental reconceptualization of pedagogical relationships and epistemological assumptions (Zhao, 2018). Innovation models must be grounded in constructivist and socio-cultural theories of learning, ensuring that new practices elevate student agency and cognitive depth rather than operational speed alone (Vygotsky, 1978). When research investigates innovation, it must evaluate variables such as learner motivation, equitable access, teacher professional identity, and the systemic alignment of the curriculum (Koehler & Mishra, 2009). Without a robust theoretical core, innovations risk becoming transient fads that dissipate upon the exhaustion of initial funding or administrative support.

Systemic Research Frameworks and Policy Integration

Systematizing innovation requires robust national and international policy frameworks that provide financial backing, institutional autonomy, and collaborative networks. For instance, the establishment of centralized funding entities such as the National Research Foundation under India's National Education Policy 2020 exemplifies how nations attempt to build a coherent culture of research and development across disciplines (Ministry of Education [MoE], 2020). Internationally, initiatives by the OECD Centre for Educational Research and Innovation (CERI) demonstrate the value of cross-border comparative data, tracking emerging trends in teaching, learning, and assessment (OECD, 2021). These policy structures democratize access to empirical insights, allowing under-resourced institutions to implement validated pedagogical enhancements without starting from zero. Furthermore, building active linkages between universities, research laboratories, and industry incubators accelerates the translation of deep-tech and methodological innovations into everyday classroom realities.

Addressing Institutional Bottlenecks

Despite clear policy intentions, systemic educational research and innovation face formidable barriers. Institutional inertia within traditional universities and schools frequently penalizes pedagogical risk-taking, favoring standardized testing outcomes over creative inquiry and multi-disciplinary problem solving (Tyack & Cuban, 1995). Moreover, a persistent disconnect remains between educational researchers and frontline practitioners, often due to academic language barriers and lack of dedicated time for teachers to engage in action research (Cochran-Smith & Lytle, 2009). Overcoming these roadblocks demands distributed leadership, ongoing professional development that treats teachers as active researchers rather than passive recipients of reform, and safe institutional sandboxes where experimental instructional designs can be tested, analyzed, and refined without punitive evaluation metrics.

Conclusion

Educational research and innovation are inseparable components of sustainable educational development. To meet the complex demands of the modern era, educational institutions must move past isolated pilot projects and embed a continuous, evidence-based culture of inquiry into their foundational operations. By aligning localized practices with international comparative frameworks, fostering multi-disciplinary funding structures, and empowering educators as active research partners, the global educational community can construct resilient, equitable, and future-ready learning ecosystems.

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Effect of Physical Exercise and Yoga Practices on Stress Self-Confidence and Blood Pressure

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Abstract

The aim of this study was to investigate the impact of physical exercise and yoga on stress levels, self-confidence, and blood pressure (systolic and diastolic). To achieve this, forty-five working women aged 35 to 40 from Virudhachalam town, Tamil Nadu, were chosen. They were split into three equal groups ($n = 15$), with each group having fifteen subjects; group I participated in physical exercise, group II engaged in yoga practice, and group III served as the control group, which did not take part in any specific training. The duration of training for this research was six days a week over a span of twelve weeks. Before and after the training phase, the participants were evaluated for self-confidence and blood pressure (systolic and diastolic). Stress was evaluated utilizing the Girdano and Everly Stress Scale, self-confidence was measured with the Agnihotri Self-Confidence Inventory (ASCI), and blood pressure was determined using a sphygmomanometer. The analysis of covariance (ANCOVA) was employed to determine if there were significant differences among the experimental groups and the control group on chosen criterion variables individually. As three groups were part of this study, the Scheffé S test was utilized as a post-hoc analysis. The study's results indicated that physical exercise and yoga practice have positively impacted the criterion variables, including stress, self-confidence, and both systolic and diastolic blood pressure. The study's results also indicated that no significant difference was observed between the experimental groups, including the physical exercise group and the yoga practice group.

Keywords: *yoga practice, physical exercise, stress, self-confidence, systolic and diastolic blood pressure.*

Introduction

Wellbeing refers to the extent of functional and metabolic efficiency of an organism. In individuals, the primary concern is their overall condition, encompassing both body and spirit, typically focused on being free from illness, harm, or suffering (referred to as "healthy" or "sound"). In 1946, the World Health Organization (WHO) defined health in a broad sense as "a state of total physical, mental, and social well-being and not merely the absence of illness or infirmity." Physical exercise is a term that denotes any form of physical activity aimed at enhancing or preserving health, well-being, and overall wellness [1]. Physical exercise is also associated with a positive effect on depression, anxiety, mood, self-esteem, and improved academic performance [2]. Engaging in physical activity is considered crucial for maintaining physical health, which includes managing a healthy weight; developing and sustaining strong bones, muscles, and joints; enhancing overall wellness; lowering the chances of surgical complications; and boosting the immune system. Certain studies indicate that physical activity may also increase lifespan and the overall quality of life [3].

Physical activity in the context of outdoor sports, gyms, and athletics displaying physical endurance and strength dates back to the early 18th century [4], when these activities were primarily engaged in for leisure. They are further validated by medical science as therapeutic tools for the prevention and treatment/correction of health issues [5]. The term yoga is derived from Sanskrit and signifies union or combination. A central aspect of this mindset is to establish a balance between the mind and body, resulting in personal enlightenment. To achieve this, yoga employs movement, breathing, posture, relaxation, and meditation to establish a healthy, energetic, and balanced approach to living [6]. Joshi (1986) [7] states that our breaths are limited and our lifespan is tied to how many times we breathe throughout our lives; thus, in light of this truth, we should reduce the number of breaths to extend our lives, which led to the origin of pranayama.

Women's fitness in India can be assessed through various indicators that differ based on geography, socioeconomic status, and culture [21]. To enhance the fitness of girls in India, various aspects of wellness must be assessed against global fitness benchmarks and also in comparison with boys in India. Health is a crucial issue that affects personal wellness and economic progress. Currently, women in India face several fitness obstacles, which ultimately affect the overall economic performance. Addressing gender, category, or ethnic disparities in healthcare and enhancing fitness results can result in economic benefits by nurturing outstanding human capital and increasing savings and investment levels [22]. Stress is defined as a shift that results in physical, emotional, or mental strain. Stress is the body's reaction to anything that requires focus or action. All individuals feel pressure to a certain degree. How he/she reacts to stress, regardless of the situation, greatly affects your overall wellness. In specific circumstances, the most effective approach to managing stress includes modifying the surroundings. In many cases, the best approach is to change how the person reacts to the circumstances [8]. Blood pressure (BP) is the force exerted by circulating blood against the walls of blood vessels and is regarded as one of the primary vital signs. With each heartbeat, blood pressure varies between a maximum (systolic) and a minimum (diastolic) pressure [9]. Self-assurance is a mindset regarding your skills and capabilities. It suggests trusting and relying on others while feeling a sense of control over life. The person should understand their strengths and weaknesses well and maintain a positive outlook on themselves. Establish realistic assumptions and goals, communicate assertively, and manage analysis effectively [10].

Methods

This research focuses on testing the effects of physical exercise and yoga on stress, self-esteem, and blood pressure (both systolic and diastolic). Only middle-aged employed women, specifically those working as school teachers, in the Virudhachalam town area of Tamil Nadu State and aged between 35 and 40 years, were chosen. Forty-five participants were randomly chosen and allocated into three groups of fifteen participants per group; group - I (n = 15) engaged in physical exercise, group - II (n = 15) practiced yoga, and group - III (n = 15) served as the control group. The training program took place for six days a week (Monday to Saturday) in the morning session only (6 am to 8 am) over a duration of twelve weeks. Stress was evaluated through a sit-ups test, self-confidence was gauged using Muktha Rani Rasthogi's self-confidence scale, and blood pressure was recorded with a sphygmomanometer.

Analysis of Data

The data collected prior to and after the experimental periods on stress, self-confidence and blood pressure (systolic and diastolic) on physical exercise group, yoga practice group and control group were analysed and presented in the following table - I.

Table I - Analysis of Covariance and 'F' ratio for Stress, Self-confidence and Blood Pressure (systolic and diastolic) for Physical exercise Group, Yoga Practice Group and Control Group

Variable Name	Group Name Test $\pm$ S.D	Physical Exercise Group	Yoga Practice Group	Control Group	'F' Ratio
Stress (in nos./min)	Pre-test Mean $\pm$ S.D	22.87 $\pm$ 1.85	21.87 $\pm$ 1.83	23.20 $\pm$ 2.54	1.63
	Post-test Mean $\pm$ S.D.	20.40 $\pm$ 2.44	19.40 $\pm$ 2.12	23.67 $\pm$ 2.16	13.49*
	Adj. Post-test Mean	20.225	20.013	23.226	16.35*
Self – confidence (in points)	Pre-test Mean $\pm$ S.D	29.13 $\pm$ 1.36	28.60 $\pm$ 1.30	28.47 $\pm$ 1.13	1.17
	Post-test Mean $\pm$ S.D.	26.93 $\pm$ 1.34	26.40 $\pm$ 1.18	28.20 $\pm$ 1.08	8.84*
	Adj. Post-test Mean	26.688	26.482	28.364	18.03*
Systolic Blood Pressure (in mmHg)	Pre-test Mean $\pm$ S.D	132.47 $\pm$ 3.68	134.20 $\pm$ 2.68	134.20 $\pm$ 2.40	1.70
	Post-test Mean $\pm$ S.D.	130.40 $\pm$ 3.58	131.60 $\pm$ 2.70	134.93 $\pm$ 2.72	9.05*
	Adj. Post-test Mean	131.531	131.081	134.496	42.56*
Diastolic Blood Pressure (in mmHg)	Pre-test Mean $\pm$ S.D	95.80 $\pm$ 2.04	94.20 $\pm$ 1.86	94.93 $\pm$ 2.40	2.15
	Post-test Mean $\pm$ S.D.	93.80 $\pm$ 2.11	91.53 $\pm$ 2.13	94.87 $\pm$ 2.20	9.42*
	Adj. Post-test Mean	93.026	92.265	94.906	41.03*

* Significant at .05 level of confidence. (The table value required for significant at .05 level with df 2 and 42 and 2 and 41 are 3.22 and 3.23 correspondingly).

Table – I displays the 'f' - ratio values of pre-test mean of stress for physical exercise group, yoga practice group and control group was 1.63, which was less significant. The 'f' - ratio of post- and adjusted post-test means were 13.49 and 16.35 was superior to the requisite table value of 3.23 for significance with df 2 and 41 at .05 level of confidence. The result of this study showed that there was a significant dissimilarity among physical exercise group, yoga practice group and control group on stress. The above table shows the 'f' - ratio values of pre-test mean of self-confidence for physical exercise group, yoga practice group and control group was 1.17, which was less significant. The 'f' - ratio of

post- and adjusted post-test mean was 8.84 and 18.03, which was superior to the requisite table value of 3.23 for significance with df 2 and 41 at .05 level of confidence.

Table – I shows the ‘f’ - ratio values of pre-test mean of systolic blood pressure for physical exercise group, yoga practice group and control group was 1.70, which was not significant at 0.05 level of confidence. The ‘f’ - ratio of post- and adjusted post-test means was 9.05 and 42.56 was superior to the requisite table value of 3.23 for significance with df 2 and 41 at .05 level of confidence. The above table shows the ‘f’ - ratio values of pre-test mean of diastolic blood pressure for physical exercise group, yoga practice group and control group was 2.15, which was not significant at 0.05 level of confidence. The ‘f’ ratio of post and adjusted post-test means was 9.42 and 41.03 was superior to the requisite table value of 3.23 for significance with df 2 and 41 at .05 level of confidence.

The result of this study showed that there was a significant dissimilarity among physical exercise group, yoga practice group and control group on stress. Further to determine which of the paired means has a significant difference, Scheffé S test was applied as post-hoc test. The result of the follow-up test is presented in Table - II.

Table II - Scheffé S Test for the Difference Between the Adjusted Post-Test Means of Stress, Self-confidence and Blood Pressure (systolic and diastolic)

Adjusted Post-test Mean of Stress				
Physical Exercise Group	Yoga Practice Group	Control Group	Mean Difference	CI
20.225	20.013		0.212	1.567
20.225		23.226	3.001*	1.567
	20.013	23.226	3.213*	1.567
Adjusted Post-test Mean of Self-confidence				
26.688	26.482		0.206	0.866
26.688		28.364	1.676*	0.866
	26.482	28.364	1.882*	0.866
Adjusted Post-test Mean of Systolic Blood Pressure				
131.531	131.081		0.45	0.990
131.531		134.496	2.965*	0.990
	131.081	134.496	3.415*	0.990
Adjusted Post-test Mean of Diastolic Blood Pressure				
93.206	92.265		0.941	0.762
93.206		94.906	1.70*	0.762
	92.265	94.906	2.641*	0.762

* Significant at 0.05 level of confidence.

Results

After applying the analysis of covariance, the result of this study showed that there was a significant difference among physical exercise, yoga practice and control groups on the changes in stress, self-confidence and blood pressure after twelve weeks of training. The criterion variables such as, stress and self-confidence was improved for both the physical exercise group and yoga practice group and systolic and diastolic blood pressure has significantly decreased after the physical exercise, yoga practice period. Basically the physical exercise and yoga practice has tremendously improves the physical fitness, physiological and psychological variables.

Conclusions

Emery and colleagues (2005) [11] discovered a notable decrease in stress following the physical exercise program. Engaging in physical activity may lower cortisol levels, a hormone associated with stress, and enhance the immune system [12,13]. Choi et al. (2019) [14] discovered a notable reduction in stress following the yogic practice regimen. Moreover, the result of the study shows that there was no significant difference was found between the experimental groups. Daily routine physical exercise or yoga practice may also improve the self-esteem or self-confidence [15]. The physical exercise group and yoga practice group has significantly decreased the systolic and diastolic blood pressure when compared with the control group. A research produced that there was a significant reduction in systolic and diastolic blood pressure after physical exercise and yoga practices among middle aged working women [16]. Walking exercise also reduces the systolic and diastolic blood pressure because performing any continuous activity can increase the energy expenditure and improves the body working condition [17,18]. Some research studies found that there was a significant decrease in blood pressure, both in systolic and diastolic due to the yoga practice [19,20].

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The e-Learning Revolution: Five Emerging Trends Shaping

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Abstract

Emerging technologies (ETs), including artificial intelligence (AI), block chain, non-fungible tokens (NFTs), the Internet of Things (IoT), augmented reality (AR), virtual reality (VR), mixed reality (MR), extended reality (XR), robotics, and 3D printing, have greatly impacted education. While these technologies are commonly used in informal learning, their application in formal education remains under explored. This systematic review addresses this gap by analyzing the effective use of these technologies in formal education. The study identifies gaps in technology adoption arising from economic status, infrastructure, and digital literacy challenges. It highlights the benefits of mobile apps and Learning Management Systems (LMS) in enhancing information retrieval, communication, and learning support. Challenges include the need for pedagogical skills, ICT competencies, and information literacy. Additionally, the study explores the potential of adaptive learning technologies and personalized learning environments to transform education by tailoring experiences to individual needs. Effective technology integration in education provides valuable insights for educators, policymakers, and researchers, highlighting strategies to overcome existing challenges and improve educational outcomes. 21st Century Learning demands exercising Higher-Order Thinking Skills in the process of both teaching and learning. Among the Higher order thinking skills (HOTS), Critical Thinking, Creative Thinking, Collaboration, and Communication (4Cs) are so essential and need to be included consistently on a daily basis. Students who were exposed to these 4Cs have proven their efficiency through mastery of the given content and problem-solving.

Introduction

The e-Learning industry is evolving rapidly, driven by technological advancements and changing learner needs. In 2025 -2026, key trends like AI-powered personalization, micro learning, gamification, hybrid learning models, and social learning are reshaping online education. The world of e-Learning has been rapidly evolving, and as we venture into 2025, its transformation shows no signs of slowing down. For e-Learning professionals, students, and educators, staying ahead of the curve is crucial to leveraging new technologies and methodologies that can enhance the learning experience. This article explores the top trends in e-Learning for 2025-2026, offering insights and practical tips to help you stay informed and prepared for what lies ahead. In this article, we'll dissect the emerging technologies, innovative teaching methods, and shifts in educational paradigms that are set to redefine e-Learning. You'll gain a deeper understanding of how these trends can improve learner engagement, accessibility, and overall effectiveness. Read on to discover the future of education and how you can be part of this exciting journey.

The e-Learning Revolution: Five Emerging Trends Shaping

The e-Learning industry is undergoing a dynamic transformation as we move through 2025-2026. Driven by rapid advances in technology and shifting learner expectations, online education is now more engaging, accessible, and outcome-focused than ever before. From Artificial Intelligence (AI) to immersive technologies, modern e-Learning platforms are redefining how knowledge is delivered and consumed across disciplines, from web development with the

MERN stack to financial risk management. Let's explore the five most impactful emerging trends shaping this exciting landscape and see how they are being implemented in real-world learning environments.

AI-Powered Personalized Learning Paths

Artificial Intelligence is no longer just a buzzword in the e-Learning space; it has become the backbone of modern educational platforms. AI-driven systems are now capable of analyzing each learner's progress, preferences, and performance to deliver a truly personalized learning experience. These platforms can recommend the next best course (for example, suggesting data structures and algorithms with Python after a student completes basic Python modules), adjust the difficulty level of exercises in real time (especially useful in competitive programming), and even provide virtual tutoring for complex topics like Machine Learning.

Personalized Learning Pathways

When leveraging Artificial Intelligence (AI) in eLearning, one compelling aspect is how it can tailor educational experiences to individual needs. According to recent Artificial Intelligence statistics, over 60% of educators believe that AI-driven personalized learning pathways significantly enhance student engagement and knowledge retention. AI can identify strengths and weaknesses, recommending specific resources and activities to optimize learning outcomes. This level of personalization ensures that each learner receives the support they need to succeed, making education more effective and inclusive.

Intelligent Tutoring Systems

Intelligent tutoring systems (ITS) use AI to provide real-time feedback and support to students. These systems can simulate one-on-one tutoring sessions, offering personalized guidance and answering questions as they arise.

Automated Administrative Tasks

AI can also streamline administrative tasks, reducing the workload for educators and allowing them to focus on teaching. Automated grading, attendance tracking, and course management are just a few examples of how AI can enhance efficiency in eLearning environments. By automating these tasks, educators can dedicate more time to developing innovative teaching methods and supporting their students.

Virtual and Augmented Reality

Virtual Reality (VR) and Augmented Reality (AR) are transforming eLearning by creating immersive learning experiences that engage students in new and exciting ways. VR can transport learners to different environments, allowing them to explore complex concepts and scenarios first hand. AR, on the other hand, overlays digital information onto the real world, providing interactive and contextually relevant content.

Enhanced Collaboration

AR and VR can also facilitate collaboration by enabling students to work together in virtual environments. Group projects, discussions, and problem-solving activities can all be conducted in VR, fostering a sense of community and teamwork among learners. This level of interaction can

help bridge the gap between remote and in-person learning, creating a more cohesive educational experience.

Real-World Applications

Incorporating AR and VR into eLearning in 2025 can help students apply their knowledge in real-world situations. For example, medical students can practice surgical procedures in a virtual environment, while engineering students can design and test structures using AR. These hands-on experiences can enhance understanding and retention, preparing students for their future careers.

Micro-Credentials and Skill-Specific Learning

As the job market becomes increasingly dynamic, the demand for focused, career-relevant skills is higher than ever. This has led to the rise of micro-credentials—short, skill-specific certifications that can be earned quickly and stacked to create a customized skillset. Learners now pursue nano-degrees in high-demand fields such as DevOps, Web3, and cloud computing, or combine modular courses like SQL and Power BI to tailor their expertise for specific roles.

Real-world impact

Consider marketing professional who needs to master Google Analytics for their job. Instead of enrolling in a semester-long program, they can now complete a 20-hour micro-course and immediately apply those skills at work. This modular, stackable approach empowers learners to adapt quickly to new technologies and changing job requirements, making them more competitive in the workforce.

Micro learning

Micro learning delivers content in small, manageable chunks, making it easier for learners to absorb and retain information. This approach is particularly effective for busy professionals who may not have the time to commit to long courses. By breaking down complex topics into bite-sized modules, micro learning ensures that learners can make progress at their own pace. One of the key benefits of micro learning is its flexibility. Learners can access content anytime, anywhere, using their preferred devices. This accessibility makes it easier for individuals to fit learning into their busy schedules, increasing engagement and participation. Micro learning can also be tailored to different learning styles, ensuring that all students can benefit from the content.

Increased Engagement

Micro learning can boost engagement by incorporating interactive elements, such as quizzes, videos, and gamified activities. These features make learning more enjoyable and can help reinforce key concepts. By keeping learners engaged, micro learning can improve retention and overall learning outcomes.

Gamification

Gamification involves incorporating game-like elements into eLearning to motivate and engage students. Points, badges, leader boards, and rewards can all be used to encourage participation and perseverance. By making learning fun and competitive, gamification can help students stay motivated and invested in their education. Gamified e-Learning can also help students develop crucial skills, such as problem-solving, critical thinking, and teamwork. By presenting challenges and obstacles that require creative solutions, gamification encourages

learners to think outside the box and collaborate with their peers. These skills are essential for success in both academic and professional settings.

Real-Time Feedback

One of the key advantages of gamification is the ability to provide real-time feedback. Learners can instantly see their progress and identify areas for improvement, allowing them to adjust their strategies and continue working towards their goals. This immediate feedback can enhance the learning experience and help students stay on track.

Mobile Learning

Mobile learning, or m-Learning, leverages smartphones and tablets to deliver educational content anytime, anywhere. This flexibility is particularly beneficial for students and professionals with busy schedules, as it allows them to fit learning into their daily routines. By making education more accessible, m-Learning can increase participation and engagement.

Responsive Design

To ensure a seamless mobile learning experience, eLearning platforms must adopt responsive design principles. Content should be optimized for different screen sizes and orientations, ensuring that learners can access materials easily on any device. By prioritizing User Experience, e-Learning providers can enhance the effectiveness of their mobile offerings.

Interactive Features

Mobile learning can incorporate interactive features, such as touch-based navigation, multimedia content, and gamified elements. These features can make learning more engaging and enjoyable, helping students stay motivated and focused. By leveraging the unique capabilities of mobile devices, eLearning providers can create a more dynamic and immersive educational experience.

Immersive Technologies in Practical Training

Immersive technologies—such as Virtual Reality (VR), Augmented Reality (AR), and interactive 3D environments—are revolutionizing hands-on learning. These tools provide engaging, risk-free environments for learners to practice real-world skills and scenarios that would be difficult, expensive, or dangerous to replicate in traditional classrooms.

Virtual labs

These are now common in app development and React Native training, allowing students to build and test applications in simulated environments.

AR simulations

These help UI/UX designers' prototype and test interfaces, offering instant feedback and the ability to iterate quickly.

3D environments

These are used for financial modelling, enabling learners to visualize complex data and scenarios in a more intuitive way.

Case study

Some C++ courses have integrated browser-based coding sandboxes with real-time compiler feedback. This eliminates the need for complex software setup, allowing beginners to focus on learning core programming concepts and experiment freely, which boosts both confidence and skill retention.

Community-Driven Learning Ecosystems

Learning is no longer a solitary endeavour. Modern e-Learning platforms are building vibrant, collaborative communities that extend education beyond the digital classroom. Features like peer code reviews in web development, live trading sessions for stock market courses, and design critique groups are now standard.

Data-Driven Decision Making

Data-driven decision making involves using analytics and insights to inform instructional strategies and improve learning outcomes. E-Learning platforms can collect data on student performance, engagement, and behavior, providing valuable information for educators. By analyzing this data, educators can identify trends, pinpoint areas for improvement, and tailor their teaching methods to better meet the needs of their students.

Personalized Learning Experiences

Data can also be used to create personalized learning experiences that cater to individual needs and preferences. By analyzing student data, eLearning platforms can recommend specific resources, activities, and assessments that align with each learner's unique strengths and weaknesses. This level of personalization can enhance engagement and improve overall learning outcomes.

Continuous Improvement

Continuous improvement is a key principle of data-driven decision making. By regularly collecting and analyzing data, eLearning providers can identify areas for enhancement and implement changes to improve the learning experience. This iterative process ensures that eLearning platforms remain effective and relevant, meeting the evolving needs of students and educators.

Social Learning

Social learning emphasizes the importance of collaboration and interaction in the learning process. E-Learning platforms can create collaborative learning environments where students can work together on projects, participate in discussions, and share resources. This sense of community can enhance motivation and engagement, helping learners stay connected and invested in their education.

Peer-to-Peer Learning

Peer-to-peer learning involves students teaching and learning from one another. e-Learning platforms can facilitate peer-to-peer learning by providing opportunities for students to share their knowledge and expertise. This collaborative approach can help students develop communication and teamwork skills, while also reinforcing their understanding of key concepts.

Social Media Integration

Integrating social media into e-Learning in 2025 can further enhance the social learning experience. Platforms like Facebook, Twitter, and LinkedIn can be used to create online communities where students can connect, share resources, and participate in discussions. By leveraging the power of social media, eLearning providers can create a more engaging and interactive learning environment.

Adaptive Learning

Adaptive learning uses technology to create personalized learning paths that adjust to each student's needs and progress. By continuously monitoring performance and providing tailored feedback, adaptive learning systems can ensure that learners receive the support they need to succeed. This personalized approach can help students stay motivated and achieve better outcomes. Adaptive learning systems can make real-time adjustments to the learning experience based on student performance. For example, if a student is struggling with a particular concept, the system can provide additional resources and activities to help them master the material. This level of responsiveness ensures that learners receive the support they need when they need it most.

Improved Retention

One of the key benefits of adaptive learning is improved retention. By providing personalized support and continuously adjusting the learning experience, adaptive learning systems can help students retain information more effectively. This can lead to better long-term outcomes and a deeper understanding of the material.

Block chain in Education

Block chain technology offers a secure and transparent way to manage educational credentials. By storing credentials on a block chain, institutions can ensure that they are tamper-proof and easily verifiable. This can help reduce fraud and streamline the credentialing process, making it easier for students and employers to verify qualifications. Block chain can also be used to create decentralized learning records that follow students throughout their educational journeys. These records can include information on courses completed, skills acquired, and achievements earned. By providing a comprehensive and secure record of learning, block chain can help students showcase their abilities and unlock new opportunities.

Increased Trust and Transparency

One of the key advantages of block chain technology is its ability to increase trust and transparency in the education system. By providing a secure and tamper-proof record of learning, block chain can help build confidence in educational credentials and reduce the risk of fraud. This increased trust can benefit students, educators, and employers alike.

Notable development

Many data analytics programs have integrated Slack or Discord communities where students collaborate on real-world datasets, share resources, and solve problems together—mirroring the teamwork found in professional analytics environments. These ecosystems foster knowledge sharing, networking, and peer support, making learning more social, interactive, and enjoyable.

Hybrid Skill Stacks for Future-Proof Careers

The most successful learners in 2025 are those who combine technical skills with soft skills and interdisciplinary knowledge. Employers increasingly seek professionals who can bridge gaps between domains, communicate effectively, and adapt to new challenges. Popular hybrid combinations include:

- React JS expertise paired with communication and teamwork skills.
- Tableau data visualization combined with storytelling techniques.
- AI tools proficiency merged with ethical application awareness.

Emerging career stacks

Java + financial risk management for FinTech developers, and Machine Learning + technical analysis for quantitative traders are two examples of hybrid stacks that are in high demand.

Four Cs

It is clear that the “Four Cs” needs to be fully integrated into classrooms, schools, and districts around the country to produce citizens and employees adequately prepared for the 21st century. Amongst those skills four of them are named by experts the super skills for the 21st Century. These four Cs of Education, as we call them, include critical thinking, communication, collaboration and creativity. In this tool you can tag each of your activities with one or more of the four Cs for Education.

Critical thinking

Critical thinking, closely linked to problem-solving, can be understood as the ability to apply a number high-order thinking levels including interpreting, analysing, synthesising, evaluating, as well as constructing new ideas. Instead of putting the focus just on memorisation, teachers must equip students with the skills to understand and solve real-world problems. Students must be encouraged to create and implement their designs or solutions. They must get the chance to generate ideas, procedures and alternatives. Building critical thinking skills will help students to be successful in a complex society.

Creativity

Creativity and being a creative thinker allow students to be able to deal with problems which may not have been invented yet. Consequently, schools should allow students to acquire the ability to think divergently, which means to come up with a few options of a solution for the problems that they face.

Communication

Skilled communication means the ability to get your desired message effectively sent to your target audience. Communication skills have always been important, but the ubiquitous presence of digital media and communication channels has made the need for effective communication more apparent than ever. We have the ability to reach wide audiences and have a plethora of tools and channels at our disposal, spoken, written, visual or multimodal, in print or digitally. Students need to acquire the skills, not only to use different ways of expressing themselves and building a dialogue, but also to reach high standards in the many other aspects related to skilled communication.

Collaboration

Learning occurs more and more in a collaborative setting with students being together in a learning journey. Moreover, employers require from prospective employees collaboration skills to perform in team work. Real collaboration takes place when students of a team have a shared responsibility to reach the common goal like discussing an issue, solving a problem or creating a product. High-level collaboration can also be increased when giving group members ownership about how they showcase their learning. Students need to acquire the skills of negotiation, conflict resolution, listening to others and developing a common strategy to be empowered for their future careers. Which is one of the key characteristics required nowadays. Our society is constantly changing and therefore our students need to have the skills to adapt to new realities.

Conclusion

The Future is Adaptive and Integrated, the emerging trends shaping eLearning in 2025 - 2026 demonstrate that effective online education must be:

- Personalized through AI-powered learning paths.
- Modular and stackable with micro-credentials.
- Experiential via immersive technologies.
- Community-oriented for collaborative growth.
- Interdisciplinary to build future-proof careers.

For learners, this means unprecedented opportunities to build customized, relevant skill portfolios. As technology and pedagogy continue to evolve, the most successful eLearning platforms will integrate these emerging trends, delivering flexible, engaging, and outcome-driven education for all. The future of e-Learning is bright, with innovative technologies and methodologies set to transform the educational landscape by 2025. From AI and VR to micro learning and block chain, these trends offer exciting opportunities to enhance the learning experience for students, educators, and eLearning professionals. By staying informed and adapting to these changes, you can ensure that you remain at the forefront of this rapidly evolving field.

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Transforming Education Through E-learning and Virtual Learning Environments

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Abstract

The rapid evolution of Information and Communication Technology (ICT) has initiated a philosophical and physical shift in global education systems. This paper explores how E-learning platforms and Virtual Learning Environments (VLE's) are moving education away from rigid, traditional, face-to-face instruction toward highly collaborative, flexible and learner - centric models. By examining recent technological adoptions this study outlines how VLEs optimize curriculum planning, pedagogical delivery, and academic analytics. It reviews key innovations such as Artificial Intelligence (AI) immersive Virtual Reality (VR), and data-driven learning management systems. Finally, this study addresses systemic challenges - including the digital divide infrastructure limitations, and the critical need for teacher digital competence - offering strategic frameworks to optimize future - ready digital pedagogy.

Keywords: *E-Learning, Virtual Learning Environments (VLEs), Educational Technology, Digital Pedagogy, Personalized Learning.*

Introduction

Traditional education systems, heavily rooted in the models of the second Industrial Revolution, prioritize standardized, mass-production frameworks with uniform assessments. Information and communication Technology (TCT) acts as the primary catalyst in this revolution. Transforming education through digital learning does not imply merely distributing hardware devices. Rather, it involves deeply embedding structured digital ecosystems that foster interactive, collaborative and learner-centered engagement. This paper investigates how these digital spaces are reshaping curriculum design, pedagogical execution and academic assessment.

Theoretical Framework and conceptual Evolution

The shift from traditional classrooms to VLEs atters the fundamental framework of learning management. Unlike basic electronic data repositories, a comprehensive E-learning environment integrates advanced collaboration features designed to simulate real-world situational problem-solving

Table 1 - Structural Evolution of Educational Formats

Instructional Dimension	Traditional classroom Environment	Virtual Learning Environment (VLE)
Pedagogical center	Teacher – Centric, instructional lectures	Learner-Centric, facilitative engagement
Pacing & Access	Rigidly synchronous, scheduled physical access	24/7/365 asynchronous accessibility
Material format	Static physical textbooks, localized resources	Interactive multimedia adaptive digital objects.
Evaluation Model	Delayed manual assessments, uniform testing	Real-item adaptive learning analytic automated insights

Pedagogical Implementation

The role of the educator is transitioning from an authoritative lecturer to a digital facilitator. Instruction in a virtual space emphasizes asynchronous flexibility alongside synchronous, real-time collaboration tools (eg., chat, shared digital whiteboards, and interactive forums) This shift encourages active participation and critical thinking over passive learning.

Curriculum Planning

Institutions are pivoting away from rigid, linear physical textbooks toward modular, digitally integrated curricula. VLEs allow educator to dynamically update courses to reflect real-world advancements, deploying multimedia objects such as graphics, animations and simulation models that accommodate diverse learning styles.

Educational Evaluation

VLE data ecosystems alter how student performance is monitored and measured. Manual, high stakes testing is increasingly supplemented or replaced by continuous, adaptive digital analytics. Algorithms track real-time metrics - such as system access frequency, module completion velocity, and micro-quiz performance - allowing for immediate diagnostic feedback.

Core Architectural components of E-learning and Virtual Learning Environments

The core architectural of modern e-learning and Virtual Learning Environments (VLEs) include the Learning Management System (LMS), digital content repositories, communication and collaboration tools, online assessment systems, learning analytics, artificial intelligence, cloud infrastructure, integration services, security and privacy mechanisms and accessibility features. These components work together to provide learners with easy access to digital resources, interactive learning activities, assessments, feedback, and personalize learning experiences. The architecture also enables teachers to monitor learner progress and facilitate communication beyond the traditional classroom. Thus, a well-designed VLE creates a flexible, interactive, accessible, secure and learner-centered environment, contributing significantly to the transformation of education through e-learning.

Socio-Technical Challenges in E-learning and VLEs

- Digital Divide - Unequal access to internet connectivity, digital devices and technological resources can create disparities among learners.
- Digital Literacy - Students and teachers may lack the skills required to effectively use VLE platforms and digital learning tools.
- Resistance to change - Teachers, students and institutions may hesitate to adopt new technologies because of unfamiliarity, workload or concerns about changing traditional teaching practices.
- Teacher Training and Support - Effective use of VLEs requires continuous professional development, technical training and institutional support for teachers.
- Infrastructure and Technical issues - Poor internet connectivity, inadequate hardware, system failures and limited technical support can affect the quality of online learning.
- Data privacy and cyber security - Protecting students' personal information, academic records and online activities is an important challenge for VLE providers and institutions.

- Learner Engagement and Motivation - Maintaining student participation, interaction, motivation and self regulated learning can be difficult in virtual environments.
- Accessibility and Inclusion - VLEs need to accommodate learners with different abilities, languages, socio economic backgrounds and learning requirements.
- Institutional and Financial Challenges - Implementing and maintaining VLEs requires investment in infrastructure, software, training, maintenance and technical personnel.
- Ethical use of AI - The use of AI in VLEs raises concerns about bias, transparency, academic integrity, data protection, and responsible use of automated systems

Integrated Implementation Framework.

The challenges are interconnected, so institutions should address them through an integrated approach.



- Assess: Identify technological, financial accessibility and learner needs.
- Plan: Develop clear policies, infrastructure plans, budgets and learning objectives.
- Pilot: Test the VLE with a small group before institution-wide implementation.
- Train: provide continuous training for teachers, students, administrators, and technical staff.
- Implement: Introduce the system gradually with reliable technical support.
- Monitor: Evaluate participation, learning outcomes, accessibility, security and user satisfaction.
- Improve: Use feedback and evidence to continuously refine the VLE.

Conclusion

E-learning and Virtual Learning Environments (VLEs) have transformed education by improving flexibility, accessibility, collaboration, personalized learning and access to digital resources. However, their successful implementation depends on addressing socio-technical challenges such as digital inequality, infrastructure limitations, teacher preparedness, cyber security, accessibility, and learner engagement. Institutions must therefore adopt a learner-centered, inclusive, secure and sustainable approach in integrating technology with pedagogy.

Recommendations.

- Strengthen digital infrastructure and provide reliable internet and affordable access to devices.
- Enhance teacher training in digital pedagogy, VLEs, AI and emerging educational technologies.
- Promote digital inclusion and accessibility to ensure equal learning opportunities for all students.
- Strengthen cybersecurity and data privacy through appropriate policies, awareness and regular monitoring.
- Encourage responsible AI integration while maintaining teacher supervision and academic integrity.
- Establish continuous monitoring and evaluation to measure VLE effectiveness and improve educational outcomes.

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Exploring the Role of e-Content in English Grammar Learning among High School Students in the Nilgiris

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Abstract

The present study explored the role of e-content in English grammar learning among high school students in the Nilgiris District. The study aimed to examine the effectiveness of e-content-based instruction in enhancing students' achievement in English grammar and to compare the learning outcomes of students taught through e-content-based and conventional methods. A quasi-experimental design with pre-test and post-test was adopted for the study. A sample of sixty (60) high school students was selected using the simple random sampling technique and divided into control and experimental groups. The experimental group was taught English grammar using e-content-based instruction, while the control group received instruction through the conventional method. Data were collected using a researcher-developed English Grammar Achievement Test and analysed using inferential statistical techniques. The findings revealed an improvement in the English grammar achievement of students exposed to e-content-based instruction. The study further indicated that e-content provides an engaging and learner-centred environment for learning English grammar. The findings suggest that e-content can play an important role in facilitating effective grammar learning and providing meaningful learning opportunities for high school students.

Keywords: *E-Content, English Grammar, High School Students, Language Learning, Nilgiris District*

Introduction

E-content has become an important tool in modern education and language learning. It uses text, images, audio, video, animation, and interactive activities to make learning more interesting and effective. English grammar is essential for developing students' language and communication skills, but many high school students find grammar difficult through traditional teaching methods. E-content can make grammar learning easier, engaging, and interactive by providing opportunities for practice and revision. The present study explores the role of e-content in improving English grammar learning among high school students in the Nilgiris District.

Review of Literature Foreign Studies

Several studies have explored E-Content package in language learning.

Indian Studies

- **Jasmin (2018)** studied on “A Study of Effect of an E-Content in Teaching Tamil Language Learning to 9th Standard English Medium Students.” The findings showed that students taught through an e-content learning package performed better than those taught through conventional methods.
- **Komalavalli and Amsayal (2022)** investigated on “Effectiveness of Multimedia E-Content Module in Enhancing Achievement in English among Standard IX Students.” The findings

revealed that multimedia e-content significantly supported students' English achievement and provided an engaging learning experience.

- **Singaravelu (2021)** investigated on “*Effectiveness of Computer Assisted Learning in Tamil Grammar.*” The findings revealed that computer-assisted learning simplified grammar learning and increased students' interest and participation.

Foreign Studies

- **Busack (2023)** investigated on “*Are Digital Learning Paths Sufficient for Learning/Practising English Grammar? Views of Secondary School Pupils.*” The findings showed that digital learning paths supported grammar learning, particularly through interactive activities, multimedia content, and immediate feedback.
- **Hwang et al. (2021)** investigated on “*Facilitating English Grammar Learning by a Personalized Mobile-Assisted System with a Self-Regulated Learning Mechanism.*” The findings showed that students using the personalized mobile-assisted system achieved significantly higher English grammar scores than the control group.
- **Zainal et al. (2022)** investigated on “*An Account of EFL Learners' Grammatical Knowledge and Motivation toward Learning in an Online Instructional Environment.*” The findings revealed that online instruction improved both grammar achievement and learning motivation compared with face-to-face instruction.

Objectives of this Study

- To find out the significant difference between male and female students in the post-test scores of the control group with regard to their achievement in English grammar.
- To find out the significant difference between male and female students in the post-test scores of the experimental group with regard to their achievement in English grammar.
- To find out the significant difference between rural and urban students in the post-test scores of the control group with regard to their achievement in English grammar.
- To find out the significant difference between rural and urban students in the post-test scores of the experimental group with regard to their achievement in English grammar.

Hypotheses of this Study

- There is no significant difference between male and female students in the post-test scores of the control group with regard to their achievement in English grammar.
- There is no significant difference between male and female students in the post-test scores of the experimental group with regard to their achievement in English grammar.
- There is no significant difference between rural and urban students in the post-test scores of the control group with regard to their achievement in English grammar.
- There is no significant difference between rural and urban students in the post-test scores of the experimental group with regard to their achievement in English grammar.

Methodology

The present study adopted a quasi-experimental research design to examine the effectiveness of e-content in English grammar learning among high school students. The selected 60 students were divided into control and experimental groups with 30 students in each group.

Population

The population of the present study consisted of Standard IX students studying under the State Board Curriculum during the academic year 2024–2025 in the Nilgiris District, Tamil Nadu.

Sampling Technique

The Simple Random Sampling Technique was adopted for the present study.

Sample

The sample comprised 60 Standard IX students selected from C.S.I. Higher Secondary School, Kotagiri, The Nilgiris District, Tamil Nadu.

Analysis and Interpretation

H₀₁: There is no significant difference between male and female students in the post-test scores of the control group with regard to their achievement in English grammar.

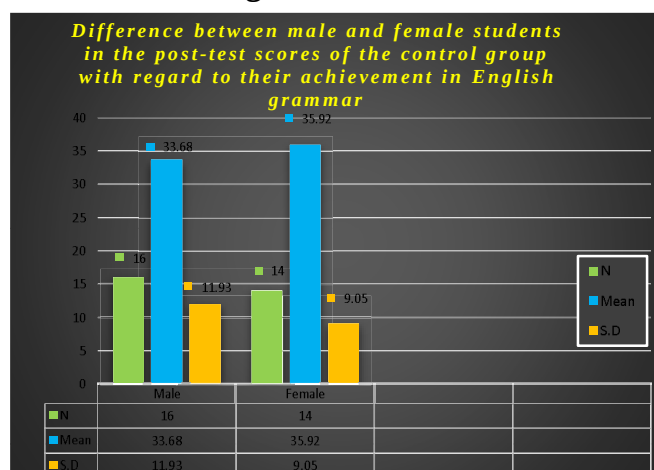
Table 4.1 - Difference between male and female students in the post-test scores of the control group with regard to their achievement in English grammar

Post-test	Gender	N	Mean	S.D	Calculated 't' Value	Result
CONTROL GROUP	Male	16	33.68	11.93	0.57	NS
	Female	14	35.92	9.05		

(the table value of 't' is 1.96, NS – Not Significant)

From the table 4.1 it is inferred that the calculated “t” value (0.57) is lesser than the table value (1.96) at 0.05 level of significance. Therefore the null hypothesis (H₀₁) is accepted. Hence it is concluded that there is no significant difference between male and female students in the post-test scores of the control group with regard to their achievement in English grammar. The finding is aligned with Chakraborty (2025) and Nazarova (2026), who reported that multimedia-supported English learning did not produce significant differences in achievement based on gender. By comparing the mean scores of male (Mean= 33.68) and female (Mean= 35.92) in the post-test scores of control group, it is inferred that scores of female are greater than the male. It is shown in figure 4.1.

Figure 4.1



H₀₂: There is no significant difference between male and female students in the post-test scores of the experimental group with regard to their achievement in English grammar.

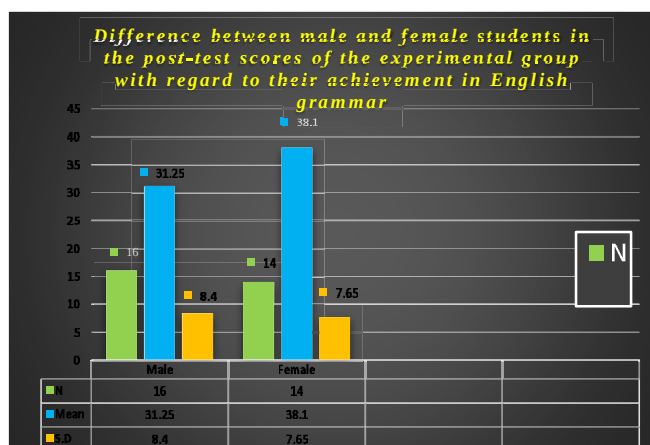
Table 4.2
Difference between male and female students in the post-test scores of the experimental group with regard to their achievement in English grammar.

Post-test	Gender	N	Mean	S.D	Calculated 't' Value	Result
EXPERIMENTAL GROUP	Male	16	31.25	8.40	2.35	S
	Female	14	38.10	7.65		

(the table value of 't' is 1.96, S – Significant)

From the table 4.2 it is inferred that the calculated “t” value (2.35) is greater than the table value (1.96) at 0.05 level of significance. Therefore the null hypothesis (H_0) is rejected. Hence it is concluded that there is significant difference between male and female students in the post-test scores of the experimental group with regard to their achievement in English grammar. The present finding is aligned with **Wang et al. (2023)**, who reported that female students demonstrated better English learning achievement than male students. “The difference in achievement may be due to female students’ greater interest, active participation, and engagement in the e-content-based learning activities. The interactive nature of e-content may have encouraged them to pay greater attention, practise grammar exercises, and participate actively in the learning process.” By comparing the mean scores of male (Mean= 31.25) and female (Mean= 38.10) in the post-test scores of experimental group, it is inferred that scores of female are greater than the male. It is shown in figure 4.2.

Figure 4.2



H₀3: There is no significant difference between rural and urban students in the post-test scores of the control group with regard to their achievement in English grammar.

Table 4.3 - Difference between rural and urban students in the post-test scores of the control group with regard to their achievement in English grammar

Post-test	Location	N	Mean	S.D	Calculated 't' Value	Result
Control Group	Rural	18	35.94	10.28	0.79	NS
	Urban	12	33.15	11.14		

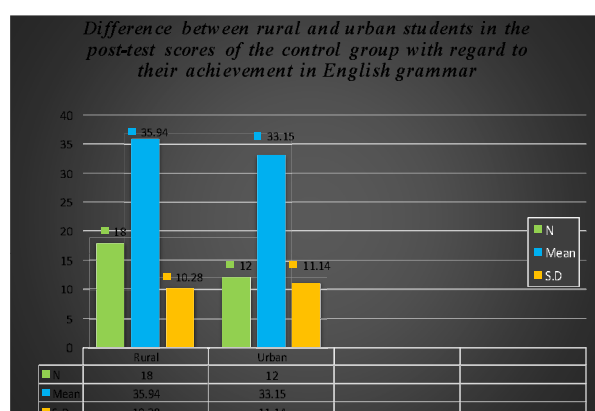
(the table value of 't' is 1.96, NS – Not Significant)

From the table 4.3 it is inferred that the calculated “t” value (0.79) is lesser than the table value (1.96) at 0.05 level of significance. Therefore the null hypothesis (H_03) is accepted. Hence it is concluded that there is no significant difference between rural and urban in the post-test scores of control group students in the achievement of English grammar.

The finding is aligned with **Chakraborty (2025)**, **Singaravelu (2021)**, and **Nazarova (2026)**, who reported that multimedia-supported English learning was effective among students from different localities and that students’ area of residence did not significantly affect their learning achievement.

By comparing the mean scores of rural (Mean= 35.94) and urban (Mean= 33.15) in the post-test scores of control group, it is inferred that the scores of rural students are greater than the urban students. It is shown in the figure 4.3.

FIGURE: 4.3



H₀₄: There is no significant difference between rural and urban students in the post-test scores of the experimental group with regard to their achievement in English grammar.

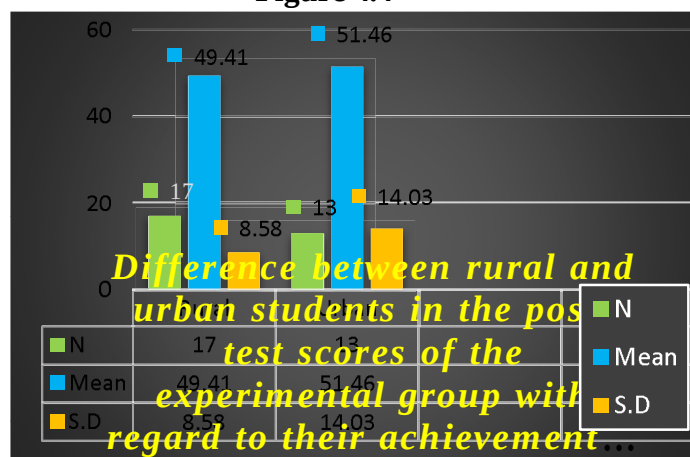
Table 4.4 - Difference between rural and urban students in the post-test scores of the experimental group with regard to their achievement in English grammar

Post-test	Location	N	Mean	S.D	Calculated 't' Value	Result
EXPERIMENTAL GROUP	Rural	17	49.41	8.58	0.52	NS
	Urban	13	51.46	14.03		

(the table value of 't' is 1.96, NS –Not Significant)

From the table 4.4 it is inferred that the calculated “t” value (0.52) is lesser than the table value (1.96) at 0.05 level of significance. Therefore the null hypothesis (H_04) is accepted. Hence it is concluded that there is no significant difference between rural and urban in the post-test scores of experimental group students in the achievement of English grammar. The present finding is consistent with **Alejo and Piquer-Píriz (2016)**, who found no significant difference in English achievement between rural and urban students. Similarly, **Awe and Thompson (2020)** reported no significant difference in English achievement between rural and urban students using ICT supported teaching. By comparing the mean scores of rural (Mean= 49.41) and urban (Mean= 51.46) in the post-test scores of experimental group, it is inferred that the scores of urban students are greater than the rural students. It is shown in the figure 4.4.

Figure 4.4



Findings of this Study

- There exists no significant difference between male and female students in the post-test scores of the control group with regard to their achievement in English grammar. In this case, the mean scores of male (Mean= 33.68) and female (Mean= 35.92) in the post-test scores of control group, it is inferred that scores of female are greater than the male.
- There exists there is significant difference between male and female students in the post-test scores of the experimental group with regard to their achievement in English grammar. In this case, comparing the mean scores of male (Mean= 31.25) and female (Mean= 38.10) in the post-test scores of experimental group, it is inferred that scores of female are greater than the male.
- There exists no significant difference between rural and urban in the post-test scores of control group students in the achievement of English grammar. In this case, the mean scores of rural (Mean= 35.94) and urban (Mean= 33.15) in the post-test scores of control group, it is inferred that the scores of rural students are greater than the urban students.
- There exists no significant difference between rural and urban in the post-test scores of experimental group students in the achievement of English grammar. In this case, the mean scores of rural (Mean= 49.41) and urban (Mean= 51.46) in the post-test scores of experimental group, it is inferred that the scores of urban students are greater than the rural students.

Conclusion

Based on the present study findings, gender and locality did not significantly influence students' achievement in English grammar in either the control or experimental group. Although female students performed better than male students, and rural and urban students showed variations in achievement, these differences were not consistent. Overall, the findings suggest that e-content-based instruction provides a supportive and engaging learning environment that enhances students' participation, understanding, and learning experiences in English grammar. Thus, e-content has considerable potential to improve English grammar learning among high school students in the Nilgiris District.

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E-Attitude of Distance Teacher Trainees towards E-Learning

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Distance Teaching in a Digital Age

Tony Bates (2019) in his Monumental Book “Teaching in a Digital Age” has observed in Chapter 11 “Trends in Open Education” that thanks to Open Educational Resources (OERs) and Massive Open Online Courses (MOOCs), there is a resurgence of interest in Open and Distance e-Learning (Ode-L). The ODL system has experienced a paradigm shift in the recent years moving as a fertile ground for 21st-century skills thanks to Web 2.0 Technologies and Social Media. In this Backdrop, the present study has identified a socially relevant research problem with significant contribution for implementation in the field of Open and Distance e-Learning (OdeL). Wrenching change has emerged as a hallmark of the present digital decade of 2020-30. Mind boggling developments in Artificial Intelligence (AI), E-Learning, Satellite Technology, 5G Network and Robotic Engineering Systems are the manifestations of the Technological and Digital Possibilities of Education in general and Distance Education in particular, giving rise to the new concept of Open and Distance e-Learning (OdeL).

In reshaping education to cope with rapid changes at the threshold of the twenty-first century, innovation, technology and research are indispensable tools of education. There is a growing international consensus on the importance of distance education in society and for national development generally. Teaching is the mother of all professions, according to the National Education Policy 2020 (Subsection 15.4). It has devoted two full chapters, namely “Chapter 23-Technology Use and Integration” and “Chapter 24 on “Online Education”. Teacher education is defined by the National Council for Teacher Education (NCTE) as a programme of education, research, and training for people who want to teach at all levels, from pre-primary to higher education. Tamil Nadu has the oldest teacher training institution (IASE, Saidapet) in the country. Before Independence, there were only 4 colleges of Education – two under the government and two managed by Christian Missionaries. Other Colleges of Education were established under the Five Year Plans.

Context, Social Relevance and Rationale of the Present Study

In the Digital era of Education, e-learning technologies have become integral to the Distance Education Transactions, offering unprecedented benefits in terms of accessibility, convenience, and interactivity. In this backdrop, the attitude of student-teachers towards e-learning plays a key role in their adoption of digital tools. Positive e-attitudes, marked by openness, receptivity, and enthusiasm towards technology, have been shown to promote greater engagement and satisfaction with online learning experiences. Similarly, the negative e-attitudes can mar the achievement of desired learning outcomes.

Objectives of the Study

The present study has set forth the ensuing objectives to be accomplished

- To measure the E-Attitude of Teacher Trainees through Distance Mode in Madurai Kamaraj University.
- What remedial strategies may be taken for improving the Quality of E-Learning at Madurai Kamaraj University, on the basis of the findings of the study on E-Attitude.

Operational Definitions of the Terms Used

E-Attitude

An "E-attitude" is a psychological variable that describes a learner's proclivity to respond favourably or negatively to e-learning. It is the learner's mental and neural state of preparedness that has been organised via experience and exerts a directional or dynamic impact.

Positive e-attitude: This is when learners have positive feelings and beliefs towards online learning. They are interested, motivated, and confident and satisfied with their e-learning experience. They also have high expectations and goals for their learning outcomes.

Negative e-attitude: This is when learners have negative feelings and beliefs towards online learning. They are bored, frustrated, anxious and dissatisfied with their e-learning experience. They also have low expectations and goals for their learning outcomes.

Neutral e-attitude: This is when learners have neither positive nor negative feelings and beliefs towards online learning. They are indifferent, ambivalent or uncertain about their e-learning experience. They also have moderate expectations and goals for their learning outcomes.

Delimitation and Limitation of the Present Study

The present study has deliberately delimited the scope of the study and size of the sample to a manageable level within the duration of 1 year. Hence the sample size is relatively small and limited to one university namely Madurai Kamaraj University with limited generalizability of the findings. The data collection techniques were self-reported with scope for little, unavoidable and inherent error.

Review of Studies related to E-Attitude of Distance Learners

- A Study by Al-Shehri (2014) evaluated the e-attitude of distance learners in Saudi Arabia and found that the majority of participants had a positive e-attitude towards online learning, and that their e-attitude was influenced by factors such as their previous experience with technology and their motivation to learn.
- An Investigation by Al-Saleh et al. (2015) evaluated the e-attitude of distance learners in Kuwait and found that the majority of participants had a positive e-attitude towards online learning, and that their e-attitude was influenced by factors such as their perceived usefulness and ease of use of technology.
- A Survey by Al-Jaber et al. (2016) investigated the e-attitude of distance learners in the United Arab Emirates and found that the majority of participants had a positive e-attitude towards online learning, and that their e-attitude was influenced by factors such as their previous experience with technology and their motivation to learn.
- A Research by Al-Shammari et al. (2017) examined the e-attitude of distance learners in Saudi Arabia and found that the majority of participants had a positive e-attitude towards online learning, and that their e-attitude was influenced by factors such as their perceived usefulness and ease of use of technology.

- The study by Al-Jaber et al. (2020) investigated the e-attitude of distance learners in the United Arab Emirates. The study found that the majority of participants had a positive e-attitude towards online learning, and that their e-attitude was influenced by factors such as their previous experience with technology and their motivation to learn.

The studies reviewed suggest that distance learners have a positive e-attitude towards online learning, and that their e-attitude is influenced by various factors such as their previous experience with technology and their motivation to learn. The present study identified the research gaps which provided the rationale for the present research. The review has also given new insights into the different methods, models, and measures used in these studies and evaluate their strengths and weaknesses, which have been useful for the present study at every stage.

Methodology-Online Survey

The present online survey has been administered via email, and has been completed by participants at their own pace. The data have been collected from online surveys through Google Forms. The E-Attitude Scale is a tool used to measure attitudes towards online learning. It assesses the extent to which individuals perceive online learning as a positive or negative experience. The scale consists of a series of statements that ask respondents to indicate their level of agreement or disagreement. The responses are then scored and analyzed to provide insights into attitudes towards online learning. The E-Attitude Scale will identify areas where programs need improvement, as well as tracking changes in attitudes over time. The Validity Assessment has been done to ensure that the tool has Content Validity, Construct Validity, Convergent and Discriminant Validity and Criterion-Related Validity. The reliability of the tool has been established through Test-Retest Reliability by administering the scale to a subset of distance learners at two different time points to assess its stability over time.

The present study has applied Cluster sampling technique. The student –teachers of the B.Ed Programme offered by the Directorate of Distance Education, Madurai Kamaraj University for the in-service untrained teachers form the sample for the present study. The population is all the B.Ed students of the Directorate of Distance Education, Madurai Kamaraj University. The Student – Teachers of the Personal Contact Programme (PCP) form the clusters. The advantages of this cluster sampling techniques are its cost effectiveness and feasibility. Cluster sampling is widely used in various fields, such as education, public health, sociology, and market research, and its effectiveness relies on appropriate cluster selection and careful consideration of the cluster's characteristics to ensure a representative sample. For the present study, the tools have been administered to the cluster samples of Personal Contact Programme (PCP) centres via online mode to 202 student – teachers from whom 199 responses (98.5% of responses) have been received for the Research Tool No. 1 (E-Attitude Scale) and 202 responses from all the members of the cluster (100% responses).

Analysis and interpretation of the finding

The cautious analysis and interpretation of the finding has revealed that though majority of student teachers do not have techno-phobia, around 40% of student teachers are not fully equipped to face the changing landscape of technology based education, which is a matter of concern, in the social context of the Digital Initiatives of the Government of India and the recommendations of the National Policy on Education (NPE), 2020. This finding of the present study is in agreement with the finding of the study of Thiyagu (2021) who attributed the teachers' Techno-Phobia to the

poor awareness of E-learning tools. The positive attitude towards E-books, as preferred by 50.3% of Student-Teachers needs loud thinking. E-books have promising advantages such as instant accessibility, (anytime, anywhere), easy updates, shareable quality, Augmented Reality Experience, Cost Effective and Environment Friendly. Hence it is suggested to update the E-book experience among the teaching community through emerging trends in E-books namely Virtual Reality E-books providing an immersive reading experience, Interactive Enhanced E-books, Block-Chain Technology and Virtual Book Clubs.

Student-Teachers use of different educational blogs for interaction. It is suggested that every student-teacher builds a new blog or extends the existing blogs with a new topic. Awareness programs on content-related blogs, notification, links for references, teaching tips and sharing of knowledge or recommended to be conducted for the benefit of teachers. School Head Masters are suggested to make use of blogs for creative writings by the teachers, homework submission, collaborative output etc. While 15.3% strongly agree and 51% positively just agree that they are technologically ready, indicating that they fall into the “technologically ready” category. Further research study are recommended to identify the factors which impede the technological unpreparedness (Strongly disagree 8.2%, Disagree 3.1% and neutral 22.6%) to suggest follow-up strategies by Policy Makers.

Distance Education is currently experiencing a level of reshaping from many new technologies, such as Artificial Intelligence (AI), 5G Technologies in Education, Augmented Reality and Simulations, Adaptive Learning, Automation and Learning Analytics. Hence, an attempt has been made through this Item No. 6 to find out the extent of attempt by the student teachers of the distance mode in trying new technologies for learning. It is an encouraging finding that 44.6% of student teachers try new technologies and 23.6% of student teachers strongly try new technologies for their learning. Eventhough Blogs have a definite edge over Websites as Teaching Tools by virtue of their User-Friendliness, Easy Maintenance etc., it is a disheartening finding of the present study on the student-teachers’ dismal use of different educational blogs for interaction. (Only 9.5% strongly agree and 41.5% Just agree while they remaining 49% are non-takers). It is suggested that every student-teacher builds a new blog or extends the existing blogs with a new topic. Awareness programs on content-related blogs, notification, links for references, teaching tips and sharing of knowledge or recommended to be conducted for the benefit of teachers. Heads of the Institutions are suggested to make use of blogs for creative writings by the teachers, homework submission, collaborative output etc.

Implications of the Findings

In this comprehensive study on e-attitude among distance student-teachers, we have gained valuable insights into the multifaceted aspects of their engagement in digital learning environments. Positive e-attitudes contribute to higher motivation and satisfaction, while e-readiness ensures the effective utilization of technological tools for academic success. The findings have enormous implications for various stakeholders in the field of education, distance learning, and technology integration as listed below:

- Technology integrated Curriculum Redesigning
- Professional Recharging and e-skill development Programs to effectively navigate online learning environments.

Suggestions for Further Research

The research findings reported and discussed here have identified gaps in knowledge and areas in this area of research that require further exploration. It also stimulates future research on related topics, such as the impact of e-attitude and e-readiness on teaching effectiveness or student motivation in distance education. It is further suggested that Future Researchers may expand the scope of the present study by replicating the same with a wider and diversified sample across the Country at the National Level, across different disciplines and institutions by applying more standardised and triangulated tools like online tests, analytics and observations.

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Transforming Library Services through Information and Communication Technology: A Focus on Web-Based Delivery

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Abstract

Information Communication Technology provides a gigantic area to Library and Information Centers. It develops their collection and services on the click of mouse. Changing user's need force LIS professional to be change. New services include access to internet and internet based tools and services, access to electronic information sources and digital library of local and institutional documents. This reading helps to investigate the ICT skills and its use by LIS Professionals. Through this study we enable to look into the ways in which the Library Professionals are using ICT in libraries, identify problems the Library Professionals faced in the use of ICTs and enable to find the needs of ICT training in Library Professionals in libraries. This article comes across the current ICT and Web based facilities in libraries. Journals, books, dissertation and theses, course material and patents are some of important sources of information that are now available in electronic form. Digital libraries provide local contents in the electronic form through internet to global clients

Keywords: *ICT, ICT based services, Web, Web based services*

Introduction:-

Libraries have undergone considerable change in the past decade. With increasing use of technology to organize and disseminate information, the ICT has become an important tool for accessing information. Libraries not only have to provide the technology necessary for patrons to use their OPACs, but also must supply a means for access to scholarly digital resources and a growing number of electronic databases. The physical space in libraries has been modified to accommodate the additional technology necessary to provide patrons with the tools to use library resources successfully and to meet their information needs. The librarian's role has changed rapidly in recent years, in response to new forms of information and new methods of teaching and learning. Increased patrons numbers have spread existing staff more thinly; widening modes of access have brought in more part time patrons; more patron centered learning demands a greater variety of teaching skills; and the explosion of electronic information (from CD-ROM to the Internet) requires continuous updating of knowledge and skills. Academic libraries are facing many challenges posed by the contemporary environment, most of which are the result of ICT and digital revolution.

Impact of ICT on Library and Information Centers

It is a genuine fact that every development makes an impact on library and information service. The ICT has also made impact on library and information services. This age is being termed as Information Age, Information Explosion, and Paperless Society. In the field of library and information service ICT technology includes computers (computer hardware and software), computer networking, telecommunications, internet including WWW, search engines, computer

and networking security, computer software methodologies, software engineering, scanner, digital camera, photocopier, network authentication and access control, automated language processing, automatic text retrieval, data base management system, relational DBMS, artificial intelligence, library automation system, etc

Library Services through Information Communication Technology

Data Processing

Processing of Data is any process that uses a computer program to summaries, analyze or otherwise convert data into usable information. The process may be automated and run on a computer. In the data processing libraries can do Data Entry, Data Coding, Data Transformation, Data Translation, Data Summarization, Data Aggregation, Data Validation, Data Tabulation, Statistical Analysis, Computer graphics, Data Warehousing, Data Mining

CD Rom Searching

The CD-ROMs coming along with books are assigned accession numbers and are kept at the computer section to be issued to the users to get information whenever needed. Library has also subscribed to CD ROM database provides for online Access.

On-line Networking

Networking is one of the most effective ways of serving users' needs comprehensively. Networked access to databases would help get newly-published information to library users.

On-line Information Service

Online Information services are anticipatory or responsive. Both these services promote the use of library materials, make available library materials to users and thus meet user requirements. The various services include News Paper clipping, Abstracting/Indexing Services, Current Awareness Services, translation services, referral services, photocopying services and computerized services.

News Clipping Scanning service

Newspaper Constitute an important source of Information as they contain the latest information in the form of news with, often daily, updating. Print media is useful for research needs but many organization and individuals are turning to online newspaper clipping services and some are organization do this by their library.

On-line Reservation Service

The Online Reservation Service allows you to reserve books and journals which are on order, being processed by the Library or on loan to another reader. User can place a reservation at the Issue or Information Support Desk using the request option on the on-line catalogue.

Database Searching Service

Through this service, we regularly provide the users with the exact information they need, depending on their interest profile, from our collection of major national and international databases (retrospective and current) on our subject. The databases are in CD ROM or

computerized form which saves their valuable time and energy, as the information available here is pinpointed and readily accessible.

Audio-Visual Service

Audiovisual materials are important sources of information, education and entertainment. Many libraries particularly media libraries and large academic and public libraries hold audio visual material such as DVD, films, pictures and photographs etc. Libraries allow their members to borrow these. Recent developments in storage media, compression and encryption technology have made it possible to store large amount of multimedia documents on hard disk and disseminate through internet.

Internet Access

The use of the Internet around the world has been growing rapidly over the last decade. Libraries provide free or controlled access to internet and email. Depending upon the availability users can be given time slots for use of internet facility. Usually internet enabled terminals are provided in the library that can be used for internet access and email etc.

E-Query Services

E-Query Service is a Web-enabled contemporary reference service offered to the registered members of the Library together handle queries received in person or by e-Mail. E-Queries may sometimes need to be followed-up with telephone, fax, regular mail, or personal interactions. Library, appropriate and brief information gathered in response will be sent to the enquirer through e-Mail within three consecutive working days from the date of receipt of the query.

Web Based Library Services

Today, users may have access a variety of textual information resources. There are different kinds of web-based reference resources and services for accessing information from libraries such as OPAC, Gateways, Portals, Subject Portals, Electronic Journals, Online Databases, Subject Directories and Search Engines. These resources overlap considerably in the type of information they cover, and sometimes it is difficult to distinguish between some of them. A library should have a good collection of these resources like selected Web links, subscription resources, and library materials in well-organized pages for serving better services to their users. Many libraries and organizations are providing digital reference service through collaborative services. Existing library consortia are adding digital reference to current shared services, and networks of libraries. Some regional library consortia are offering member libraries the opportunity to share reference questions with each other using the Internet and other technologies.

OPAC

OPAS's - On Line Public Access Catalogues, form an important part of many digital library's collections. It allows users to search for the bibliographic records contained within a library's collections. Now days, some OPAC also provide access to electronic resources and databases, in addition to the traditional bibliographic records.

Gateways

A gateway is defined as a facility that allows easier access to network based resources in a given subject area. Gateways provide a simple search facility and a much-enhanced service through a resource database and indexes, which can be searched through a web based interface. Information provided by gateways is catalogued by hand. Gateways cover a wide range of subjects, through some areas, such as music and religious studies, currently lack subject gateways.

Portals

In the library community, portals may be defined as an amalgamation of services to the users where the amalgamation is achieved through seamless integration of existing services by using binding agents such as customization and authentication services, search protocols such as Z39.50, loan protocols such as ISO10161, and e-commerce. The result is a personalized service which allows the individual to access the rich content of both print-based and electronic systems. Portals are either commercial or free web facilities that offer information services to a specific audience. The facilities include web search to communication to email to news etc. There are three kinds of portals; Consumer (or horizontal), Vertical and Enterprise.

Subject Portals

Web Search Engines had been developed initially by computer scientists, by borrowing techniques from information retrieval search such as best match searching and relevance ranking. Information professional are increasing bringing their skills to help organize the growing wealth of Internet resources. A good example of their influence is the development of subject-specific web search engines known as subject portals, where evaluation of material covered is a major concern. Two prime UK subject portals are SOSIG Social Science Information Gateway, covering social science resources and OMNI Organizing medical networked information covering medical resources.

Electronic Journals

Electronic journals form a large part of the collection of a library for providing web based services. Today many journals are available electronically - some are full text and some contain only bibliographic information with abstract. Major advantage of electronic journals is that they are constantly updated and easy to access but disadvantage is that breaching of copyright law is very easy. They are available as bitmaps, PostScript, PDF, ASCII, SGML and HTML. Library services may be delivering to users on CD-Rom, through email or through web. Some international societies and associations have developed their own digital libraries through which users can get access to all their publications. Services are available to the members of society or associations through subscription.

Online Databases

These are large collections of machine-readable data that are maintained by commercial agencies and are accessed through communication lines. Many libraries subscribe to them for easy access and use 431 of current information. The disadvantage is that only bibliographic data is presented and not full text. The information cannot be accessed when the system is down for any reason. Examples Ei Compendex, SciFinder Scholar, Web of Science, Current Contents etc.

Search Engines

Search Engines are huge databases of web page files that have been assembled automatically by machines whereas the subject directories are human-compiled and maintained. Search engine indexes every page of a website and subject directories linked only homepages. Search Engine is the popular term for an information retrieval (IR) system. A search engine is computer software that searches a collection of electronic materials to retrieve citations, documents, or information that matches or answers a user's query. The retrieved materials may be text documents, facts that have been extracted from text, images, or sounds. A query is a question phrased so that it can be interpreted properly by search engine. Depending on the type of software, it may be a collection of commands, a statement in either full or partial sentences, one or more keywords, or in the case of non-text searching, an image or sequence of sounds to be matched.

Subject Directories

Subject directories differ from search engines in that search engines are populated by robots that find and index sites whereas humans make editorial decisions that populate subject directories. Subject directories are basically index home pages of sites and can be classified as general, academic, commercial or portal. Among the well known subject directories are the Argus Clearinghouse (www.clearinghouse.net) and Yahoo (www.yahoo.com). Strengths include relevance, effectiveness and relative high quality of content. Weaknesses are that they lack depth in their coverage.

New Web Based Library Services**Virtual Library Tours**

Websites of libraries provide virtual library guide to the physical facilities including collections, services and infrastructure available in the library. The combination of library maps and floor plans, library departments and photographic views are used for the tour. Virtual library tours are also using new technologies such as QuickTime movies etc and are beginning to replace image maps on main campus Web sites.

Ask-A-Librarian

Ask-A-Librarian services are Internet-based question and answer service that connects users with individuals who possess specialized subject knowledge and skill in conducting precision searches. Most "Ask-a-Librarians" services have a web-based question submission form or an e-mail address or both. Users are invited to submit their queries by using web forms or through e-mail. Once a query is read by a service, it is assigned to an individual expert for answering. An expert responds to the query with factual information and or a list of information resources. The response is either sent to the user's e-mail account or is posted on the web so that the user can access it after a certain period of time. Many services have informative web sites that include archives of questions and answers and a set of FAQs. Users are usually encouraged to browse archives and FAQs before submitting a question in case sufficient information already exists.

Real Time Services

A new and exciting method of digital reference service that libraries are attempting to provide more and more now is live reference. These are real-time, interactive reference services

in which the users can talk to a real, live reference librarian at any time, from anywhere in the world. User and librarian can interact using chat technologies, and unlike with email reference the librarian can perform a reference interview of sorts by asking the users to elaborate or clarify if needed before proceeding to answer the question.

The librarian can perform Internet searches and push websites onto the user's browser, and can receive immediate feedback from the users as to whether their question have been answered to satisfaction.

Bulletin Boards

A bulletin board is an electronic communications forum that hosts posted messages and articles connected to a common subject or theme or interest. It allows users to call in and either leaves or retrieves messages. The messages may be directed to all users of the bulletin board or only to particular users. But all messages can be read by all users. Several libraries are using bulletin boards for their web-based library services. The bulletin board system is also used as an interactive interface to invite suggestions on activities and services of a library. It can also be used as an interface to distribute library services.

Web-based User Education

Web guides and teaching tools are found everywhere on the Web because they are easily updated, accessed, and printed on demand. The web-based user education provides a high degree of interactivity and flexibility to the users. The library web sites can use web-based user education for imparting training to users in teaching the basic library skills along with glossary of library terms, using Library OPAC, locating books, magazines, biographical data and other library materials, understanding how to navigate the libraries website and how to select the most relevant database, instructions for searching CD ROM and guidance in locating web-based databases and other electronic resources and instructions on subject searching training, using Boolean operators and searching internet resources through search engines

Web Forms

Library web sites have some web forms for suggestions and comments on the Library Services. Different types of Web Forms are available on web that may be an Indent form for acquiring some publications, interlibrary loan request form for document delivery, Ask-a-Librarian forms, on line reservation form or user survey form etc.

Conclusion

Information and Communication Technologies play an important role in enhancing efficiency in development of Library service. ICT is changing the work of libraries and information centers. Librarians, library patrons and supporters, and, above all, must help develop ICT-based libraries to meet the changing demands of the users. Impact of ICT on information services is characterized by changes in format, contents and methods of production and delivery of information products, emergence of Internet as largest repository of information and knowledge, changed role of LIS professional from intermediary to facilitator, new tools for dissemination of information, shift from physical to virtual service environment, and extinction of some conventional information services and emergence of new and innovative web based LIS. The study concludes that the LIS professionals who are working in engineering educational institutions in

Indore in one way or the other are acquiring considerable basic skills in ICT. But they need to concentrate more on network based services and digital library services.

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E-Learning and Virtual Education

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Abstract

E-learning and virtual education have emerged as significant components of the modern educational system due to rapid developments in information and communication technology. Traditional education, which primarily depends on physical classrooms and face-to-face interaction, is increasingly being supplemented and, in some situations, replaced by technology-enabled learning environments. E-learning refers to the use of digital technologies, electronic resources, online platforms, multimedia content, and internet-based communication to facilitate teaching and learning. Virtual education extends this concept by providing an educational environment in which students and teachers can interact through digital platforms without being physically present in the same location. This article examines the concept, development, characteristics, benefits, challenges, and future prospects of e-learning and virtual education. It discusses how online learning platforms, learning management systems, video conferencing applications, digital libraries, educational videos, artificial intelligence, and mobile technologies have changed teaching and learning practices. E-learning provides flexibility, accessibility, cost-effectiveness, personalized learning opportunities, and access to educational resources beyond geographical boundaries. At the same time, it presents challenges such as the digital divide, lack of digital literacy, inadequate infrastructure, reduced face-to-face interaction, student motivation, cybersecurity, privacy concerns, and difficulties in assessing learners effectively. The study adopts a descriptive and analytical research methodology based primarily on secondary sources, including books, journal articles, reports, and publications from educational and international organizations. The article concludes that e-learning and virtual education should not simply be viewed as alternatives to traditional education but as important components of a blended and technology-enhanced educational ecosystem.

Keywords: *E-learning, Virtual Education, Online Learning, Digital Education, Educational Technology, Learning Management System, Distance Education, Virtual Classroom, Digital Literacy, Blended Learning*

Introduction

Education is one of the most important instruments for individual development, social progress, economic growth, and national development. Traditionally, education has been delivered through physical classrooms in which teachers and students interact directly. Although this model continues to be important, technological developments have transformed the ways in which knowledge is created, distributed, accessed, and evaluated. The emergence of computers, the internet, smartphones, cloud computing, artificial intelligence, and digital communication technologies has created new possibilities for teaching and learning. E-learning is one of the most important outcomes of this technological transformation. In simple terms, e-learning refers to learning that is supported or delivered through electronic and digital technologies. It may include online courses, recorded lectures, digital textbooks, educational applications, interactive simulations, online assessments, discussion forums, and learning management systems. E-learning can be synchronous, where teachers and students interact at the same time through technologies such as video conferencing, or asynchronous, where learners access educational materials at a time convenient to them. accessibility,

learning outcomes, and educational equality. The present article provides an overview of these developments and critically examines the opportunities and challenges associated with e-learning and virtual education.

Objectives of the Study

To explain the concepts of e-learning and virtual education.

- To examine the development and growing importance of digital education
- To identify the major technologies used in e-learning and virtual education
- To examine the advantages of e-learning for students, teachers, and educational institutions.
- To analyze the major challenges associated with online and virtual education.
- To examine the role of teachers and learners in technology-supported education.
- To understand the importance of digital literacy and technological infrastructure in successful e-learning.

Research Methodology

Research Design

The present study adopts a descriptive and analytical research design. The purpose is to describe the development and characteristics of e-learning and virtual education and to analyze their benefits, limitations, and future implications.

Sources of Data

The major sources considered for the study include:

- Academic books on educational technology
- Research articles published in academic journals
- Reports from international educational organizations
- Publications related to distance and online education

Scope of the Study

The study focuses broadly on e-learning and virtual education in schools, colleges, universities, professional education, and lifelong learning. Particular attention is given to the educational and technological dimensions of digital learning.

Role of Teachers in E-Learning

The emergence of virtual education does not eliminate the importance of teachers. Instead, it changes their roles. In conventional education, teachers are often viewed primarily as sources of knowledge. In digital education, teachers increasingly act as:

- Facilitators of learning
- Designers of digital learning experiences
- Mentors
- Online discussion moderators
- Assessors
- Providers of feedback
- Motivators
- Guides for digital information

Teachers must develop digital pedagogical skills in addition to subject knowledge. Effective online teaching requires appropriate use of multimedia, discussion activities, online assessments, collaborative tools, and learner-support strategies.

Role of Students in Virtual Education

Students also have increased responsibility in virtual learning environments. Successful online learners generally need:

- Self-discipline
- Time-management skills
- Digital literacy
- Independent learning skills
- Communication skills
- Ability to locate and evaluate information
- Active participation

Unlike traditional classrooms, where teachers can directly observe students, online environments require learners to take greater responsibility for their academic progress.

Future Prospects of E-Learning and Virtual Education

The future of digital education is closely connected with developments in emerging technologies. Artificial intelligence may increasingly support personalized learning, automated feedback, intelligent tutoring, and educational content development. Learning analytics can help teachers identify students who are struggling and provide appropriate support. Virtual reality and augmented reality may make online learning more immersive. Students could potentially explore virtual laboratories, historical environments, geographical locations, or professional simulations. Cloud computing can enable students and teachers to access learning materials from multiple devices. Mobile technologies can further expand educational access.

Conclusion

E-learning and virtual education have become important elements of contemporary education. The development of internet technologies, mobile devices, learning management systems, video conferencing, artificial intelligence, and other digital tools has expanded the possibilities for teaching and learning. Students can now access educational resources beyond traditional classrooms and geographical boundaries. The major advantages of e-learning include flexibility, accessibility, self-paced learning, resource availability, personalized learning, cost savings in some contexts, and opportunities for lifelong education. Virtual education can also help institutions provide courses to learners who cannot participate in conventional classroom programs.

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AI-Enabled Curriculum-Aligned Lesson Planning: Design and Development of a Faiss– Gemini Intelligent Lesson Plan Agent

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ABSTRACT

Lesson planning is an essential professional activity that connects curriculum expectations, learning objectives, instructional strategies, learning resources and assessment. However, preparing detailed lesson plans repeatedly can require considerable time, particularly for student-teachers and teachers handling multiple topics. Generative Artificial Intelligence (AI) offers opportunities to support lesson planning, but general-purpose AI may generate content that is inaccurate or insufficiently aligned with a prescribed curriculum. This paper presents the design and development of an AI-enabled Lesson Plan Agent that combines Retrieval-Augmented Generation (RAG), FAISS vector similarity search and the Gemini generative AI model within a Streamlit web application. Curriculum and syllabus documents are used as the knowledge source. Relevant information is retrieved through semantic similarity search and supplied as contextual information to the generative model before lesson-plan generation.

The development follows a design-and-development approach involving requirement identification, document preparation, text chunking, embedding generation, vector indexing, semantic retrieval, prompt construction, generation and functional testing. The prototype demonstrates a human-in-the-loop approach in which AI produces an initial lesson-plan draft while the teacher remains responsible for validation and modification. Functional examination indicates that the system can integrate curriculum information with generative AI to produce structured lesson-plan content. The project has potential significance for AI in education, digital pedagogy and teacher education by reducing repetitive drafting work and supporting reflective lesson planning. Nevertheless, AI-generated outputs require teacher verification for factual accuracy, curriculum appropriateness, inclusivity, learner needs and classroom feasibility. The study concludes that curriculum-grounded AI can serve as a practical teacher-support technology when combined with professional judgement and responsible use.

Keywords: Artificial Intelligence in Education, AI Lesson Planning, Generative AI, Retrieval-Augmented Generation, FAISS, Gemini, Teacher Education, Digital Pedagogy, Curriculum Alignment.

1. INTRODUCTION

Artificial Intelligence (AI) is increasingly being integrated into education for teaching, learning, assessment, educational administration and teacher professional development. The emergence of generative AI has further expanded these possibilities because AI systems can respond to natural-language instructions and generate educational content such as explanations, examples, questions, activities and lesson plans.

Lesson planning is an important component of effective teaching. A lesson plan provides a structured framework for translating curriculum expectations into classroom activities. It normally includes learning objectives, previous knowledge, teaching-learning materials, instructional

activities, questioning, assessment and closure. Although lesson planning is professionally important, preparing detailed plans for several topics can become repetitive and time-consuming. Generative AI can assist by producing an initial lesson-plan draft. However, a general-purpose language model does not necessarily know or follow the exact curriculum or syllabus used by a particular school, institution or educational board. It may generate fluent content that contains topics outside the prescribed syllabus, omit required concepts or provide unsuitable activities. Therefore, educational AI systems require mechanisms for grounding generated content in reliable educational sources.

Retrieval-Augmented Generation (RAG) provides one such approach. In RAG, relevant information is retrieved from an external knowledge source and supplied to a generative model as context. In the present project, curriculum and syllabus documents constitute the knowledge source. FAISS is used to perform vector similarity search, while Gemini is used to generate the lesson-plan draft. A Streamlit interface provides access to the system through a web application.

The central workflow is:

Curriculum/Syllabus → Retrieval → Relevant Context → Gemini Generation → Lesson Plan → Teacher Review

The system is therefore designed as an **AI-assisted planning tool rather than a replacement for teachers**. The teacher remains responsible for determining whether the generated lesson plan is pedagogically appropriate and suitable for the actual classroom.

2. PROBLEM STATEMENT AND OBJECTIVES

Traditional lesson planning requires teachers and student-teachers to consult curriculum documents, syllabi, textbooks and lesson-plan formats. This can involve considerable repetitive work. At the same time, unrestricted use of generative AI may result in hallucinations, curriculum misalignment, inappropriate activities or inaccurate assessment suggestions.

The problem addressed in this study is the development of an AI-assisted lesson-planning system that can retrieve relevant curriculum information before generating a structured lesson plan while retaining teacher control over the final output.

Objectives

1. To design and develop a web-based AI lesson-planning agent using FAISS and Gemini.
2. To integrate curriculum and syllabus documents into an AI-supported lesson-planning workflow.
3. To retrieve relevant curriculum information using semantic similarity search.
4. To generate structured lesson plans using generative AI.
5. To explore the usefulness of AI-assisted lesson planning for teacher education and digital pedagogy.
6. To identify important ethical and pedagogical considerations associated with AI-generated lesson plans.

3. REVIEW OF RELATED LITERATURE

3.1 Artificial Intelligence in Education

AI has been applied in several educational areas, including intelligent tutoring, adaptive learning, assessment, prediction, recommendation and teacher support. Zawacki-Richter et al. (2019), in a systematic review of AI applications in higher education, identified major areas of AI use while also drawing attention to the role of educators and the need for stronger pedagogical consideration.

Holmes, Bialik and Fadel (2019) similarly discussed the potential of AI to support educational processes while emphasising the continuing importance of teachers and human interaction. The development of generative AI has increased the range of educational tasks that can be supported. Teachers may use generative systems to prepare examples, questions, explanations and preliminary lesson plans. However, educational usefulness depends not only on the fluency of generated text but also on its accuracy, relevance and alignment with learning objectives.

3.2 Retrieval-Augmented Generation

Retrieval-Augmented Generation combines information retrieval with text generation. Lewis et al. (2020) described RAG as a framework in which a generative model can access information from an external non-parametric memory. This is particularly relevant to curriculum-based applications because institutional curriculum and syllabus documents can serve as an external knowledge source.

Instead of asking the generative model to produce a lesson plan using only its general knowledge, the system first identifies relevant curriculum information and provides it as context. This can help the generated response remain closer to the source material.

3.3 FAISS and Semantic Search

FAISS is a library designed for efficient similarity search and clustering of dense vectors (Johnson, Douze, & Jégou, 2017; Douze et al., 2024). In a retrieval system, textual information can be converted into numerical vector representations known as embeddings. Similarity between vectors can then be used to identify text segments that are semantically related to a user's query.

In the present project, curriculum and syllabus text is divided into manageable sections, converted into vector representations and indexed using FAISS. When the teacher submits a topic or lesson request, the query is embedded and compared with the stored vectors. Relevant text segments are retrieved and passed to the generation stage.

3.4 Generative AI and Teacher Education

Gemini is a family of generative AI models capable of processing and generating information through natural-language interaction (Gemini Team, 2023). In teacher education, such technology can support lesson preparation while also creating opportunities for student-teachers to critically evaluate AI-generated instructional content.

UNESCO (2024) highlights AI competencies for teachers including AI ethics, AI foundations and applications, AI pedagogy and AI for professional learning. Consequently, an AI lesson-planning tool can serve not only as a productivity tool but also as a context for developing AI literacy and reflective teaching practices.

4. RESEARCH METHODOLOGY

The study adopts a **Design and Development Research approach**. The main outcome is a functional prototype rather than a controlled intervention study. Therefore, the present study does not claim statistical improvement in student achievement, teacher effectiveness or teaching quality. The development process consisted of the following stages.

4.1 Requirement Identification

The system was designed to accept a teacher's lesson-planning request and produce a structured lesson plan containing important instructional components.

4.2 Knowledge-Base Preparation

Curriculum and syllabus documents were selected as the primary knowledge sources. The purpose was to provide educational context for lesson-plan generation.

4.3 Text Processing and Chunking

The source documents were processed and divided into smaller text segments. Chunking enables the retrieval system to identify relevant sections instead of processing an entire document for every query.

4.4 Embedding and Indexing

The text segments were converted into numerical embeddings. These embeddings were stored in a FAISS vector index to enable similarity-based retrieval.

4.5 Query and Retrieval

The teacher provides information such as class, subject, topic and lesson requirements. The query is converted into an embedding and compared with the indexed curriculum vectors. The most relevant text segments are retrieved.

4.6 Prompt Construction and Generation

The retrieved information is combined with the user's lesson-planning requirements to construct a contextual prompt. The Gemini model then generates a structured lesson-plan draft.

4.7 Human Validation

The final stage is teacher review. The teacher or student-teacher checks the generated objectives, activities, examples, questioning and assessment and modifies them where necessary.

Table 1. Major System Components

Component	Technology/Resource	Purpose
Knowledge source	Curriculum and syllabus documents	Provides educational context
Retrieval	Embeddings + FAISS	Finds relevant curriculum content
Generation	Gemini	Produces lesson-plan draft
Application	Streamlit	Provides web interface
Validation	Teacher/student-teacher	Reviews and modifies output

5. SYSTEM ARCHITECTURE AND IMPLEMENTATION

The proposed system follows a retrieval-and-generation architecture. The major stages are:

Curriculum/Syllabus Documents → Text Extraction and Chunking → Embedding Generation → FAISS Vector Index → Teacher Query → Semantic Retrieval → Relevant Curriculum Context → Prompt Construction → Gemini Generation → AI-Generated Lesson Plan → Teacher Review and Modification

5.1 User Interface

The application is developed using Streamlit. The interface allows users to enter information such as class, subject, topic, objectives, duration and lesson requirements. The aim is to provide a simple interaction environment without requiring users to work directly with the underlying Python implementation.

5.2 Retrieval Layer

The retrieval layer is responsible for locating relevant curriculum information. The process can be summarised as:

Document → Chunk → Embedding → FAISS Index

For a user query:

Query → Embedding → Similarity Search → Relevant Chunks

The retrieved chunks provide contextual information for the generation stage. A keyword-search fallback can also be used when required, providing an alternative mechanism for locating relevant terms.

5.3 Generation Layer

The Gemini model receives the user's lesson-planning requirements together with the retrieved educational context. The generated output can contain:

- Class, subject and topic
- Duration
- Learning objectives
- Previous knowledge
- Teaching-learning materials
- Introduction
- Teacher activity
- Student activity
- Presentation/development
- Questioning
- Learning resources
- Assessment
- Remedial activities
- Closure

The exact content can be modified by the teacher according to classroom requirements.

5.4 Web Deployment

The prototype is deployed as a Streamlit web application and is available at:

<https://ai-teacher-plan.streamlit.app/>

The web-based design makes the prototype accessible to teachers and student-teachers without requiring direct interaction with the underlying development environment.

6. PROTOTYPE EVALUATION AND FINDINGS

The prototype was evaluated through functional testing and qualitative examination of its workflow. The purpose of this evaluation was to determine whether the major components operated as intended rather than to establish causal educational effectiveness.

Table 2. Functional Evaluation

Evaluation Area	Prototype Observation
Curriculum grounding	Curriculum/syllabus information is used as contextual input
Semantic retrieval	Relevant information can be retrieved through FAISS
AI generation	Gemini produces structured lesson-plan content
Web access	Streamlit provides browser-based interaction
Retrieval fallback	Keyword-based search can provide an alternative retrieval mechanism
Human control	Teacher review is included before classroom use

The functional evaluation indicates that the prototype integrates retrieval and generation into a single lesson-planning workflow. The retrieval layer provides curriculum-related context, while the generative layer converts the context and user requirements into a structured lesson-plan draft. A major feature of the system is the separation of responsibilities between FAISS and Gemini. FAISS performs information retrieval, whereas Gemini performs natural-language generation. This separation provides a clear architecture in which the generative model is not expected to independently identify all relevant curriculum information.

The prototype also demonstrates the usefulness of a simple web interface. Teachers and student-teachers can interact with the system through a browser rather than directly using programming tools.

The generated lesson plan should be considered a **first draft** rather than a final authoritative teaching document. Its value lies in reducing repetitive drafting and providing material that can be critically examined and improved by the teacher.

7. EDUCATIONAL SIGNIFICANCE

The project is particularly relevant to the conference themes of **Artificial Intelligence in Education, Digital Pedagogy and Teacher Education, Educational Research and Innovation, Innovations in Teaching and Learning, Emerging Technologies in Education, Teacher Professional Development, Learner-Centred Digital Education, and 21st Century Skills and Digital Literacy**.

For teachers, the system can provide a starting point for lesson preparation rather than requiring every component to be written from the beginning. This may be especially useful when teachers need to prepare multiple lesson plans.

For B.Ed. student-teachers, the system has an additional educational function. A student-teacher can compare an AI-generated lesson plan with principles learned in teacher education. Instead of simply accepting the generated content, the student-teacher can critically examine whether the objectives are measurable, activities are learner-centred, questions are age-appropriate, assessment corresponds to the objectives and content is aligned with the syllabus.

The system may also support learner-centred planning by suggesting examples, group activities, questioning strategies, differentiated tasks and remedial activities. However, the presence of such suggestions does not automatically make a lesson learner-centred. Their appropriateness depends on the actual learners, classroom environment and teacher's professional judgement.

Thus, the project demonstrates a shift from viewing AI only as a content generator towards viewing AI as a **planning assistant and reflective teaching-support tool**.

8. ETHICAL CHALLENGES, LIMITATIONS AND FUTURE SCOPE

Generative AI in education requires responsible human oversight. AI-generated content may contain factual errors or hallucinations; therefore, teachers must verify generated lesson plans. Retrieval improves curriculum grounding but cannot guarantee complete alignment with prescribed requirements. Outputs should also be reviewed for cultural, linguistic, gender and other biases.

Student-sensitive information should not be unnecessarily entered into external AI systems, and the use of copyrighted curriculum and learning materials must follow institutional and legal requirements. Excessive dependence on AI may weaken independent planning and professional judgement; hence, AI should function as an assistant rather than an authority. Unequal access to devices, connectivity and AI tools may also create digital inequality.

Limitations

The present study is a design-and-development project focused on producing and examining a functional prototype. It does not provide experimental evidence of improvements in student learning, teacher workload, teaching effectiveness or classroom outcomes. The quality of generated lesson plans depends on the quality of source documents, retrieval performance, user prompts and the generative model. The evaluation is primarily functional and qualitative rather than a large-scale empirical evaluation involving teachers and students.

Future Scope

Future development may include support for multiple subjects, educational boards and languages, multilingual generation, voice interaction, Word/PDF export and lesson-history management. Further possibilities include differentiated and inclusive lesson planning, automated learning-outcome and assessment alignment, and worksheet or quiz generation.

Future empirical studies can compare conventional and AI-assisted lesson planning using measures such as planning time, curriculum alignment, objective clarity, learner-centredness, assessment quality, inclusivity and teacher satisfaction. Such studies would provide stronger evidence regarding the educational effectiveness and practical value of the proposed system.

9. CONCLUSION

This study presented an AI-enabled Lesson Plan Agent integrating **Retrieval-Augmented Generation (RAG), FAISS, Gemini and Streamlit**. Curriculum and syllabus documents are used as the knowledge base; relevant information is retrieved through semantic similarity search and supplied as context for generating structured lesson-plan drafts.

The key contribution is the integration of **curriculum grounding with generative AI**. FAISS supports information retrieval, Gemini generates lesson-plan content and Streamlit provides an accessible web interface. The prototype can support lesson preparation and student-teacher training by reducing repetitive drafting and encouraging the use of digital pedagogy and AI literacy.

However, AI-generated plans cannot independently guarantee accuracy, curriculum alignment, inclusivity or pedagogical suitability. Teacher review and professional judgement therefore remain essential. The proposed approach can be summarised as:

AI-assisted planning + curriculum grounding + teacher judgement + human validation.

Responsible use of this model can position generative AI as a practical support for instructional planning and teacher professional development rather than a replacement for teachers.

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Internet of Things (IoT) as an Emerging Technology in Education

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1. Executive Summary

The Internet of Things (IoT) is transforming education by enabling smart learning environments, hands-on experiential learning, and real-time data interactions. This study explores the impact of teaching IoT concepts to students through a practical project using Arduino UNO with a breadboard by connecting an LED and an ultrasonic sensor. The study was conducted among students to analyze their learning experience, engagement, and understanding of IoT concepts. Data were collected using structured questionnaires and analyzed using descriptive statistics. The findings reveal that practical IoT learning enhances students' understanding, problem-solving skills, and interest in technology.

2. Introduction

IoT connects physical devices to the internet, allowing them to sense, collect, exchange, and act on data. In education, IoT offers opportunities for interactive and practical learning. Introducing IoT through simple circuits using Arduino UNO helps students understand core concepts such as sensors, actuators, and real-time data processing. A typical beginner project includes blinking an LED and measuring distance using an ultrasonic sensor. Such activities help Students Bridge the gap between theoretical knowledge and real-world applications.

3. Importance of the Study

This study is important as it evaluates how practical IoT activities improve student learning outcomes, engagement, and skill development. It also helps educators understand the challenges and benefits of integrating IoT in classroom teaching.

4. Need for the Study

With the rapid growth of IoT in industries and daily life, students must be prepared with hands-on skills from an early stage. However, there is limited research on the effectiveness of simple Arduino-based IoT projects in educational settings. This study addresses that gap.

4.1 Purpose of the Study

To evaluate the effectiveness of teaching IoT concepts using Arduino UNO with LED and Ultrasonic sensor through hands-on activities.

4.2 Scope of the Study

The study is limited to school/college students who have basic knowledge of electronics and programming. It focuses on a single IoT project setup and its educational impact.

4.3 Objectives of the Study

- To introduce IoT concepts using Arduino UNO.
- To assess students' understanding and engagement through practical activities.
- To analyze the impact of hands-on IoT learning on problem-solving skills.
- To identify the challenges faced by students in learning IoT practically.

5. Research Methodology

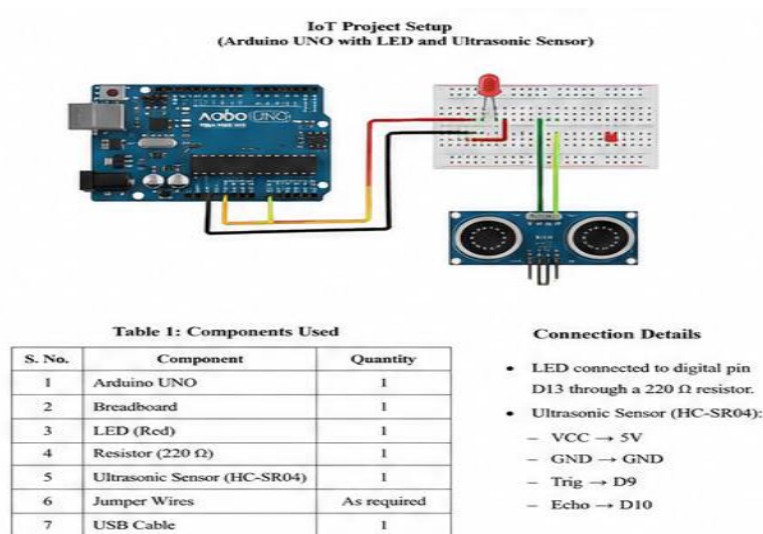
The study follows an experimental learning approach with a pre-defined IoT project. Students were trained and then evaluated through questionnaires.

5.1 Sampling Plan

A total of 50 students were selected using convenience sampling from a higher secondary school/college.

5.2 Methodology

The methodology involves training students on IoT basics and guiding them to build a simple project using Arduino UNO with an LED and an ultrasonic sensor. Data were collected before and after the activity to measure learning improvement.



6. Data Collection

6.1 Primary Data

Primary data were collected using a structured questionnaire consisting of Likert scale questions (1 to 5) and multiple-choice questions. The questionnaire measured understanding, engagement, and satisfaction levels.

Table 1: Sample Questionnaire (Likert Scale)

No.	Question	Scale (1–5)
1	I understand IoT concepts after the activity.	1 2 3 4 5
2	The hands-on activity was interesting.	1 2 3 4 5
3	The project improved my practical skills.	1 2 3 4 5
4	I can build similar IoT projects in the future.	1 2 3 4 5
5	IoT learning will help in my future career.	1 2 3 4 5

7. Data Analysis

7.1 Statistical Tool

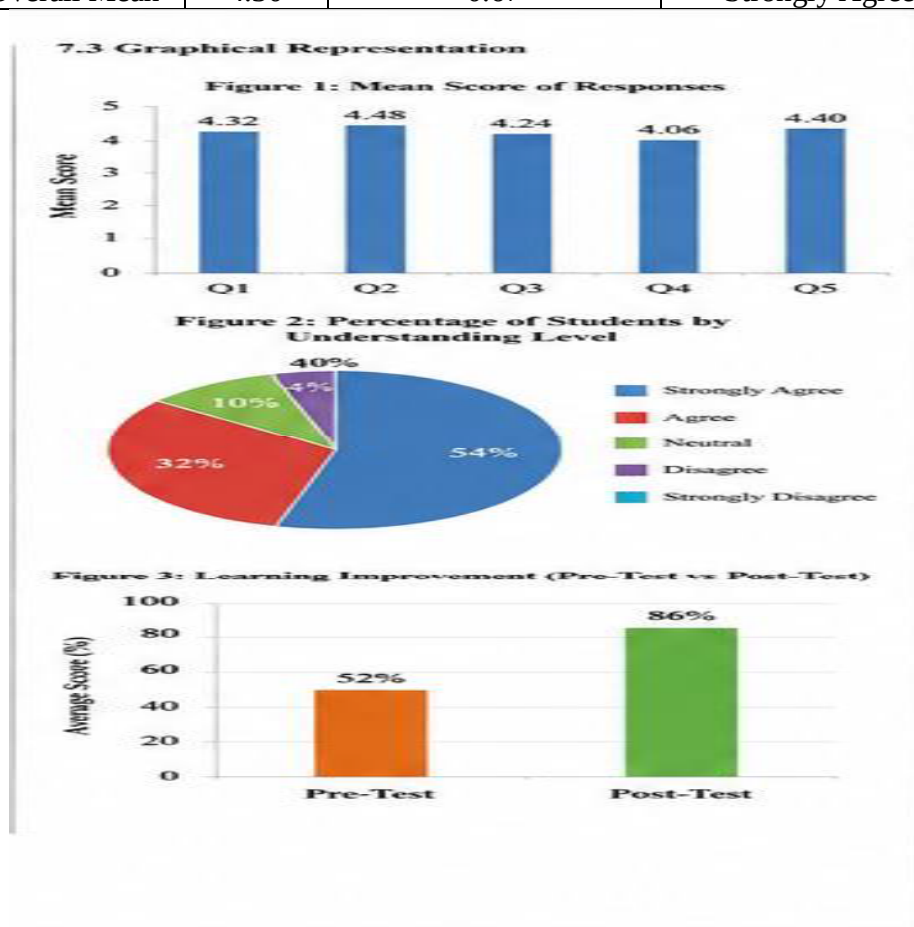
Microsoft Excel was used to find the Descriptive statistics (Mean, Standard Deviation, Percentage).

7.2 Statistical Package

The data analysis was performed using Microsoft Excel.

Table 2: Descriptive Statistics (N = 50)

Question No.	Mean	Standard Deviation	Interpretation
1	4.32	0.68	Strongly Agree
2	4.48	0.59	Strongly Agree
3	4.24	0.71	Agree
4	4.06	0.73	Agree
5	4.40	0.63	Strongly Agree
Overall Mean	4.30	0.67	Strongly Agree



8. Limitations of the Study

- The study is limited to 50 students from a single institution.
- The project involved only basic IoT components.
- Results may vary with different age groups and prior knowledge.
- The study measures short-term learning impact only.

9. Analysis and Interpretation

The results indicate that students show a high level of understanding and interest in IoT through hands-on activities. The average mean score of 4.30 shows a positive impact on learning. The post-test scores (86%) are significantly higher than pre-test scores (52%), indicating learning improvement.

10. Findings

- Hands-on IoT learning improves understanding and retention.
- Students are highly engaged in practical activities.
- Simple projects enhance confidence and creativity.
- IoT learning motivates students toward future technology exploration.

11. Suggestions

- Integrate more IoT projects in the curriculum.
- Provide more lab facilities and IoT kits.
- Conduct workshops and competitions.
- Introduce advanced IoT applications gradually.

12. Conclusion

This study concludes that teaching IoT using Arduino UNO with LED and ultrasonic sensor is an effective way to introduce emerging technology concepts in education. It enhances practical skills, engagement, and prepares students for future technological challenges.

13. Scope of Further Work

- Expand the study to multiple institutions and larger sample size.
- Include advanced IoT projects (Wi-Fi, Cloud, Mobile Apps).
- Conduct longitudinal study to measure long-term impact.
- Integration of AI and IoT for smart learning environments.

14. Social Contribution

The proposed IoT-based educational experiment using an **Arduino UNO, ultrasonic sensor, LED, and breadboard** provides several important benefits to society by connecting theoretical knowledge with practical applications. The experiment introduces students to the basic concepts of sensors, microcontrollers, programming, automation, and IoT in a simple and affordable manner.

1. Practical STEM Education: The experiment provides hands-on learning in Science, Technology, Engineering, and Mathematics (STEM). Students can understand how an ultrasonic sensor detects objects and how the Arduino processes the sensor data to control an LED.

2. Skill Development: Working with Arduino and electronic components develops students' programming, circuit-design, logical-thinking, problem-solving, and troubleshooting skills. These skills are valuable for higher education and employment in technology-related fields.

3. Smart Classroom Development: The same sensor-based concept can be extended to smart classrooms for applications such as automatic lighting, student presence detection, distance monitoring, and classroom automation.

4. Energy and Resource Management: IoT sensors can help educational institutions monitor and control electricity, lighting, temperature, water usage, and other resources. This can contribute to energy conservation and efficient resource utilization.

5. Encouragement of Innovation: Low-cost Arduino-based experiments allow students to develop their own IoT prototypes. Students can transform classroom ideas into practical solutions for real-world problems.

6. Preparation for IoT Careers: Early exposure to microcontrollers, sensors, programming, and connected devices prepares students for emerging careers in IoT, embedded systems, robotics, automation, smart cities, healthcare technology, agriculture technology, and Industry 4.0.

7. Affordable Technology Education:

Arduino-based learning can be implemented with relatively low-cost components, making practical IoT education accessible to schools and colleges with limited laboratory resources.

8. Social and Economic Benefits:

Developing technically skilled students contributes to a knowledgeable workforce capable of creating innovative technological solutions. In the long term, this can support entrepreneurship, employment generation, digital transformation, and technological development.

9. Real-World Problem Solving:

The ultrasonic sensor experiment demonstrates how a simple IoT system can detect physical conditions and generate an immediate response. Students can use this basic principle to develop applications such as obstacle detection, smart parking, security systems, assistive technologies, and automated control systems.

10. Overall Societal Impact:

IoT-based education helps bridge the gap between academic learning and real-world technological applications. By providing students with practical experience using Arduino, sensors, and programming, educational institutions can contribute to developing innovative, technically skilled, and future-ready citizens.

Thus, the Arduino UNO-based ultrasonic sensor and LED experiment is not only an educational activity but also a foundation for developing the technical knowledge, creativity, innovation, and problem-solving abilities required for a digitally connected society.

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From Chisel to Cursor: A Digital-Arts-Education-Framework for Drawing and Sculpture Pedagogy in Traditional Śilpa Śāstra Patashala

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ABSTRACT

Traditional heritage drawings and sculpture-making education have long relied on studio-based instruction, physical demonstrations, and teacher-guided evaluation, which have long been considered effective for arts-based, skill-oriented teaching and development. However, current pedagogy offers limited scope for objectives such as dimensional measurement, digital documentation, and systematic evaluation of classical artistic principles. The study puts forward Digital-Arts-Education-Framework (DAEF) that integrates modern digital technologies with conventional drawing and sculpture instruction to create an interactive, measurable, and knowledge-driven learning environment. This framework spans four domains: Capture (3D Scanner), Design and modelling (Computer-aided Drawings), Computational analysis (AI), and Visualization (AR/VR), which collectively enable a progressive digital learning path for students to adopt 3D sculpture-making from 2D sketching foundations. Specifically, for Indian traditional arts such as Śilpa Śāstra. The DAEF encodes iconography and canonical proportions (e.g., tālamāna) into a digital knowledge base, showing rule-based evaluations conducted to evaluate students against established artistic canons. The framework brings in a continuous cycle of learning, drawing, creating, capturing, digitizing, analysing, validating, and correcting to perfection. Contemporary art teaching is now harmonized with digital learning and the continuity of heritage art knowledge. Furthermore, students will be able to create digital repositories of heritage objects for long-duration documentation, digital drawing, AR/VR-based visualization, and 3D-printed educational replicas. The proposed model by fusing human-artistic creativity and computation-driven assistance considers technology as a support, not a substitute, for traditional craftsmanship. It offers measurable benefits such as skill learning, objective evaluation, cultural knowledge transfer, and sustainable preservation of antique artistic and sculptural heritage.

Keywords: Digital arts education; Śilpa Śāstra; tālamāna; Heritage craft pedagogy; 3D scanning and modelling; AR/VR visualization; Computational art assessment; Digital heritage preservation.

1. Introduction

The art and sculpture of Indian temples are deeply embedded in a codified tradition of knowledge in which the creation and treatment of an icon is directed by the principles of its iconography, geometry, proportion, measurement, and material practice. Within this tradition, tālamāna (iconometry) provides proportional systems for the construction of sacred images identified through canonical prescriptions that relate the measurements between parts of the sculptural form (Rao 1920; Sharma et al. 2025). The rendering of an iconographic idea into a three-dimensional stone sculpture from a two-dimensional canonical drawing is, in effect, a systematic transference of traditional knowledge. Further, we see this systematic transference of a traditional idea into a

new form. New studies show that photogrammetric three-dimensional models can provide iconometric measurement and digital documentation of temple sculptures (Salvi, 2024).

Traditionally, in Śilpa education, the emphasis is on an apprenticeship-oriented progression which runs: after the learning of the canonical principles, the learner goes to the practice of traditional drawing, transference of the drawing into sculptural form, carving, and finishing of the surface, measuring proportion, ruling correction, and finishing the sculpture. Through such pedagogy, the embodied knowledge and craftsmanship of the master–student interaction gets preserved. However, assessment and correction are still largely manual and expert-dependent. A traditional Śilpa institute still emphasizes that scriptural knowledge, drawing practice and practical sculpture training are interrelated facets of sculpture education.

Recent advancements in AI, computer vision, image processing, augmented reality, and 3D digitisation create an opportunity to augment, not replace, this century-old pedagogy. AI-supported programmes to teach art have already proven outline recognition, visual evaluation and personalised feedback on drawing tasks. The use of deep-learning systems for immediate and personal guidance of learners has also been explored in art education (Chen et al., 2022; Hwang et al., 2024). AI must be integrated into visual-art education with pedagogical cohesion and sensitivity to disciplines, according to recent reviews (Hong et al., 2026).

This study thus proposes an alternative Digital Arts Education Framework (DAEF) that runs parallel to the tradition of Śilpa Śāstra pedagogy. The system provides machine-vision-assisted self-validation at two critical learning transitions – it ensures whether the learner’s 2D canonical drawing adheres to proper geometric and Tālamāna proportions. And whether the subsequently carved three-dimensional sculpture retains those canonical relationships. DAEF, through a continuous cycle of Learn → Draw → Create → Digitise → Analyse → Validate → Correct → Recreate, aims to link traditional knowledge and embodied craftsmanship with computational assessment, allowing the student to recognise proportional deviations and gradually refine the work without disempowering the traditional pedagogical system.

2. Literature Survey

2.1 Educational Pedagogical Survey: From Traditional Arts Learning to AI-Assisted Digital Pedagogy

In a traditional art and sculpture educational pedagogy, progressive learning, repeated exercise, observation, creation, expert feedback, corrections, and refinement form the cornerstone of the subject, where knowledge is transferred through the continuous interaction of the learner, the artistic material, and the teacher. Upon analysis of the Śilpa Śāstra education, the trajectory can be understood as Learn the canonical → Draw → Practise → Sculpt → Measure → Refine → Correct And Recreate, which can be interpreted as the journey that preserves both the theory and practice. However, modern education research shows a growing shift to technology-enabled, student-centered, and digitally assisted learning environments. Between 2020 and 2026, a systematic evidence synthesis of 2,258 publications found that digital/technology-enhanced arts education (1,276 publications; 56.51% thematic coverage) was the largest thematic category, indicating interest in the integration of digital technologies in arts learning.

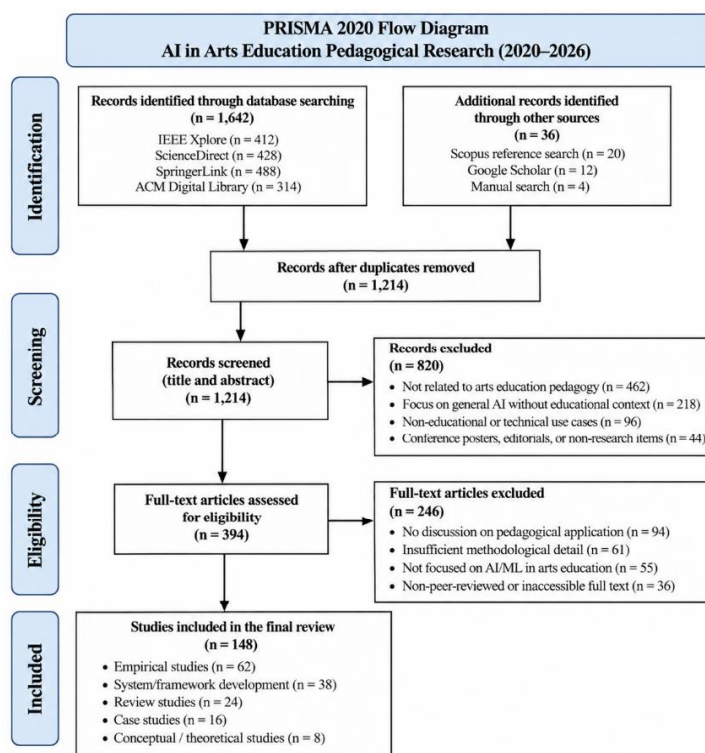


Fig. 1. PRISMA 2020 Flow Diagram for the Systematic Selection of Studies on AI-Assisted Pedagogy in Arts Education (2020–2026).

According to Han et al. (2026), more research is popping up about how to introduce digital technology into pedagogical practices in art education. Hong (2026) takes a different approach that reflects on how intelligent technologies will assist visual-arts learning, creativity, and opportunities. In 2025 Liu et al. said that generative AI has also been explored in design-drawing education in drawing-related learning work. Methods can extend the pedagogical environment further. We see that 3D virtual reality has been studied for its application on undergraduate sculpting and carving skills (Qian & Luo, 2026). In addition, experts argue that augmented and mixed-reality approaches can bring new possibilities for immersive, embodied, and material-based artistic experiences (Atlavina, 2026; Doyle, 2025). The evidence base across the project is showing increasing integration across all areas of educational, heritage, AI, and immersive-technology research. Notably, system/framework development is the most identified methodology.

Thus, the educational opportunity is not a replacement for conventional teacher-led craft-making but rather a supplementary digital pedagogical level that could complement observation, visualization, practice, formative feedback, and self-assessment. This gives pedagogic grounding for the Digital Arts Education Framework (DAEF), whereby the existing process of Silpa learning (traditional art-making disciplines) remains the point of reference but is enhanced through the agency of AI and computer vision, which help students authenticate and rectify their movement from normative 2D drawing to physical sculpture.

2.2 Technological Evolution from Iconometry to Machine-Vision-Based Sculpture Analysis

From the first half of the 19th century, iconometry became a new form of knowledge in India, based on the systematic principles of *tālamāna*, canonical proportion, geometry, and iconographic representation. These are rule-based techniques to convert scriptural knowledge into drawings and physically into sculpture (Meister 1985; Mosteller 1988; Rao 1920). Recent systematic evidence suggests that this traditional knowledge is increasingly getting into image processing, computer vision (CV), machine learning (ML), photogrammetry, and 3D reconstruction (Kumar et al., 2026). The authors' PRISMA-based review scanned four effective literature sources, namely IEEE Xplore, ScienceDirect, SpringerLink, and ACM Digital Library. It found 286 records. The screening and eligibility assessment retained 33 studies.

Technological literature reflects multiple complementary evolutions. Digital heritage investigation has made use of image processing and structured documentation for preservation (Bhaumik and Govil, 2020), while ML has been deployed for classification of religious sculptures (Shivane et al., 2021). Yang and Fan (2023) additionally undertook computational analysis of canonical facial traits utilizing Dlib-based machine learning, exhibiting the feasibility of landmark-based geometric estimation. Similar advancements have brought about deep learning to automate the recognition of 2D engineering drawings (Lin et al., 2023), while digitization of complex drawings can also enhance automatic interpretation of geometric information (Moreno-Garcia et al., 2019). Vision-based 3D reconstruction and photogrammetry also offer us techniques for transforming several images into measurable three-dimensional forms (Liu et al., 2024; Polidori, 2020).

Even with this development, the technologies are insufficiently integrated with traditional *Tālamāna*-based sculpture-making processes. According to Kumar et al. (2026), most existing research treats iconometry, CV/ML, digital heritage, and 3D reconstruction as distinct domains. Their review does not find any CV/ML–*Tālamāna* proportional-verification pipeline in the corpus surveyed. Furthermore, they note that experimental validation is limited, there are no benchmark *Tālamāna*-labelled datasets, and there is insufficient computational formalisation of canonical rules. As a result, there is a considerable research scope to connect canonical 2D drawing → machine-vision validating → real-life sculpture → 3D digitisation → proportional comparison → corrective feedback, which can be the technological foundation for an essential Digital Arts Education framework that adds a computational self-validating process to the traditional *Śilpa* pedagogical process (Kumar et al. 2026).

Methodology

3.1 Research Design and Framework Development

This study takes a conceptual framework-development approach to generate the Digital Arts Education Framework (DAEF) drawing evidence from traditional arts pedagogy, digital arts education, artificial intelligence, and computational approaches to making, documenting and assessing art. The evidence base demonstrates significant research activity on the technology-enhanced arts education and AI/ML. In contrast, the literature we examined shows relatively lesser focus on computer vision, 3D reconstruction, and integrated computational assessment. Studies reveal that technologies (e.g. AI, digital drawing, VR/AR, and other education technologies) are commonly studied as stand-alone tools rather than constituent parts of an ongoing artistic learning

and assessment process (Liu et al., 2025; Hong, 2026). The structure of DAEF focused on the attempt to preserve traditional teacher-guided and practice-oriented artistic learning while introducing digital technologies for documentation, analysis, validation, feedback and incremental improvement.

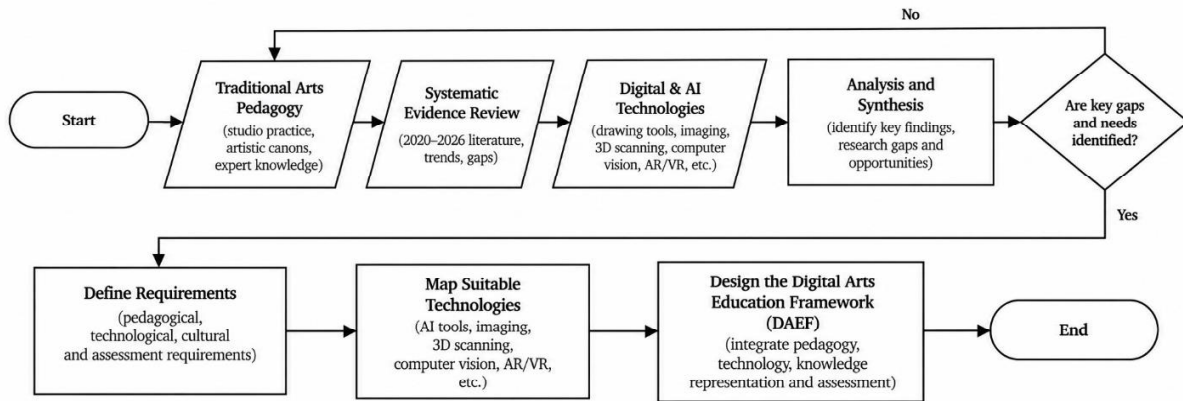


Fig. 2. Methodological Development of the Digital Arts Education Framework (DAEF).

3.2 DAEF Architecture and Nine-Stage Pedagogical Cycle

DAEF functions as a combined learning–production–validation system which traditional art practice stands at the learning focus with digital technology providing further functionalities for documentation, measurement, analysis and feedback. The nine interconnected stages are Learn → Draw → Create → Capture → Digitise → Analyse → Validate → Correct → Recreate. First three stages establish knowledge and artistic production. Capture and digitise: turn the learner’s work into computationally-accessible evidence. Analyse and validate: measure artistic characteristics against references or knowledge rules, and measure association. Correct and recreate: turn the feedback into further artistic practice. As a result, an artwork is not treated as something that has merely been learned, but forms the basis for further observation, assessment, correction and improvement. The iterative design also exemplifies formative-assessment principles. This entails that feedback serves a formative purpose when students can act on the feedback and develop self-regulation progressively (Nicol & Macfarlane-Dick, 2006; Carless, 2014).

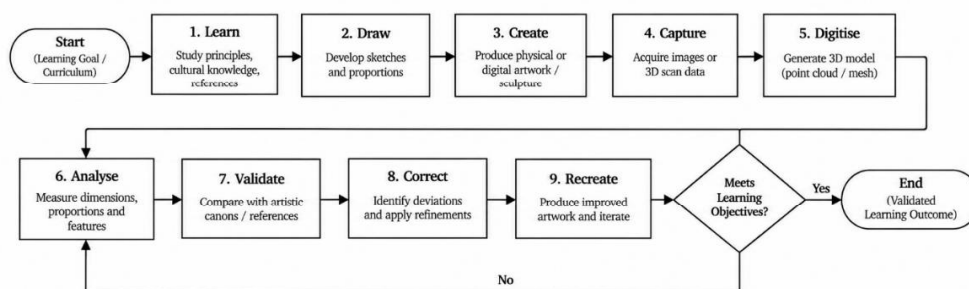


Fig. 3. Continuous Nine-Stage DAEF Pedagogical Cycle for Artistic Learning, Assessment, and Improvement.

3.3 Digital Analysis, Validation and Feedback Mechanism

The computational part of DAEF links the learner's physical or digital artwork to measurable evidence and understandable feedback. Through Capture and Digitise, imaging can be performed by using photography, controlled imaging, photogrammetry, or 3D scanning to create an image, point cloud or 3D model of an object. As part of the project analysis computer vision, artificial intelligence, geometric analysis and digital metrology could be used to study measurables like dimensions, proportionality, symmetry, landmarks, relationships, and deviations. This observation can be compared with some pre-defined knowledge (artistic, geometric, iconographic, domain-specific) during Validate, generating the relationship Expected Parameter → Observed Parameter → Deviation → Feedback. The learner and the teacher can then interpret overlays, measurements or corrective suggestions visually before they return to correct and recreate. In a crucial distinction, DAEF does not cast computational assessment as the ultimate arbiter of artistic quality. Creativity, skill, cultural understanding, and final artistic judgement all remain human domains.

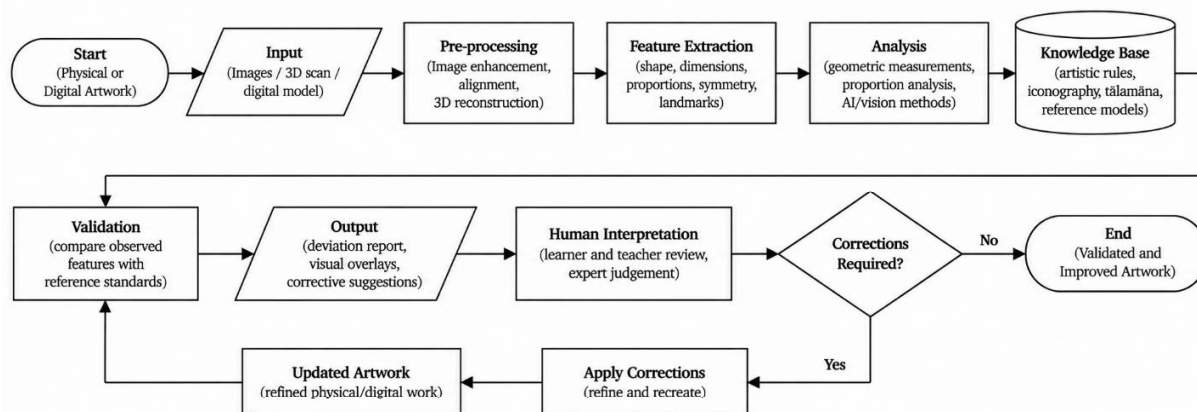


Fig. 4. Digital Analysis, Knowledge-Based Validation, and Human-in-the-Loop Feedback Mechanism of DAEF.

4. Discussion

4.1 Research Findings

The research literature on AI-pedagogy reveals various related gaps in research

- (1) fragmented technological integration, where AI, digital drawing, VR/AR and other educational technologies are usually studied as freestanding inventions rather than as components of a big pedagogical architecture (Liu & Wang, 2025; Hong, 2026);
- (2) lack of learning–assessment–correction loop, linking artistic learning–creating–digital capturing–computational analysis–feedback–correction–recreating;
- (3) lack of objective and computational assessment of students' artistic learning while retaining expert teacher judgement;
- (4) lack of evidence on long-term educational impact of AI-supported arts learning;
- (5) lack of iterative and actionable feedback for sustained improvement of drawing, sculpting and craft skills;
- (6) weak integration of AI-based learning environments with embodied artistic practice where actual interaction with materials remain the essential;
- (7) lack of self-assessment and self-regulated correction by learners although formative feedback has pedagogical value; and

(8) lack of full digital documentation of the learner-development trajectory, including all intermediate attempts, feedback, corrections, and progressive improvements.

When taken together, these gaps indicate that the main challenge is not so much the introduction of an individual AI tool into any arts education approach. Instead, it is the overall development of a human-centred pedagogy that is able to connect Learn → Create → Digitize → Analyse → Validate → Feedback → Correct → Recreate in a way that ensures constant self-validation of learners. Teacher guidance and embodied artistic practice will remain essential (Hong, 2026; Zhang & Peng, 2026).

4.2 SOLUTION Framework

The proposed Digital Arts Education Framework (DAEF) provides an integrated Learn → Draw → Create → Capture → Digitize → Analyze → Validate → Correct → Recreate cycle that can help address the fragmentation and limited objective assessment and weak feedback continuity in existing research on digital arts education. DAEF does not stand in place for studio practice or expert instruction; rather, it means the addition of a computational layer that converts the learner's artwork into digitalizable evidence, which can be measured, which in turn receives interpretable feedback, which can help the learner to improve. This positioning, grounded in the human, is in solidarity with the framework that favors technology that expands artistic practice with the learner and educator as active decision-makers. The Learn stage develops knowledge of the artist's artistic, cultural, historical, and canon background; Draw provides a 2D reference through sketches and visual studies, and Create produces ephemeral or digital artwork from knowledge. The resulting sculpture is captured through controlled photography, multi-view photogrammetry, or 3D scanning. Digitized as a measurable point cloud or 3D mesh, these acquisition methods have established applications for metrically reliable documentation of artistic and heritage objects (Balletti et al. 2017). The key computation takes place during analysis, where we can extract dimensions, proportions, anatomical landmarks, symmetry, shape characteristics, and geometric deviations using computer vision, image processing, AI, and 3D geometry. After conducting the validation process, the observed results are compared with references selected by the educator, artistic criteria, or formally prescribed criteria. This process creates a relationship that is interpretable in terms of Expected Parameter → Observed Parameter → Deviation → Feedback, rather than a black box automated judgement. While correct, deviations may be reported via measurement reports, overlays, highlighted areas, and recommendations for correction to show the learner what is different, where it is different, and what to improve.

The student recreates the drawing or sculpt and puts it through another analysis-validation cycle. The iterative nature of this structure is pedagogically relevant since formative assessment only works when evidence is converted into something achievable for corrective action and supports progressively self-regulated learning (Nicol & Macfarlane-Dick, 2006; Carless, 2014). As a result, the DAEF provides the scholar or art educator with an accessible post-validation environment. As a result, 3D inspection complexities can be translated into comprehensible visual and quantitative evidence. Ultimately, the final aesthetic, cultural, and artistic interpretation remains in human expert judgement. Each cycle also generates a traceable learning record, Drawing Sculpture Digital Capture 3D Model Analysis Validation Correction Final Artwork, which can be used for formative assessment, learner self-validation, digital documentation, and preservation.

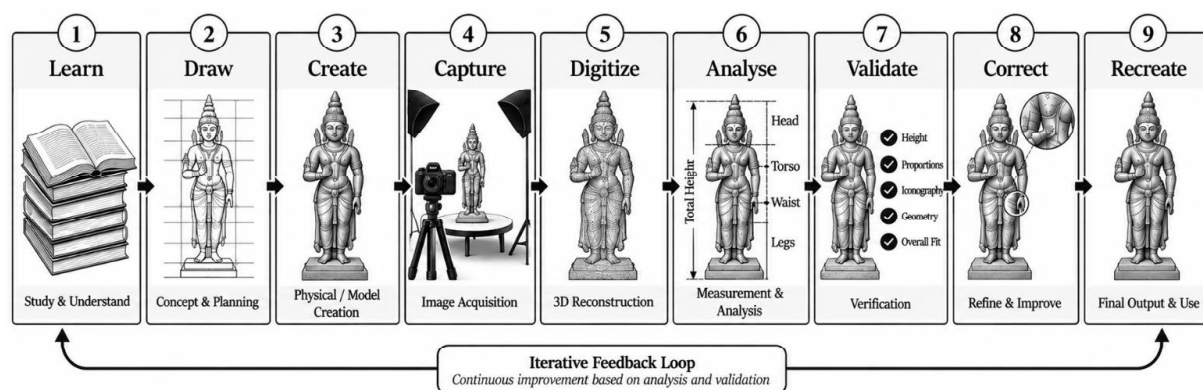


Fig. 5. Proposed DAEF Solution Framework Integrating AI, Computer Vision, Photogrammetry, and 3D Scanning for Continuous Artistic Learning, Computational Assessment, Post-Validation, and Iterative Correction.

The DAEF enables a continuum of such traditional artistic learning, physical making, digital documenting, computational evaluation and refining to be established. Photogrammetry and 3D scanning can convert physical artworks into quantifiable digital representations for documentation and analysis (Balletti et al., 2017). DAEF has incorporated AI and vision-assisted analysis, correction, and feedback and allow learners to see deviations from their desired outcome and progressively develop their work. Feedback of this kind facilitates reflective and self-regulated learning while still maintaining the expert judgement of an artist. The validated digital files produced as a result can be useful for education, research, knowledge preservation, digital repositories, 3D reproduction and AR/VR applications, and for their long-term safeguarding as cultural heritage.

5. Conclusion and Future work

The Digital Arts Education Framework (DAEF) is a 9-stage continuous pedagogical framework for linking traditional art-making and new digital technologies in a meaningful learning process. The framework mirrors the natural way a learner learns, draws, makes, looks, evaluates, corrects and improves. It brings in digital support wherever it can strengthen learning and assessment. Technologies that include digital drawing platforms, AI, computer vision, photogrammetry, 3D scanning and 3D modelling already assist in several stages. However, these technologies work more as standalone tools than components of an educational system. This means there is a facility to actually analyse the performance of a given AI system. It certainly helps further research by inciting AI and engineering researchers to design and experimentally validate intelligent modules for stages and progressively integrate them into the interoperable DAEF platform. A platform like that would enable a learner to naturally traverse the following path: artwork → digital → AI/vision-based analysis → rule-based validation → visual feedback → correction → re-validation. After the validations, students would likely find it easier to grasp conceptually complex material. The ultimate aim is not to permit AI to assess whether something is artistically good or not, but rather to create a human-in-the-loop intelligent learning environment where technology makes assessment more measurable, transparent and accessible while helping learners to self-correct. Creativity, craftsmanship, cultural interpretation, and final artistic judgement thus rest firmly with the learner, artist, teacher, and traditional scholar.

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Problems and Challenges Faced by Career Aspirants in Utilising Cloud-Based Learning and Assessment Infrastructure

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ABSTRACT

The rapid expansion of cloud-based platforms has transformed how career aspirants in India prepare for competitive examinations, offering flexible access to learning material and online assessments, though the transition has not been uniformly beneficial. This study examined problems and challenges faced by 310 career aspirants preparing for competitive examinations around Karaikudi, Tamil Nadu, in utilising cloud-based learning and assessment infrastructure across seven dimensions. A quantitative survey method was adopted, and data were analysed using percentage analysis, Pearson correlation and multiple linear regression. The level of problems and challenges was predominantly moderate across gender, examination type, device and internet connection. The seven dimensions were significantly inter-correlated, with the strongest relationships among the dimensions. Regression analysis showed that difficulty with the online assessment infrastructure was significantly predicted by security, privacy and fairness concerns, and by interaction, guidance and learning support, together explaining 43.9 % of the variance. These findings suggest that once foundational access barriers are addressed, trust in the fairness of cloud-based assessment becomes the more pressing concern for career aspirants. The study offers implications for coaching institutions, e-learning providers and policymakers designing more inclusive, learner-friendly cloud-based infrastructure for examination preparation.

Keywords: Cloud-based learning; Career aspirants; Online assessment; Digital divide; Self-regulated learning

INTRODUCTION

Career aspirants across India prepare for competitive examinations has undergone a marked transformation over the past decade. Traditional classroom coaching, printed study material and physical test centers are steadily being supplemented, and in many cases replaced, by cloud-based learning management systems, mobile applications, video-lecture platforms and online test series. Cloud computing, understood as an internet-delivered model that provides on-demand access to shared computing resources, storage and software (Ercan, 2010), has enabled coaching providers and government agencies alike to deliver study material, mock tests and result analytics to aspirants located far from urban coaching hubs. In Tamil Nadu, for instance, the state government's Virtual Learning Portal was launched to provide free e-content for TNPSC, UPSC, SSC, banking and railway examinations to aspirants across the state, reflecting a broader policy push toward democratizing access to competitive-examination preparation through digital infrastructure.

For a large section of career aspirants in India, many of whom are first-generation learners from rural, semi-urban and economically constrained backgrounds, this shift carries the promise of flexible, low-cost and continuously available learning. At the same time, it introduces its own set of demands: a stable internet connection, a functional device, basic digital literacy, the ability to navigate unfamiliar platforms, and the capacity to manage one's own learning without the structure

of a physical classroom. The COVID-19 pandemic accelerated this transition abruptly, and Indian research conducted during that period repeatedly reported that inadequate access to devices and the internet, unstable connectivity and rising data costs placed a disproportionate burden on students from lower-income and rural households (Rannaware et al., 2022; Suresh Babu, 2024). Whether the difficulties documented for school and college students during the pandemic still describe the everyday experience of career aspirants preparing for competitive examinations today, several years after the initial disruption, remains an open empirical question.

Career aspirants preparing for TNPSC, UPSC, SSC, banking, railway and similar examinations occupy a somewhat distinct position within the wider e-learning literature. Unlike enrolled university students, they are typically self-directed learners who voluntarily use cloud-based coaching platforms, mock-test portals and mobile applications over extended, often multi-year, preparation periods, frequently without the structured support of an institution. This places a heavier burden on their own self-regulation, digital competence and access to reliable infrastructure than is usually the case for students following a fixed academic curriculum. High-stakes online assessments, which many aspirants now complete as part of their preparation or, in some cases, as part of the actual selection process, add a further layer of difficulty: technical failures, unfamiliar test interfaces and identity-verification procedures can affect a candidate's performance and wellbeing in ways that have only recently begun to receive scholarly attention (Hartnett et al., 2023).

Despite the growing dependence of career aspirants on cloud-based infrastructure, much of the existing Indian literature on digital learning barriers was generated in the context of formal school and university education during the pandemic, and comparatively little research has specifically examined the problems and challenges experienced by career aspirants who use such infrastructure on a sustained, voluntary basis for competitive-examination preparation.

This gap is particularly evident in semi-urban and rural clusters such as Karaikudi in Sivaganga district, Tamil Nadu, where a sizeable population of aspirants prepares for government examinations while contending with variable infrastructure and limited institutional support. Against this backdrop, the present study seeks to systematically examine the problems and challenges faced by career aspirants in utilising cloud-based learning and assessment infrastructure, covering access and connectivity, device and digital skills, platform usability, self-regulation, learning support, online assessment infrastructure, and security and privacy concerns. The findings are expected to inform coaching institutions, e-learning platform developers and policymakers seeking to make cloud-based examination preparation more accessible, equitable and learner-friendly.

REVIEW OF LITERATURE

Digital Divide and Infrastructural Barriers in India

Access to reliable infrastructure continues to be the most frequently reported barrier to digital learning in India. National school-level data indicate that only 57.2 % of schools have computer facilities and 53.9 % have internet access, with sharp interstate variation; internet access in Bihar's schools, for example, stood at around 18.5 % compared to near-universal digital readiness in Delhi (UDISE+, 2024). At the household level, the Azim Premji Foundation (2021) estimated that close to 60 % of school-going children in India could not access online learning during pandemic-related

closures, a finding that underscored how unevenly digital resources are distributed across income groups and geographic regions. Studies conducted among school and college students in urban and semi-urban settings echo these figures at the individual level: in a survey of school children in an urban slum area of Pune, Rannaware et al. (2022) found that 16 % of respondents had no access to a smartphone, 95.5 % had no laptop, and close to a fifth reported no internet access at all, with the majority of parents also reporting increased financial strain from rising internet expenses. Suresh Babu (2024) similarly argued that the rapid shift to online education during the pandemic was embedded within pre-existing social and educational inequalities, disproportionately disadvantaging students from marginalised castes, tribes and low-income households. While these studies were largely situated in formal school and university settings, the underlying infrastructural constraints, unstable connectivity, shared or absent devices, and the rising cost of data, are equally, if not more, relevant to career aspirants who must sustain their own cloud-based preparation, often for several years, without institutional subsidy or support.

Self-Regulation and Learner Autonomy in Online Learning

Cloud-based learning removes many of the external structures, fixed timetables, the physical presence of instructors, and peer accountability, that traditionally support learners, placing greater demands on self-regulated learning (SRL). Zimmerman's (2002) cyclical model describes SRL as comprising forethought, performance and self-reflection phases, through which learners plan, monitor and evaluate their own study behaviour. A systematic review by Edisherashvili et al. (2022) found that distance and online learners in higher education frequently struggle with the planning and self-monitoring phases of SRL, particularly around time management and resistance to digital distraction. Consistent with this, a meta-analysis by Doo et al. (2023) reported that self-directed learning is a significant predictor of learning outcomes in Massive Open Online Courses, while Guntur and Purnomo (2024), synthesising intervention studies across online and blended environments, concluded that structured SRL support meaningfully improves learner outcomes, implying that its absence is similarly consequential. Jin et al. (2023) observed that learners in online settings commonly find it difficult to sustain motivation and monitor their own progress without external cues, a difficulty that artificial-intelligence-based tools have increasingly been designed to address. For career aspirants preparing over extended, multi-year periods with minimal institutional oversight, the demand for sustained self-regulation is arguably more acute than for enrolled students following a semester-bound curriculum, making motivation, time management and content overload central, rather than peripheral, dimensions of the cloud-based learning experience.

Challenges in Online Assessment and Proctoring

The shift of high-stakes testing on to cloud-based platforms has introduced a distinct category of problems connected to the assessment process itself rather than to learning content. Hartnett et al. (2023), studying online proctored examinations during the pandemic, found that while most students felt reasonably confident using exam software, digital inequalities persisted in candidates' perceived competence and comfort with the technology, with implications for equity in high-stakes testing. Complexities associated with unfamiliar exam interfaces, limited opportunity to practise on the actual assessment system, and technical failures during a live test have been repeatedly linked to elevated test-related anxiety and to candidates' concerns that their responses may not be recorded correctly. Automatic session timeouts, restricted navigation between questions, and identity-verification procedures such as webcam-based monitoring introduce additional friction

that is largely absent from paper-based examinations. For career aspirants, many of whom now sit for preliminary screening tests, mock examinations, and even parts of the selection process itself, through cloud-based platforms, these technical and procedural difficulties are not incidental but can directly influence performance in examinations that carry substantial career consequences. Concerns regarding the security of personal data and the fairness of automated scoring, given unequal access to high-quality devices and connectivity among candidates, further compound the difficulties associated with cloud-based assessment infrastructure.

Technology Adoption Perspectives on Cloud-Based Learning

A parallel body of research has examined why and how far individuals adopt cloud-based educational technologies, largely through the lens of the Technology Acceptance Model and the Unified Theory of Acceptance and Use of Technology (UTAUT). Venkatesh et al. (2003) proposed that performance expectancy, effort expectancy, social influence and facilitating conditions jointly determine behavioural intention to use a technology, a model later extended by Venkatesh et al. (2012) to include hedonic motivation, price value and habit. A systematic review of UTAUT applications in higher education by Xue et al. (2024) found that perceived usefulness and ease of use remain the most consistently significant predictors of technology adoption across educational contexts, including cloud-based platforms. In a related study conducted among pre-service teachers in the Karaikudi locality, perceived ease of use emerged as the strongest predictor of favourable inclination toward cloud-based technologies, ahead of perceived usefulness, perceived security and frequency of use (Ramya & Rajeswari, 2024). These adoption-focused studies clarify why aspirants might choose to use cloud-based platforms, but they say comparatively little about the specific operational difficulties, connectivity failures, device limitations, platform-navigation problems and assessment-related anxieties, that aspirants encounter once they have adopted such platforms, a gap the present study addresses directly.

The reviewed literature establishes that infrastructural inequality, self-regulation demands, online-assessment difficulties and technology-adoption factors each shape learners' experience of cloud-based education. However, most Indian studies were conducted among school or university students during the acute phase of the COVID-19 pandemic, and adoption-focused studies typically measure inclination or intention to use technology rather than the concrete operational problems users encounter. Few studies have examined career aspirants, a large and growing population who use cloud-based learning and assessment infrastructure voluntarily and continuously over extended preparation periods, often without institutional support. The present study addresses this gap by empirically examining the problems and challenges experienced by career aspirants in the Karaikudi vicinity across seven interrelated dimensions.

THEORETICAL FRAMEWORK

This study draws on three complementary theoretical perspectives to explain why career aspirants might experience difficulty in utilising cloud-based learning and assessment infrastructure. First, the digital divide framework, most influentially articulated as a sequence of first-level (physical access), second-level (skills and usage), and third-level (outcome) inequalities (van Dijk, 2005), provides the basis for the access and connectivity, and device and digital skills, dimensions examined in this study: aspirants who lack reliable connectivity or a suitable device, or who lack confidence navigating digital platforms, experience difficulty at the most basic level, before

questions of learning or motivation even arise. Second, Zimmerman's (2002) cyclical model of self-regulated learning explains why the removal of the institutional structure inherent in cloud-based, self-paced preparation places additional cognitive and motivational demands on the learner, corresponding to the learning, motivation and self-regulation, and interaction and learning support, dimensions of the study. Third, the Unified Theory of Acceptance and Use of Technology (Venkatesh et al., 2003, 2012) contributes the notion of facilitating conditions, organizational and technical support that enables effective use of a technology, which is reflected here in the platform usability, online assessment infrastructure, and security, privacy and fairness dimensions. Rather than treating these as competing explanations, the present study integrates them: digital divide theory explains structural barriers to access, self-regulated learning theory explains individual-level management of the learning process once access is available, and the facilitating-conditions construct from UTAUT explains the platform- and system-level factors that determine whether use, once attempted, proceeds smoothly. Together, these three perspectives justify the seven-dimension structure adopted for examining the problems and challenges faced by career aspirants in this study.

CONCEPTUAL FRAMEWORK

Building on the theoretical perspectives outlined above, the conceptual framework for this study positions selected demographic and access-related variables, age, gender, educational qualification, type of competitive examination, duration of preparation, locality of residence, primary device used, and type of internet connection, as background variables that may influence the extent of difficulty career aspirants experience. These background variables are examined in relation to seven interrelated dimensions of problems and challenges identified through the literature review and operationalized in the adapted research questionnaire. These seven dimensions are conceptualized as distinct but potentially correlated facets of a broader construct, the overall level of difficulty career aspirants experience in utilising cloud-based learning and assessment infrastructure, which forms the outcome of interest in this study. The conceptual model, summarized in Table 1, thus proceeds from background and demographic characteristics, through the seven problem dimensions, to the overall perceived difficulty that the study seeks to measure, compare across groups, and explain.

Background / Demographic Variables	Seven Dimensions of Problems and Challenges	Outcome Variable
<ul style="list-style-type: none"> Gender (Male/Female) Examination Type (TNPSC/TRB/SSC/RRB/UPSC) Primary Device Used (Smartphone / Tablet / Laptop / Desktop /) Primary Internet Connection (Broadband-Wi-Fi/Mobile Data/Public Network) 	<ol style="list-style-type: none"> 1. Access and Connectivity 2. Device and Digital Skills 3. Platform Access and Usability 4. Learning, Motivation and Self-Regulation 5. Interaction, Guidance and Learning Support 6. Online Assessment Infrastructure 7. Security, Privacy and Fairness 	Overall Perceived Problems and Challenges in Utilising Cloud-Based Learning and Assessment Infrastructure

Table 1 Conceptual Table of the Study

RESEARCH OBJECTIVES

Specific Objectives

1. To assess the overall level of problems and challenges experienced by career aspirants with respect to the following demographic variables:
 - ✓ Gender (Male/Female)
 - ✓ Examination Type (TNPSC/TRB/SSC/RRB/UPSC)
 - ✓ Primary Device Used (Smartphone / Tablet / Laptop / Desktop /)
 - ✓ Primary Internet Connection (Broadband-Wi-Fi/Mobile Data/Public Network)
2. To examine the relationship among the seven dimensions of problems and challenges faced by career aspirants.
3. To identify the dimensions that significantly predict the overall difficulty perceived by career aspirants in utilising cloud-based learning and assessment infrastructure.

RESEARCH HYPOTHESES

H01: The overall level of problems and challenges experienced by career aspirants with respect to the following demographic variables is moderate.

- ✓ Gender (Male/Female)
- ✓ Examination Type (TNPSC/TRB/SSC/RRB/UPSC)
- ✓ Primary Device Used (Smartphone / Tablet / Laptop / Desktop /)
- ✓ Primary Internet Connection (Broadband-Wi-Fi/Mobile Data/Public Network)

H02: There is no significant relationship among the seven dimensions of problems and challenges faced by career aspirants.

H03: The dimensions of problems and challenges do not significantly predict the overall difficulty perceived by career aspirants in utilising cloud-based learning and assessment infrastructure.

METHODOLOGY

Research Design

This study employed a quantitative, descriptive and analytical survey design to examine the problems and challenges career aspirants face in utilising cloud-based learning and assessment infrastructure. A cross-sectional survey was considered appropriate given the study's aim of capturing the current level and pattern of difficulty across a defined population at a single point in time, rather than tracking change over an extended period. The design allowed the researcher to collect structured, numerically coded responses that could subsequently be summarized, compared across demographic groups, and examined for underlying relationships using standard inferential statistical procedures.

Population and Sample

The population for this study comprised career aspirants preparing for competitive examinations such as TNPSC, UPSC, SSC, banking and railway recruitment examinations, residing in and around Karaikudi, in the Sivaganga district of Tamil Nadu. A sample of 310 career aspirants was drawn using a convenience and purposive sampling technique, with respondents approached at coaching centers, public libraries, study circles and examination-preparation hubs within the Karaikudi vicinity. A sample of this size is generally regarded as adequate for survey research involving multi-item scales and subsequent statistical procedures such as correlation and regression analysis (Comrey & Lee, 1992). Aspirants were included in the sample irrespective of the specific examination they were preparing for, provided they had some prior experience of using cloud-based or internet-based resources for learning, practice tests or assessment.

Research Instrument

Data were collected using an adapted questionnaire (Basir et al., 2021) formatted as a Google Form, comprising three sections. Part A recorded demographic details (gender, examination being prepared for). Part B recorded the aspirants' access and usage profile (primary device used, primary internet connection). Part C consisted of 42 statements distributed across seven dimensions, Access and Connectivity (6 items), Device and Digital Skills (6 items), Platform Access and Usability (6 items), Learning, Motivation and Self-Regulation (6 items), Interaction, Guidance and Learning Support (5 items), Online Assessment Infrastructure (8 items), and Security, Privacy and Fairness (5 items), each rated on a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

Validity of the Instrument

Face validity of the questionnaire was established by administering the draft instrument to a small group of career aspirants and research scholars, who reviewed the clarity, language and layout of the items and whose feedback was used to refine ambiguous statements. Content validity was established by submitting the item pool, developed on the basis of the reviewed literature and the seven conceptual dimensions of the study, to subject experts and the research guide for judgment on the relevance and representativeness of each item, following the general logic of the content-validity approach described by Lawshe (1975); items were retained, reworded or dropped on the basis of this expert review.

Reliability of the Instrument

The internal consistency of the questionnaire was examined using Cronbach's alpha coefficient, computed for the overall scale and separately for each of the seven dimensions. While a threshold of 0.83 is conventionally treated as acceptable, alpha values were interpreted cautiously and in relation to the number of items in each dimension (Taber, 2018; Zakariya, 2022). As Table 2 shows, all seven dimensions returned alpha values between 0.65 and 0.75.

Dimension	Items	N	Cronbach's Alpha
Access and Connectivity	6	310	0.675
Device and Digital Skills	6	310	0.676
Platform Access and Usability	6	310	0.665
Learning, Motivation and Self-Regulation	6	310	0.651
Interaction, Guidance and Learning Support	5	310	0.761
Online Assessment Infrastructure	8	310	0.741
Security, Privacy and Fairness	5	310	0.697
Overall Scale (42 items)	42	310	0.826

Table 2: Reliability of the Research Instrument (Cronbach's Alpha)

Data Collection Procedure

Data were collected through a Google Form link, distributed at coaching centers and study circles frequented by career aspirants in the Karaikudi vicinity. Participation was voluntary, and respondents were informed of the purpose of the study, the confidentiality of their responses, and

their right to withdraw at any stage before submission. No personally identifying information was collected, and responses were used exclusively for academic research purposes.

Statistical Techniques for Data Analysis

The collected data were analyzed using IBM SPSS Statistics, version 23. Percentage analysis was used to examine the level of problems and challenges by demographic variables, Pearson's product-moment correlation was used to examine the relationship among the seven dimensions, and multiple linear regression was used to identify which dimensions significantly predict the overall difficulty perceived by career aspirants. All statistical tests were conducted at the 0.05 level of significance.

DATA ANALYSIS

H01: The overall level of problems and challenges experienced by career aspirants with respect to the following demographic variables is moderate.

Test of H01: Level of Problems and Challenges by Demographic Variables

Variable	Category	N	Low (%)	Moderate (%)	High (%)
Gender	Male	175	35 (20.0)	109 (62.3)	31 (17.7)
	Female	135	19 (14.1)	95 (70.4)	21 (15.6)
Examination Type	TNPSC	205	32 (15.6)	136 (66.3)	37 (18.0)
	RRB	69	12 (17.4)	49 (71.0)	8 (11.6)
	SSC	32	9 (28.1)	18 (56.2)	5 (15.6)
	TRB	3	1 (33.3)	1 (33.3)	1 (33.3)
	UPSC	1	0 (0.0)	0 (0.0)	1 (100.0)
Primary Device Used	Smartphone	242	44 (18.2)	160 (66.1)	38 (15.7)
	Laptop	52	9 (17.3)	34 (65.4)	9 (17.3)
	Desktop	16	1 (6.2)	10 (62.5)	5 (31.2)
Primary Internet Connection	Broadband-Wi-Fi	72	14 (19.4)	49 (68.1)	9 (12.5)
	Mobile Data	238	40 (16.8)	155 (65.1)	43 (18.1)

Table 3: Percentage Analysis of the Level of Problems and Challenges by Demographic Variables (N = 310)

Table 3 presents the percentage distribution of the overall level of problems and challenges (Low, Moderate, High), based on the composite score across all seven dimensions, for each category of the four demographic variables. The Moderate category was the predominant response in every demographic group, ranging from 56.2% among SSC aspirants to 71.0% among RRB aspirants, with the Low and High categories accounting for smaller and broadly comparable shares in most groups. Male and female aspirants showed a similar pattern (62.3% and 70.4% Moderate, respectively), as did aspirants using different primary devices and internet connections, although desktop users reported a comparatively higher share in the High category (31.2%) than smartphone or laptop users. The TRB group (n = 3) showed an atypical even split across the three levels, but this cell is too small to interpret with confidence. Overall, the consistent predominance of the Moderate category across almost every demographic subgroup supports H01: the level of problems

and challenges experienced by career aspirants in utilising cloud-based learning and assessment infrastructure is, on the whole, moderate, irrespective of gender, examination type, device or internet connection.

H02: There is no significant relationship among the seven dimensions of problems and challenges faced by career aspirants.

Test of H02: Correlation among the Seven Dimensions

Dimension	I	II	III	IV	V	VI	VII
Access and Connectivity	1						
Device and Digital Skills	.619**	1					
Platform Access and Usability	.555**	.598**	1				
Learning, Motivation and Self-Regulation	.570**	.555**	.572**	1			
Interaction, Guidance and Learning Support	.023	.158**	.084	.059	1		
Online Assessment Infrastructure	.102	.095	.043	.113*	.231**	1	
Security, Privacy and Fairness	.076	.102	.035	.078	.169**	.646**	1

Table 4: Pearson Correlation Matrix among the Seven Dimensions ($N = 310$)

Note. * $p < .05$, ** $p < .01$ (two-tailed).

A Pearson correlation analysis was conducted to determine the relationship among the seven dimensions of problems and challenges (Table 4). Dimensions I to IV were strongly and significantly inter-correlated with one another ($r = .555$ to $.619$, $p < .01$), indicating that access and connectivity, device and digital skills, platform usability, and self-regulation difficulties tend to rise and fall together. Dimension VI (Online Assessment Infrastructure) was significantly correlated with Dimension VII ($r = .646$, $p < .01$) and with Dimension V ($r = .231$, $p < .01$), while Dimension V showed weak or negative correlations with Dimensions I to IV. As the majority of the pairwise correlations were statistically significant, H02 is rejected: the seven dimensions of problems and challenges are not independent of one another, but are meaningfully related, particularly within the access-related cluster (I-IV) and the assessment-related cluster (V, VI and VII).

H03: The dimensions of problems and challenges do not significantly predict the overall difficulty perceived by career aspirants in utilising cloud-based learning and assessment infrastructure.

Table 5. Results of Multiple Linear Regression Analysis

Multiple R	.662				
R ²	.439				
Std. Error	.270				
F	39.483				
Sig. F	.000				
Variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error			
Constant	0.839	0.238	-	3.529	0.001
I. Access and Connectivity	0.027	0.061	0.027	0.448	0.654
II. Device and Digital Skills	0.018	0.058	0.019	0.306	0.760

III. Platform Access and Usability	-0.029	0.053	-0.032	-0.537	0.592
IV. Learning, Motivation and Self-Regulation	0.058	0.051	0.065	1.131	0.259
V. Interaction, Guidance and Learning Support	0.145	0.049	0.131	2.941	0.004
VII. Security, Privacy and Fairness	0.555	0.040	0.616	13.966	0.000

Dependent Variable: VI. Online Assessment Infrastructure

The relationship between the explanatory and dependent variables was studied using multiple linear regression analysis, and the results are summarised in Table 5. The F statistic was found to be significant at the 1 per cent level (Sig. F < .01), thus demonstrating the fitness of the data. Consequently, there is a statistically significant association between the six dimensions and the difficulty perceived with the online assessment infrastructure. The R² value of .439 denotes that the six dimensions explain close to 44 per cent of the variance in this outcome. Considering these coefficients, it can be said that the explanatory variables predict the dependent variable to a moderate degree.

The absolute value of Beta shows the magnitude of importance of the explanatory variables; the one with the highest Beta value is the most influential factor in predicting the dependent variable. Table 5 revealed that Security, Privacy and Fairness had the greatest effect on career aspirants' difficulty with the online assessment infrastructure, with a value of $\beta = .616$, followed by Interaction, Guidance and Learning Support ($\beta = .131$). Access and Connectivity ($\beta = .027$), Device and Digital Skills ($\beta = .019$), Learning, Motivation and Self-Regulation ($\beta = .065$) and Platform Access and Usability ($\beta = -.032$) did not contribute significantly. After analyzing Table 5, the following regression equation was formulated:

Difficulty with online assessment infrastructure ($\hat{y}$)

$$= 0.839 + 0.027x_1 + 0.018x_2 - 0.029x_3 + 0.058x_4 + 0.145x_5 + 0.555x_6$$

Where,

x_1 = Access and Connectivity,

x_2 = Device and Digital Skills,

x_3 = Platform Access and Usability,

x_4 = Learning, Motivation and Self-Regulation,

x_5 = Interaction, Guidance and Learning Support,

x_6 = Security, Privacy and Fairness

FINDINGS AND DISCUSSION

The finding that the level of problems and challenges is predominantly moderate across demographic groups is consistent with the broader pattern reported in Indian online-learning research since the pandemic, where aspirants are neither wholly excluded from digital infrastructure nor using it without friction (Rannaware et al., 2022; Suresh Babu, 2024). The strong inter-correlation among Dimensions I to IV supports the theoretical distinction between structural digital-divide barriers and individual self-regulation demands, which tend to co-occur among self-directed online learners (van Dijk, 2005; Zimmerman, 2002). Dimension VII emerging as the strongest predictor of difficulty with the online assessment infrastructure echoes Hartnett et al.'s (2023) finding that digital inequalities in online proctored examinations are increasingly about candidates' trust and comfort with the testing technology rather than bare access. The significant,

though weaker, contribution of Interaction, Guidance and Learning Support is consistent with Edisherashvili et al.'s (2022) observation that online learners' difficulties are compounded when adequate guidance is unavailable.

CONCLUSION AND SUGGESTIONS FOR FURTHER RESEARCH

Cloud-based learning and assessment infrastructure has become an integral part of how career aspirants in Tamil Nadu, and across India more broadly, prepare for competitive examinations. This study examined the problems and challenges that 310 aspirants encounter across seven interrelated dimensions, drawing on digital divide theory, self-regulated learning theory and the Unified Theory of Acceptance and Use of Technology. The level of difficulty reported was predominantly moderate across demographic groups, the seven dimensions were meaningfully inter-correlated rather than independent, and difficulty with the online assessment infrastructure was best predicted by concerns about security, privacy and fairness, and by the adequacy of interaction, guidance and learning support, rather than by more basic access or device constraints. Such evidence can guide coaching institutions, e-learning platform developers and government agencies, such as the Tamil Nadu Department of Employment and Training, in designing more accessible, affordable and learner-friendly cloud-based infrastructure, with particular attention to the fairness, security and support dimensions that this study found to matter most.

Future research could usefully extend this study by drawing a larger, multi-district or state-wide sample to improve generalizability, by incorporating qualitative interviews to capture aspirants' lived experience in greater depth, by adopting a longitudinal design to track how difficulties change over an aspirant's multi-year preparation period, and by evaluating targeted interventions, such as digital-literacy training or structured self-regulated learning support, designed to reduce the specific problems identified in this study.

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Data Availability Statement

Data that supports the findings of this study is available upon reasonable request to the corresponding author without disclosing participant information.

Conflict of Interest

The authors of the manuscript declare no conflict of interest.

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Emerging Technologies in Education: Transforming Teaching and Learning

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Abstract

Emerging technologies are rapidly transforming the education sector by changing traditional methods of teaching and learning. Technologies such as Artificial Intelligence (AI), Virtual Reality (VR), Augmented Reality (AR), cloud computing, learning analytics, and the Internet of Things (IoT) provide new opportunities for personalised, interactive, and flexible education. These technologies can improve student engagement, provide faster feedback, support teachers, and increase access to educational resources. At the same time, their use creates challenges relating to data privacy, cybersecurity, digital inequality, academic integrity, algorithmic bias, and intellectual property. This paper examines the role, opportunities, challenges, and future potential of emerging technologies in education. It emphasises that technology should complement teachers rather than replace human interaction. Responsible technological adoption, digital literacy, ethical safeguards, and equal access are essential for creating an inclusive and effective education system.

Keywords: Emerging Technologies, Artificial Intelligence, Education, Digital Learning, Virtual Reality, Data Privacy, Digital Inclusion.

Introduction

Education is undergoing a major transformation due to rapid technological development. Traditional classroom-based education is increasingly supported by digital platforms, artificial intelligence, virtual environments, and data-driven learning systems. Emerging technologies enable students to access educational resources beyond the physical classroom. Teachers can use technology to provide personalised learning materials, monitor student progress, and create interactive learning experiences.

Objectives

To examine emerging technologies used in education.

To analyse their impact on teaching and learning.

To identify their benefits and challenges.

To examine important ethical and legal concerns.

To suggest measures for responsible technological use.

Emerging Technologies in Education

Artificial Intelligence

AI can support personalised learning, automated feedback, educational content creation, language learning, and administrative activities. AI-powered systems can analyse learning patterns and provide assistance according to individual student needs.

Virtual and Augmented Reality

Virtual Reality creates immersive digital environments, while Augmented Reality adds digital information to the physical environment. These technologies can be used for virtual laboratories, medical training, historical exploration, scientific experiments, and simulated professional environments.

Cloud Computing

Cloud technology enables students and teachers to access educational materials, assignments, documents, and learning platforms from different locations. It supports remote and collaborative learning.

Learning Analytics

Learning analytics uses educational data to understand student participation and performance. It can help teachers identify students who may require additional academic support.

Internet of Things

IoT connects physical devices through digital networks. Educational institutions can use connected technologies for smart classrooms, attendance management, The objective is not to replace conventional education but to combine technological innovation with effective teaching and human interaction.

Benefits and Impact on Education

Personalised Learning: Students can receive learning materials and feedback according to their individual needs and learning pace.

Interactive Learning: VR, AR, simulations, and educational applications can make difficult concepts easier to visualise and understand.

Flexible Education: Online resources allow students to learn beyond traditional classroom hours and geographical boundaries.

Improved Accessibility: Assistive technologies such as speech-to-text and text-to-speech tools can support learners with different educational needs.

Challenges and Legal-Ethical Concerns

Despite its advantages, technological integration creates several concerns.

Data Privacy

Educational platforms may collect personal and academic information about students. Such information requires appropriate protection and responsible handling.

Cybersecurity

Digital educational systems may face cyberattacks, unauthorised access, and data breaches. Institutions therefore need strong security practices.

Digital Divide

Students do not have equal access to smartphones, computers, high-speed internet, or digital learning resources. Lack of access can increase educational inequality.

Academic Integrity

Generative AI can be used to produce assignments and answers without sufficient independent work. Institutions need clear rules regarding responsible AI use.

Algorithmic Bias

AI systems can produce unfair or inaccurate results when the data used to develop them contains bias.

Recommendations

To ensure responsible technological development in education:

Educational institutions should establish clear policies regarding AI and digital technologies.

Teachers and students should receive digital and AI literacy training.

Student data should be collected and processed responsibly.

Governments and institutions should improve affordable digital access.

Human oversight should remain important in educational decision-making

Technology should be used to support teachers rather than completely replace them.

Educational institutions should promote academic honesty and responsible use of AI.

Conclusion

Emerging technologies are reshaping education by providing new methods of teaching, learning, assessment, and knowledge sharing. AI, VR, AR, cloud computing, learning analytics, and IoT can make education more personalised, interactive, flexible, and accessible. At the same time, issues such as privacy, cybersecurity, digital inequality, academic integrity, algorithmic bias, and intellectual property must be addressed. Therefore, technology should not be viewed as a replacement for teachers. The future of education should be technology with teachers, not technology instead of teachers. Responsible innovation, strong ethical safeguards, digital literacy, and equal access can help create an effective and inclusive education system.

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Role of Information Communication Technology in Secondary Education

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Abstract

An analysis of its effect on the teaching-learning process, aims to describe the most recent impact of online communication technologies on education within a new environment, as are the new ICT schools, characterized by the large-scale implementation of technology in primary and secondary education. By combined qualitative and quantitative methods, the study shows that, due to the presence of ICTs (Information and Communication Technologies) in educational centres, the frequency of computer use in the classroom has increased, along with an expansion of a teacher training process that is progressively oriented towards contextualized models of learning. After investigating the most important factors behind the success of the mass computer installation programmes at the centres, a series of recommendations at centre and governmental level are presented that will ensure the maximizing of the potential of these technological resources.

Keywords: ICT and secondary education.

Introduction

Information and communication technology (ICT) has become, within a very short time, one of the basic building blocks of modern society. Many countries now regard understanding ICT and mastering the basic skills and concepts of ICT as part of the core of education, alongside reading, writing and numeracy. UNESCO aims to ensure that all countries, both developed and developing, have access to the best educational facilities necessary to prepare young people to play full roles in modern society and to contribute to a knowledge nation.

ICT Definition

ICT is technology that supports activities involving information. Such activities include gathering, processing, storing and presenting data. Increasingly these activities also involve collaboration and communication.

Secondary Education

Secondary education is in most countries the phase in the education continuum responsible for the development of the young during their adolescence, the most rapid phase of their physical, mental and emotional growth. It is at this very education level, particularly in its first cycle, where values and attitudes formed at primary school are more firmly ingrained alongside the acquisition of knowledge and skills.

Aim of secondary education

1. To bring allround development among the learner.
2. To train the young mass of the country to be good citizens who will be competent to play their part effectively in the social and economic development of the country.
3. To promote social virtues,
4. To improve intellectual development and practical skills of students.
5. To Train character of students to enable them to participate creatively as citizens in the emerging social order.
6. To improve practical and vocational efficiency of the students.

ICT and Education

All governments aim to provide the most comprehensive education possible for their citizens within the constraints of available finance. Because of the pivotal position of ICT in modern societies, its introduction into secondary schools will be high on any political agenda.

ICTs for Teaching in Secondary Education

Teachers are the key players in the learning process. Teacher training is crucial for laying a road map toward "learning schools" via "learning teachers". ICTs are a sympathetic mode to mobilize teachers' creativeness and make their didactic practice more flexible and ingenious.

ICT and Quality of Education

It goes without saying that emergence and successful development of the evolving societies is impossible without improving quality of education of individuals and, consequently, improving quality of education of a given society as a whole.

The role of Information Technology in Secondary Education

Making life easier for one and all: The main advantage of school management software is that it can make life a lot easier for one and all concerned. Making better decisions: Taking the right decision at right time is the vital part of every institution. Features for all: Each school functionality is varying not every institute is similar.

Conclusion

Information and communication technologies are already a vital factor in successful development of education. Secondary Education is a decisive stage, however; learning and studying at this age has the most potential impact on forming new members of the knowledge community. This paper is a plea for educational policies that promote and sustain further ICT infrastructures for Secondary Schools.

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Ethics and Challenges of Generative Artificial Intelligence in Higher Education: Issues of Academic Integrity, Privacy and Responsible Use

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Abstract:

Generative Artificial Intelligence (AI) has emerged as an important technological development in higher education, offering new possibilities for teaching, learning, content creation, assessment, research and academic support. Generative AI tools can assist students in generating ideas, summarising information, improving language, explaining difficult concepts and obtaining personalised academic assistance. For teachers, these technologies can support lesson planning, content development, feedback and the preparation of educational resources. Research on generative AI in education indicates that such technologies can provide educational opportunities while simultaneously creating concerns regarding accuracy, assessment, academic integrity and responsible use (Lo, 2023; Montenegro-Rueda et al., 2023).

However, the rapid adoption of generative AI also creates significant ethical challenges for educational institutions. Concerns relating to academic integrity, plagiarism, originality, privacy, data protection, misinformation, algorithmic bias, transparency and responsible use have become increasingly important.

1. Introduction:

Education has undergone significant transformation with the development of digital technologies. Computers, smartphones, internet-based platforms, learning management systems, online resources and artificial intelligence have changed the ways in which knowledge is accessed, created and communicated. Educational technology has provided students and teachers with opportunities to obtain information beyond the boundaries of traditional classrooms.

Artificial Intelligence has become one of the significant emerging technologies in education. AI-based systems can support personalised learning, automated feedback, educational content development and learning analytics. Generative AI represents a further development because it can produce new text, images, summaries and other forms of content in response to user instructions.

The introduction of ChatGPT and similar large language models has attracted particular attention in higher education. Such systems can generate coherent and apparently informative responses to natural-language instructions. Lo (2023) identified several potential educational applications while also highlighting challenges that institutions need to address.

In higher education, generative AI can assist students with brainstorming, language improvement, explanations and preparation of learning materials. Teachers can also use AI for lesson planning, generating examples, developing educational activities and providing learning support. Montenegro-Rueda et al. (2023) found that ChatGPT can have positive implications for teaching and learning, while also emphasising the importance of teacher preparation.

1. Chia-Wen Lo, "What Is the Impact of ChatGPT on Education? A Rapid Review of the Literature," Education Sciences (2023).

2. Objectives of the Study:

The present study aims:

1. To explain the concept and development of Generative Artificial Intelligence in higher education.
2. To examine the major applications of generative AI in teaching and learning.
3. To identify the major ethical issues associated with the use of generative AI in higher education.
4. To analyse the challenges relating to academic integrity and AI generated academic content.
5. To examine privacy and data protection concerns associated with AI based educational tools.
6. To understand issues relating to bias, fairness, transparency and accountability in AI-supported education.
7. To examine the role of teachers and educational institutions in promoting responsible AI use.
8. To suggest measures for the ethical and responsible integration of generative AI in higher education.

2John W. Creswell and J. David Creswell, *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*, 5th ed. (SAGE Publications, 2018).

3. Research Methodology:

Research Design

The present study adopts a descriptive and analytical research design. The study describes the development and applications of generative AI in higher education and analyses the ethical issues and challenges associated with its use.

Nature of the Study

The study is primarily based on secondary data. No primary survey or experimental intervention is undertaken. The study relies on existing academic literature and reliable institutional publications relating to artificial intelligence, educational technology, ethics and higher education.

Sources of Data

The major sources considered for the study include research articles published in scholarly journals, academic publications, reports of educational organisations, UNESCO publications and other reliable literature relating to artificial intelligence and digital education. The study considers systematic and rapid reviews of research concerning ChatGPT and AI in education.

3. Mark N. K. Saunders, Philip Lewis, and Adrian Thornhill, *Research Methods for Business Students*, 8th ed. (Pearson, 2019).

4. Scope of the Study:

The study focuses on the use of generative AI in higher education, including colleges, universities and other institutions of tertiary education. Particular attention is given to the ethical and educational dimensions of AI-based technologies.

The study examines academic integrity, privacy, responsible use, bias, transparency, student learning and the changing role of teachers. It also considers the need for institutional policies and digital literacy for effective implementation.

The study does not focus on the technical development of AI systems. Instead, it concentrates on how generative AI affects educational practices and the ethical responsibilities of students, teachers and institutions. The scope is particularly relevant because generative AI has developed faster than many institutional policies, creating a need for ethical and pedagogically appropriate institutional responses (Miao & Holmes, 2023).

Fengchun Miao and Wayne Holmes, *Guidance for Generative AI in Education and Research* (Paris: UNESCO, 2023).

5.Role of Educational Institutions:

Educational institutions have an important role in ensuring that generative AI is integrated ethically. Institutions should provide students and teachers with clear guidance regarding appropriate AI use.

Training programmes can help teachers understand AI technologies and develop effective assessment strategies. Students should also receive digital literacy education so that they can critically evaluate AI-generated information.

Institutions should consider privacy and security before adopting AI-based educational platforms. They should also ensure that technological innovation does not reduce the importance of human interaction and effective teaching.

Institutional policy should avoid simply banning AI without considering its legitimate educational applications. A balanced approach can allow students to benefit from AI while maintaining academic standards.

5.Fengchun Miao and Wayne Holmes, *Guidance for Generative AI in Education and Research* (Paris: UNESCO, 2023).

6. Future Prospects:

The future of higher education is likely to involve increasing interaction between human teachers and AI-supported technologies. Generative AI may contribute to personalised learning, automated feedback, educational content development and student support.

AI may also become integrated with learning management systems and other educational technologies. This could allow institutions to provide more flexible and personalised learning experiences.

Research on ChatGPT in education suggests that the technology has potential to enhance educational experiences, but effective implementation requires teachers to understand how the technology operates and how it should be integrated into teaching (Montenegro-Rueda et al., 2023).

7.Manuel Montenegro-Rueda, José Fernández-Cerero, José Manuel Fernández-Batanero, and Sergio LópezMeneses, “Impact of the Implementation of ChatGPT in Education: A Systematic Review,” *Education Sciences* 13, no. 5 (2023).

Conclusion:

Generative Artificial Intelligence has created significant opportunities for higher education by supporting teaching, learning, content development and personalised educational assistance. It can help students access explanations and learning resources while assisting teachers in developing

educational materials and activities. Research reviews have identified meaningful educational applications of generative AI while also emphasising the need to address its limitations and risks (Lo, 2023; Montenegro-Rueda et al., 2023).

However, the integration of generative AI also presents important ethical challenges. Academic integrity, privacy, misinformation, bias, transparency and excessive dependence on technology require serious attention. The use of AI without appropriate guidance may weaken independent learning and create uncertainty regarding the originality of academic work.

Generative AI should therefore not be regarded simply as a substitute for traditional educational practices. It should be integrated with human teaching, critical thinking, ethical responsibility and appropriate institutional support.

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AI Tutors and Legal Accountability for Harm Caused by AI Educational Systems in India

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Abstract

Artificial intelligence now mediates the relationship between the learner, the curriculum and the institution. India has made this shift compulsory: Artificial Intelligence and Computational Thinking enters the school curriculum from Class 3 in the 2026-27 session,[1] while generative tutoring applications reach millions of minors through the commercial edtech market. This paper asks who is legally responsible when such a system harms a student. It classifies the harms as epistemic, psychological, discriminatory, procedural and informational, and argues that Indian law disperses responsibility across the foundation-model developer, the edtech deployer, the institution, the teacher, the parent and the student, with the result that it attaches to none of them. Four structural gaps are identified: the product-or-service gap under the Consumer Protection Act, 2019; the intermediary gap under section 79 of the Information Technology Act, 2000; the contractual capacity gap created by minors accepting terms that are void under section 11 of the Indian Contract Act, 1872; and the absence of any standard of care against which an automated tutor can be measured. Drawing on the European Union's risk-based regulation, the revised Product Liability Directive and the first wave of chatbot-harm litigation in the United States, the paper proposes a graded, role-based framework resting on a rebuttable presumption of defect against the deployer, a non-delegable institutional duty of care, a statutory duty of human review, and a mandatory logging and disclosure obligation.

Keywords

Artificial intelligence in education; AI tutors; legal accountability; product liability; Consumer Protection Act, 2019; Digital Personal Data Protection Act, 2023; algorithmic accountability; duty of care; child rights; automated decision-making.

1. Introduction and Statement of the Problem

For most of educational history the intermediary between knowledge and the learner was a person, and the law had little difficulty locating responsibility when that intermediary failed. The architecture of negligence, vicarious liability and consumer protection assumed a human agent, an identifiable employer, a foreseeable harm and a traceable causal chain.

Artificial intelligence disturbs each assumption. An AI tutor is not one thing but a stack: a foundation model trained by one enterprise, wrapped in a pedagogical interface by a second, licensed to a school by a third, configured by an administrator, assigned by a teacher and used by a fourteen-year-old without supervision. When harm occurs at the end of that chain, the law must decide where in the stack responsibility lies. At present it does not decide; it disperses.

Three developments make the question urgent in India. First, adoption is now mandated rather than elective, which defeats any argument that the student voluntarily assumed the risk.[2] Second, the regulatory scaffolding is incomplete and none of it is education-specific: the Digital Personal Data Protection Rules, 2025 commence in phases,[3] the India AI Governance Guidelines are

advisory,[4] and the 2026 amendments to the intermediary rules address synthetic content generally rather than educational deployment.[5] Third, the threshold question whether a student is a consumer at all remains unresolved before the Supreme Court.[6] As of early 2026 no comprehensive instrument from the University Grants Commission, the Central Board of Secondary Education or any State education department governs institutional AI use or AI-related academic misconduct. AI has been made compulsory in the curriculum before it has been made accountable in the classroom.

2. Objectives

- To define the AI educational system as a legal category distinct from general-purpose software.
- To classify the harms such systems inflict on students into legally cognisable heads.
- To map the applicable constitutional, statutory, delegated and soft-law provisions in India against each head of harm.
- To evaluate the adequacy of tort, contract, consumer and data-protection doctrine in multi-actor AI value chains.
- To compare the Indian position with the European Union and the United States and to identify transplantable elements.
- To propose a graded, role-linked allocation of liability that does not foreclose beneficial educational innovation.

3. Research Methodology

The study is doctrinal and analytical, supplemented by comparative and case-analysis methods. Primary sources comprise the Constitution of India, central legislation and delegated legislation, judgments of the Supreme Court, High Courts and the National Consumer Disputes Redressal Commission, European Union regulations and directives, United States federal and state law, and official policy instruments. Secondary sources include peer-reviewed literature on detection accuracy and machine responsibility. The study is normative in its concluding parts. Its principal limitation is that the field is moving faster than adjudication: several decisions discussed are interlocutory and several statutory regimes have not yet fully commenced.

4. Harms and the Accountability Gap

4.1 A taxonomy of harm

Liability rules cannot sensibly be designed for an undifferentiated category called AI harm. Six heads may be distinguished. Epistemic harm arises where a fluent falsehood is reasonably relied upon and costs a mark, an examination or an admission, which in Indian conditions is not a trivial loss. Psychological harm arises where anthropomorphic, engagement-optimised design shades into adolescent dependence and the reinforcement rather than the interruption of distress. Discriminatory harm arises where an adaptive engine allocates learners by proxies for language, caste, location and household income. Procedural and reputational harm arises where an unreliable detection output founds a finding of academic misconduct. Informational harm arises from the silent conversion of a child's keystrokes, voice and affect into a behavioural profile. Autonomy harm, the longer-term degradation of independent reasoning, is real but presently non-justiciable.

4.2 The problem of many hands

Every actor has a plausible answer. The developer built a general-purpose tool and disclaimed educational use. The deployer wrapped a model whose internals it cannot inspect. The institution procured a commercial product it lacks the capacity to audit. The teacher was directed to use it. The parent clicked a consent form. The student, who alone suffers, is told he ought to have verified the output. This produces both failure modes described in the literature: the responsibility gap, in which no one is fairly blameable,[7] and the moral crumple zone, in which blame is absorbed by the least powerful actor nearest the point of impact.[8]

4.3 Four Indian doctrinal gaps

First, product or service. Chapter VI of the Consumer Protection Act, 2019 is anchored to a definition of product framed around articles and goods capable of delivery; whether a hosted, continuously updated generative model qualifies is untested, and where the tutor is supplied free of charge the consideration requirement defeats the claim at the threshold.[9] Second, safe harbour. A generative tutor authors first-party output rather than carrying third-party information, and on the reasoning that an active participant forfeits intermediary status it should fall outside section 79, but no Indian court has yet so held of a generative system.[10] Third, capacity. Liability caps and arbitration clauses accepted by minors are void ab initio, so the industry's principal risk-allocation device is unenforceable against its principal users.[11] Fourth, standard of care. Negligence requires a benchmark; for an automated tutor there is no professional body, no accepted practice and no equivalent of the Bolam standard.[12]

5. Relevant Laws and Provisions

5.1 Constitutional framework

Article 21 protects life, dignity and, after Puttaswamy, informational privacy, subject to legality, necessity and proportionality.[13] Article 21A guarantees free and compulsory education, so that deficiencies in a State-mediated AI system engage a constitutional obligation and not merely a private contract. Article 14 prohibits arbitrariness, and an unexplainable algorithmic decision affecting a student in a State or State-aided institution is a species of arbitrariness. Articles 15(3) and 39(e)-(f) support a heightened standard for systems directed at children.

5.2 Data protection

The Digital Personal Data Protection Act, 2023 treats every individual below eighteen as a child, a wider net than the General Data Protection Regulation. Section 9(1) requires verifiable parental consent, given operational content by rule 10 of the 2025 Rules, and section 9(3) prohibits tracking, behavioural monitoring and targeted advertising directed at children. Section 10 imposes impact assessment, audit and algorithmic due diligence on Significant Data Fiduciaries, and section 33 with the Schedule prescribes penalties at the higher end for children's-data breaches.[14] Schools, coaching centres and edtech platforms are data fiduciaries; cloud, analytics and assessment vendors are ordinarily processors, with primary liability remaining on the fiduciary. The tension is fundamental: adaptive learning analytics is behavioural monitoring by design.

5.3 Consumer protection, tort, contract and criminal law

The Consumer Protection Act, 2019 supplies deficiency in service, unfair trade practice and a product liability action against manufacturers, sellers and product service providers, subject to the definitional difficulties noted above.[15] Tort supplies negligence, vicarious liability and the non-delegable duty of an institution towards children in its custody. Contract supplies the incapacity of minors and judicial control of unconscionable adhesion terms.[16] Criminal law supplies causing death by negligence, abetment of suicide of a child, offences relating to sexualised material shown to a child, cruelty by a person having charge of a child, and the statutory prohibition on mental harassment in schools.[17] Ambitiously, the absolute liability principle developed for hazardous enterprise could be extended to the deployment of unpredictable autonomous systems on captive populations of children.[18]

5.4 Comparative regimes

The European Union classifies educational AI used for admission, evaluation of learning outcomes, allocation of educational level and monitoring of prohibited behaviour during tests as high-risk, and prohibits emotion recognition in educational institutions outright.[19] Those high-risk obligations were, however, deferred from 2 August 2026 to 2 December 2027 by the Digital Omnibus, so that even the most advanced regime has not yet brought educational AI within its enforceable perimeter.[20] The revised Product Liability Directive is the more useful model, extending no-fault liability to software and reversing the burden where technical proof is excessively difficult.[21] In the United States, in the absence of federal legislation, state companion-chatbot statutes now require non-human disclosure, published crisis protocols, break reminders for minors and restrictions on sexualised content, with a private right of action.[22]

6. Case Law

The pivotal decision is *Garcia v. Character Technologies*, where a mother sued following the death of her fourteen-year-old son after prolonged interaction with an anthropomorphic chatbot. In May 2025 the District Court allowed the core product liability and negligence claims to proceed, declining at the pleading stage to treat algorithmically generated outputs as protected speech on the reasoning that they do not reflect the human intent the constitutional inquiry presupposes, and accepting as plausible the allegation that the system was a product and the impugned conduct design rather than publication.[23] The ruling should not be overstated; it moved the threshold question into discovery rather than resolving it, and the first wave of claims settled confidentially in January 2026 without appellate determination.[24] The same contest continues in the coordinated California proceedings and in public enforcement action.[25] The mechanism alleged is not confined to companion applications: it is present in any conversational tutor designed to feel like a patient, always-available mentor.

A second line concerns automated accusation. Students disciplined on the strength of AI-detection outputs have litigated on grounds of procedural neutrality, disability discrimination and the evidentiary foundation of the finding, with at least one 2026 ruling in a student's favour.[26] The pattern is instructive: no court has yet held that the use of a detector is unlawful in itself, and every decision has turned on process. Given that detection tools show markedly elevated false-positive rates for writers who are not native speakers of English (Liang et al., 2023; Weber-Wulff et al.,

2023), their use as the basis of misconduct findings in India, where most students write in a second or third language, would be indefensible.

A third line establishes deployer responsibility for machine output. A commercial tribunal has held that a company cannot treat its own chatbot as a separate legal entity answerable for its own statements,[27] and an American court has permitted a discrimination claim to proceed against a software vendor performing a function delegated by its customer.[28] Public-law authority meanwhile establishes decisional non-determinativeness and the impermissibility of opaque profiling.[29]

In India the position is unsettled but not empty. Professional services fall within consumer jurisdiction and students have been held to be consumers where an institution misrepresented recognition, though other authority holds that education is not a commodity.[30] Critically, the very decision that excludes degree-granting institutions expressly retains coaching institutions,[31] from which it follows that a commercial edtech platform, being analogous to a coaching service rather than to a university, falls within consumer jurisdiction. That is presently the strongest available Indian remedy and it is markedly under-used.

7. Findings

1. Responsibility is dispersed to the point of disappearance. No Indian statute allocates responsibility among developer, deployer, institution and educator, and the loss rests on a minor.
2. The consumer remedy is doubly uncertain, requiring the claimant to survive both the unresolved question whether education is a service and the untested question whether a hosted generative model is a product; where the tutor is free, the claim fails at the threshold.
3. Commercial edtech is nonetheless within consumer jurisdiction on the reasoning of the leading authority itself, and this route is under-used.
4. Intermediary immunity should not extend to a system that authors its own output, but the point awaits Indian judicial determination.
5. The industry's principal risk-allocation device is void as against its principal users, since terms accepted by minors are unenforceable.
6. Data protection is the strongest Indian hook and is not yet fully in force; section 9(3) prohibits precisely what adaptive learning analytics does, and a substantial compliance reckoning is approaching.
7. There is no education-specific AI regulation in India, and no national instrument governs AI-assisted academic misconduct procedure.
8. The soft-law framework identifies the correct architecture, graded liability tied to function, control and risk, but does not enforce it.[32]
9. Comparative law is converging on the deployer and on reversed burdens of proof, while causation remains the practical barrier: without logging and disclosure obligations, substantive rights are unenforceable.

8. Suggestions

1. Amend the definition of product in the Consumer Protection Act, 2019 to include software and AI systems, and amend section 84 to recognise defects arising from post-deployment learning, model updates and inadequate guardrails.

2. Enact a rebuttable presumption of defect and causation where a student is harmed and proof would require access to information exclusively within the defendant's control.
3. Disapply the consideration requirement for AI systems supplied to minors in educational settings, so that a free tool is not an unremediable one.
4. Impose a statutory duty of human review: no grade, progression, misconduct finding, streaming or admission decision should be made solely by automated means, stated as an institutional duty rather than only as an individual right.[33]
5. Legislate a non-delegable duty of care for institutions in respect of AI systems they mandate or provide; procurement from a vendor should not dilute the obligation.
6. Extend safety-by-design duties to systems directed at or foreseeably used by minors: non-human disclosure, published crisis protocols referring to recognised Indian helplines, prohibition of self-harm and sexualised content in response to a known minor, break prompts, and prohibition of engagement-maximising design in products marketed for education.
7. Clarify by amendment that section 79 of the Information Technology Act, 2000 does not extend to first-party generative output.
8. Void any clause limiting liability for harm to a minor arising from an AI educational system, and render arbitration clauses in minor-facing contracts unenforceable against the minor.
9. Issue a joint framework of the Ministry of Education, the University Grants Commission and the school boards governing permissible use, mandatory disclosure of AI use by students and institutions, and a due-process protocol prohibiting reliance on detection output as the sole basis of a misconduct finding.
10. Establish pre-deployment certification for AI educational products covering pedagogical accuracy, age-appropriateness, safety evaluation, bias testing across language, region and socio-economic proxies, and data-protection compliance, as a condition of public procurement.
11. Mandate retention and disclosure of interaction logs, model and prompt version history, safety configurations and incident reports, and establish an education-sector AI incident reporting mechanism.
12. Adopt graded liability judicially and legislatively: the developer answers for foreseeable model-level defects and inadequate documentation; the deployer for the system as presented, its guardrails, marketing and age-gating; the institution for the decision to deploy, supervision and procedural fairness; the teacher only for conduct within her actual control.

9. Conclusion

The question in the title admits of an uncomfortable answer: at present, in India, in most cases, no one is responsible in any practically enforceable sense. This is not because Indian law is indifferent to student welfare. The constitutional guarantees, the criminal provisions protecting children, the tort of negligence, the product liability chapter and the new data protection regime are individually robust. The failure is architectural. Each doctrine was built for a world in which the entity that caused the harm was the entity that could foresee it, and in which the person nearest the harm was the person most responsible for it. AI education inverts both assumptions: foresight sits with the developer, control with the deployer, authority with the institution, and the harm lands on a child

who could not have contracted, cannot have consented meaningfully, and cannot obtain the evidence to prove what happened.

Both instinctive responses are wrong. Banning AI from Indian classrooms is neither feasible nor desirable in a system of some 247 million learners with a chronic shortage of qualified teachers. Treating AI tutors as neutral tools whose outputs are the user's problem is a moral crumple zone dressed as a terms-of-service clause. The workable path has four elements: allocate responsibility by role, function and control; presume defect where the claimant is a child and the evidence lies with the defendant; preserve human judgment wherever a decision materially affects a learner; and compel retention of the records that make causation provable.

The timing is favourable. The European Union has deferred its high-risk educational obligations to December 2027 and the first wave of foreign litigation has settled without precedent, while India will deploy educational AI at national scale from the 2026-27 session. That window should be used. The law need not predict what AI will do to students; it need only decide, in advance, who will answer when it does something wrong.

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- [1] Ministry of Education, Government of India, curriculum mandate under the National Education Policy 2020; Artificial Intelligence and Computational Thinking introduced from Class 3 in the 2026-27 academic session, with CBSE developing the integration framework across grades.
- [2] *Supra* n. 1.
- [3] Digital Personal Data Protection Act, 2023 (No. 22 of 2023); Digital Personal Data Protection Rules, 2025, notified 13 November 2025 with phased commencement extending into 2026 and 2027.
- [4] Ministry of Electronics and Information Technology, India AI Governance Guidelines (5 November 2025). The Guidelines are advisory and expressly adopt a "techno-legal" approach relying on existing law rather than a standalone AI statute.
- [5] Information Technology (Intermediary Guidelines and Digital Media Ethics Code) Amendment Rules, 2026, G.S.R. 120(E), notified 10 February 2026, in force 20 February 2026.
- [6] *Manu Solanki v. Vinayaka Mission University*, 2020 SCC OnLine NCDRC 7 (larger bench). Leave granted by the Supreme Court in Civil Appeal arising out of D. No. 12901/2020, order dated 15 October 2020, noting divergent views; the appeal remains pending.
- [7] Matthias (2004) describes the gap that arises where a machine's behaviour is not fully predictable by its creator, so that attributing blame to the creator offends the fairness principle that responsibility presupposes control.
- [8] Elish (2019). The teacher who "should have checked the output" and the student who "should not have trusted a chatbot" are the classic crumple zones of educational AI.
- [9] Consumer Protection Act, 2019, ss. 2(7), 2(11), 2(33)-(38), 2(42), 2(47), 82-87.
- [10] *Christian Louboutin SAS v. Nakul Bajaj*, 2018 SCC OnLine Del 12215; see also *Shreya Singhal v. Union of India*, (2015) 5 SCC 1, reading down s. 79(3)(b) of the Information Technology Act, 2000.
- [11] Indian Contract Act, 1872, s. 11; *Mohori Bibee v. Dharmodas Ghose*, (1903) 30 IA 114. See also *LIC of India v. Consumer Education and Research Centre*, (1995) 5 SCC 482 on judicial control of unconscionable standard-form terms.
- [12] *Jacob Mathew v. State of Punjab*, (2005) 6 SCC 1, adopting the Bolam standard of the ordinary competent practitioner.
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- [14] DPDP Act, 2023, ss. 2(f), 8, 9(1), 9(3), 10, 33 and the Schedule; DPDP Rules, 2025, r. 10 (verifiable parental consent through authoritative identity credentials, including Digital Locker tokens, rather than self-declaration).
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- [18] *M.C. Mehta v. Union of India*, (1987) 1 SCC 395. On corporate attribution of mens rea, see *Iridium India Telecom Ltd. v. Motorola Inc.*, (2011) 1 SCC 74.
- [19] Regulation (EU) 2024/1689 (Artificial Intelligence Act), Annex III(3) and art. 5(1)(f).

- [20] Regulation (EU) 2026/1744 (Digital Omnibus on AI), published in the Official Journal on 24 July 2026 and in force from 27 July 2026. Article 50 transparency duties were not deferred and applied from 2 August 2026.
- [21] Directive (EU) 2024/2853 on liability for defective products, extending no-fault liability to software and AI systems and introducing rebuttable presumptions of defect and causation where proof is excessively difficult. The proposed AI Liability Directive was withdrawn by the European Commission in 2025.
- [22] California SB 243 (2025), Business and Professions Code ch. 22.6, effective 1 January 2026; New York General Business Law art. 47, effective 5 November 2025. Colorado SB 24-205 imposes a duty of reasonable care against algorithmic discrimination by high-risk systems.
- [23] *Garcia v. Character Technologies, Inc.*, No. 6:24-cv-01903 (M.D. Fla.), order on motions to dismiss dated 21 May 2025.
- [24] A mediated settlement in principle covering the first wave of these claims was disclosed to the court in January 2026 on confidential terms, without admission of liability and without appellate determination.
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- [26] *Newby v. Adelphi University* (2026); *Doe v. University of Michigan* (2026); *Yang v. University of Minnesota*.
- [27] *Moffatt v. Air Canada*, 2024 BCCRT 149.
- [28] *Mobley v. Workday, Inc.*, No. 3:23-cv-00770 (N.D. Cal.).
- [29] *State v. Loomis*, 881 N.W.2d 749 (Wis. 2016); *NJCM v. The Netherlands (SyRI)*, District Court of The Hague, 5 February 2020 (ECLI:NL:RBDHA:2020:865).
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- [31] *Manu Solanki*, *supra* n. 5, expressly retained coaching institutions within consumer jurisdiction while excluding degree-granting institutions.
- [32] The India AI Governance Guidelines (*supra* n. 3) adopt Accountability as one of seven principles and propose a graded, risk-linked liability model tying responsibility to function, control and risk across the AI value chain.
- [33] Regulation (EU) 2

Role of Counselling in Managing Examination Anxiety among Secondary School Students

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Abstract

Examination anxiety is a common concern among secondary school students and can affect their concentration, motivation, confidence, and academic performance. Counselling can provide students with appropriate strategies to understand and manage anxiety associated with examinations. Putwain and von der Embse (2021) conducted a systematic review and meta-analysis of cognitive-behavioural interventions for test anxiety. Their study examined evidence concerning interventions designed to reduce test anxiety using cognitive-behavioural approaches. The present study focused on examining the role of counselling in managing examination anxiety among secondary school students. Counselling interventions included relaxation techniques, time-management skills, study-planning strategies, positive self-talk, and emotional support. The study aims to understand whether systematic counselling can help students develop better coping mechanisms and reduce examination-related anxiety. The findings indicated that participation in the structured counselling programme was associated with reduced examination anxiety and improved coping strategies among secondary school students.

Keywords: *Counselling, Examination Anxiety, Secondary School Students, Academic Stress, Coping Strategies*

Introduction

Examinations are an important component of the educational system and are often associated with expectations regarding academic achievement. While a certain level of concern may motivate students to prepare, excessive examination anxiety can interfere with learning and performance. Students may experience worry, fear of failure, lack of concentration, sleep difficulties, and reduced confidence before or during examinations.

Guidance and counselling services in schools can help students understand the sources of their anxiety and develop appropriate ways of coping with examination-related challenges. A counsellor can provide emotional support and teach practical techniques such as relaxation, effective study planning, time management, and positive thinking.

Therefore, examining the role of counselling in managing examination anxiety is important for promoting students' academic and emotional well-being.

Need and Significance of the Study

Secondary school students experience several academic demands, including regular assessments, examinations, competition, parental expectations, and decisions regarding their future education. These factors may contribute to examination-related anxiety.

School counselling can provide students with a structured opportunity to discuss their concerns and learn appropriate coping strategies. Understanding the effectiveness of counselling may help schools strengthen their student-support systems.

The study may be significant to:

- **Students:** by helping them develop healthy strategies for managing examination anxiety.
- **Teachers:** by increasing awareness of students' emotional and academic needs.
- **Counsellors:** by providing information for designing suitable counselling interventions.

- **Parents:** by helping them understand the importance of supportive approaches during examination periods.
- **Schools:** by supporting the development of effective counselling programmes.

Objectives of the Study

- To assess the level of examination anxiety among secondary school students.
- To identify the factors associated with examination anxiety among secondary school students.
- To study the role of counselling in managing examination anxiety.
- To examine the effectiveness of counselling intervention in reducing examination anxiety among students.
- To suggest suitable counselling strategies for managing examination anxiety.

Research Questions

- What is the level of examination anxiety among secondary school students?
- What factors contribute to examination anxiety among students?
- What counselling strategies can be used to manage examination anxiety?
- Does counselling help students develop better coping strategies for examination-related stress?

Hypotheses

- H₀₁: There is no significant difference in the pre-test examination anxiety scores of the experimental and control groups.
- H₀₂: There is no significant difference in the post-test examination anxiety scores of the experimental and control groups.
- H₀₃: There is no significant difference between the pre-test and post-test examination anxiety scores of students who receive counselling intervention.
- H₀₄: There is no significant difference in coping-strategy scores between students who receive counselling intervention and those who do not.

Review of related literature

Author(s) and Year	Main Focus	Objective	Population	Major Finding	Major Contribution to Present Study
American Psychological Association (2023)	Stress and psychological well-being	To examine major sources and effects of stress on psychological well-being	General population	Persistent stress can negatively affect emotional and psychological functioning	Provides broader context for understanding stress and the need for support mechanisms
Pascoe et al. (2020)	Student stress	To review the impact of stress on students' mental health, academic experiences, and well-being	Secondary and higher education	Academic demands and educational environments are important sources of student stress	Establishes the importance of addressing stress among secondary school students

Research Gap

Putwain and von der Embse (2021) provide evidence regarding cognitive-behavioural interventions for test anxiety, but further research can examine how structured counselling programmes incorporating practical coping strategies can be implemented specifically among secondary school students.

Therefore, the present study proposes to examine the role of counselling in managing examination anxiety among secondary school students, with particular attention to structured counselling strategies such as psychoeducation, study planning, time management, relaxation, positive self-talk, and coping skills.

Methodology

Research Design

A quasi-experimental research design is adopted to examine the effectiveness of counselling intervention.

Population

The population consist of secondary school students studying in selected schools from Kallakurichi district of Tamil Nadu.

Sample

A sample of 60 secondary school students were selected using simple random sampling technique. Students divided into an experimental group (30) and a control group (30) for an intervention study which is conducted for 4 weeks and pre-test for 1 week (before intervention) and post-test for 1 week (after intervention).

Tools for Data Collection

- A standardized **Examination Anxiety Scale**
- A **Student Information Schedule**
- A **Counselling Intervention Programme**
- A **Coping Strategies Questionnaire**

Counselling Intervention

- i. Understanding examination anxiety
- ii. Identifying anxiety-producing thoughts
- iii. Time management and study planning
- iv. Relaxation and breathing techniques
- v. Positive self-talk and confidence building
- vi. Problem-solving and coping strategies
- vii. Preparing emotionally for examinations

Data Analysis

The collected data may be analysed using appropriate statistical techniques such as:

- Mean
- Standard deviation
- Percentage
- t-test
- Correlation
- ANCOVA

Table 1.1: Pre-test Examination Anxiety Scores

Group	N	Mean	SD	t-value	df	p-value	Significance	Decision
Experimental	30	70.87	7.42	0.18	58	0.858	Not significant	H₀₁ not rejected
Control	30	70.57	7.31					

Interpretation: There is no significant difference between the experimental and control groups in pre-test examination anxiety scores, $t(58) = 0.18$, $p = .858$. Therefore, **H₀₁ is not rejected**.

Table 1.2: Post-test Examination Anxiety — ANCOVA

Source	df	F-value	p-value	Significance	Decision
Pre-test anxiety (covariate)	1	38.64	< .001	Significant	—
Group	1	18.72	< .001	Significant	H₀₂ rejected
Error	57				
Total	60				

Interpretation: After controlling for pre-test anxiety scores, there is a statistically significant difference between the experimental and control groups in post-test examination anxiety, $F(1,57) = 18.72$, $p < .001$. Therefore, **H₀₂ is rejected**.

Table 1.3: Pre-test and Post-test Anxiety in Experimental Group

Test	N	Mean	SD	t-value	df	p-value	Significance	Decision
Pre-test	30	70.87	7.42	7.36	29	< .001	Significant	H₀₃ rejected
Post-test	30	56.97	6.84					

Interpretation: There is a statistically significant difference between the pre-test and post-test examination anxiety scores of students who received counselling intervention, $t(29) = 7.36$, $p < .001$. Therefore, **H₀₃ is rejected**.

Table 1.4: Coping-Strategy Scores

Group	N	Mean	SD	t-value	df	p-value	Significance	Decision
Experimental	30	72.43	6.51	3.89	58	< .001	Significant	H₀₄ rejected
Control	30	65.17	7.69					

Interpretation: There is a statistically significant difference in coping-strategy scores between students who received counselling intervention and those who did not, $t(58) = 3.89$, $p < .001$. Therefore, **H₀₄ is rejected**.

Overall Hypothesis Testing

Hypothesis	Test used	p-value	Result	Decision
H₀₁	Independent-samples t-test	.858	Not significant	Not rejected
H₀₂	ANCOVA	< .001	Significant	Rejected
H₀₃	Paired-samples t-test	< .001	Significant	Rejected
H₀₄	Independent-samples t-test	< .001	Significant	Rejected

Findings

- i. The pre-test examination anxiety scores of the experimental and control groups did not differ significantly ($t(58) = 0.18, p = .858$).
- ii. After controlling for pre-test scores, a statistically significant difference was observed in post-test examination anxiety between the experimental and control groups ($F(1,57) = 18.72, p < .001$).
- iii. The experimental group demonstrated a statistically significant reduction in examination anxiety from pre-test to post-test ($t(29) = 7.36, p < .001$).
- iv. A statistically significant difference was found in coping-strategy scores between the experimental and control groups ($t(58) = 3.89, p < .001$), with higher scores observed in the experimental group.

Recommendations

- i. Schools should provide regular counselling services for examination anxiety.
- ii. Structured counselling programmes should be conducted before major examinations.
- iii. Students should be trained in stress management, relaxation, and coping strategies.
- iv. Teachers and parents should provide emotional support and encouragement during examination periods.

Educational Implications

- i. Schools can strengthen counselling services by providing students with regular opportunities to discuss academic and emotional concerns.
- ii. Counsellors and teachers can work together to identify students who require additional support.
- iii. Schools may also conduct workshops on examination preparation, time management, relaxation techniques, and coping skills.
- iv. Parents can be encouraged to provide emotional support and maintain realistic expectations during examination periods.

Conclusion

Examination anxiety can influence students' educational experiences and emotional well-being. Guidance and counselling can play an important role in helping students understand their anxiety and develop appropriate coping strategies. A systematic counselling programme that combines emotional support with practical skills such as study planning, time management, relaxation, and positive self-talk may help students approach examinations with greater confidence. Overall, the findings indicated that participation in the structured counselling programme was associated with reduced examination anxiety and improved coping strategies among secondary school students. Strengthening counselling services in schools can therefore contribute to a more supportive educational environment.

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Balancing Para Vidya And Apar Vidya Through Circadian Alignment, Ayurvedic Dinacharya and Nutrition: An Exploration of Sri Madhusudan Sai Siper–Palmary Complete Education Ecosystem

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Abstract

Contemporary higher education tends to privilege academic achievement and professional competence while giving comparatively little attention to the physical, emotional, spiritual, and regenerative needs of students. Drawing on the Sri Madhusudan Sai SIPER–PALMARY Complete Education Ecosystem developed and documented at Sri Sathya Sai University for Human Excellence (SSSUHE), Karnataka, India, this paper examines four interconnected foundations of complete education: the classical Indian distinction between Para Vidya (inner or spiritual knowledge) and Apar Vidya (worldly or academic knowledge); the biological principle of circadian rhythm; the Ayurvedic practice of Dinacharya, or disciplined daily routine; and nutrition as a determinant of learning and well-being. Using an institutional design-based descriptive approach, the paper shows how these four elements are woven into a single daily and annual rhythm at a residential university and argues that the deliberate synchronisation of ancient wisdom with modern education system, chronobiological and nutritional science offers a replicable model for holistic student development. The paper concludes that timetables, diet, and daily discipline are not administrative background to education but are themselves educational instruments that shape attention, character, and well-being.

Keywords: Para Vidya, Apar Vidya, circadian rhythm, Ayurveda, Dinacharya, chrononutrition, holistic education, SIPER–PALMARY

1. Introduction

Education is expected to prepare young people not merely for employment but for a balanced, meaningful, and socially responsible life (Miller, J. P. 2007). In practice, however, many institutions continue to measure success chiefly through examinations and career readiness, while the physical, emotional, ethical, spiritual, and regenerative needs of learners receive comparatively little structured attention. This gap has been noted in Indian policy discourse at least since the Kothari Education Commission (1964–66) and is reiterated in the National Education Policy 2020, both of which call for education that builds character, values, and holistic capability alongside academic knowledge.

The Indian educational tradition has historically resisted this narrowing by insisting on a distinction between two forms of knowledge, Para Vidya and Apar Vidya, (Olivelle, P. (Trans.). Mundaka Upanishad, 1996) and by treating the organisation of daily life sleep, food, work, and rest as inseparable from learning itself. (Madhusudan Sai. (2020, May 16).

This paper presents a conceptual and descriptive analysis of the Sri Madhusudan Sai SIPER–PALMARY Complete Education Ecosystem, an institutional framework developed over three academic years at Sri Sathya Sai University for Human Excellence (SSSUHE). SIPER designates five interconnected developmental domains Spiritual, Intellectual, Personal, Experiential, and Regenerational while PALMARY stands for Para Vidya–Apar Vidya (balanced) Learning Model

in Alignment with Circadian Rhythmicity. The paper focuses on four elements that anchor this model: the philosophical integration of Para Vidya and Apari Vidya; Circadian rhythm, Ayurvedic Dinacharya as a biological basis for timetable design and nutrition as an educational and physiological resource. The purpose is to demonstrate, through the SSSUHE case, how ancient Indian knowledge systems and contemporary science can be brought into a single coherent structure for residential higher education.

2. Background: Holistic Education and the SIPER-PALMARY Positioning

Holistic education, value education, and experiential learning have each been studied extensively as separate strands of pedagogy, alongside a growing body of chronobiological research on how sleep, meal timing, and daily rhythm affect cognition and well-being (Abbott, S. M., Malkani, R. G., & Zee, P. C. 2020). Indian educational thought from the ancient Gurukulam tradition to Ayurvedic concepts of Dinacharya (daily routine) and Ritucharya (seasonal routine) has long treated the student's inner development (Para Vidya) as inseparable from worldly competence (Apari Vidya) (Sharma, R. K., & Dash, B. (Trans, 2014). What existing literature has offered less often is a single operational model that integrates spiritual formation, academic learning, personal care, experiential/service learning, and biological regeneration into one measurable, time-quantified institutional system. The SIPER-PALMARY model is positioned to fill this gap: rather than proposing a new educational philosophy, the study scientifically documents and quantifies practices already followed at SSSUHE, translating an established residential culture into an explicit, auditable ecosystem model.

3. The SIPER-PALMARY Complete Education Ecosystem

The Sri Madhusudan Sai SIPER-PALMARY Complete Education Ecosystem is defined as an interconnected, natural-rhythm-aligned, regenerative model of student development spanning five domains. It integrates Para Vidya (spiritual/inner knowledge) and Apari Vidya (worldly/academic knowledge) with equal emphasis, guided by the body's natural rhythm and supported by balanced nutrition. PALMARY stands for Para Vidya-Apari Vidya (balanced) Learning Model in Alignment with circadian Rhythmicity, while SIPER denotes the five domains: Spiritual, Intellectual, Personal, Experiential, and Regenerational (Figure 1).

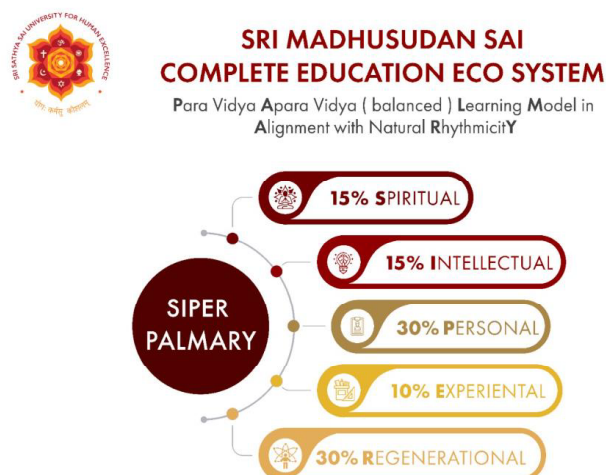


Figure 1. The SIPER-PALMARY Complete Education Ecosystem model, showing the five domains and their proportional share of annual student time.

Each domain was assigned a proportional share of the 525,600 minutes in an academic year (365 days $\times$ 24 hours $\times$ 60 minutes), based on empirical analysis of three years of institutional timetables: 15% to the Spiritual domain, 15% to the Intellectual domain, 30% to the Personal domain, 10% to the Experiential domain, and 30% to the Regenerational domain (Table 1).

Table 1. Annual time allocation across the five SIPER domains.

Domain	Share of Year	Annual Minutes	Core Elements
Spiritual	15%	78,840 min	Prayer, Bhajan, Adhyatmic sessions, Satsang/Swadhyaya
Intellectual	15%	78,840 min	Academics, structured study hours
Personal	30%	157,680 min	Yoga, games, daily routine, buffer time
Experiential	10%	52,560 min	Seva, internships, academic & non-academic activities
Regenerational	30%	157,680 min	Sleep, rest, nutrition, circadian/Dinacharya alignment

2. Para Vidya and Aparā Vidya: The Philosophical Foundation

The Mundaka Upanishad distinguishes between two categories of knowledge: Aparā Vidya, the worldly knowledge that equips a person to understand and function in the world, and Para Vidya, the higher knowledge oriented toward, values, and world welfare can lead to complete fulfilment in life, deeper meaning of existence. Aparā Vidya encompasses the sciences, technology, languages, humanities, and professional skills; Para Vidya directs attention inward, toward character, purpose, and spiritual growth. (Mundaka Upanishad, 1996).

An education confined to Aparā Vidya risks producing competence without conscience technically capable graduates whose knowledge is not anchored in ethical direction. Conversely, an education confined to Para Vidya risks producing withdrawal from practical responsibility. (Sri Madhusudan Sai, 2020, May 16).

2.1 Complete Education and the Complete Personality

The central purpose of Complete Education is to mould students into complete personalities. A complete personality is an integrated personality in which the different dimensions and faculties of the human being develop harmoniously rather than independently of one another. Such an integrated personality represents a harmonious synthesis of a sharp brain, a kind heart and competent hands, supported by a strong and healthy body. Education must therefore go beyond intellectual development and encompass the physical, emotional, moral, social and spiritual dimensions of the individual (Narasimha Murthy, B. N., 2025).

The development of the whole human personality consequently involves the harmonious development of four broad dimensions:

1. Physical development – development of health, strength, stamina, discipline and physical well-being;
2. Intellectual development – development of knowledge, reasoning, academic competence and the pursuit of truth;
3. Emotional development – cultivation of emotional maturity, love, empathy and harmonious relationships.

4. Spiritual development – development of spiritual awareness, self-control, selflessness and an understanding of the higher purpose of human life.

The philosophy therefore views education as a process of integrated human development rather than merely as a means of acquiring academic qualifications (Narasimha Murthy, B. N. 2025).

The SIPER–PALMARY model treats the two forms of knowledge as complementary rather than competing and insists that their integration must be lived rather than merely stated. Within the five SIPER domains, the Spiritual domain most directly expresses Para Vidya, while the Intellectual and Experiential domains chiefly cultivate Apra Vidya; the Personal and Regenerational domains support both by strengthening the learner's self-awareness, discipline, and capacity for sustained effort. In institutional terms, this integration is not confined to the classroom or the prayer hall it is expressed structurally, through the proportion of time the university allocates to each domain across the academic year.

3. Circadian Rhythm and the Timing of Education



Figure 2: Daily Routine with Natural Rhythmicity

Circadian rhythms are approximately twenty-four-hour biological cycles that govern sleep and wakefulness, hormone secretion, body temperature, alertness, and metabolism. (Adafer, R., Messaadi, et al., 2020). These rhythms are entrained chiefly by light but are also shaped by meal timing, physical activity, and social routine, (Golombek, D. A., & Rosenstein, R. E. (2010). Because attention, mood, and readiness to learn fluctuate across the day, the timing of educational activity is not a neutral administrative matter but a variable with direct bearing on learning outcomes. Disruption of circadian regularity has been associated with impaired concentration, mood disturbance, and elevated risk of metabolic and psychological dysfunction. (Kim, T. W., Jeong, J. H., & Hong, S. C., 2015).

Most educational institutions design timetables around the availability of faculty and infrastructure rather than around the biological rhythms of students. A fully residential university, where sleep, meals, study, and recreation are all managed within a single institutional structure, offers an unusual opportunity to align the entire daily schedule with circadian principles. At SSSUHE, the working-day timetable places prayer, meditation, and physical activity in the early morning; intellectual and practical work during the main period of daytime alertness; collective spiritual and

cultural activity in the evening; and reserves the night for food, quietening and sleep. Across the different categories of institutional days working days, examinations, vacations, Shibira, Dasara, sports days, and Sundays the timing of waking, sleeping, and meals is held broadly constant, even as the balance among academic, experiential, and recreational activity shifts according to the purpose of the day. This consistency is intended to protect the regularity of the students' biological clock regardless of the demands of a particular day.

4. Ayurvedic Dinacharya and Institutional Routine

Ayurveda conceives of health as a dynamic balance among the individual, environment, diet, behaviour, and time. Dinacharya, the Ayurvedic principle of daily routine, prescribes the sequencing of waking, cleansing, movement, food, work, rest, and sleep in harmony with natural cycles. Long before the emergence of chronobiology as a modern scientific discipline, Ayurveda had articulated a whole-person, lifestyle-oriented account of temporal organisation, describing the day through the shifting dominance of Vata, Pitta, and Kapha. (Sharma & Dash, 2014; Murthy, 2000).

The SIPER–PALMARY framework draws directly on Dinacharya, treating the institutional timetable not as an administrative convenience but as a health-supporting structure. Early rising, morning prayer and movement, a midday meal timed to coincide with the period of strongest digestive capacity, focused work during the day, a light and early evening meal, and a consistent bedtime are organised as a connected sequence. While Ayurveda and modern chronobiology employ different concepts, vocabularies, and forms of evidence, the two traditions converge on several practical recommendations, including early waking, regular mealtimes, daytime physical activity, avoidance of late-night eating, and adequate, consistently timed sleep.

Table 2: Parallel between Ayurvedic Dinacharya and chronobiological principles in the SSSUHE timetable.

Ayurvedic Principle	Time-Based Recommendation	Chronobiological Equivalent	Health Relevance
Dinacharya	Regular time for waking, eating, studying and sleep	Time-cued behaviour strengthens circadian regulation	Irregular routines are linked to metabolic and mood disturbance
Brahma Muhurta	Wake before sunrise, 4:30–6:00 am	Cortisol rises naturally toward morning alertness	Early waking with adequate sleep supports clarity and readiness
Main meal at Pitta time	Lunch around 12:00–1:00 pm	Digestive and metabolic capacity peaks in daytime	Midday meals support glycaemic control and energy use
Avoid late-night eating	Light, early dinner before the sleep phase	Late eating conflicts with melatonin rise and glucose tolerance	Late meals are linked to poor sleep and insulin resistance
Sleep by 10 pm	Sleep before the late-night Pitta phase	Deep sleep supports repair and memory consolidation	Delayed sleep weakens recovery and next-day performance

Ayurvedic Principle	Time-Based Recommendation	Chronobiological Equivalent	Health Relevance
Meditation and prayer	Pre-dawn and evening spiritual practice	Low-stimulation periods support parasympathetic balance	Supports emotional regulation and attention

Source: (Morin et al., 2025; Kim et al., 2015; Sharma & Dash, 2014; Murthy, 2000)

5. Nutrition as an Educational Resource

"For sacred thoughts and sacred deeds, sacred food is essential" - this teaching, foundational to the SSSUHE ethos, frames nutrition not as incidental to education but as one of its instruments. Nutrition shapes energy, concentration, emotional balance, immunity, and sleep quality, all of which bear directly on academic performance. Irregular, nutritionally inadequate, or convenience-based diets are associated with reduced attention span, impaired memory, and behavioural difficulty, (Benton, D. 2008). while regular and balanced meals support classroom engagement and cognitive function. Nutrition is also gaining attention at the policy level. (UNESCO. 2025, March 27). Educational frameworks increasingly recognize that proper nutrition is essential for both health and learning. The National Education Policy 2020 emphasizes the importance of nutrition (poshan) in education (NEP 2020), (Sidaner, E. 2022). Poor dietary habits have been associated with a range of negative outcomes, including decreased attention span, impaired memory and behavioural problems, all of which can hinder students' ability to engage effectively in learning activities and succeed academically. (Benton, D. 2008)

Traditional Indian knowledge systems and contemporary chronobiology (Morin, R., Forest, G., & Imbeault, P. (2025). converge on the view that meal timing matters as much as meal content. Chrononutrition research shows that peripheral clocks in the liver, gut, and pancreas respond strongly to feeding schedules, (Kim, T. W., Jeong, J. H., & Hong, S. C., 2015) and that irregular or late eating is associated with obesity, inflammation, and metabolic disorder.

Ayurveda similarly treats Ahara (diet) as a pillar of life alongside sleep and disciplined conduct, and stresses Jatharagni, or digestive fire, as the determinant of how effectively food is digested and absorbed. (Sharma, R. K., & Dash, B. (Trans.). (2014).

It is observed that for many years, the modern medical field did not fully acknowledge the connection between mood and food. But now nutritional psychiatry is finding there are many consequences and correlations between not only what we eat, how we feel, and how we ultimately behave, but also the kinds of bacteria that live in our gut. (Selhub, E. 2022)

Regular meal timing, freshly prepared vegetarian food, and consistent scheduling are treated as direct contributors to concentration, emotional balance, and sustained learning capacity, rather than as matters separate from academic performance.

Table 3. Food groups and their nutrient contributions, per ICMR classification, as applied in hostel menu analysis.

Food Group	Main Nutrient Supplied	Other Nutrients Present
Cereals and grains	Energy, protein	Invisible fats, B vitamins, iron, calcium, fibre
Pulses and legumes	Protein, energy	Invisible fat, B vitamins, iron, calcium, fibre
Milk and dairy products	Protein	Fat, riboflavin, calcium, vitamin B12, fat-soluble vitamins
Fruits and vegetables	Vitamins, minerals, fibre	Invisible fats, trace minerals and vitamins
Fats and sugar	Energy	Essential fatty acids

Source: ICMR

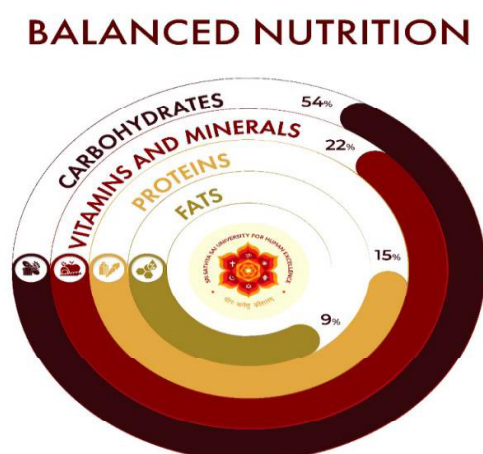


Figure 3: Macronutrient distribution of the SSSUHE hostel menu

6. Integration within the SIPER–PALMARY Ecosystem

The four elements discussed above do not operate in isolation. Within the SIPER-PALMARY model, the Regenerational domain encompassing sleep, rest, nutrition, and recovery is assigned with sufficient amount of annual institutional time, reflecting the premise that sustained learning depends on biological renewal as much as on instruction. The Spiritual domain expresses Para Vidya directly; the Intellectual and Experiential domains cultivate Apra Vidya; and the Personal and Regenerational domains, organised according to Circadian rhythm, Dinacharya principles and supported by balanced nutrition, provide the physiological foundation on which both forms of knowledge can be pursued. The annual timetable, spanning 365 days and 525,600 minutes across ten categories of institutional days, was developed iteratively over three years in consultation with university administration, faculty, and nutrition professionals, and represents a design-based rather than outcome-based study: it documents concordance between institutional practice and the

principles of chronobiology, Ayurveda and nutrition without claiming to demonstrate measured effects on student health or performance.

7. Discussion

The SSSUHE case illustrates that ancient Indian frameworks and modern scientific finding, while methodologically distinct, can be brought into productive dialogue rather than being treated as equivalent or as rivals. Ayurveda's account of Vata, Pitta, and Kapha (Sharma, R. K., & Dash, B. (Trans, 2014). Regular meal timing, freshly prepared vegetarian food, and consistent scheduling are treated as direct contributors to concentration, emotional balance, and sustained learning capacity, rather than as matters separate from academic performance. (Adafer, et, al 2020)

Regular meal timing, freshly prepared vegetarian food, and consistent scheduling are treated as direct contributors to concentration, emotional balance, and sustained learning capacity, rather than as matters separate from academic performance.

and modern chronobiology's account of hormonal and metabolic rhythm (Kim, T. W., Jeong, J. H., & Hong, S. C. 2015). arrive at broadly similar practical guidance regular waking and sleeping times, daytime physical exertion, midday emphasis on the main meal, and avoidance of late-night stimulation through entirely different explanatory frameworks (Morin, R., Forest, G., & Imbeault, P. (2025). The value of the SIPER–PALMARY model lies less in claiming scientific equivalence between the two systems than in using each to reinforce practices that neither could establish institutionally on its own.

The model also demonstrates that time itself can be treated as an educational resource. The sequencing of prayer, study, food, and rest within the day is not empty scheduling but an expression of institutional priorities, and it forms habits that persist beyond the specific activities scheduled. At the same time, the descriptive, design-based nature of this study means its claims should be read as evidence of concordance between timetable design and established principles, not as proof of improved learning outcomes. Longitudinal research comparing student well-being and academic performance across residential institutions that do and do not adopt such integrated scheduling would be needed to establish causal benefit.

8. Conclusion

This paper has presented the Sri Madhusudan Sai SIPER–PALMARY Complete Education Ecosystem as a structured, quantified account of holistic residential higher education at Sri Sathya Sai University for Human Excellence. By partitioning the 365days (525,600 minutes) of the academic year across five interconnected domains - Spiritual, Intellectual, Personal, Experiential, and Regenerational and by treating circadian rhythm, Ayurvedic Dinacharya, and balanced nutrition as integral rather than incidental. The SIPER–PALMARY Complete Education Ecosystem at Sri Sathya Sai University for Human Excellence offers a structured example of how the classical Indian distinction between Para Vidya and Aparā Vidya can be operationalised through attention to circadian rhythm, Ayurvedic Dinacharya, and nutrition. By treating the organisation of the daily and annual routine as an educational instrument rather than administrative background, the model brings spiritual formation, academic development, physical health, and regenerative rest into a single coherent structure.

While further outcome-based research is required to establish measurable benefits for student well-being and academic achievement. Longitudinal outcome studies, Future work should pair the descriptive time-partitioning model with longitudinal measurement of sleep quality, academic performance, and psychological well-being, ideally with comparison groups from non-residential institutions.

Explicit linkage of activities to learning outcomes. Each experiential and co-curricular activity within the Experiential domain could be more formally mapped to specific competencies (leadership, communication, empathy, problem-solving) to strengthen assessment and accreditation value. Modular adaptation for other institutions. Non-residential colleges and schools could adopt selected elements circadian-aligned scheduling, explicit domain proportions, or nutrition-as-education without requiring the full residential infrastructure.

The SSSUHE experience suggests that residential higher education institutions are well placed to translate the convergence of traditional and contemporary knowledge into practical, replicable timetable design.

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Effects of Saq and Aerobic Interval Training on Speed and Agility among College Level Kho-Kho Players

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Abstract

The purpose of the study was to find out the effect of SAQ and aerobic interval training on speed and agility among college level kho-kho players. To achieve the purpose of the study forty five (45) college studying in the various courses, Annamalai university campus, Chidambaram, Tamil Nadu, India, were randomly selected and divided into three groups of fifteen each. The age of the subjects, ranged from 18 to 24 years. This study consisted of two experimental variables the. SAQ training and aerobic interval training. They were divided into three equal groups (two experimental and one control group) the experimental group I was given SAQ training, experimental group II was given aerobic interval training for twelve weeks and control group was not allowed to participate in any training programme. Pre-test was conducted on selected dependent variable namely speed and agility at the beginning before the experimental treatment and post-test was taken after the experimental treatment. The data were analysed by applying Paired 't' test and ANCOVA was also applied to find out the difference. The result revealed that the SAQ training and aerobic interval training had significantly improved speed and agility of the college level men kho-kho players.

Keywords: SAQ Training, Aerobic Interval Training, Speed, Agility and Kho Kho

INTRODUCTION

Speed is one of the basic components necessary bio-motor in some sports. Every sports activities both games, competitions, and games always require speed bio motor components. it is the ability of the complex, because in general, speed is an ability that allows a basketball player to move as quickly as possible at the level of specific resistance [Jovanovic (2011)]. Exercise of speed, agility, and quickness cover the complete spectrum of training intensity, from low intensity to high intensity. Every athlete has a different level. Therefore, the intensity of exercise should coincide with the individual's ability [Sharma & Dhapola (2015)]. Exercise involving speed, agility, and quickness is a training method aimed at developing motor skills and body motion control through the development of the neuromuscular system. It aims to improve the athlete's ability to perform multi directional explosive power movements by reprogramming the neuromuscular system, so it can work more efficiently [Vallimurugan & Vincent (2012)]. Exercise of speed, agility, and quickness (SAQ) has become a popular way to train athletes. Speed, agility, and quickness to cover the complete spectrum intensity of exercise, from low intensity to high intensity. SAQ drills can also be used to teach movements, such as heating, or to improve the physical condition of athletes [Anitha (2017)]. Exercise of speed, agility, and quickness is a system of progressive exercises and instruction aimed at developing fundamental motor skills to improve the ability of the athlete to be more skilled at faster speeds and with greater precision. This exercise has become a popular way to train athletes in improving the speed, strength, or the ability into maximum potency. SAQ training encompasses a diverse array of exercises and drills tailored to enhance an athlete's speed, agility, and quickness. These may include plyometric exercises, ladder drills, cone drills, and reaction time exercises, among others (Sheppard & Young, 2006). By targeting specific

neuromuscular pathways and motor skills, SAQ training aims to improve an athlete's ability to accelerate, change direction, and react quickly to stimuli.

Methods and Procedures

The purpose of the study was to find out the effect of SAQ training and aerobic interval training on speed and agility among college level kho-kho players. To achieve this purpose forty five male Kho Kho players studying in the various courses, Annamalai university campus, Chidambaram, Tamil Nadu, India, were randomly selected and divided into three groups of fifteen each. The age of the subjects, ranged from 18 to 24 years. This study consisted of two experimental variables the given SAQ training and aerobic interval training. The allotment of groups was done at random, thus the Group-I underwent SAQ training, the Group-II underwent Aerobic interval training for three days per week for twelve weeks and the Group-III acted as control was not given any specific training.

Statistical Technique

The data collected from the three groups prior to and post experimentation were statistically analyzed to find out the significant difference if any, by applying the analysis of covariance (ANCOVA). Since three groups were involved, whenever the obtained F ratio was found to be significant for adjusted post test means, the Scheffe's test was applied as post hoc test to determine the paired mean differences, if any. In all the cases statistical significance was fixed at .05 levels.

Results of Study

TABLE – 3ANACOVA FOR BEFORE TRAINING AND AFTER TRAINING ON SPEED AND AGILITY OF EXPERIMENTAL AND CONTROL GROUPS

VARIABLES		SAQ	AIT	CG	SOV	SS	df	MS	F- ratio
Speed	Pre test	7.32	7.35	7.31	B	0.015	2	0.008	1.29
	Mean								
	SD	0.07	0.09	0.06	W	0.248	42	0.006	15.15*
	Post test	6.87	6.91	7.30	B	1.67	2	0.836	
	Mean								
	SD	0.29	0.27	0.05	W	2.31	42	0.055	
Agility	Adjusted				B	1.33	2	0.666	13.74*
	Post Test								
	Mean	6.90	6.91	7.28	W	1.98	41	0.048	0.003
	Pre test	11.92	11.89	11.90	B	0.005	2	0.002	
	Mean								26.08*
	SD	0.84	0.90	0.85	W	31.69	42	0.75	
Agility	Post test	10.42	10.55	11.92	B	20.56	2	10.28	28.52*
	Mean								
	SD	0.63	0.57	0.66	W	16.55	42	0.39	28.52*
	Adjusted				B	20.55	2	10.27	
	Post Test								
	Mean	10.43	10.52	11.92	W	14.78	41	0.36	

The adjusted post test mean values on speed of SAQTG, AITG and CG were 6.90, 6.91 and 7.28 respectively. The obtained 'F' ratio of 13.74 for adjusted post test scores was greater than the table value of 3.22 for df 2 and 41 required for significance at 0.05 level of confidence on speed. The results of the study indicated that there was significant difference between the adjusted post test means of SAQTG, AITG and CG on speed.

The adjusted post test mean values on agility of SAQTG, AITG and CG were 10.43, 10.52 and 11.92 respectively. The obtained 'F' ratio of 28.52 for adjusted post test scores was greater than the table value of 3.22 for df 2 and 41 required for significance at 0.05 level of confidence on agility. The results of the study indicated that there was significant difference between the adjusted post test means of SAQTG, AITG and CG on agility.

TABLE – 4 SCHEFFE'S POST HOC TEST FOR THE ADJUSTED POST-TEST PAIRED MEANS DIFFERENCE ON SPEED AND AGILITY

	Adjusted Post-Test Means			Mean difference	Confidence Interval
	SAQTG	AITG	CG		
SPEED	6.90	6.91		0.01	0.20
	6.90		7.28	0.38*	0.20
		6.91	7.28	0.37*	0.20
AGILITY	10.43	10.52		0.9*	0.55
	10.43		11.92	1.49*	0.55
		10.52	11.92	1.40*	0.55

***Significant at 0.05 level of Confidence.**

The table -4 shows that the adjusted post test paired mean difference between SAQ training group and aerobic interval training group, SAQ training group and control group and aerobic interval training group and control group are 0.01, 0.38 and 0.37 for speed and 0.90, 1.49 and 1.40 for agility respectively. They were greater than the confidence interval value of 0.20 and 0.55 at 0.05 levels which indicate that the twelve weeks of SAQ training and aerobic interval training groups have significantly speed and agility as compared to the control group. The result also reveals that the increase in agility is significantly improved SAQ training group as compared with aerobic interval training group.

Discussion on Finding

The result of present study was that speed and agility have increased significantly SAQ training group and the aerobic interval training group as compared to the control group. However the result of the present study also reveals that the increase in speed and agility were significantly more for the SAQ training group than the aerobic interval training group kho kho players. The results of the present study are also in line with the results observed from the previous studies. The results of this study demonstrate the significant positive impact of Speed, Agility, and Quickness (SAQ) training on the performance of female Kho-Kho players in the Mumbai region. Through an eight-week SAQ training program, participants exhibited notable improvements in sprint times, agility test scores, and reaction times compared to those in the control group. These findings underscore the efficacy of SAQ training in enhancing the speed, agility, and quickness of female athletes engaged in dynamic field sports like Kho-Kho (Shinde, & Sonwane, 2015). Similarly, the

substantial increase in agility test scores among SAQ-trained participants reflects the training program's effectiveness in enhancing athletes' agility and change-of-direction capabilities. Agility is a critical attribute in sports like Kho-Kho, which require athletes to rapidly change direction while evading opponents and maintaining control of their body position (**Deshmukh & Suryavanshi, 2019**). The observed Improvements in sprint times following SAQ training align with previous research highlighting the effectiveness of SAQ interventions in enhancing linear speed performance (**Sheppard & Young, 2006**).

The significant reduction in sprint times among participants in the experimental group suggests that SAQ training positively influenced their ability to generate speed on the Kho-Kho field (**Rathi, & Kaur, 2018**). SAQ training, with its emphasis on multidirectional movements and reactive agility drills, appears to have translated into improved agility performance among female Kho-Kho players (**Mahanta et al., 2017**). Furthermore, the notable improvement in reaction times following SAQ training is consistent with the training program's focus on enhancing athletes' quickness and responsiveness to stimuli. Quick reaction times are essential in sports like Kho-Kho, where split-second decisions and rapid movements can determine the outcome of a game (**Miller et al., 2020**). The observed reduction in reaction times among SAQ-trained participants suggests that the training program effectively enhanced their perceptual and cognitive skills, enabling them to react more swiftly to game situations.. The findings of this study provide empirical evidence supporting the effectiveness of SAQ training in enhancing the speed, agility, and quickness of female Kho-Kho players in the Mumbai region. By improving athletes' sprint times, agility test scores, and reaction times, SAQ training holds promise as a valuable tool for optimizing the performance of female athletes engaged in dynamic field sports like Kho-Kho. Future research endeavors should continue to explore the potential benefits of SAQ training across diverse sporting disciplines and populations, with a focus on developing evidence-based training protocols tailored to the specific needs of female athletes.

Conclusion

The analysis of data revealed significant improvement on speed and agility have increased significantly for the SAQ training group and the aerobic interval training group as compared to the control group. However the result of the present study also reveals that the increase in speed and agility were significantly more for the SAQ training group than the aerobic interval training group kho kho players.

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Health, Well-being and Education: An Overview

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ABSTRACT

Health, well-being and education are closely interconnected dimensions of human development. Education is not limited to academic achievement; it also contributes to the physical, mental, emotional and social development of learners. Similarly, the health and well-being of students and teachers have a significant influence on learning, participation, motivation, academic performance and the overall quality of the educational experience. In the contemporary context, students face several challenges, including academic pressure, examination stress, social difficulties, unhealthy lifestyles, excessive digital engagement and emotional problems. Teachers also experience workload, professional stress and changing educational demands. These issues highlight the need to integrate health and well-being into educational practices and policies. This paper examines the concept and relationship between health, well-being and education, identifies major challenges, and discusses their educational implications. It emphasizes the importance of creating supportive, inclusive, safe and health-promoting educational environments. The paper concludes that a holistic approach to education, involving students, teachers, families, institutions and communities, is essential for developing healthy, resilient, confident and lifelong learners.

Keywords: Health, Well-being, Education, Mental Health, Holistic Education, Students, Teachers, Educational Environment

INTRODUCTION

Education is a fundamental process through which individuals develop knowledge, skills, attitudes, values and competencies required for personal and social development. Traditionally, educational success has been measured primarily through academic achievement, examination results and intellectual development. However, contemporary perspectives recognize that effective education must address the learner as a whole person.

Health and well-being are essential foundations of effective learning. A student who is physically healthy, emotionally secure, mentally balanced and socially connected is more likely to attend school regularly, participate actively and engage positively in learning. Conversely, poor health, psychological stress, anxiety, social isolation and unhealthy lifestyles may negatively affect concentration, motivation, attendance and academic performance.

The relationship between education and health is also reciprocal. Education provides individuals with knowledge and skills that can improve health literacy, decision-making, healthy behaviour and quality of life. Educational institutions provide an important environment in which healthy habits, emotional resilience, social skills and responsible behaviour can be developed.

In addition, teacher well-being is an important component of educational quality. Teachers experiencing excessive workload, professional stress or inadequate organizational support may face difficulties in maintaining positive classroom relationships and effective teaching practices. Therefore, student well-being and teacher well-being need to be considered together. A Holistic educational approach should consequently recognize physical, mental, emotional and social well-being as integral components of quality education.

NEED AND SIGNIFICANCE OF THE STUDY

The need for examining health, well-being and education has increased because of significant changes in students' educational and social environments.

Increasing Academic Pressure

Students increasingly experience pressure related to examinations, competition, academic expectations and future career decisions. Excessive pressure may affect emotional and psychological well-being.

Mental Health Concerns

Anxiety, stress, loneliness, low self-confidence and emotional difficulties can interfere with students' learning and social relationships. Educational institutions therefore need appropriate preventive and supportive mechanisms.

Changing Lifestyles

Reduced physical activity, unhealthy dietary habits, inadequate sleep and sedentary behaviour can affect students' physical health and learning readiness.

Digital Technology

Digital technology provides valuable educational opportunities but excessive screen use, distraction, disrupted sleep and unhealthy online behaviour may create challenges for well-being.

Teacher Well-being

Teachers are important contributors to the educational process. Their physical and psychological well-being can influence classroom climate, teaching effectiveness, professional commitment and student relationships.

Need for Holistic Education

Education should not focus exclusively on academic achievement. There is a growing need to develop students who are physically healthy, mentally resilient, emotionally competent, socially responsible and capable of lifelong learning.

SIGNIFICANCE

The study is significant for:

Students: Promotes physical health, emotional balance, resilience and positive learning.

Teachers: Highlights the importance of teacher health and professional well-being.

Schools: Supports the development of safe, inclusive and supportive educational environments.

Parents: Encourages cooperation between home and educational institutions.

Educational administrators: Provides a basis for developing student and teacher wellness programmes.

Policy makers: Highlights the importance of incorporating health and well-being into educational policies and planning.

Society: Contributes to the development of healthy, responsible and productive citizens.

OBJECTIVES OF THE STUDY

The study aims to:

- Examine the relationship between health, well-being and education.
- Explain the major concepts and dimensions of health and well-being in education.
- Identify the major challenges affecting health and well-being in educational settings.
- Examine the importance of physical, mental, emotional and social well-being for effective learning.

- Highlight the role of teachers and educational institutions in promoting health and well-being.
- Discuss the educational implications of integrating health and well-being into education.
- Suggest a holistic approach for promoting healthy and effective learning environments.

CONCEPT OF HEALTH, WELL-BEING AND EDUCATION

Concept of Health

Health is a multidimensional concept that extends beyond the absence of disease. It includes physical, mental and social dimensions of functioning. In education, health includes the learner's physical fitness, nutrition, sleep, hygiene, psychological condition and ability to participate effectively in educational activities.

Concept of Well-being

Well-being refers to a positive state in which individuals are able to function effectively, develop meaningful relationships, cope with challenges and experience a sense of purpose and satisfaction.

In an educational context, well-being includes:

- Physical well-being
- Mental well-being
- Emotional well-being
- Social well-being
- Psychological resilience
- Sense of belonging
- Self-confidence
- Purpose and meaning

Concept of Education

Education is a lifelong process of developing knowledge, skills, values, attitudes and competencies. Modern education emphasizes holistic development rather than intellectual development alone.

Relationship Between Health, Well-being and Education

The relationship can be understood as a continuous cycle:

Good Health → Better Well-being → Effective Learning → Educational Achievement → Improved Quality of Life

At the same time:

Quality Education → Health Knowledge → Healthy Behaviour → Better Health and Well-being
Therefore, health, well-being and education mutually reinforce each other.

MAJOR CHALLENGES

Several challenges may affect the integration of health and well-being into education.

Academic and Examination Stress

Continuous academic pressure and fear of failure can negatively affect students' emotional and psychological well-being.

Mental Health Stigma

Students may hesitate to seek counselling or psychological support because of fear, misunderstanding or social stigma.

Lack of Professional Support

Some educational institutions have limited access to trained counsellors, psychologists, nurses and other health professionals.

Teacher Workload and Stress

Excessive workload, administrative responsibilities and limited organizational support can affect teacher well-being.

Unhealthy Lifestyle

Insufficient physical activity, unhealthy food habits and inadequate sleep may affect physical and mental functioning.

Excessive Digital Engagement

Excessive use of smartphones, social media and other digital platforms can contribute to distraction, sedentary behaviour and sleep-related problems.

Bullying and Social Exclusion

Bullying, discrimination, peer pressure and lack of belonging can negatively influence students' mental and social well-being.

Limited Family-School Collaboration

Insufficient communication between families and educational institutions can make it difficult to identify and address student well-being concerns.

Resource Constraints

Lack of financial resources, infrastructure and trained personnel can limit the implementation of comprehensive health and wellness programmes.

Overemphasis on Academic Achievement

When examination performance becomes the primary measure of success, physical, emotional and social development may receive inadequate attention.

EDUCATIONAL IMPLICATIONS

The relationship between health, well-being and education has important implications for educational practice and policy.

Holistic Curriculum

Health and well-being should be integrated into the curriculum through health education, life skills, physical education and social-emotional learning.

Supportive Learning Environment

Schools should create environments characterized by safety, respect, inclusion, cooperation and positive teacher-student relationships.

Mental Health Support

Educational institutions should provide accessible counselling, awareness programmes, early identification and appropriate referral services.

Promotion of Physical Activity

Regular physical education, sports, yoga, exercise and recreational activities should be encouraged as part of school life.

Teacher Well-being

Educational institutions should support teachers through manageable workloads, professional development, collegial relationships, recognition and supportive leadership.

Parent-School Partnership

Parents and teachers should work together to understand students' academic, emotional and social needs.

Digital Well-being

Students should be educated about responsible technology use, online safety, screen-time balance, physical breaks and healthy sleep practices.

Inclusive Education

Educational institutions should promote equality, respect diversity and prevent bullying, discrimination and social exclusion.

Student Participation

Students should be encouraged to participate in school activities and decisions that affect their learning environment. Student voice can strengthen confidence, autonomy and belonging.

Policy Development

Educational policies should recognize student and teacher well-being as important indicators of educational quality rather than focusing exclusively on examination results.

CONCLUSION

Health, well-being and education are inseparable components of holistic human development. Education becomes more meaningful and effective when it addresses not only academic achievement but also the physical, mental, emotional and social needs of learners. Students who experience good health, emotional security, positive relationships and supportive learning environments are better positioned to participate actively in education. Similarly, teachers who experience professional and personal well-being can contribute more effectively to positive classroom environments and quality teaching.

The challenges associated with academic pressure, mental health, unhealthy lifestyles, digital engagement, teacher stress and social exclusion demonstrate the need for a comprehensive approach. Educational institutions should therefore move beyond an examination-centred model toward a whole-person and well-being-centred approach to education.

Promoting health and well-being should be a shared responsibility involving students, teachers, parents, school administrators, health professionals, communities and policy makers. Such collaboration can help create educational environments that nurture healthy, resilient, confident, socially responsible and lifelong learners.

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Literature and Well-Being: The Role of Literary Reading in Education

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ABSTRACT

Contemporary educational frameworks increasingly prioritise student health and well-being. However, mainstream educational discourse often adopts a reductive focus, conceptualising well-being primarily through physiological metrics or functional psychological coping mechanisms. This paper argues that true student flourishing requires a broader, humanistic approach encompassing emotional literacy, moral reflection, and existential resilience. Within this expanded framework, literary reading emerges as an essential educational catalyst. Rather than treating literature merely as an aesthetic luxury or a tool for linguistic instruction, this study positions literary engagement as a direct encounter with the complexity of human experience. Through Martha Nussbaum's concept of the "narrative imagination" and cognitive theory of mind, literary reading enables students to cultivate perspective-taking, empathy, and emotional reflection within a safe aesthetic distance. Crucially, the paper distinguishes humanistic classroom dialogue from clinical therapy, emphasizing that literature offers a mediator for exploring sensitive human issues without pathologising the learner. Grounded in this theoretical orientation, five practical pedagogical applications are outlined: dialogue-driven literature circles, character-proxied discussion, reflective writing, diversified text selection, and slow reading. Finally, conceptual limitations, critical research gaps, and future empirical directions are discussed. Re-centering literary reading within educational policy ultimately provides a transformative pathway toward nurturing empathetic, self-aware, and resilient individuals.

Keywords: Literary Reading, Well-Being in Education, Narrative Imagination, Emotional Literacy, Empathy, Aesthetic Distance, Humanistic Pedagogy

INTRODUCTION

In recent years, global educational paradigms have undergone a significant transformation. Once focused primarily on standardized academic achievement, now educational discourse increasingly recognizes that learning is deeply tied to student well-being. Consequently, combining well-being into education has gained central priority (OECD; Ross and Wu). Educational institutions are now expected to create environments that support emotional, social, and personal growth (OECD).

Still, mainstream discussions often adopt a narrow view of well-being, focusing heavily on physical health, stress management, and emotional regulation. While these functional dimensions matter, true well-being involves how individuals understand themselves, relate to others, respond to adversity, and search for meaning (OECD). Emotional awareness, empathy, and self-reflection are important to personal development (OECD), framing the learner as a complete human being rather than a mere recipient of academic content (Ross and Wu).

Within this understanding, literature occupies an important place. Literary reading is far more than an aesthetic exercise or linguistic drill; it provides a direct encounter with different human experiences (Nussbaum; Oatley). Through prose, poetry, and drama, readers get to know different perspectives, moral ambiguities, and existential questions that differ from their own perspective (Nussbaum; Oatley). These bring intellectual and emotional reflections within a structured environment (Nussbaum).

This paper argues that literary reading basically enhances student well-being by developing empathy, perspective-taking, and emotional awareness (Nussbaum; Kidd and Castano; Oatley). Positioning literature as a humanistic educational practice rather than a clinical intervention, it examines how engaging with narrative texts allows learners to process complex emotions, understand different viewpoints, and reflect deeply on life (Nussbaum; Oatley).

Literature, Human Experience, and Well-Being

Literature and the Complexity of Human Life

Education often gives importance to highly structured knowledge such as facts, logic, and quantifiable skills. However, human existence is inherently nonlinear, shaped by contradiction, moral ambiguity, and uncertainty. Literature reflects this complexity rather than reducing it to simplified directives (Nussbaum; Oatley). Literary works require readers to navigate conflicting motives, grief, joy, and ethical dilemmas, rather than like a guide book (Oatley). Experiencing these narratives helps students build comfort with ambiguity and develop an understanding of themselves and society (Nussbaum).

Reading as an Imaginative Encounter

Basically, literary reading is an active, imaginative act. Readers must construct meaning, envision unfamiliar scenarios, and inhabit perspectives beyond their immediate reality (Oatley). Through stylistic devices, characterization, and narrative point of view, literature draws readers into alternative states of consciousness (Nussbaum; Oatley). This process aligns directly with Martha Nussbaum's concept of the "narrative imagination"—the capacity to mentally inhabit the circumstances of another (Nussbaum). This imaginative step broadens personal boundaries and deepens social awareness (Nussbaum; Kidd and Castano).

Why Human Experience Matters in Education

When education centers exclusively on intellectual output, students' lived experiences remain external to the classroom. Yet, education is fundamentally concerned with developing self-aware individuals who can navigate complex relational dynamics (Ross and Wu). Literature brings formal learning and lived human experience together, by depicting themes of love, loss, isolation, belonging, and hope. Literary works link academic engagement directly to existential questions (Nussbaum).

The Role of Literary Reading in Well-Being

Literary reading actively supports personal well-being through two primary mechanisms:

- **Emotional Literacy and Reflection:** Literature provides a set of vocabulary for identifying and processing certain emotions (Nussbaum; Oatley). Observing characters navigate emotional distress or joy, enabling readers to articulate feelings that are difficult to express, offering emotional clarity without demanding personal disclosure (Nussbaum; Oatley).
- **Reflective Space and Meaning-Making:** Unlike rapid digital information consumption, literary texts demand slow processing and interpretation (Nussbaum). They allow readers to pause, reconsider assumptions, and reflect on core questions of identity, purpose, and responsibility (Nussbaum).

Literature, Emotional Reflection, and Dialogue

Literature and Emotional Reflection: Confronting the Spectrum of Feeling

Everyday experiences of grief, loneliness, fear, or uncertainty can feel isolating and difficult to articulate. Literature translates these feelings into expressive language, narration, and imagery

(Nussbaum). Encountering these feelings in stories validates the reader's personal inner life by situating individual suffering within broader human patterns (Nussbaum; Oatley).

Reading allows students to examine intense emotions from a safe distance (Nussbaum). Analyzing a character's responses to grief or conflict offers critical insights into human behavior without requiring students to reveal their own personal vulnerabilities (Oatley).

Literature as a Space for Discussion, Not Therapy

A critical distinction must be maintained between humanistic literary engagement and clinical therapy. Reducing literature to a therapeutic instrument risks overlooking its aesthetic, cultural, and philosophical values (Nussbaum). The primary goal in an educational setting is not psychological diagnosis, but collaborative intellectual inquiry (Nussbaum).

While clinical psychological therapy focuses on diagnosis, coping strategies, real-world trauma, and direct self-disclosure, humanistic literary pedagogy centers on intellectual reflection, aesthetic appreciation, and shared inquiry. Fictional characters and narrative structures serve as the object of focus, allowing high protection of personal boundaries shielded by aesthetic distance. By centering discussion on fictional proxies, classrooms become low-stakes, safe environments for exploring sensitive themes. Students encounter different interpretations from peers, cultivating mutual respect, intellectual openness, and collective problem-solving (Nussbaum).

Literature and Empathy: Crossing the Boundaries of Self

Encountering Lives Different from One's Own

Individuals notice the world through their own social, historical, and cultural filters. Literature expands this viewpoint by introducing students to unfamiliar communities, values, and worldviews (Nussbaum; Oatley). Rather than engaging with diversity through abstract concepts, narrative reading presents human difference through lived and made-up stories (Nussbaum). This supports broader educational commitments to inclusion and social understanding (Nussbaum; Kidd and Castano).

Empathy and Perspective-Taking

The shift from observing an unfamiliar life to actively understanding it relies on perspective-taking. Through monologue, character development, and point of view, literary texts make readers consider internal motivations and complex moral choices (Nussbaum). Cognitive research suggests that engaging with complex fiction sharpens social reasoning and "theory of mind" (Kidd and Castano). This process builds intellectual humility, showing that human situations are rarely reducible to a single viewpoint (Nussbaum).

The Educational Value of Understanding Others

Learning to engage with contrasting viewpoints is important beyond the humanities classroom. Dialogues in narrative texts demonstrate that a single story can evoke different interpretations. This practice discourages immediate judgment, promotes active listening, and highlights the shared human experiences connecting individuals across differences (Nussbaum; Oatley).

Pedagogical Applications: Literary Reading and Well-Being

Translating these theoretical benefits into classroom practice requires intentional pedagogical choices. Educators must look beyond standard analytical tests and adopt strategies that foster active reflection, open dialogue, and personal engagement.

1. Dialogue-Driven and Inquiry-Based Literature Circles

Moving away from lecture-dominated instruction, classrooms can implement student-centered literature circles. Focused on open-ended questions—such as "Why might the character have chosen this path?" or "How does this situation look from another character's view?"—students collaboratively explore narrative dilemmas. This validates student voices, promotes active listening, and builds a sense of community around shared text analysis.

2. Aesthetic Distance and "Character-Proxied" Discussion

Teachers can leverage distance by keeping initial analytical discussions focused strictly on character actions, circumstances, and choices. This enables deep exploration of grief, anxiety, or ethical conflict without forcing students to disclose private, real-world experiences.

3. Reflective and Perspective-Taking Writing

Structured writing allows students to internalize narrative perspectives. Role-taking journals (writing entries from the viewpoint of a character with contrasting values) and reflective response logs (recording personal reactions or emotional shifts during reading) develop emotional vocabulary and sharpen cognitive empathy through active perspective-taking (Kidd and Castano; Oatley).

4. Inclusive and Diversified Text Selection

Curricula should provide a balance of text types, serving both as mirrors (texts reflecting students' lived realities, fostering validation and belonging) and windows (texts exposing students to unfamiliar cultural backgrounds, broadening worldviews). This develops identity validation while expanding cross-cultural empathy and institutional inclusion.

5. Slow Reading and Contemplative Pedagogies

In an era dominated by hyper-digital skimming, slow reading reserves quiet, dedicated classroom time to deeply analyze short passages, followed by silent reflection or guided group discussions. This reduces cognitive overload, encourages sustained attention, and offers space for contemplative meaning-making.

Limitations, Research Gap, and Future Directions

1. Conceptual and Practical Limitations

- **Subjectivity of Interpretation:** Reader responses vary widely. A text that inspires empathy in one student may cause disinterest or distress in another, making outcomes difficult to standardize.
- **Curricular Constraints:** High-stakes testing and skill-based mandates leave little instructional time for slow reading and open-ended dialogue.
- **Teacher Preparedness:** Facilitating conversations on sensitive themes requires careful boundary management. Without proper training, teachers may struggle to balance humanistic discussion with therapeutic boundaries (OECD).

2. Identified Research Gaps

- **Lack of Longitudinal Data:** Existing scholarship relies heavily on short-term qualitative feedback. Long-term studies are needed to trace how sustained literary reading influences social-emotional development over time (Kidd and Castano).
- **Under-Representation of Non-Traditional Media:** Greater research should explore graphic novels, digital literature, audiobooks, and non-Western storytelling traditions (Oatley).
- **Contextual and Cross-Cultural Dynamics:** Responses to literature are deeply shaped by cultural and economic environments. Comparative cross-cultural studies are essential.

3. Future Research Directions

- **Mixed-Methods Designs:** Combining longitudinal qualitative tracking (journals, interviews) with validated psychological measures of emotional well-being.
- **Interdisciplinary Collaboration:** Fostering ongoing dialogue between literary scholars, developmental psychologists, and health humanities researchers (OECD).
- **Pedagogical Framework Development:** Creating actionable, evidence-based instructional toolkits and teacher-training initiatives for managing sensitive classroom discussions effectively.

Conclusion

As educational systems adapt to an increasingly complex world, student well-being must remain a central priority. However, well-being extends beyond functional metrics and physiological coping strategies; it requires emotional depth, self-reflection, and social understanding.

Literary reading offers a vital, humanistic pathway toward this goal. Through narrative imagination, aesthetic distance, and dialogue-driven pedagogy, literature provides a structured space for exploring human complexity, nurturing empathy, and building personal resilience (Nussbaum). By re-centering literature within educational policy, schools can create environments that support both academic learning and personal growth.

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Physical Activities in Inclusive Learning

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Abstract

Physical activity is a vital part of a child's development, boosting physical health, sharp focus, and emotional resilience. However, traditional gym classes often create barriers for students with special educational needs (SEN) or physical disabilities. True inclusion means that every child is respected as a valuable member of the school community who can fully participate alongside their peers. For teachers, the goal is not merely to have students with special needs present in the room, but to actively engage them. Achieving this requires deliberate, thoughtful teaching strategies that modify activities so that every child can experience the joy of movement.

Key Words

Physical Activity, Health, SEN (Special Educational Needs), Physical Disabilities and Movement.

Introduction

Inclusive learning ensures equal opportunities for all learners, regardless of physical, intellectual, or emotional differences. Physical activities in inclusive settings promote health, social interaction, confidence, and academic success. Meaning of Inclusive Learning is an approach where students with diverse abilities learn together. Focuses on participation, accessibility, and support. Encourages acceptance, empathy, and teamwork.

Role and Benefits of Physical Activities in Inclusive Learning:

Develops motor skills and coordination. Improves health and fitness for every student. Builds confidence, cooperation, and social skills. Provides opportunities for experiential learning.

Physical Development – Strength, balance, flexibility.

Psychological Growth – Self-esteem, reduced anxiety, motivation.

Social Inclusion – Teamwork, empathy, communication.

Academic Support – Improves focus, discipline, and problem-solving.

Examples of Inclusive Physical Activities:

Adapted Games: Modified rules (e.g., larger ball, slower pace).

Parachute Games: Easy participation for all abilities.

Dance & Movement Therapy: Expressive, flexible, inclusive.

Yoga & Mindfulness: Improves focus, calmness, and flexibility.

Wheelchair Sports: Basketball, racing, or badminton with modifications.

Strategies for Teachers:

The **TREE** Modification Framework:

One of the most effective tools for a teacher planning inclusive physical activities is the **TREE framework**, which stands for **T**eaching style, **R**ules, **E**nvironment, and **E**quipment:

T – Teaching Style: Teachers should vary how they deliver information. Instead of just calling out instructions, a teacher can use visual aid cards, demonstrate the movement physically, or use clear hand signals.

R – Rules and Cues: Standard game rules can be bent to ensure success. For instance, during a game of volleyball, teachers can allow the ball to bounce once on the floor before a student hits it. In baseball or cricket, using a batting tee allows students with motor challenges to practice hitting without the pressure of a moving pitch.

E – Environment: The physical layout of the playing area can be adjusted. Teachers can decrease the size of a playing field to reduce the amount of running required, or use brightly coloured floor tape instead of plastic cones, which helps prevent students from tripping.

E – Equipment: Modifying the tools of the game can instantly change a student's experience. Replacing hard, fast-moving tennis balls with slow-moving scarves or lightweight, oversized Nerf balls gives students more time to catch and track the object.

Modify Equipment – lighter balls, visual cues, ramps.

Flexible Rules – focus on participation rather than competition.

Peer Support / Buddy System – pairing students for assistance.

Positive Reinforcement – encourage effort, not just performance.

Universal Design for Learning (UDL) – plan activities accessible to all.

Inclusion thrives on **Differentiated Instruction**, which means tailoring lessons to match various skill levels simultaneously. Instead of expecting every student to complete the exact same exercise, teachers can set up multi-tiered goals. For example, during a jumping unit, the objective can be generalized to "finding a way to leave the ground and land safely." A student in a wheelchair might practice lifting their front wheels safely over a small mat, while another student practices a traditional two-foot jump. This aligns with the principles of **Universal Design for Learning (UDL)**, which offers multiple ways for students to engage, express themselves, and build physical literacy at their own pace.

Challenges of Inclusive Physical Activities:

Lack of trained teachers.

Limited resources or adapted equipment.

Attitudinal barriers (bias, low expectations).

Safety concerns.

The Knowledge Gap and Lack of Training:

The first major obstacle is that many educators feel unprepared to teach students with diverse needs. Most general physical education teachers do not receive deep training in adapted physical education—which is the specialized study of modifying exercises for individuals with disabilities. Without this specific knowledge, teachers may worry about student safety or feel anxious about managing complex health conditions. This lack of confidence often leads to "accidental exclusion," where a teacher leaves a student on the sidelines simply because they do not know how to safely adapt the game.

Resource and Budget Constraints:

A second major challenge is the lack of proper funding and resources. True inclusion often requires specialized, adaptive equipment, such as:

Beeper balls or high-contrast gear for students with visual impairments.

Sport-specific wheelchairs that allow for quick movements on a court.

Sensory-friendly items like weighted vests or quiet zones for neurodivergent students.

This specialized gear is often highly expensive. Many school districts operate on tight budgets and cannot afford these tools. Additionally, older school buildings often feature physical barriers, such as broken pavement, steep steps, or narrow doorways, which restrict access before a student even reaches the playing field.

Social Stigmas and the "Bystander" Effect:

Even when the right equipment is available, social and emotional barriers can still ruin inclusive efforts. Students with special educational needs often face low expectations from both peers and adults. Well-meaning teachers might overly protect a student with a disability, keeping them out of a game out of fear they might get hurt. Meanwhile, peers may hesitate to pass the ball to a teammate with special needs because they are overly focused on winning the game. This creates a painful social barrier where a student is physically present in the gym but completely isolated from the team spirit.

Time and Curriculum Pressure:

Finally, teachers face intense pressure from strict school schedules and heavy curriculums. Adapting a standard physical education lesson requires extra planning time, collaborative meetings with special education staff, and regular individual student assessments. In a typical school day, gym classes are often short and crowded with large groups of students. Teachers frequently find themselves torn between meeting the strict requirements of a standardized curriculum and spending the extra time needed to personalize a lesson for a student with special needs.

Solutions:

Physical activities offer a unique space to build social skills and empathy. **Peer tutoring** and **cooperative groupings** pair students with different abilities together to achieve a shared goal. In a relay race, a student without a disability can partner with a peer who uses a walker, running side-by-side to ensure teamwork dominates the spirit of the game. This dynamic teaches students how to communicate effectively, respect differences, and celebrate the diverse strengths that each classmate brings to the table.

Teacher training in inclusive physical education.

Collaboration with therapists and special educators.

Community support and inclusive policies.

Use of assistive devices and adaptive sports programs.

Conclusion:

Physical activities in inclusive learning are not just about exercise but about building an environment of acceptance, equal opportunity, and holistic growth. When adapted thoughtfully, physical education becomes a powerful tool for inclusion and empowerment. Implementing inclusive physical activities is not about lowering standards; it is about widening the circle of participation. By creatively altering teaching styles, rules, environments, and equipment, educators can remove the invisible barriers that keep children on the sidelines. When inclusive strategies are

woven into the fabric of daily school routines, physical education becomes a powerful tool that builds not just stronger bodies, but a more compassionate, united, and equitable student body. The path to truly inclusive physical activity is filled with challenges, from limited budgets and training gaps to deeply rooted social habits. However, these hurdles are not impossible to overcome. Recognizing these obstacles allows schools to advocate for better teacher training, invest in adaptive equipment, and build a culture of empathy. By tackling these challenges head-on, schools can transform physical education into a space where every child without exception can experience the joy, health, and belonging that comes with active play.

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Health, Well-Being and Education: An Over View

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Abstract

Health, well-being and education are closely interconnected dimensions of human development. Education not only develops intellectual abilities but also contributes to physical, mental, emotional and social well-being. At the same time, good health and positive well-being enable learners to participate actively and effectively in the educational process. In the contemporary educational context, increasing academic pressure, sedentary lifestyles, social challenges and mental-health concerns highlight the need for a holistic approach to education. This paper examines the relationship between health, well-being and education, and discusses the role of teachers, schools, families and educational institutions in promoting healthy and balanced development among learners. It also highlights the importance of health education, physical activity, emotional well-being, social relationships, nutrition and a supportive school environment. The paper concludes that education systems should move beyond academic achievement and promote the overall well-being of every learner.

Keywords: Health, Well-being, Education, Holistic Development, Mental Health, Health Education, School Environment

1. Introduction

Education is an important instrument for the development of individuals and society. Traditionally, educational success has been associated mainly with academic achievement, examination performance and intellectual development. However, contemporary education recognizes that learning is influenced by the physical, psychological, emotional and social conditions of learners. The World Health Organization defines health as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity (WHO, 1948). This broader understanding of health emphasizes that educational institutions have an important role in creating conditions that support learners' overall well-being.

A healthy learner is more likely to attend school regularly, participate actively in classroom activities, develop positive relationships and achieve better educational outcomes. Similarly, education provides learners with knowledge, attitudes and skills that help them make healthy decisions throughout their lives. Therefore, health, well-being and education should be considered interconnected rather than separate areas.

2. Concept of Health

Health is a multidimensional concept that includes physical, mental, emotional and social aspects.

2.1 Physical Health

Physical health refers to the proper functioning of the body and the ability to perform daily activities effectively. Adequate nutrition, regular physical activity, sufficient sleep, personal hygiene and access to healthcare are important components of physical health.

Schools can promote physical health through physical education, sports, yoga, health awareness programmes, nutritious food practices and hygienic surroundings.

2.2 Mental and Emotional Health

Mental health affects how learners think, feel and behave. Academic pressure, examinations, family problems, peer relationships and social expectations can influence students' emotional well-being.

Schools should therefore create an environment where students can communicate their concerns without fear or stigma. Teachers can contribute by identifying signs of emotional distress, providing appropriate support and referring students to qualified professionals when necessary.

2.3 Social Health

Social health refers to the ability to establish and maintain healthy relationships with others. Cooperation, empathy, communication, respect and conflict-resolution skills are essential for healthy social development.

Collaborative learning, group activities, sports and community-based activities can help students develop positive social relationships.

3. Meaning of Well-being

Well-being is a broad concept that involves individuals' positive functioning and quality of life. It includes emotional satisfaction, positive relationships, a sense of belonging, purpose, safety and the ability to cope with challenges.

For students, well-being means more than simply being free from illness. A student with good well-being is able to enjoy learning, develop meaningful relationships, manage emotions and face academic and personal challenges constructively.

The OECD emphasizes the importance of students' social and emotional skills, including self-control, resilience, empathy and cooperation, for successful personal and social development (OECD, 2021).

4. Relationship Between Health, Well-being and Education

Health, well-being and education influence one another in several ways.

Health → Learning:

Good physical and mental health improves students' concentration, attendance, participation and readiness to learn.

Education → Health:

Education develops health literacy and enables individuals to understand nutrition, hygiene, physical activity, disease prevention and healthy lifestyles.

Well-being → Learning:

Students who feel safe, valued and supported are more likely to participate positively in learning.

Education → Well-being:

A positive educational experience can develop confidence, self-esteem, social skills, purpose and a sense of achievement.

Thus, education should be viewed as an important determinant of health and well-being, while health and well-being are essential foundations for effective learning.

5. Importance of Health and Well-being in Education

5.1 Improved Academic Performance

Students who maintain good physical and psychological health are generally better prepared to concentrate and participate in learning activities.

5.2 Better Attendance

Illness, stress and emotional difficulties can contribute to absenteeism. Health-promoting school practices can support regular attendance.

5.3 Development of Life Skills

Health and well-being education helps students develop decision-making, problem-solving, communication, self-management and interpersonal skills.

5.4 Prevention of Risky Behaviour

Appropriate health education can help learners understand the consequences of harmful behaviours and encourage responsible decision-making.

5.5 Development of Resilience

Education should prepare learners to deal with failure, stress and challenges. Emotional learning and supportive relationships can strengthen resilience.

6. Role of Teachers

Teachers are important contributors to students' health and well-being. Their responsibilities include:

- Creating a safe and inclusive classroom environment.
- Encouraging healthy habits and physical activity.
- Recognizing students' emotional and behavioural difficulties.
- Promoting positive peer relationships.
- Reducing unnecessary fear and excessive academic pressure.
- Encouraging students to express their feelings and concerns.
- Integrating health-related themes into classroom teaching.
- Working with parents, counsellors and health professionals when required.
- Teachers should not be expected to replace mental-health professionals, but they can play an important role in early identification, support and referral.

7. Role of Schools and Educational Institutions

A school can become a health-promoting environment by providing:

- Clean drinking water and sanitation facilities.
- Safe classrooms and playgrounds.
- Opportunities for physical activity.
- Health and nutrition education.
- Counselling and psychological support.
- Anti-bullying measures.
- Inclusive educational practices.
- Opportunities for creative and recreational activities.
- Healthy relationships among students and teachers.

The WHO's Health Promoting Schools approach emphasizes that health promotion should be integrated into the policies, environment, curriculum and community relationships of schools.

8. Role of Physical Education

Physical education is an essential component of holistic education. Regular physical activity contributes to physical fitness and can also support psychological and social well-being.

Sports and physical activities can develop:

- Teamwork

- Leadership
- Discipline
- Cooperation
- Self-confidence
- Emotional regulation
- Perseverance

Therefore, physical education should not be considered merely an extracurricular activity but an important part of comprehensive education.

9. Mental Health and Education

Mental health has become an important educational concern. Students may experience stress related to examinations, academic expectations, family circumstances, peer pressure and social media.

Schools can support mental well-being by:

- Providing accessible counselling services.
- Developing social-emotional learning programmes.
- Promoting healthy teacher-student relationships.
- Encouraging adequate rest and physical activity.
- Reducing stigma associated with seeking help.
- Establishing clear anti-bullying policies.
- Creating opportunities for students to discuss concerns.
- A supportive school culture can help students develop confidence and resilience.

10. Health Education and Sustainable Development

Health education also contributes to the broader Sustainable Development Goals (SDGs), particularly SDG 3: Good Health and Well-being and SDG 4: Quality Education. Quality education should promote knowledge, skills, values and attitudes that enable individuals to lead healthy and sustainable lives.

Health education can also be connected with environmental education, nutrition, sanitation, climate change, physical activity and community health. Such interdisciplinary learning helps students understand the relationship between personal well-being, society and the environment.

11. Recommendations

The following measures can strengthen the integration of health, well-being and education:

- Integrate health and well-being into the school curriculum.
- Strengthen physical education and sports programmes.
- Provide age-appropriate mental-health education.
- Establish effective counselling and referral systems.
- Promote nutritious food and healthy lifestyle practices.
- Create safe and inclusive learning environments.
- Provide professional development for teachers on student well-being.
- Strengthen cooperation among schools, families and communities.
- Encourage adequate sleep, physical activity and balanced use of digital devices.
- Evaluate educational success through both academic achievement and broader indicators of student well-being.

12. Conclusion

Health, well-being and education are fundamental components of holistic human development. Education cannot achieve its full purpose when learners' physical, emotional, mental and social needs are neglected. Similarly, health promotion becomes more effective when individuals possess the knowledge and skills developed through quality education.

Therefore, schools and colleges should move from an examination-centred approach towards a learner-centred and well-being-oriented educational system. Teachers, parents, educational institutions, health professionals and communities must work together to create environments in which learners can learn, grow, participate and flourish.

Ultimately, a healthy learner is a better learner, and quality education is an important foundation for a healthy and meaningful life.

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Contemporary Approaches for Enhancing Sports Performance

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Abstract

Physical fitness is a fundamental component of health, physical performance, and successful participation in sports. It comprises several interrelated variables, including cardiovascular endurance, muscular strength, muscular endurance, flexibility, speed, agility, power, balance, coordination, reaction time, and body composition. Appropriate training methods are essential for developing these fitness variables according to the specific requirements of individuals, sports, and performance levels. This paper examines the major physical fitness variables and discusses systematic training methods used to improve them. Training approaches such as continuous training, interval training, circuit training, fartlek training, repetition training, resistance training, plyometric training, flexibility training, and speed and agility training are reviewed in relation to their physiological and performance benefits. The paper also emphasizes the principles of training, including specificity, overload, progression, individuality, regularity, variation, recovery, and reversibility. Contemporary physical education increasingly requires scientifically planned and individualized fitness programmes supported by appropriate assessment and monitoring. The integration of fitness testing, technology, recovery strategies, and evidence-based training can help physical education professionals optimize performance while reducing injury risk. The paper concludes that a balanced combination of fitness variables and scientifically structured training methods is essential for developing healthy, physically competent, and high-performing individuals.

Keywords: Physical Fitness, Fitness Variables, Training Methods, Sports Performance, Physical Education, Exercise Training, Fitness Assessment.

Introduction

Physical education plays an important role in developing physically fit, mentally alert, socially responsible, and emotionally balanced individuals. Physical fitness is one of the major objectives of physical education because it provides the foundation for efficient movement, participation in sports, prevention of lifestyle-related health problems, and improvement of quality of life.

In sports, physical fitness is closely associated with performance. Different sports require different combinations of fitness variables. For example, long-distance running primarily requires cardiovascular endurance, whereas sprinting requires speed and explosive power. Games such as football, basketball, handball, and hockey require a combination of speed, agility, endurance, strength, power, coordination, and reaction ability.

Therefore, physical education professionals and coaches need to understand both the components of fitness and the appropriate training methods required to develop them systematically.

Objectives of the Paper

The major objectives are:

1. To explain the concept and importance of physical fitness.

2. To identify the major physical fitness variables.
3. To examine different training methods used in physical education and sports.
4. To relate specific training methods to specific fitness variables.
5. To explain the principles of effective physical training.
6. To highlight the importance of fitness assessment and monitoring.
7. To suggest contemporary approaches for improving physical performance.

Major Physical Fitness Variables

Physical fitness can be broadly classified into health-related and skill-related components.

➤ **Cardiovascular Endurance**

Cardiovascular endurance is the ability of the heart, lungs, and circulatory system to supply oxygen to working muscles during prolonged physical activity.

Examples of activities:

- Distance running
- Cycling
- Swimming
- Brisk walking
- Continuous aerobic exercise

Suitable training methods:

- Continuous training
- Fartlek training
- Interval training
- Circuit training

➤ **Muscular Strength**

Muscular strength refers to the maximum force that a muscle or muscle group can produce against resistance.

Examples:

- Weight training
- Resistance exercises
- Squats
- Bench press
- Deadlift

Suitable training methods:

- Resistance training
- Weight training
- Isometric training
- Circuit resistance training

➤ **Muscular Endurance**

Muscular endurance is the ability of a muscle or muscle group to perform repeated contractions or sustain contraction over an extended period.

Examples:

- Push-ups
- Sit-ups
- Planks
- Repeated body-weight exercises

Suitable training methods:

- Circuit training

- Resistance training
- Repetition training

➤ **Flexibility**

Flexibility is the ability of a joint or series of joints to move through an appropriate range of motion.

Flexibility is important for:

- Efficient movement
- Posture
- Injury prevention
- Technical performance

Training methods:

- Static stretching
- Dynamic stretching
- Active stretching
- Passive stretching
- PNF stretching

➤ **Speed**

Speed is the ability to perform a movement or cover a distance in the shortest possible time.

Speed is particularly important in:

- Sprinting
- Football
- Hockey
- Handball
- Basketball
- Tennis

Training methods:

- Repetition training
- Sprint training
- Acceleration training
- Resistance sprinting
- Assisted sprinting

➤ **Agility**

Agility is the ability to change body position or direction rapidly and efficiently while maintaining control.

Examples:

- Shuttle runs
- T-drill
- Illinois agility test
- Zig-zag running

Training methods:

- Shuttle training
- Cone drills
- Reaction drills
- Change-of-direction training

➤ **Power**

Power is the ability to produce force rapidly.

It is particularly important in:

- Jumping
- Throwing
- Sprinting
- Handball
- Volleyball
- Basketball

Training methods:

- Plyometric training
- Medicine-ball exercises
- Olympic lifting variations
- Jump training
- Explosive resistance training

➤ **Balance**

Balance is the ability to maintain body stability during stationary or moving activities.

It may be classified as:

- Static balance
- Dynamic balance

Balance is important in gymnastics, athletics, martial arts, football, basketball, and many other activities.

➤ **Coordination**

Coordination is the ability to perform movements smoothly and efficiently through the effective integration of the nervous and muscular systems.

Coordination can be developed through:

- Skill drills
- Ball exercises
- Movement patterns
- Rhythm exercises
- Sport-specific practice

➤ **Reaction Time**

Reaction time refers to the time taken to respond to a stimulus.

It is particularly important in:

- Tennis
- Badminton
- Boxing
- Volleyball
- Handball
- Football
- Table tennis

Reaction drills, visual cues, auditory cues, and sport-specific response exercises can be used to improve reaction ability.

➤ **Body Composition**

Body composition refers to the relative proportions of fat mass, lean body mass, bone, and other tissues in the body.

Healthy body composition contributes to:

- Movement efficiency

- Physical performance
- Health
- Weight management

Regular exercise combined with appropriate nutrition is important for maintaining healthy body composition.

Major Training Methods

➤ **Continuous Training**

Continuous training involves performing an exercise continuously for a prolonged period without planned rest intervals.

Examples:

- Long-distance running
- Cycling
- Swimming

Benefits:

- Improves aerobic endurance
- Enhances cardiovascular efficiency
- Develops exercise tolerance

➤ **Interval Training**

Interval training alternates periods of work with planned recovery periods.

Structure:

Work → Recovery → Work → Recovery → Repetition

The intensity and duration can be modified according to the training objective.

Benefits:

- Improves cardiovascular fitness
- Develops speed endurance
- Allows controlled high-intensity exercise
- Can be adapted to different fitness levels

➤ **Fartlek Training**

Fartlek means “speed play.” It involves changing exercise intensity and pace during continuous activity.

For example:

Slow running → Fast running → Jogging → Sprinting → Walking → Fast running

It is useful for developing:

- Endurance
- Speed
- Speed endurance
- Adaptability to changing exercise intensity

➤ **Circuit Training**

Circuit training consists of several exercise stations arranged in a sequence.

Example:



The number of stations, work duration, repetitions, and recovery periods can be adjusted.

Benefits:

- Develops multiple fitness components
- Efficient use of training time
- Suitable for group training
- Easily adapted for school and college students

➤ **Repetition Training**

Repetition training involves performing high-quality repetitions with sufficient recovery between efforts.

It is commonly used for:

- Speed development
- Sprint performance
- Technical development
- Speed endurance

The recovery period should allow the athlete to perform subsequent repetitions effectively.

➤ **Resistance Training**

Resistance training involves exercising against an external or internal resistance.

Resistance may be provided by:



It primarily develops muscular strength, endurance, and power depending on the programme design.

➤ **Plyometric Training**

Plyometric training uses rapid stretching and shortening of muscles to develop explosive power.

Examples:

- Squat jumps
- Box jumps
- Bounding
- Hopping
- Depth jumps

It is especially useful for sports requiring explosive movements.

➤ **Flexibility Training**

Flexibility training improves the range of motion of joints and muscles.

Common methods include:

- Static stretching
- Dynamic stretching
- Active stretching
- Passive stretching
- PNF stretching

Dynamic movements are particularly useful as part of an appropriate warm-up, while static stretching is commonly used during cool-down or dedicated flexibility sessions.

➤ **Speed and Agility Training**

Speed and agility training combines acceleration, deceleration, directional changes, and reaction exercises.

Examples:

- Ladder drills
- Cone drills
- Shuttle runs
- Reaction drills
- Sprint starts
- Change-of-direction drills

These methods are highly relevant to team games and racket sports.

➤ **Relationship Between Fitness Variables and Training Methods**

Fitness Variable	Major Training Methods
Cardiovascular Endurance	Continuous, Interval, Fartlek
Muscular Strength	Resistance, Weight, Isometric
Muscular Endurance	Circuit, Repetition, Resistance
Flexibility	Static, Dynamic, PNF
Speed	Sprint, Repetition, Acceleration
Agility	Shuttle, Cone, Reaction Drills
Power	Plyometric, Explosive Resistance
Balance	Balance Drills, Proprioceptive Training
Coordination	Skill Drills, Movement Training
Reaction Time	Reaction and Sport-Specific Drills
Body Composition	Aerobic + Resistance Training

Principles of Training

Effective training should follow scientifically established principles.

➤ **Principle of Specificity**

Training adaptations are specific to the type of activity performed. Therefore, training should reflect the demands of the sport or activity.

➤ **Principle of Overload**

The body must be exposed to an appropriate training stimulus greater than its usual level of demand to promote adaptation.

➤ **Principle of Progression**

Training load should increase gradually as the individual's fitness improves.

➤ **Principle of Individuality**

Training programmes should consider age, sex, fitness level, training experience, health status, and individual needs.

➤ **Principle of Regularity**

Consistent participation is essential for maintaining and improving fitness.

➤ **Principle of Variation**

Variation in exercises, intensity, volume, and training methods can help prevent monotony and promote continued adaptation.

➤ **Principle of Recovery**

Adequate rest and recovery are essential for adaptation and performance.

➤ **Principle of Reversibility**

Fitness adaptations may decrease when training is substantially reduced or discontinued.

Fitness Assessment and Monitoring

Fitness assessment is essential for determining the initial fitness level and evaluating training progress.

Common assessments include:

- **Cardiovascular endurance:** Cooper 12-minute run/walk, beep test
- **Strength:** Handgrip strength, repetition-based tests
- **Muscular endurance:** Push-up and sit-up tests
- **Flexibility:** Sit-and-reach test
- **Speed:** 30 m or 50 m sprint
- **Agility:** Shuttle or T-test
- **Power:** Standing broad jump, vertical jump
- **Body composition:** BMI and appropriate body-composition assessments

Assessment results can be used to design individualized training programmes.

Contemporary Approaches in Physical Fitness Training

Modern physical education and sports training increasingly use technology and evidence-based approaches.

➤ **Wearable Technology**

Fitness watches and activity trackers can monitor:

- Heart rate
- Steps
- Training duration
- Energy expenditure
- Exercise intensity
- Digital Fitness Assessment

Digital tools can support systematic recording and comparison of fitness test results.

➤ **Individualized Training**

Training programmes can be adjusted according to individual fitness levels, goals, and sport-specific requirements.

➤ **Recovery Management**

Recovery strategies such as adequate sleep, hydration, nutrition, active recovery, and appropriate rest periods are important parts of modern training.

➤ **Functional Training**

Functional exercises use movement patterns that resemble activities performed in daily life or sports.

➤ **Role of Physical Education Professionals**

Physical education teachers and coaches have an important role in:

1. Assessing students' fitness levels.
2. Identifying individual strengths and weaknesses.
3. Designing age-appropriate exercise programmes.
4. Teaching correct exercise techniques.
5. Monitoring training load and progress.
6. Promoting safe participation.
7. Encouraging lifelong physical activity.
8. Integrating health, fitness, and sports performance.
9. Developing positive attitudes toward exercise.
10. Promoting scientifically based physical education practices.

➤ **Discussion**

Physical fitness is multidimensional, and no single training method can optimally develop every fitness component. The selection of a training method should depend on the desired adaptation and the characteristics of the individual.

For example, continuous training may be highly appropriate for improving aerobic endurance, whereas resistance training is more suitable for muscular strength. Plyometric training can improve explosive power, while agility drills develop the ability to change direction efficiently.

A combination of training methods is therefore often required. In team sports, athletes need several fitness qualities simultaneously. Consequently, integrated training programmes should combine endurance, strength, speed, agility, power, flexibility, coordination, and recovery.

For students in physical education, training should also be enjoyable, progressive, safe, and developmentally appropriate. Regular fitness assessment helps teachers determine whether the programme is producing the desired outcomes.

➤ **Recommendations**

Based on the discussion, the following recommendations are proposed:

1. Physical fitness programmes should begin with an appropriate fitness assessment.
2. Training should be based on individual needs and objectives.
3. Multiple training methods should be integrated where appropriate.
4. Training intensity and volume should be progressed gradually.
5. Adequate warm-up and cool-down should be included.
6. Recovery should be treated as an essential part of training.
7. Technology may be used to monitor training and physical activity.
8. Fitness programmes should include both health-related and skill-related components.
9. Physical education institutions should provide adequate sports facilities and equipment.
10. Students should be encouraged to maintain physical activity beyond the classroom.

12. Conclusion

Physical fitness is a fundamental element of physical education, health, and sports performance. Cardiovascular endurance, muscular strength, muscular endurance, flexibility, speed, agility, power, balance, coordination, reaction time, and body composition collectively contribute to physical competence.

Different training methods provide different physiological and performance adaptations. Continuous, interval, fartlek, circuit, repetition, resistance, plyometric, flexibility, and speed-agility training can be appropriately combined to meet specific training objectives.

The effectiveness of training depends on systematic application of the principles of specificity, overload, progression, individuality, regularity, variation, recovery, and reversibility. Fitness assessment and continuous monitoring further improve programme effectiveness.

Thus, a scientifically planned and individualized approach to physical fitness training can help physical education professionals develop healthier, more active, physically competent, and better-performing individuals. The integration of traditional training principles with contemporary assessment and technology-based approaches can strengthen the role of physical education in promoting lifelong fitness and sports excellence.

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Health, Well-being and Education in Ayurveda Perspective

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Abstract

Ayurveda is a holistic system of medicine that emphasizes the maintenance of health along with the prevention and treatment of disease. According to Ayurveda, health is not merely the absence of disease but a state of balance between Dosha, Agni, Dhatu and Mala, along with a healthy state of mind, senses and soul. Education plays an important role in developing healthy habits, awareness and responsible behaviour. This paper discusses the concepts of health, well-being and health education from an Ayurvedic perspective and their relevance in modern life.

Keywords

Ayurveda, Health, Well-being, Swasthavritta, Health Education, Dinacharya, Ritucharya, Sadvritta.

1. Introduction

Ayurveda literally means “the science of life.” Its primary objective is to maintain the health of a healthy individual and to cure the disease of a diseased person.

“Swasthasya swasthya rakshanam, aturasya vikara prashamanam cha.”

Thus, Ayurveda gives importance to preventive healthcare, healthy lifestyle, proper diet, mental well-being and social conduct.

2. Concept of Health in Ayurveda

The classical definition of health is described in Sushruta Samhita:

> “Samadoshah samagnishcha samadhatumala kriyah |

Prasannatmendriyamanah swastha ityabhidhiyate ||”

According to this definition, a healthy person has:

Balanced Doshas – Vata, Pitta and Kapha

Proper Agni (digestive and metabolic function)

Proper state of Dhatus

Normal elimination of Malas

Pleasant and balanced Atma

Healthy Indriyas (senses)

Peaceful and stable Manas (mind)

Therefore, Ayurvedic health is a physical, mental, sensory and spiritual concept.

3. Well-being in Ayurveda

A. Physical well-being

Ayurveda promotes physical well-being through:

Dinacharya – daily regimen

Ritucharya – seasonal regimen

Proper Ahara (diet)

Adequate sleep
Exercise and physical activity
Personal hygiene
Prevention of disease

B. Mental well-being

Mental health is supported through:
Sattvic lifestyle
Control of emotions
Meditation and Yoga
Proper sleep
Sadvritta
Avoidance of excessive stress and unhealthy habits

C. Social well-being

Ayurveda emphasizes good behaviour through Sadvritta, including:
Respect for others
Truthfulness
Compassion
Self-control
Cleanliness
Responsible social behaviour

D. Spiritual well-being

Ayurveda considers the harmonious state of Atma, Manas and Indriyas important for overall well-being.

4. Role of Education in Ayurveda

Health education helps individuals understand how their daily choices influence health. Ayurvedic education can promote:

1. Knowledge of healthy diet
2. Understanding of individual Prakriti
3. Awareness about Dinacharya and Ritucharya
4. Importance of exercise and sleep
5. Personal and environmental hygiene
6. Prevention of lifestyle disorders
7. Mental health awareness
8. Responsible use of medicines
9. Development of healthy social behaviour

Education should therefore not only provide information but also encourage healthy behaviour and lifestyle practices.

5. Ayurveda and Preventive Healthcare

Ayurveda gives considerable importance to prevention. Important preventive approaches include:

Dinacharya → Ritucharya → Sadvritta → Rasayana → Proper Ahara and Vihara
These approaches aim to preserve health and improve quality of life.

6. Relevance in Modern Life

Modern lifestyles are associated with sedentary behaviour, irregular food habits, inadequate sleep and psychological stress. Ayurvedic principles can provide a framework for promoting healthy routines, provided they are applied appropriately and supported by contemporary scientific evidence.

Health education based on Ayurveda can be incorporated into schools, colleges, workplaces and community health programmes to promote awareness about nutrition, physical activity, hygiene, sleep and mental well-being.

7. Conclusion

Ayurveda presents health as a multidimensional state of physical, mental, sensory and spiritual well-being. Its emphasis on prevention, lifestyle, diet, behaviour and education makes it relevant to health promotion. Integrating appropriate Ayurvedic principles with evidence-based modern health education may contribute to healthier individuals and communities.

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Effect of Complex Plyometric and Resistance Training on Strength Endurance

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ABSTRACT

The purpose of the study was to find out the effect of complex plyometric and resistance training on strength endurance. To achieve this purpose of the study, twenty men Kabaddi players in the Department of Physical Education, Manukula Vinyagar Institute of Technology, Kalitheerthalkuppam, Puducherry were selected as subjects at random. The selected subjects were divided into two equal groups of ten subjects each, such as complex training group and control group. The group I underwent plyometric and resistance training for three days per week for six weeks. Group II acted as control who did not participate any special training programmes apart from their regular physical education activities as per their curriculum. The following variable namely strength endurance was selected as criterion variable. All the subjects of two groups were tested on selected dependent variables at prior to and immediately after the training programme. The analysis of covariance (ANCOVA) was used to analyze the significant difference, if any among the groups. The 0.05 level of confidence was fixed as the level of significance to test the “F” ratio obtained by the analysis of covariance, which was considered as an appropriate. There was a significant difference between complex training group and control group on strength endurance. There was a significant improvement on strength endurance due to complex plyometric and resistance training.

Key words: *complex training, plyometric training, resistance training and strength endurance.*

Introduction

Weight training is use of resistance other than weight of the body to develop specific areas of the body. Generally, it is used to develop muscular strength and power. It also develops muscular endurance elasticity and co-ordination. Weight training is the use of systematic exercises with weight and it is used merely as a mean to increase resistance of the muscle contraction. The primary objective is not to learn to lift as much weight as possible, but to increase strength and power for application to some other sports. Weight training refers to an interest in physical fitness or importance of strong in a particular sport. It is not usually an end in itself but as a means to an end. Plyometrics is the term now applied to exercises that have their roots in Europe, where they were first known simply as jump training. Interest in this jump training increased during the early 1970s as East European athletes emerged as powers on the world sport scene. As the Eastern block countries began to produce superior athletes in such sports as track and field, gymnastics and weight lifting the mystique of their success began to center on their training methods.

Complex training involves the completion of a resistance exercise prior to a plyometric exercise. A classic example is to perform vertical jumps or depth jumps after the completion of a back squat exercise. The term ‘complex training’ is credited to Verkhoshansky et al. (1973). It is postulated that the resistance exercise will have a performance enhancing effect on the plyometric activity (Ebben and Watts, 1998), resulting in increased power output, increased performance

outcome and enhanced efficiency of the SSC behavior. Complex training is widely used in the practical setting and is a popular training modality. A number of reviews have been written on complex training (Docherty et al., 2004; Ebben, 2002; Ebben and Watts, 1998; ffreys, 2008). Research has found the complex training can be beneficial to athletic performance (Comyns et al., 2007; Evans et al., 2000; Güllich and Schmidtbleicher, 1996; Young et al., 1998), while the opposite has also been reported (Jones and Less, 2003; Scott and Docherty, 2004). A possible explanation for this contradiction in findings is that many variables have an influence on the research outcomes and thus the efficiency of complex training, such as the magnitude and mode of the preload exercise as well as the rest interval between the preload and the plyometric components of complex training. In addition, the gender, training status, training age, strength levels of the participant may influence the potentiating benefits of complex training (Docherty et al., 2004; Robbins 2005).

METHODOLOGY

The purpose of the study was to find out the effect of complex plyometric and resistance training on strength endurance. To achieve this purpose of the study, twenty men Kabaddi players in the Department of Physical Education, Manukula Vinyagar Institute of Technology, Kalitheerthalkuppam, Puducherry were selected as subjects at random. The selected subjects were divided into two equal groups of ten subjects each, such as complex training group and control group. The group I underwent plyometric training and resistance training for three days per week for six weeks. Group II acted as control who did not participate any special training programmers apart from their regular physical education activities as per their curriculum. The following variable namely strength endurance was selected as criterion variable. All the subjects of two groups were tested on selected dependent variables at prior to and immediately after the training programme. The analysis of covariance (ANCOVA) was used to analyze the significant difference, if any among the groups. The 0.05 level of confidence was fixed as the level of significance to test the “F” ratio obtained by the analysis of covariance, which was considered as an appropriate.

ANALYSIS OF THE DATA

The analysis of covariance on strength endurance of the pre and post test scores of complex training group and control group have been analyzed and presented in Table I.

Table I: Analysis of covariance of the data on strength endurance of pre and post tests scores of complex training and control groups

scores of complex training and control groups							
Test	Control Group	Complex training	Source of Variance	Sum of Squares	Df	Mean Squares	Obtained 'F' Ratio
Pre Test							
Mean	46.50	47.70	Between	7.20	1	7.20	2.46
S.D.	1.35	2.00	Within	52.60	18	2.92	
Post Test							
Mean	47.10	50.20	Between	48.05	1	48.05	18.60
S.D.	0.737	2.14	Within	46.50	18	2.58	
Adjusted Post Test							
Mean	47.44	49.85	Between	25.61	1	25.61	14.87
			Within	29.27	17	1.72	

* Significant at 0.05 level of confidence.

(The table values required for significance at 0.05 level of confidence for 1 and 17 and 1 and 18 are 4.45 and 4.41 respectively).

Results

The table I shows that the pre-test mean values on strength endurance of complex training group and control group are 47.70 and 46.50 respectively. The obtained “F” ratio of 2.46 for pre-test scores is less than the table value of 4.41 for df 1 and 18 required for significance at .05 level of confidence on strength endurance. The post-test mean values on strength endurance of complex training group and control group are 50.20 and 47.10 respectively. The obtained “F” ratio of 18.60 for post test scores is more than the table value of 4.41 df 1 and 18 required for significance at .05 level of confidence on strength endurance.

The adjusted post-test means of complex training group and control group are 49.85 and 47.44 respectively. The obtained “F” ratio of 14.87 for adjusted post-test means is more than the table value of 4.45 for df 1 and 17 required for significance at .05 level of confidence on strength endurance.

The results of the study indicated that there was a significant difference between the adjusted post-test means of complex training group and control group on strength endurance.

Conclusions

Blakey and southard (1987) determined the effects of plyometric exercise combined with weight training on leg strength and leg power plyometrics which shows significant gains in both strength and power for each group. Depth jumping (plyometrics) and traditional weight training on performance of vertical jump and other measures of strength shows significant improvement on vertical jump (clutch et al; 1998). From the results of the study it was concluded that there was a significant improvement on strength endurance for experimental group with six weeks of complex resistance and plyometric training.

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Traditional Yoga Practices and Modern Aerobic Exercise: a Comparative Review of Cultural Foundations, Physiological Adaptations

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Abstract

Physical activity occupies a central place in physical education, sport, and everyday health, and among the many activities available, traditional yoga and modern aerobic exercise stand out as two long-standing but quite different routes to fitness. Yoga grew out of the Indian cultural and philosophical tradition and brings together physical postures, breath regulation, and mental attention, while aerobic exercise took shape within twentieth-century exercise science and is built around sustained, rhythmic movement that challenges the heart and lungs. This review compares the two traditions across four lenses: their cultural origins, their physiological effects, their place in physical education, and their relevance to sport.

Keywords: yoga, aerobic exercise, physical education, sport, physical fitness, cardiorespiratory fitness, flexibility, physiological adaptation, Indian tradition, exercise science

1. INTRODUCTION

Regular physical activity is one of the more reliable levers available for protecting health across the lifespan. It shapes cardiovascular function, mental health, bone strength, and motor development, and it is bound up with the prevention of a long list of non-communicable diseases. Even so, most of the world's population does not move enough: the World Health Organization estimates that close to a third of adults and roughly four in five adolescents fall short of recommended activity levels (World Health Organization [WHO],

Aerobic exercise belongs to a different lineage. It is closely tied to modern exercise physiology and fitness culture, and it covers activities such as walking, jogging, running, cycling, swimming, and aerobic dance. What unites these activities is that they work large muscle groups repeatedly and for long enough to place a sustained demand on the cardiorespiratory system.

2. METHODOLOGY

Research Design

This is a narrative and integrative literature review. No primary data were collected from students, athletes, teachers, or any other participants; the article draws entirely on secondary sources. A narrative approach suited the aim of the review, which was not to derive a pooled statistical effect but to set two broad activity traditions side by side across cultural, physiological, educational, and sporting dimensions.

Sources of Literature

Literature was drawn from the following sources:

PubMed

Google Scholar

Scopus-indexed literature

Web of Science-indexed literature

SPORTDiscus-related literature

Main Areas of Literature Review

Literature was examined under the following themes:

Yoga and physical fitness

Yoga and physiological function

Yoga and balance

Yoga and flexibility

Traditional Yoga: Cultural and Physical Foundations

Yoga occupies a distinctive place in Indian cultural history, having developed through philosophical, spiritual, and physical traditions over a long period. In contemporary settings, however, it is practised in many different forms and for many different purposes, and it is worth separating traditional yoga as a broad cultural and philosophical system from the narrower selection of yoga practices now used for physical fitness.

Modern Aerobic Exercise

Aerobic exercise is generally understood as rhythmic activity that uses large muscle groups and can be sustained for a period of time — walking, jogging, running, cycling, swimming, and aerobic dance are the familiar examples. Its defining physiological feature is the demand it places on the cardiorespiratory system: during exercise, the heart and lungs work together to deliver oxygen to active muscle and clear metabolic by-products.

Balance	Strong emphasis in many practices	Present, but usually not the central aim
Cardiorespiratory demand	Depends strongly on style and intensity	Usually a central training objective
Muscular endurance	Developed through postures and sequences	Developed through repeated movement
Breathing	Often consciously regulated	Usually responds naturally to demand
Mindfulness	Frequently integrated	Usually not a central component
Cultural foundation	Indian tradition	Modern exercise and fitness culture
Sports application	Mobility, balance, recovery, body awareness	Conditioning and endurance
Educational use	Flexibility, balance, breathing, relaxation	Cardiovascular fitness and general conditioning

Aerobic Exercise and Cardio respiratory Fitness

Cardio respiratory fitness is where aerobic exercise has its strongest and most consistent evidence base. Repeated aerobic training raises the demand placed on the heart and lungs, and with appropriate progression, the body adapts: exercise tolerance improves, aerobic capacity rises, cardiovascular efficiency increases, muscles become more efficient at extracting oxygen, and endurance improves.

16. Physiological Adaptation: A Comparative View

Physiological adaptation occurs when the body is repeatedly exposed to a physical demand and responds by changing its structure or function. Depending on the form practised, yoga provides

repeated stimuli to the muscles, joints, balance systems, respiratory system, and postural control mechanisms, and its effects tend to show up most clearly in flexibility, balance, muscular control, and body awareness. Aerobic training, by contrast, provides a more direct and repeated stimulus to the cardiovascular system, the respiratory system, skeletal muscle, and aerobic energy metabolism, and its principal adaptation is an improved ability to sustain physical activity over time. Table 2 sets out the main physiological areas associated with each approach.

As with Table 1, this comparison describes a conceptual pattern rather than a fixed physiological law.

Table 2

Major Physiological Areas Associated With Yoga and Aerobic Exercise

Physiological area	Yoga	Aerobic exercise
Flexibility	Strong potential	Moderate / secondary
Balance	Strong potential	Activity-dependent
Muscular endurance	Moderate	Moderate to high
Maximal strength	Limited to moderate, depending on practice	Limited unless combined with resistance exercise
Cardiorespiratory fitness	Variable	Strong
Breathing control	Strong emphasis	Primarily exercise-driven
Mobility	Strong	Moderate
Postural control	Strong	Activity-dependent
Energy expenditure	Variable	Usually moderate to high, depending on intensity
Recovery / relaxation	Common component	Usually not central
Mindfulness	Often integrated	Not normally central

18. Can Yoga and Aerobic Exercise Complement Each Other?

The evidence reviewed here points toward complementarity rather than competition. A physical education programme could reasonably use aerobic activities — walking, running, aerobic games, cycling, rhythmic movement — to build cardiovascular fitness, while drawing on yoga-based activities — asana, balance postures, mobility work, pranayama, relaxation — to support flexibility, balance, mobility, and controlled breathing. Combined, these strands can contribute to cardiovascular fitness, flexibility, balance, muscular endurance, body awareness, general physical well-being, and simple variety in the activities on offer.

24. Discussion

Taken as a whole, this comparison suggests that physical activity should not be judged along a single dimension. Yoga and aerobic exercise differ in their historical backgrounds, their characteristic movement patterns, and what they emphasise in training: yoga typically combines postures with breathing and attention, while aerobic exercise concentrates more directly on sustained rhythmic movement and cardiorespiratory demand.

25. Conclusion

Traditional yoga and modern aerobic exercise represent two different but genuinely complementary approaches to physical activity. Yoga carries a distinctive cultural foundation and

brings together physical postures, breathing practice, and, in many of its forms, attention and relaxation; the evidence reviewed here suggests it can contribute meaningfully to flexibility, balance, muscular function, and aspects of physical and psychological well-being, though its effects depend heavily on the style and intensity practised.

Overall, the literature supports a broad view of physical education in which traditional and modern activity forms can coexist. Rather than asking whether yoga or aerobic exercise is universally superior, future research would do better to examine which combination of activities suits particular age groups, educational settings, sports, and fitness objectives.

26. Recommendations

Based on the literature reviewed, the following recommendations are proposed:

Physical education programmes should offer variety rather than depending on a single form of exercise.

Yoga can be included for flexibility, balance, mobility, body awareness, and controlled breathing.

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Health, Well-being and Education: An Integrated Approach to Learner Development

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Abstract

Health, well-being and education are closely interconnected dimensions of human development. Education is not limited to the transmission of academic knowledge; it also contributes to the physical, psychological, emotional and social development of learners. At the same time, good health and positive well-being create conditions that enable students to attend school regularly, participate actively in learning and achieve their educational potential. This paper examines the relationship between health, well-being and education and discusses the importance of physical health, mental health, nutrition, physical activity, social-emotional development and safe learning environments. It also considers the role of educational institutions, teachers, families and communities in creating environments that support healthy development. International guidance increasingly emphasizes a whole-school approach in which health and well-being are integrated into education policies, curricula, school services and the wider learning environment. The paper identifies challenges including stress, bullying, discrimination, inadequate nutrition, limited access to health services and inequalities in educational opportunities. It argues that health and well-being should be treated as fundamental components of quality education rather than as separate or additional activities. Integrating these dimensions can help educational institutions create supportive environments in which learners are able to learn, develop resilience, build healthy relationships and participate meaningfully in society.

Keywords: health, well-being, education, mental health, physical health, learners, schools, holistic development

1. Introduction

Education is one of the most important determinants of individual and social development. Traditionally, educational success has been associated mainly with academic achievement, examination performance and the acquisition of knowledge and skills. However, contemporary approaches increasingly recognize that learning cannot be separated from the physical, mental, emotional and social conditions in which learners live and study. A student who is hungry, unwell, anxious, isolated or exposed to violence may experience significant barriers to learning even when appropriate educational materials and teachers are available. The relationship between health and education is therefore multidirectional. Education can improve health by developing knowledge, skills, attitudes and behaviours that support healthy living. In turn, good health can improve learners' capacity to attend school, participate in classroom activities and benefit from educational opportunities. UNESCO notes that children and young people who receive good-quality education are more likely to be healthy, while healthy learners are better able to learn and complete their education.

Well-being extends this relationship beyond the absence of disease. It includes positive psychological functioning, emotional stability, social relationships, a sense of safety, belonging and the ability to cope with everyday challenges. Educational institutions therefore have an

important role in creating environments where learners can develop academically while also developing healthy lifestyles, social skills, emotional resilience and responsible decision-making.

2. Understanding Health and Well-being in Education

Health is a broad concept that includes physical, mental and social dimensions. Within education, physical health includes adequate nutrition, physical activity, hygiene, prevention of illness and access to appropriate health services. Mental health involves emotional well-being, the ability to manage ordinary stresses, maintain relationships and participate effectively in learning and everyday life. Well-being is similarly multidimensional. For learners, it can include feeling safe at school, having supportive relationships, experiencing a sense of belonging, developing confidence and having opportunities to participate in meaningful activities. This perspective changes the way educational quality is understood. A successful educational institution is not simply one in which students obtain high examination scores. It is also one that provides a safe, inclusive and supportive environment in which learners can develop the knowledge and skills necessary for healthy and productive lives.

3. Relationship between Health, Well-being and Education

The relationship between health and education operates in both directions. First, education can influence health outcomes. Students acquire knowledge about nutrition, hygiene, disease prevention, physical activity, emotional regulation and healthy relationships. Education can also develop critical-thinking and decision-making skills that help individuals evaluate health information and make informed choices. Second, health affects educational participation. Illness, malnutrition, psychological distress and unsafe environments can contribute to absenteeism and disengagement. Education also has long-term implications for health. Individuals with greater access to quality education may develop stronger health literacy and greater capacity to navigate health information and services. Education can therefore contribute to healthier behaviours and improved social and economic opportunities across the life course.

4. Physical Health and Learning

Physical health is a fundamental condition for effective learning. Adequate nutrition, sufficient physical activity, appropriate sleep, hygiene and access to healthcare can influence students' ability to participate in education.

Nutrition is particularly important during childhood and adolescence because the body and brain are developing rapidly. Students who lack adequate food may experience fatigue, difficulty concentrating and reduced classroom participation. Schools can contribute to healthier eating habits through nutrition education, healthy food environments and, where appropriate, school meal programmes. Physical activity is another important component of school health. Regular physical activity supports physical fitness and contributes to psychological and social well-being. Schools can encourage physical activity by providing appropriate physical education, recreational opportunities, active breaks and safe spaces for movement. Such measures should be inclusive so that students with different abilities and interests can participate. Basic health and hygiene facilities are also essential. Safe drinking water, sanitation and handwashing facilities help create an environment conducive to health and learning. Educational institutions should also have procedures for responding to injuries and illnesses and for referring students to appropriate health services.

5. Mental Health and Emotional Well-being

Mental health is an essential part of educational development. Students may experience academic pressure, social difficulties, family problems, bullying, discrimination, financial hardship and other sources of stress. If these challenges are not appropriately addressed, they may interfere with attendance, concentration, relationships and engagement with education.

A supportive school environment can provide protective factors. Positive relationships with teachers and peers, opportunities for participation, a sense of belonging and respectful communication can contribute to students' well-being. Schools can also promote social and emotional skills such as self-awareness, empathy, communication, problem-solving and responsible decision-making.

Mental health education should also seek to reduce stigma. Students should be encouraged to understand that emotional difficulties can occur for many reasons and that seeking support is a constructive response rather than a weakness.

6. The Role of Educational Institutions in Promoting Well-being

Educational institutions are uniquely positioned to promote health because they reach large numbers of children and young people on a regular basis. However, effective health promotion requires more than adding isolated health lessons to the curriculum. It requires an institutional culture that consistently supports health and well-being.

A health-promoting educational institution can incorporate several interconnected components. These include health education, physical education, nutrition, safe infrastructure, mental-health support, inclusive policies, protection from violence and bullying, teacher well-being and links with health and community services.

Leadership is important because institutional policies determine how resources are allocated and how health-related concerns are addressed. School leaders can support well-being by establishing clear anti-bullying policies, promoting respectful behaviour, ensuring access to basic facilities and encouraging staff to identify and respond appropriately to student needs.

The physical environment also matters. Classrooms should be adequately ventilated and appropriately lit, while sanitation and drinking-water facilities should be accessible. Schools should provide spaces for physical activity and should consider accessibility for learners with disabilities.

7. Teachers, Families and Communities

Teachers influence students not only through formal instruction but also through everyday interactions. Respectful communication, encouragement, fairness and classroom inclusion can contribute to a positive learning environment. Teachers can also incorporate health and well-being into different subjects where appropriate.

At the same time, teachers require support themselves. Heavy workloads, inadequate resources and persistent occupational stress can affect teacher well-being and potentially influence classroom relationships. A sustainable approach to student well-being therefore includes attention to the health and working conditions of educational staff.

Families are also important partners. Health behaviours develop through interactions among home, school and community environments. Communication between parents or caregivers and educational institutions can help identify concerns and coordinate appropriate support.

Community partnerships can extend the capacity of schools. Health professionals, counsellors, social workers, community organizations and public-health agencies can contribute expertise that

schools may not possess internally. WHO's school-health guidance recognizes the value of connecting educational settings with health services so that children and adolescents can receive appropriate support.

8. Challenges to Health and Well-being in Education

Despite increasing recognition of the relationship between education and health, significant challenges remain. One challenge is inequality. Students do not enter educational institutions with identical social, economic or health circumstances. Poverty, inadequate nutrition, unsafe housing, discrimination and limited access to healthcare can affect educational participation.

Bullying and violence represent another important challenge. Learners who experience violence, harassment or discrimination may feel unsafe and may have difficulty participating fully in education. UNESCO identifies safe and inclusive learning environments as a central component of education for health and well-being.

Mental-health needs also present challenges. Educational institutions may lack sufficient trained personnel, referral systems or financial resources. Furthermore, stigma can discourage students from seeking help.

Digital technology creates both opportunities and challenges. Digital resources can support access to health information and educational materials, but excessive or inappropriate use may contribute to difficulties related to sleep, concentration, social interaction and online safety. Educational institutions therefore need to promote responsible and balanced digital practices.

9. Strategies for Promoting Health and Well-being

A comprehensive strategy should integrate health and well-being into educational planning rather than treating them as separate programmes. Several measures can support this goal.

First, health and well-being should be incorporated into institutional policies and curricula. Students should develop age-appropriate knowledge and practical skills related to nutrition, physical activity, hygiene, emotional well-being, relationships, safety and health decision-making. Second, schools should develop safe and inclusive environments. Anti-bullying policies, respectful behaviour standards, mechanisms for reporting concerns and appropriate responses to violence can contribute to a stronger sense of safety.

Third, educational institutions should strengthen access to health and psychosocial services. Where schools cannot provide specialist services directly, effective referral networks with health professionals and community services are important.

Fourth, physical activity should be incorporated throughout the school day. Physical education, recreational activities and active breaks can provide opportunities for movement. Fifth, nutrition should receive appropriate attention. Schools can provide nutrition education and promote healthy food choices while considering local circumstances and available resources. Sixth, teacher development should include training in health and well-being. Teachers should know how to establish supportive classroom environments, recognize potential signs of distress and refer students to appropriate services. They should also have access to support for their own well-being. Finally, programmes should be monitored and evaluated. Educational institutions should examine indicators such as attendance, participation, student perceptions of safety and belonging, access to services and relevant educational outcomes. Evidence-based planning can help institutions identify what is working and where additional resources are required.

10. Conclusion

Health, well-being and education are fundamental and interconnected dimensions of human development. Students need more than academic knowledge to thrive; they need safe environments, adequate nutrition, opportunities for physical activity, positive relationships, emotional support and access to appropriate health services. At the same time, education provides an important pathway through which individuals can develop health knowledge, life skills and the capacity to make informed decisions.

Educational institutions therefore have a responsibility to create conditions that support the whole learner. This responsibility should be shared by school leaders, teachers, families, health professionals, communities and policymakers. Effective action requires health and well-being to be integrated into educational policies, curricula, school environments and support systems.

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Innovations in Teaching and Learning: Rethinking Pedagogy in the Digital Age

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Abstract

Education is undergoing rapid transformation as digital technologies, artificial intelligence, blended learning, gamification, project-based learning, adaptive systems, and immersive environments become part of contemporary teaching practices. Yet educational innovation cannot be understood merely as the introduction of new technology. Its significance lies in its ability to promote meaningful learning, learner participation, collaboration, critical thinking, creativity, and real-world application. This paper presents a narrative review of recent research published mainly between 2020 and 2026 on major innovations in teaching and learning. It examines blended learning, artificial intelligence, personalized learning, active and project-based learning, immersive technologies, learning analytics, and innovative assessment. The review shows that these innovations can enhance engagement and personalization, but their effectiveness depends greatly on pedagogical design, teacher competence, infrastructure, equity, and ethical use. The paper also identifies a continuing lack of long-term, school-based, context-sensitive studies that examine educational innovation as an integrated system rather than as isolated technological interventions. It argues that sustainable innovation should remain human-centred, with technology supporting rather than replacing pedagogy, teachers, and meaningful learner interaction.

Keywords: educational innovation, teaching and learning, artificial intelligence, blended learning, digital pedagogy, project-based learning, educational technology

1. Introduction

The contemporary classroom is changing rapidly. Teachers may use interactive boards, digital learning platforms, virtual resources, or artificial intelligence tools, while students increasingly work through collaborative projects, online activities, simulations, and technology-supported assessments. At the same time, some of the most meaningful innovations require little technology. Peer teaching, inquiry, collaborative problem-solving, experiential activities, and project work can transform learning by making students active participants rather than passive recipients of information.

This distinction is important because innovation is often mistakenly equated with technology. A school may install smart boards or introduce digital platforms without significantly changing how students learn. New technology can simply reproduce traditional teaching in a different format. The Organisation for Economic Co-operation and Development therefore distinguishes between basic digitization and deeper digital transformation, in which technology contributes meaningfully to changes in teaching, learning, assessment, and educational organization (*OECD Digital Education Outlook 2023*).

The COVID-19 pandemic accelerated the use of online and blended learning across the world. It demonstrated that digital technologies could provide flexibility and continuity, but it also revealed inequalities in access to devices, reliable connectivity, digital competence, and supportive learning environments. UNESCO consequently cautions that educational technology should not be adopted

merely because it is available; its usefulness must be judged in relation to learning, accessibility, equity, and context (*Global Education Monitoring Report 2023*).

Generative artificial intelligence has added a new dimension to this debate. AI tools can explain concepts, generate examples, provide feedback, prepare learning materials, and support personalized instruction. At the same time, they raise concerns relating to accuracy, plagiarism, authorship, privacy, academic integrity, and student overdependence.

These developments raise a central question: What actually makes an educational innovation successful? The answer lies not in technology alone but in the relationship among pedagogy, teachers, learners, assessment, infrastructure, and educational context.

This paper examines key innovations in teaching and learning, evaluates their pedagogical possibilities and limitations, identifies gaps in recent research, and proposes a human-centred approach to educational innovation.

2. Objectives of the Study

The study aims to:

1. examine major innovations influencing contemporary teaching and learning;
2. review recent scholarship on emerging pedagogical and technological practices;
3. analyze the benefits and limitations of educational innovation;
4. identify gaps in current research, particularly at the school level; and
5. suggest principles for effective, ethical, and sustainable implementation.

3. Methodology

The paper adopts a narrative literature review approach. Research articles, systematic reviews, meta-analyses, and international reports published mainly between 2020 and 2026 were examined. The review focused on artificial intelligence, blended learning, personalized learning, gamification, active learning, project-based learning, immersive technologies, learning analytics, and innovative assessment.

The literature was synthesized thematically rather than statistically. Studies were considered in terms of their educational focus, reported contribution, limitations, and implications for teaching practice. Reports from UNESCO, the OECD, and the Government of India were also examined to connect research findings with wider educational policy.

4. Literature Review

4.1 Blended and Digitally Supported Learning

Blended learning integrates face-to-face teaching with digital or online learning. Its value lies in flexibility and in the possibility of using classroom time differently. Students may review instructional material before or after class, while direct classroom interaction can be used for discussion, application, problem-solving, and collaborative work.

The effectiveness of blended learning, however, depends on instructional design. Merely placing worksheets or lectures online does not necessarily improve learning. The stronger model is one in which digital and classroom experiences complement each other.

The OECD emphasizes that successful digital education depends not only on hardware and software but also on teacher competence, infrastructure, learner preparedness, governance, and educational design (*OECD Digital Education Outlook 2023*). UNESCO similarly argues that technology should strengthen learning and human interaction rather than replace them (*Global Education Monitoring Report 2023*).

These perspectives mark an important shift from technology adoption to pedagogical integration.

4.2 Artificial Intelligence and Generative AI

Artificial intelligence has become one of the most prominent developments in contemporary education. AI can support adaptive learning, automated feedback, intelligent tutoring, assessment, learning analytics, and personalized content.

Wang et al. identify AI in education as a rapidly expanding field with applications extending across teaching, assessment, prediction, and learner support. Almasri similarly reports growing use of AI in science education for instruction, assessment, and learning assistance.

Generative AI has expanded these possibilities because it can produce sophisticated explanations, examples, summaries, questions, and written drafts. Such tools can provide immediate support to learners and help teachers create differentiated resources.

Their educational value, however, is accompanied by significant risks. Students may submit AI-generated work without understanding it, while AI systems may produce inaccurate or biased information. Lo identifies both personalized learning opportunities and challenges relating to academic integrity and reliability. Montenegro-Rueda et al. likewise stress that teacher preparedness is essential for productive educational use of ChatGPT.

Deng et al. found that ChatGPT-supported interventions showed promising effects on academic performance and higher-order thinking, but recent research continues to call for stronger and longer-term evidence. Díaz and Nussbaum argue that AI development in schools has often advanced more quickly than appropriate pedagogical frameworks. Liu and Zhong also identify small samples, short study durations, and limited long-term curriculum development as weaknesses in K–12 AI research.

This distinction is crucial. AI may improve the quality of a completed task without necessarily improving the learner's understanding. Its educational value therefore depends on whether it supports thinking rather than replaces it.

4.3 Personalized, Active, and Gamified Learning

Personalized learning responds to differences in students' prior knowledge, pace, interests, and needs. Adaptive technologies may alter content or difficulty according to learner performance, while teachers can achieve personalization through differentiated tasks, flexible grouping, individual feedback, and learner choice.

Personalization should not, however, become complete individualization. Learning is also a social activity. Students need opportunities to communicate, cooperate, debate, and learn from one another.

Active learning addresses this need by asking students to participate directly in the learning process. Discussion, peer teaching, problem-solving, questioning, and collaborative tasks shift the classroom from knowledge transmission to knowledge construction. Theobald et al. demonstrate that active-learning practices can improve participation and help reduce achievement gaps in STEM contexts.

Gamification can further increase participation by using elements such as points, badges, levels, immediate feedback, and challenges. Zainuddin et al. report positive associations between gamification and motivation, engagement, achievement, and social interaction. Yet gamification works best when the game element supports the learning objective. Competition or reward should not become more important than understanding.

4.4 Project-Based and Experiential Learning

Project-based learning enables students to investigate meaningful questions and apply knowledge to authentic situations. Students may research, collaborate, design, create, present, and reflect as part of the learning process.

Ferrero, Vadillo, and León caution that evidence regarding project-based learning among younger students is not uniformly conclusive, partly because of methodological limitations. Nevertheless, the approach remains pedagogically significant because it can connect knowledge across disciplines and encourage application rather than memorization.

A project on water conservation, for example, may involve science, mathematics, geography, language, technology, and civic responsibility. Experiential learning can similarly include field visits, simulations, laboratory work, role play, interviews, community projects, and problem-solving.

Such approaches are particularly relevant to competency-based education because learners are expected not only to know information but also to use it.

4.5 Immersive Technologies and Innovative Assessment

Augmented reality and virtual reality can create learning experiences that conventional textbooks cannot easily reproduce. AR can add digital information to physical surroundings, while VR can place students within simulated environments.

Chang et al.'s meta-analysis reports positive effects of augmented reality on knowledge, skills, and performance. Conrad, Kablitz, and Schumann similarly identify promising learning effects associated with immersive VR. However, cost, infrastructure, accessibility, teacher training, and technical support remain important barriers.

Assessment is also changing alongside teaching. Portfolios, performance tasks, presentations, self-assessment, peer assessment, reflective journals, digital quizzes, and authentic projects can capture dimensions of learning that conventional examinations may overlook.

Generative AI makes assessment reform particularly necessary. If students can instantly generate a conventional written response, assessment needs to give greater importance to reasoning, process, application, reflection, oral explanation, and authentic performance.

Table 1: Major Innovations in Teaching and Learning

Innovation	Main Educational Purpose	Potential Contribution	Key Concern
Blended learning	Flexible integration	Access, autonomy, interaction	Digital divide
Artificial intelligence	Assistance and personalization	Feedback, tutoring, differentiation	Integrity and overdependence
Personalized learning	Differentiation	Individual support and pacing	Learner isolation
Gamification	Motivation	Engagement and participation	Excessive competition
Project-based learning	Inquiry and application	Creativity, collaboration, problem-solving	Time and assessment
AR/VR	Immersive learning	Visualization and practical experience	Cost and accessibility
Learning analytics	Evidence-informed support	Early intervention	Privacy and data ethics
Innovative assessment	Authentic evaluation	Higher-order competency assessment	Teacher workload

5. Research Gap

Despite the rapid growth of research on educational innovation, several gaps remain.

First, many studies examine individual innovations in isolation. AI, gamification, project-based learning, virtual reality, and blended learning are frequently treated as separate interventions even though they may operate together in real classrooms. More research is needed on integrated educational environments.

Second, recent research remains strongly technology-centred. The capabilities of new tools often receive greater attention than teacher beliefs, classroom practices, school culture, curriculum expectations, and institutional support. Díaz and Nussbaum specifically identify insufficient pedagogical grounding as a weakness in school-level AI research.

Third, longitudinal evidence remains limited. Liu and Zhong note that K–12 AI studies often involve short interventions and relatively small samples. Consequently, it is difficult to determine whether initial improvements in engagement or performance continue over time.

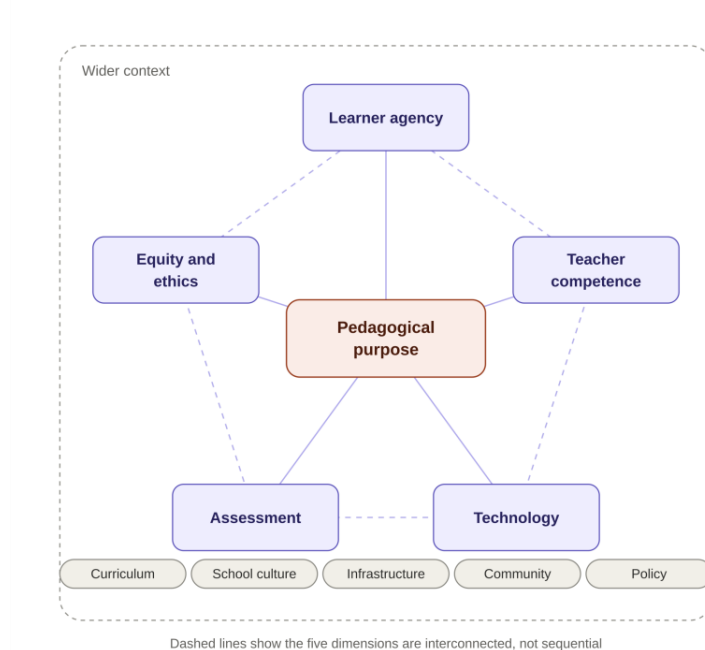
Fourth, school-level evidence remains less developed than research in higher education. School learners differ significantly from university students in developmental needs, independence, assessment structures, and levels of teacher supervision.

Finally, equity deserves greater attention. An innovation that succeeds in a well-resourced institution may not produce the same outcomes in a school facing limited connectivity, large class sizes, inadequate devices, or insufficient teacher training.

Future research should therefore investigate educational innovation as an interconnected teaching and learning ecosystem rather than as a collection of individual technologies.

6. Human-Centred Model of Educational Innovation

Figure 1. Human-Centred Model of Educational Innovation



The model suggests that innovation becomes sustainable when technology is aligned with educational objectives, learner needs, teacher competence, appropriate assessment, and ethical principles. Technology is therefore one component of innovation rather than its defining feature.

7. Indian Educational Context

The Indian education system offers an important setting for educational innovation. The *National Education Policy 2020* promotes experiential learning, competency-based education, multidisciplinary approaches, critical thinking, technology integration, and innovative assessment. Importantly, innovation in India cannot be limited to expensive digital infrastructure. Schools differ widely in connectivity, resources, language, geography, and socioeconomic context.

A technologically advanced school may use smart boards, AI tools, virtual laboratories, and adaptive systems. A less digitally equipped school may implement peer learning, storytelling, project work, community investigations, art integration, collaborative activities, and experiential learning.

Both approaches can be innovative when they improve the quality of learning.

The principles of NEP 2020 therefore support a broader understanding of innovation in which technology is important but not mandatory. What matters is whether teaching enables learners to inquire, apply knowledge, develop competencies, and participate actively.

8. Discussion and Recommendations

The reviewed literature makes one point particularly clear: no single technology or teaching strategy can transform education by itself.

Technology needs sound pedagogy. Pedagogy requires competent teachers. Teachers require institutional support. Learners need opportunities to question, create, collaborate, and reflect. Assessment must also measure the competencies that education claims to value.

Several implications follow.

First, schools should adopt a pedagogy-first approach. A technology should be selected because it addresses an educational need, not merely because it is new.

Second, teacher development must be continuous. Short technical workshops are insufficient. Teachers require sustained opportunities to understand digital pedagogy, AI literacy, assessment design, ethics, and instructional integration.

Third, technology should be combined with active and experiential learning. Digital tools should create opportunities for investigation, discussion, creativity, collaboration, and problem-solving rather than simply delivering information.

Fourth, AI literacy should become part of contemporary education. Learners need to know how to question AI-generated information, identify inaccuracies and bias, protect privacy, and use AI responsibly.

Fifth, assessment needs reconsideration. Portfolios, projects, oral explanation, reflective writing, presentations, and authentic performance can provide stronger evidence of learning in an age when AI can generate conventional written answers.

Finally, educational innovation should remain equitable. Institutions need to consider access to devices, connectivity, teacher support, learner diversity, privacy, and ethical use before adopting new technologies.

9. Conclusion

Educational innovation is often described in terms of the newest technology entering the classroom. Yet the research reviewed in this paper suggests that meaningful innovation is less about the tool itself and more about what the tool enables learners and teachers to do differently.

Blended learning is valuable when it creates space for richer classroom interaction. Gamification is useful when it strengthens engagement with meaningful learning tasks. Project-based and experiential learning become significant when students investigate, apply knowledge, collaborate, and reflect. Artificial intelligence can support personalized learning and teaching, but it becomes educationally problematic when it replaces the thinking that students are expected to develop.

The teacher therefore remains central to educational innovation. Technology can provide resources, feedback, data, and new learning environments, but teachers provide judgement, context, encouragement, ethical guidance, and human connection.

The future classroom should consequently not be judged by how much technology it contains. It should be judged by the quality of thinking, interaction, creativity, independence, and learning that takes place within it.

Ultimately, the most useful question for evaluating innovation is straightforward: Does it help students learn more deeply, meaningfully, and independently?

Future research should move beyond short-term evaluations of individual technologies and examine integrated, long-term models of innovation in authentic school settings. Such research should give greater attention to teacher competence, learner agency, equity, ethics, assessment, and contextual realities.

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Technology-Enabled Innovations in Teaching and Learning: Opportunities and Challenges

Dr. Nellore Manoj Kumar

Abstract:

Innovations in teaching and learning have become essential for addressing the evolving needs of learners in the digital age. This research explores innovative pedagogical approaches that enhance student engagement, critical thinking, creativity, and academic achievement. It examines the integration of technology, blended learning, experiential learning, collaborative methods, and learner-centred strategies in contemporary education. The study highlights how digital tools and emerging technologies can support personalized and inclusive learning experiences. It also considers the changing role of teachers from knowledge providers to facilitators of learning. The research identifies key challenges, including digital accessibility, teacher preparedness, infrastructure, and effective technology integration. Findings suggest that purposeful adoption of innovative practices can improve learning outcomes and promote lifelong learning skills. The study emphasizes the need for continuous professional development and institutional support to sustain educational innovation. It concludes that meaningful innovation should combine technology with effective pedagogy to create flexible, engaging, and future-ready learning environments.

From Gurukuls to Gigabytes: A Curriculum Framework for IKS-Enabled Digital Pedagogy

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Abstract

One useful way in which the Indian Knowledge System can help students is by providing better digital literacy. It is crucial since students are now utilizing generative AI, social media, and other online platforms where misinformation can spread easily and quickly.

India's NEP 2020 encourages the inclusion of IKS in higher education. Nevertheless, the medium of instruction for the IKS is Indian culture mainly. The paper suggests using certain ideas of IKS in a more practical manner. Students can be taught how to scrutinise evidence, interrogate information, and judge whether the source is credible. Pāṇinian rule systems help students acquire systematic and logical thinking.

In Kanchipuram, where the traditional teaching 'ghaṭikā' existed, the paper also tries to explore ideas of teaching that can be very helpful in classroom practices.

The paper recommends employing short modules in educational institutions and teacher training instead of introducing IKS as a distinct subject. It is also suggested a 12-week Nyāya module for teaching source checking. For meaningful discussions on proof, mistakes, and reliable information, teachers require training.

Keywords: Digital pedagogy, Indian Knowledge Systems, Curriculum design, Digital literacy, Dialogic teaching, NEP 2020

I. INTRODUCTION

Much of the early educational-technology literature asked whether schools had devices and connectivity. The more difficult questions now concern what learners do with networked information: how they judge sources, how they manage cognitive load, and how they work with generative systems that produce fluent but often unreliable text [1], [2]. Familiarity with phones and platforms does not, by itself, produce digital literacy [3]. Studies of expert fact-checking show that skilled readers leave a page quickly and check the organisation behind it-what Wineburg and McGrew call lateral reading-rather than trusting surface cues on the page [4]. Research into cognitive load has long warned us that badly designed multimedia will use up working memory without improving learning. In India, such general problems have a specific policy response. The curricula is envisaged to be informed by the Indian Knowledge Systems but also prepare the students for contemporary work and citizenship [6]. The next UGC guidelines consider IKS as a genuine engagement of higher education and not just an add-on culture [7]. Being permissive doesn't equal teaching. If Indigenous Knowledge Systems (IKS) programs are introduced merely as commemorative content or as unexamined claims about the past, they will not satisfy the historian or the teacher educator. The paper, therefore, poses a practical question: which pieces of IKS can be taught as classroom procedures for digital verification and dialogic learning, and how can they be timetabled without overcrowding an already overcrowded timetable?

The answer offered here is a curriculum framework rather than a revivalist programme. A limited set of IKS resources-Nyāya procedures of evidence and fallacy, Pāṇinian habits of rule and exception, and a narrowly fenced set of attention routines-are treated as *cognitive tools* for

teaching. The metaphor is pedagogical. It does not assert that classical India anticipated machine learning. It asserts only that these systems encode trainable habits that align with documented aims of digital literacy and with teachers' technological pedagogical content knowledge [8], [9]. Kanchipuram supplies a local institutional prototype. South Indian ghaṭikās were organised around debate, commentary, and encounter among traditions rather than around a single authorised feed [10], [11]. That institutional memory remains usable design material for dialogic digital studios in contemporary teacher education [12].

The paper is structured by three research questions.

RQ1- Which IKS constructs can be justified, epistemically rather than antiquarian, as tools for digital pedagogy?

RQ2- Which features of the Kanchipuram ghaṭikā can be applied to teacher education?

RQ3- In what manner can those tools be presented as modular plugins across the current subjects without creating a parallel curriculum?

II. RELATED WORK AND POLICY CONTEXT

Digital literacy is usually characterized by operational ability, critical analysis, and creative development. According to UNESCO, artificial intelligence in education should be human-centered, teachers should take control, and there should be a degree of caution about transparency and bias [2], [13]. Selwyn has made a compelling argument that highlights that teachers may not intend to do so but nonetheless use digital systems that reorganize attention and authority in classrooms. In light of this, dialogic teaching remains a useful counter-model: talk is used to build reasoning, rather than merely display correct answers [11].

NEP 2020 embeds IKS in a larger reconfiguration, which stresses conceptual understanding and lowering of rote learning [6]. The AICTE's IKS handbook and the UGC guidelines provide a conceptual repertoire and administrative cover to institutions. The teachers of class IX are not and do not say, "This is misleading," "Do not take a reel," or "A chatbot essay." Unlike the works of Kant, classical and early modern Indian philosophy does have what we would call an evidence, debate, and error section. If the statements are stuck in appendices, then the NEP clause will be enforced in a pride-like manner, not training.

Another line of literature is about formal rule systems and computational thinking. Wing refers to computational thinking as decomposition, pattern recognition, abstraction, and algorithmic procedure [18]. Pāṇini's Aṣṭādhyāyī is a generative rule system whose fineness has received sustained linguistic attention [19], [20].

There is a rather limited pedagogically useful implication: the work on rules in sūtra style can foster the habits of their ordered transformation. It is not required by that implication and is not defended here that Sanskrit, which is popularly claimed to be "the language of AI." We still have to find the framework that filters IKS constructs according to teachability and epistemic warrant, maps them onto digital-literacy outcomes, and specifies classroom routines, not slogans.

III. METHOD

The study is conceptual. It develops and justifies a curriculum design rather than reporting an experimental effect size. Three procedures were used.

First, policy documents were read for mandate, permission, and silence on method: NEP 2020 [6], UGC's 2023 IKS curricular guidelines [7], AICTE's IKS handbook [15], and UNESCO's AI-in-education guidance [2], [13]. Second, constructs were drawn from Nyāya, Pāṇinian grammar, and a small set of attention routines. An item was retained only if it could be taught as a procedure, had a recognisable counterpart in digital-literacy or teacher-education research, and could be defended by perception, inference, comparison, or reliable testimony rather than

by age alone [16], [21]. Third, Pallava-Kanchipuram historiography [10], [11] and work on dialogic pedagogy [12] were used to extract four institutional features of the ghaṭikā-debate as method, plurality of sources, teacher as umpire, and small collegium-and to redesign them for digital studios.

Limits should be stated plainly. The ghaṭikā is known chiefly through inscriptions and later literary memory; the mapping to platformed classrooms is analogical; and no learner data are reported. Those limits define the next empirical step. They do not prevent a careful design argument.

IV. THE KANCHIPURAM GHAṬIKĀ AS A DESIGN PROTOTYPE

Kanchipuram was a durable South Indian centre of learning in which several traditions worked in proximity [11], [22]. The ghaṭikā attached to this milieu functioned as an intense collegium organised around recitation, commentary, and public reasoning [10]. It would be historically careless to treat it as a modern university. It would be equally careless to discard it because it is not Nalanda. For curriculum design, four features matter more than prestige.

Debate was the approach, not an enhancement activity. There were multiple sources. The teacher acted as an umpire who oversaw the debate. The scale resembled that of a classroom, where twelve to eighteen learners were closely monitored by an instructor. Table I details how these features are translated into dialogic digital pedagogy.

TABLE I. TRANSLATING GHAṬIKĀ DESIGN PRINCIPLES INTO DIALOGIC DIGITAL PEDAGOGY

Design principle	Ghaṭikā (historical)	Platformed classroom	Dialogic digital redesign
Debate as method	Tarka / śāstrārtha	Feed-ranked attention	E-debate with evidence logs
Plural sources	Multi-tradition encounter	Single-platform authority	Lateral reading across sources
Teacher as umpire	Master guides inquiry	Dashboard as surveillance	Teacher as debate coach
Small collegium	Intense cohort	Unmoderated mass forums	Studios of 12-18 learners

The laptop is not the villain in Table I. It is ranked by attention for engagement, not for warrant. A studio designed on the model of a ghaṭikā thus keeps an observable trail of reasons, limits group size, and asks the teacher to moderate rather than just score talk [4], [12]. Example of Strategic Usage of Tirukkuraḷ Couplets [22]. The prototype is institutional. It is not costume for a smart classroom.

V. CURRICULUM FRAMEWORK

Figure 1 summarises the proposed framework. Three cognitive layers feed a curriculum *service layer*. IKS is not added as a thirteenth subject. It is introduced as short, reusable plugins inside language, social science, computer science, and teacher-education courses that already occupy the timetable. Modularity is the practical answer to RQ3.

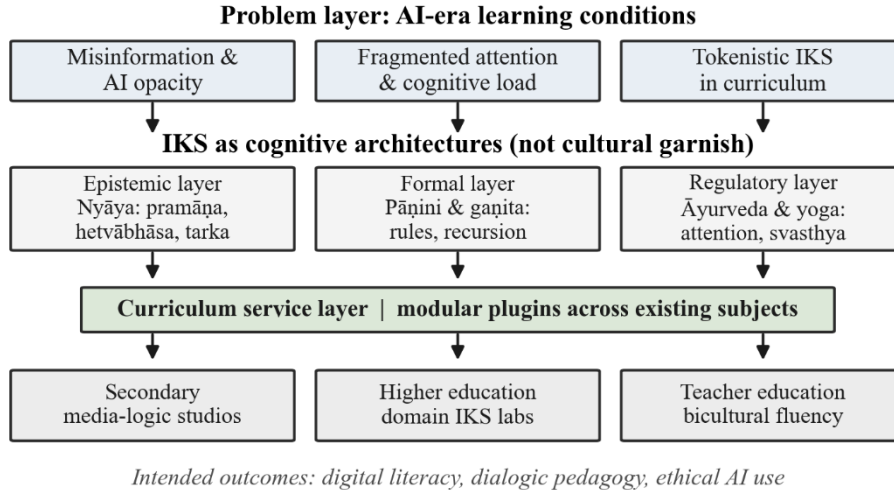


Fig. 1. Three-layer curriculum framework: IKS procedures as a service layer across school, university, and teacher education.

A. Three Cognitive Layers

The epistemic layer draws on Nyāya. *Pramāṇa* categories become classroom questions about the kind of evidence a reel or chatbot answer is using. *Hetvābhāsa* become labels for defective reasons in headlines and AI-generated prose [16], [21]. *Tarka* becomes a timed debate with an evidence log. The formal layer uses Pāṇinian and sūtra habits to teach rule, exception, order, and recursion [18]-[20]. The regulatory layer is the most easily abused, and is therefore kept small: only daily-rhythm and attention pauses that can be taught as learner routines are retained as complements to cognitive-load design [5], [23]. Diagnostic medical claims and unverified herbal narratives are excluded from science teaching.

TABLE II. CONSTRUCT-TO-COMPETENCY MAP

IKS construct	Classroom function	Target competence
Nyāya pramāṇa	Classify evidence in posts, papers, AI output	Critical thinking; information literacy
Hetvābhāsa	Name fallacies in reels, memes, headlines	Media literacy; civic reasoning
Tarka / śāstrārtha	Structured debate with evidence log	Communication; collaboration
Pāṇini sūtra-rules	Rule, exception, ordered transformation	Computational thinking
Dinacaryā (limited)	Attention hygiene around screens	Self-regulation
Ghaṭikā collegium	Studio grouping; teacher as umpire	Dialogic pedagogy

B. Three Implementation Surfaces

While studying in a social science class, learners can be shown a video clip of a person testifying to the already proved existence of racism in a particular country. In university, domain labs are more sincere compared to a generic IKS paper. Computer science can accommodate rules puzzles and a seminar on the limits of Sanskrit-AI claims; education can host ghaṭikā-style micro-teaching. Teacher education is the overriding factor. To complete the trainee programme, one studio and one local language task has to be designed by every trainee.

TPACK retains relevance as an evaluative lens. Technology, pedagogy and IKS content need to jointly feature in the lesson plan [9].

VI. ILLUSTRATIVE MODULE: NYĀYA FOR DIGITAL VERIFICATION

A curriculum is a framework that can be scheduled. Classes IX-XII could have a twelve-week (weekly period) one credit module as in Figure 2 and Table III. It is a B.Ed. Undergraduate bridge course or ICT paper first year. The passage addressed RQ1 on operational terms: One retains Nyāya because it offers a procedure for evidence, not because it is old.

Illustrative 12-week module: Nyāya for digital verification

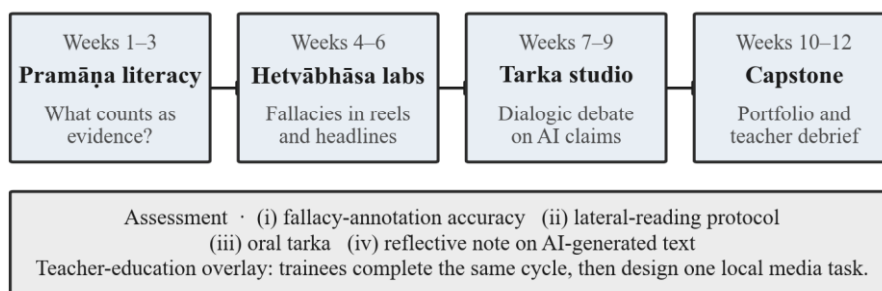


Fig. 2. Twelve-week Nyāya module for digital verification, with a teacher-education overlay.

TABLE III. SELECTED NYĀYA FALLACIES MAPPED TO DIGITAL-MEDIA TASKS

Hetvābhāsa	Detection cue	Digital classroom instance
Asiddha (unestablished)	Key fact assumed, not shown	AI image treated as a real event
Viruddha (contradictory)	Reason undermines the claim	Wellness reel that dismisses all medical advice
Anaikāntika (inconclusive)	Reason fits rival claims too	Celebrity endorsement used as proof
Kālātīta (mistimed)	Date or context stripped	Old footage recirculated as breaking news

The first three weeks create a shared vocabulary of pramāṇa. Learners to sort a photo, a forwarded message, a paragraph from the textbook, and an answer given by a chatbot into perception, inference, comparison, or testimony. Weeks 4-6 are fallacy laboratories: each pair annotates a headline, a short transcript, and an AI paragraph using Table III. Weeks 7-9 run a tarka studio-a twelve-minute debate on an AI-in-education claim-with an evidence log that records at least two lateral-reading moves [4]. Weeks 10-12 produce a portfolio and a short note on when AI output may be treated as testimony [2]. Assessment is four-part: label accuracy, the lateral-reading trail, oral tarka, and the reflective note. For B.Ed. trainees a fifth task is added: design one local-language media item. If the module works only on English celebrity content, it is not yet Indian digital pedagogy.

VII. DISCUSSION AND LIMITS

The framework is deliberately narrower than much IKS advocacy. It does not restore a gurukul, replace modern science, or treat manuscript corpora as a learning-management system. A translation challenge, not a restoration task, is presented by from gurukuls to gigabytes. There exists a quartet of perils. Revivalism relies on indigenous knowledge systems (IKS). And the pramāṇa filter teaches dissent. When antiquity stands in for a warrant, we then know pseudoscience is in operation, which is why the regulatory layer is the second smallest of the three. A Nyāya studio cannot be run with only Sanskrit and not ICT training [7]. With 100%

ICT training, faculties cannot be trained [9]. Technology can also defeat design if a software's scores speak more than its structures' speech; it violates the ghaṭikā conception of teacher-as-umpire. The actual limitation of this paper is empirical. Tables I to III are designed mappings still unused in the field. The subsequent investigation ought to implement the twelve-week module in B.Ed. In classrooms of primary and secondary level and recognition of fallacies and lateral reading in local languages.

VIII. CONCLUSION

Use of technology continues to reshape teaching, learning, and assessment. The challenge for Indian classrooms is whether that change is greeted by a way of evidence, argument, and attention. While IKS is authorized by NEP 2020, it does not, by itself, teach a student (or anybody) how to interrogate a deepfake or a fluent chatbot. This essay has argued that Nyāya procedures, Pāṇinian rule-thinking, a tightly limited attention layer, and the institutional memory of the Kanchipuram ghaṭikā, when filtered, mapped, and scheduled as modular work, can be taught as digital pedagogy. The last step is empirical and institutional: the preparation of teachers who can umpire evidence-based talk and a test of whether fallacy laboratories make verification better. Ultimately, it is a curriculum issue from Gurukuls to gigabytes.

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Potential of Leadership in Educational Technology: Improve Teaching, learning and Administration

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Abstract

Educational technology has transformed the way institutions design, deliver, monitor and evaluate educational processes. However, the availability of digital tools alone does not guarantee meaningful improvement in teaching, learning or administration. Effective leadership is essential for developing a shared technological vision, building teachers' digital competence, promoting innovative pedagogy, ensuring equitable access and establishing responsible systems for data, privacy, and digital governance. This potential of educational technology leadership in strengthening three interconnected areas: teaching, learning and educational administration. It explores how transformational, instructional, distributed and digital leadership approaches can support technology integration and organizational change. The technology leadership should move beyond purchasing devices toward creating sustainable, ethical, inclusive and pedagogically meaningful digital learning ecosystems.

Keywords: Educational technology, Digital leadership, Technology leadership, Teaching and learning, Educational administration, Digital transformation.

Introduction

Educational institutions are undergoing a profound change as digital technologies are more and more integrated into the educational process, in learning, communication, assessment and administration. The possibilities for educators and educational leaders are broadened by using Learning Management Systems, Artificial Intelligence, Learning Analytics, Digital Content, Virtual Classroom, Cloud-Based Collaboration and Mobile Technologies, along with Online Assessment Systems. Still, technology is not just about technology it is about technology, people and processes. The educational value of it will crucially depend on the organization of people, pedagogy, organizational structures and technological resources. Successful educational technology integration thus relies upon leadership as one of the key components. School leaders have been shown to impact how school staff integrates technology into their classrooms through vision, support, professional development, coordination and creating an innovation-rich school culture. For instance, school level digital transformation and the use of educational digital resources have been found to be influenced by school principals' leadership.

Technology leadership isn't just for the classroom. Digital systems can assist in better handling of student information, communication, scheduling, allocation of resources, monitoring by the institutions, quality assurance, decision-making, and strategic planning. Previous empirical studies in Taiwan revealed that technology leadership approaches were positively correlated with the effectiveness of school management. For this reason, it is crucial for educational leaders to gain a wider understanding of digital transformation. The key issue is no longer about the use of technology in education but how to ensure that technology serves an education purpose in a meaningful way and how to ensure that it is successfully led.

Concept of Educational Technology Leadership

Educational technology leadership is defined as the ability of educational leaders to create a vision, make strategic choices, build people, manage digital resources, foster pedagogical change and influence change within the organization in a successful and responsible manner using technology. The concept of 'technology leadership' is a fusion of traditional educational leadership and digital skills. Technology-oriented leaders don't necessarily have to be technical specialists. Rather the leader must gain a competency level sufficient to understand the educational potential and constraints of technology in order to make informed decisions and to bring together teachers, administrators, technical staff, students, parents and external stakeholders in a way that promotes collaboration and demonstrates an understanding of the technological tools and resources.

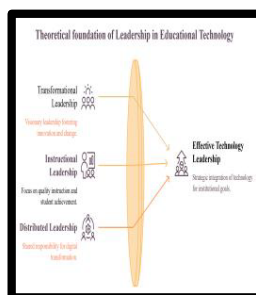
Theoretical Foundations of Technology Leadership

Transformational Leadership

Transformational leadership is centered on vision setting, motivating, creating innovative ideas and driving change within an organization. In the context of educational technology, transformational leaders promote among teachers the use of new pedagogical methods, instead of telling them to use specific software. The findings of recent study suggest that transformational leadership can facilitate the use of technology by teachers, especially by enhancing teachers' readiness, ability, pedagogical knowledge and capacity to meaningfully use technology.

Instructional Leadership

Instructional leadership focuses on instructional quality, curriculum, assessment and student achievement and teacher development. To be valuable, technology leadership can be linked to these instructional priorities. For instance, interactive displays should be evaluated to see how they will or will not enhance student engagement, formative assessment, collaboration, critical thinking and individualized learning, instead of buying them because they are technologically advanced.



Distributed Leadership

It is not possible to manage digital transformation effectively by one principal or administrator. Teachers, ICT coordinators, department heads, instructional designers, librarians, students and technical staff can all be part of technological innovation. There is an emphasis on distributed leadership and thus shared responsibility. The evidence gathered by OECD in recent years demonstrates the synergistic effects of school-level coordination of ICTs that can be achieved through pedagogical leadership, strategic administration, technical expertise, ICT mentoring and collaboration between teachers.

Digital Leadership

Digital leadership is the strategic use of digital technologies to fulfill institutions' goals specifically. This is composed of digital vision, technological competence, data-informed decision-making, digital communication, professional development, innovation, cyber-security and organizational transformation. Recent studies have shown that digital leadership can have an impact on teachers' use of technology as well as on digital school transformation at a school level.

Leadership Potential for Improving Teaching

Educational technology provides significant opportunities for improving teaching, but leaders must ensure that technology serves pedagogy rather than replacing it.

Supporting Innovative Pedagogy

Technology enables teachers to move beyond traditional lecture-based instruction. Digital simulations, interactive presentations, virtual laboratories, multimedia resources, gamification, collaborative platforms, and problem-based learning environments can provide students with richer learning experiences. Educational leaders can promote such innovation by:

- encouraging experimentation;
- providing access to appropriate digital resources;
- recognizing innovative teaching practices;
- organizing peer demonstrations;
- supporting lesson redesign;
- providing instructional technology specialists; and
- Integrating technology into professional development.

Strengthening Teacher Professional Development

One of the most important responsibilities of technology leadership is developing teachers' digital competence. Professional development should not be limited to technical training such as how to operate a platform. Teachers need to understand how technology can be integrated with subject content and pedagogy. The TPACK framework proposed by Mishra and Koehler emphasizes the interaction between technological knowledge, pedagogical knowledge, and content knowledge. Therefore, professional development should focus on pedagogically meaningful technology integration, rather than technology skills alone. OECD evidence similarly emphasizes that teachers are critical change agents in school digitalization and that providing technology alone does not guarantee meaningful educational use.

Supporting Artificial Intelligence in Teaching

Artificial intelligence is creating new opportunities for lesson planning, personalized feedback, content generation, language support, tutoring, assessment assistance, and learning analytics. However, leaders must establish clear institutional guidelines concerning:

- Academic integrity;
- Transparency;
- Student privacy;
- Copyright;
- Bias;
- Teacher responsibility;

- Appropriate AI use; and
- Human oversight.

The role of leadership is therefore not to encourage unrestricted AI adoption but to develop responsible and educationally purposeful AI use.

Leadership Potential for Improving Learning

Personalized Learning

Digital technologies can provide students with different learning pathways based on their needs, interests, learning pace, and performance. Learning management systems and adaptive technologies can help teachers identify students who require additional support. Leaders can establish systems in which technology is used to identify learning difficulties early and provide targeted interventions.

Student Engagement

Technology can increase opportunities for active participation. Students may create digital presentations, videos, podcasts, simulations, online discussions, collaborative documents, digital portfolios, and multimedia projects. The educational leader's responsibility is to ensure that these activities are designed around meaningful learning outcomes rather than technological novelty.

Collaborative Learning

Digital platforms facilitate collaboration among students within and beyond the classroom. Cloud-based applications, discussion forums, virtual classrooms, collaborative documents, and international learning networks can expand learning communities.

Inclusive Learning

Educational technology can support learners with diverse needs through:

- Screen readers;
- Speech-to-text applications;
- Captioning;
- Translation tools;
- Adjustable learning materials;
- Multimedia content; and
- Flexible online learning.

However, digital inclusion requires more than providing access. Leaders must consider affordability, connectivity, accessibility, digital skills, language, disability, and family circumstances. OECD analysis emphasizes that institutional digital capacity depends on access to technology, effective leadership, and organizational cultures and policies that support meaningful technology integration.

Leadership Potential for Improving Educational Administration

Technology has considerable potential to transform administrative processes.

Digital Information Management

Educational institutions generate large amounts of information relating to students, teachers, courses, attendance, assessment, finance, infrastructure, and institutional performance.

Digital information systems can help administrators:

- organize records;
- retrieve information quickly;
- reduce paperwork;
- monitor student attendance;
- track academic performance;
- manage institutional resources; and
- generate reports.

Data-Informed Decision-Making

Educational leaders can use dashboards and learning analytics to identify patterns and trends. However, data should support professional judgment rather than replace it. Leaders must interpret data within its educational and social context.

Communication and Collaboration

Digital communication systems enable administrators to communicate efficiently with teachers, students, parents, and other stakeholders. Technology can therefore reduce communication delays and strengthen institutional coordination.

Resource Management

Digital administration can improve management. Technology leadership ensures that these systems are integrated rather than operating as disconnected platforms.

Strategic Role of Leadership in Educational Technology

Effective technology leadership requires a systematic strategy.

Establish a Shared Vision

The leader should formulate a clear vision explaining why technology is necessary and what educational improvements are expected.

Conduct a Digital Readiness Assessment

Before implementing or expanding educational technology, institutions should conduct a comprehensive digital readiness assessment to determine their current capacity, strengths, gaps, and priorities. This assessment should examine the availability and quality of digital infrastructure, including computers, smart classrooms, servers, devices, and other technological resources, as well as the reliability and accessibility of internet connectivity. The institution should also evaluate teachers' digital competence, including their ability to select, integrate, and effectively use digital tools for teaching, assessment, communication, and professional development. In addition, leaders should examine student access to appropriate devices, internet services, digital learning resources, and technical assistance to identify potential digital inequalities. The assessment should review the effectiveness and compatibility of existing digital platforms, such as learning management systems, student information systems, communication platforms, and assessment tools. Attention must also be given to cybersecurity and data protection, including privacy policies; access controls, and secure data management practices.

Develop a Technology Action Plan

A comprehensive technology action plan should clearly define the objectives, responsibilities, resources, implementation timelines, professional development, indicators of success, and evaluation procedures required for effective educational technology integration. The objectives should identify specific and measurable goals, such as improving teaching effectiveness, enhancing student learning outcomes, strengthening digital competence, and increasing administrative efficiency.

Build Professional Capacity

Continuous professional learning should be embedded within the institution. Leaders can establish mentoring, peer coaching, professional learning communities, workshops, action research, and communities of practice.

Monitor and Evaluate

Technology initiatives should be evaluated according to educational outcomes rather than simply adoption rates.

Conclusion

The use of educational technology has tremendous potential to enhance learning, teaching and administration, however, the effective use of educational technology is strongly dependent on leadership. Technology can by itself not significantly change an educational institution. Transformational takes place when the leaders set a shared vision, empower teachers, build teacher competence, ensure quality of infrastructure, adopt innovative teaching, exploit responsibly data and build inclusive digital environments. It's becoming clear that a lot of what it takes to be an effective technology leader is not technical skill. It's about teaching people and changing education with technology. Transformational, instructional, distributed and digital leadership strategies can all be used to build institutions that can adapt to an ever-evolving technology landscape. In the context of teaching, teacher development and innovative pedagogy can be fostered by teacher leadership. It can be used to assist with personalization, collaboration, inclusion and engagement for learning. It can help to enhance communication, information management, decision-making, resource utilization and organizational efficiency for administration purposes. Finally, leaders are needed who can keep pace with innovation and maintain ethical standards, be efficient and keep equity in mind and be able to utilize technology while keeping an eye on human education. The transition should, in the context of educational institutions, be from technology adoption to sustainable digital transformation, in which technology is a tool for enhancing education's quality, instead of a goal.

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Leadership Competencies and Collaborative Skills in the Digital Era among College Students

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Abstract

In the rapidly changing digital era, leadership competencies and collaborative skills have become essential for the holistic development of college students. Leadership competencies enable students to communicate effectively, take initiative, make responsible decisions, solve problems, and adapt to changing situations, while collaborative skills help them work with peers, share responsibilities, respect diverse perspectives, and achieve common goals. The present study aims to examine the level of leadership competencies and collaborative skills among college students, determine significant differences with respect to gender and year of study, and examine the relationship between the two variables. A descriptive survey research design was adopted for the study. The sample consisted of 300 college students selected through the simple random sampling technique. Data were collected using structured questionnaires on leadership competencies and collaborative skills, along with a personal data sheet. The data were analysed using percentage analysis, mean, standard deviation, independent samples *t*-test, one-way ANOVA, and Pearson's product-moment correlation coefficient. The findings revealed that college students possess moderate levels of leadership competencies and collaborative skills. No significant differences were found based on gender for either variable. However, year of study showed a significant difference in leadership competencies, while no significant difference was found in collaborative skills. Most importantly, a strong positive and significant relationship ($r = 0.865$) was found between leadership competencies and collaborative skills. The study highlights the need for leadership development, collaborative learning, teamwork, experiential activities, and digital collaboration in higher education to prepare students for the academic, professional, and social demands of the digital era.

Keywords: Leadership Competencies, Collaborative Skills, College Students, Higher Education, Teamwork, Student Development.

Introduction

The digital era has transformed how college students learn, communicate, interact, and collaborate. Along with academic knowledge, students need leadership competencies and collaborative skills to participate effectively in academic and professional activities. Leadership competencies include communication, decision-making, problem-solving, initiative, responsibility, and adaptability, while collaborative skills involve teamwork, cooperation, active listening, sharing ideas, and respecting diverse perspectives. These skills enable students to work effectively in both face-to-face and digital environments, manage responsibilities, solve problems collectively, and adapt to changing situations. Therefore, developing leadership competencies and collaborative skills is essential for the academic, personal, social, and professional development of college students.

Need and Significance of the Study

The digital era requires college students to develop leadership competencies and collaborative skills for effective communication, teamwork, decision-making, and problem-solving. Students regularly engage in group projects, discussions, presentations, online learning, and technology-supported activities, making these skills essential for academic and professional success. The study is significant as it helps students identify areas for improvement, supports teachers in designing collaborative learning activities, and assists higher education institutions in organising leadership programmes and workshops. It may also provide useful insights for educational planners and researchers to develop strategies for students' leadership, teamwork, and digital-era readiness.

Leadership Competencies and Collaborative Skills in the Digital Era

The digital era has increased the importance of **leadership competencies and collaborative skills** among college students. Leadership competencies help students develop **initiative, decision-making, communication, responsibility, problem-solving, and adaptability**. Collaborative skills enable students to **share responsibilities, respect diverse ideas, communicate effectively, and work towards common goals**. Digital platforms further support teamwork through **online discussions, virtual collaboration, and knowledge sharing**. Therefore, developing both leadership and collaborative skills prepares college students to become **effective team members and responsible future professionals**.

Review of Related Literature

- **Zhan et al. (2024)** Zhan et al. found that working undergraduates demonstrated high digital leadership capability and intercultural competence. The study also showed that self-efficacy supported students' confidence and employability in digital environments.
- **Fernández et al. (2024)** Fernández et al. examined digital skills and collaborative attitudes among 1316 university students. The findings indicated that digital competencies were associated with students' willingness to collaborate in academic environments.
- **Suryana et al. (2026)** Suryana et al. identified technical, communication, creative, analytical, and collaboration skills as key digital leadership competencies. Organizational involvement, self-directed learning, and technology familiarity significantly supported students' digital leadership development.
- **Trihantoyo et al. (2024)** Trihantoyo et al. examined team leadership as an important factor in developing university students' digital behavior. The study emphasized leadership interventions through learning activities to strengthen students' digital competencies.

Objectives

- To find out whether there is any significant difference in Leadership Competencies and Collaborative Skills among College Students with respect to Gender.
- To find out whether there is any significant difference in Leadership Competencies and Collaborative Skills among College Students with respect to Year of Study.
- To find out whether there is any significant relationship between Leadership Competencies and Collaborative Skills among College Students.

Hypothesis

- There is no significant difference in Leadership Competencies and Collaborative Skills among College Students with respect to Gender.
- There is no significant difference in Leadership Competencies and Collaborative Skills among College Students with respect to Year of Study.
- There is no significant relationship between Leadership Competencies and Collaborative Skills among College Students.

Methodology

The present study adopted a descriptive survey research design. The sample consisted of 300 college students, selected using the simple random sampling technique. Data were collected using a structured questionnaire on Leadership Competencies and Collaborative Skills. In addition, the investigator prepared a personal Data Sheet to collect demographic information from the respondents. The collected data were analyzed using percentage analysis, mean, standard deviation, independent samples t-test, one-way ANOVA and Pearson's product-moment correlation coefficient.

Testing of Hypothesis

Hypothesis 1

There is no significant difference in Leadership Competencies and Collaborative Skills among College Students with respect to Gender.

Table 1 - Difference in Leadership Competencies and Collaborative Skills among college students with respect to Gender.

S.No	Variables	Gender	N	Mean	SD	't' Value	Significance
1	Leadership Competencies	Male	181	90.32	8.09	1.357	Not Significant
		Female	119	91.65	8.60		
2	Collaborative Skills	Male	181	150.59	16.28	0.424	Not Significant
		Female	119	151.41	16.76		

Gender and Leadership Competencies

The calculated t value (1.357) is less than 1.96, indicating no significant difference between male and female students in Leadership Competencies. However, female students have a higher mean score (91.65) than male students (90.32).

Gender and Collaborative Skills

The calculated t value (0.424) is less than 1.96, indicating no significant difference between male and female students in Collaborative Skills. However, female students have a higher mean score (151.41) than male students (150.59).

Hypothesis 2

There is no significant difference in Leadership Competencies and Collaborative Skills among College Students with respect to Year of Study.

Table 2 - Difference in Leadership Competencies and Collaborative Skills among college students with respect to Year of Study.

Sl. No.	Variables	Source	N	Mean	SD	'F' Value	Significance
1	Leadership Competencies	I Year	145	152.05	15.26	3.450	Significant
		II Year	142	156.43	11.29		
		III Year	13	147.20	15.22		
2	Collaborative Skills	I Year	145	147.08	16.78	1.789	Not Significant
		II Year	142	151.81	14.21		
		III Year	13	135.61	12.31		

Year of Study and Leadership Competencies

The calculated F value (3.450) is significant, indicating a significant difference in Leadership Competencies based on year of study. II Year students have the highest mean score (156.43), followed by I Year (152.05) and III Year (147.20).

Year of Study and Collaborative Skills

The calculated F value (1.789) is not significant, indicating no significant difference in Collaborative Skills based on year of study. However, II Year students have the highest mean score (151.81).

Hypothesis 3

There is no significant relationship between Leadership Competencies and Collaborative Skills among College Students.

Table 3 - Relationship between Leadership Competencies and Collaborative Skills among college students.

Variables	Correlation Coefficient	Significance
Leadership Competencies and Collaborative Skills	0.865	Significant

Interpretation

Table 3 shows a **strong positive and significant relationship ($r = 0.865$)** between Leadership Competencies and Collaborative Skills among college students. This indicates that students with higher leadership competencies tend to have better collaborative skills. Therefore, the **null hypothesis is rejected**, confirming a significant positive relationship between the two variables.

Educational Implications of the Study

- **Leadership Development:** Colleges should organise training, workshops, and leadership activities to improve students' decision-making, communication, and responsibility.
- **Collaborative Learning:** Group discussions, projects, and peer learning can strengthen students' teamwork and collaboration.
- **Digital Collaboration:** Technology-supported activities, virtual discussions, and online projects can develop digital collaboration skills.
- **Experiential Learning:** Clubs, committees, and project-based activities can provide practical opportunities to develop leadership and teamwork.
- **Integrated Skill Development:** Since leadership and collaboration are strongly related, colleges should develop programmes that strengthen both skills together.

Conclusion

The study concludes that college students possess a **moderate level of leadership competencies and collaborative skills**. The findings indicate that gender does not significantly influence either leadership competencies or collaborative skills. However, year of study has a significant influence on leadership competencies, with II Year students showing the highest mean score, whereas collaborative skills do not differ significantly across the years of study. The most important finding of the study is the **strong positive and significant relationship ($r = 0.865$)** between leadership competencies and collaborative skills. This indicates that students with higher leadership competencies tend to demonstrate better collaborative skills. Therefore, higher education institutions should provide systematic opportunities for leadership development, collaborative learning, teamwork, experiential learning, and digital collaboration. Integrating these activities into college education can support students in becoming effective team members, responsible individuals, and competent future professionals who are prepared to meet the demands of the digital era.

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Navigating the Digital Transition: The Role of Leadership in Educational Technology

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Abstract

The incorporation of educational technology (Ed-Tech) in educational institutions has revolutionized educational paradigms, thus necessitating a change in leadership. This seminar paper seeks to explore the importance of leadership in facilitating the successful implementation and sustainability of Ed-Tech interventions in educational institutions. Using the qualitative secondary research method, the paper analyzes how educational leaders impact the use of technological devices in learning institutions. It emerges from the findings that effective technological leadership involves more than just acquiring digital hardware and software, but developing a collective vision, ensuring equal access, training teachers and solving issues regarding data privacy. Additionally, the paper shows that distributed leadership models have been found to be much more effective than the conventional administrative model when it comes to technological innovations. Through these aspects, leaders can create durable technological environments that will improve students' learning experience. From this study, it emerges that visionary leadership is crucial in the successful integration of Ed-Tech in education.

Keywords: Educational technology, digital leadership, pedagogical integration, distributed leadership, digital equity.

Introduction

Today, in the current knowledge economy, technology has become an integral part of the teaching-learning processes and cannot be seen as merely a supplementary tool. Nevertheless, the presence of digital tools in education does not ensure improved educational outcomes (Fullan, 2016). The integration of technology into education framework highly depends on the quality of leadership within the institution. Educational technology leadership can be viewed as a practice of developing a culture which is open to the use of technology and at the same time remains completely focused on educational purposes (Sheninger, 2019). Traditionally, the challenge faced by educational institutions was a "digital use divide," in which technologies were available but used inadequately for enhancing learning processes. To overcome such a divide, educational leaders should possess visionary, instructional and change-agency qualities (Dexter, 2020). This paper focuses on the multiplicity of leadership roles in educational technology.

Objectives of the study

The main objectives of this seminar paper include:

- To analyze the core competencies and strategies required for effective leadership in the realm of educational technology.
- To identify the primary challenges and barriers educational leaders face during digital transformation and technological integration.
- To evaluate the impact of strategic digital leadership on pedagogical innovation, educator capacity building, and digital equity.

Importance of the study

The field of education is experiencing radical technological disruptions, facilitated by the global move towards hybrid and online modes of learning (Zhao, 2021). Therefore, now than ever, there is a need for understanding technological leadership. The importance of this study lies in its shift of attention from the technical aspects of Ed-Tech solutions to the organizational and human variables influencing their efficiency. It is especially important for policymakers, academic leaders and PhD scholars who investigate educational structures as it sheds light on how leadership paradigms determine the digitalization of education.

Limitations of the study

Although this paper discusses a range of leadership concepts in detail, there are several limitations associated with it. Firstly, being a conceptual seminar paper and based on secondary qualitative data, it does not feature any empirical field data to assess quantitatively the impact of leadership traits on student performance on tests. Secondly, educational technology develops very rapidly; therefore, the suggested frameworks may need regular contextual updates. Finally, the results of this research have a general nature and the implementation of the proposed models of leadership would depend greatly on local conditions including institutional budgeting issues, differences in rural and urban infrastructure and regional legislation.

Research methodology

This study utilizes a qualitative, descriptive research design based on systematic reviewing of secondary literature. The data was collected from peer-reviewed academic journals, educational policy papers and authoritative books published in the recent ten years. The process of literature review consisted in the search for recurrent themes related to technological implementation, administration and models of leadership in education. Thematic analysis was used to interpret the results and build the framework of findings presented in this paper.

Findings

Synthesis of the literature points to several crucial aspects of leadership in educational technology:

- **Development of a Shared Digital Vision:** Successful technological implementation involves a unified institutional vision. It is important for leaders to ensure that technology adoption is based on curriculum needs rather than technological innovation (Richardson, 2021). According to ISTE (2018), leaders should be able to work with the entire group of people and develop a vision that empowers both educators and students by providing them with an understanding of the reason for such changes.
- **Capacity Building and Distributed Leadership:** Top-down approaches to technology use often lead to faculty resistance. Literature suggests that distributed leadership models, when educators and department heads are responsible for leading tech projects, result in greater participation (Trust, 2016). In addition, effective leaders pay attention to professional development of educators rather than one-time workshops, since educators need time to adopt tools and implement them in their teaching practices (McLeod, 2019).
- **Digital Equity Promotion:** A major discovery is the importance of the leader in the bridging of the digital gap. The leader should not only solve the issue of hardware divide but the instructional divide as well by making sure that all the students have a chance to engage in technology through critical thinking instead of just drill-and-practice activities (Brooks, 2017).

- **Data Privacy and Ethics in Learning:** Data privacy has become one of the key concerns for leaders in recent times as the use of learning management systems and educational analytics has increased. Leaders have to develop sound data governance policies in this regard (Jones, 2022).

Conclusion

The use of educational technology is more of an adaptive problem than a technical one. It would be useless installing modern technology on a college campus without having an institutional culture that possesses the proper leadership skills needed to take advantage of that technology to facilitate learning. This paper shows that digital leadership needs careful balancing of visioning, pedagogical skills and digital equity. In order to accomplish that, educational leaders need to embrace the concept of distributed leadership and emphasize continuous professional development. Ultimately, in the digital era, educational technology becomes the means, while strategic and human leadership becomes the steering wheel.

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The Role of Social Media in Economics Teaching in the Present Educational Scenario

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Abstract

The integration of social media into education has significantly transformed teaching and learning practices by providing interactive, collaborative, and technology-enabled learning opportunities. In Economics education, social media serves as an effective platform for accessing current economic information, educational resources, online discussions, and collaborative learning experiences that enhance students' conceptual understanding. The present study investigated the role of social media in Economics teaching among higher secondary school students in Dharmapuri District, Tamil Nadu. The study adopted the **Normative Survey Method**, and a sample of 120 higher secondary school students was selected using the Simple Random Sampling Technique. Data were collected using a researcher-developed **Social Media Usage Scale** comprising 52 items measured on a five-point Likert scale. The collected data were analysed using descriptive statistics and independent samples *t*-tests. The findings revealed that students exhibited a moderately high level of social media usage in learning Economics ($M = 143.14$, $SD = 24.02$). Further, no statistically significant differences were found in social media usage with respect to gender, locality, and medium of instruction. The study concludes that social media has become an effective and widely accessible educational resource that supports student engagement, collaborative learning, and independent learning. It recommends the systematic integration of social media into Economics teaching to enhance learning outcomes and develop the digital competencies required for twenty-first-century education.

Keywords: Social Media, Economics Teaching, Higher Secondary Students, Digital Learning, Educational Technology, Online Learning, Economics Education

Introduction

The rapid advancement of information and communication technology has significantly transformed the educational system by introducing innovative teaching and learning practices. Among various digital technologies, social media has emerged as an effective educational tool that supports communication, collaboration, knowledge sharing, and interactive learning. Platforms such as YouTube, WhatsApp, Telegram, Google Classroom, Facebook, and Instagram have become increasingly popular among students and teachers for accessing educational resources and enhancing learning experiences beyond the traditional classroom.

Economics is a dynamic subject that requires students to understand current economic events, financial systems, market trends, and government policies. Traditional classroom instruction alone is often insufficient to meet these evolving learning needs. Social media provides learners with instant access to current economic information, educational videos, online discussions, digital content, and collaborative learning opportunities, thereby improving their conceptual understanding, critical thinking, and problem-solving skills. It also enables teachers to share learning materials, conduct discussions, and provide timely academic support.

In the present educational scenario, the integration of social media into Economics teaching has become increasingly important for promoting learner engagement and independent learning. Understanding students' educational use of social media is essential for developing effective teaching strategies and improving learning outcomes. Therefore, the present study examines the role of social media in Economics teaching among higher secondary school students in Dharmapuri District, with special reference to gender, locality, and medium of instruction.

Review of Related Literature

Tess (2013) conducted a comprehensive review of research on social media in higher education and concluded that social media platforms significantly enhance communication, collaboration, knowledge sharing, and student engagement. The study highlighted that effective integration of social media into classroom instruction promotes learner participation and improves academic performance when properly guided by teachers. Manca and Ranieri (2016) examined the educational applications of social networking sites and found that social media facilitates collaborative learning, peer interaction, and information exchange. Their study emphasized that social networking environments encourage active participation and support student-centred learning approaches. Greenhow and Chapman (2019) investigated the impact of social media on teaching and learning. Their findings indicated that students increasingly use digital platforms to access academic materials, participate in online discussions, and develop collaborative problem-solving skills. The researchers recommended integrating social media into classroom instruction to improve learning effectiveness. Dhawan (2020) examined online learning during the COVID-19 pandemic and reported that digital technologies became essential tools for ensuring educational continuity. The study emphasized that online platforms, including social media, provided flexibility, accessibility, and continuous interaction between teachers and learners.

Need and Significance of the Study

Education in the digital era has undergone remarkable transformation due to rapid technological advancements. Social media has emerged as an important educational resource that supports communication, collaboration, and independent learning. Since Economics is a dynamic subject closely associated with current affairs and socio-economic developments, students require continuous access to updated information beyond traditional textbooks. Social media platforms provide immediate access to economic news, policy discussions, educational videos, and interactive learning opportunities that enrich classroom instruction. Although social media has become an integral part of students' daily lives, its educational role in Economics teaching at the higher secondary level has received limited research attention. Teachers and educational administrators require empirical evidence regarding students' educational use of social media to develop effective instructional strategies. Moreover, understanding whether demographic variables such as gender, locality, and medium of instruction influence educational social media usage will help policymakers ensure equitable access to digital learning resources. The findings of the present study are expected to benefit teachers, curriculum developers, educational planners, and policymakers by providing valuable insights into the effective integration of social media in Economics education. The study also contributes to the growing body of knowledge on technology-enhanced learning in school education.

Statement of the Problem

Social media has become an important educational tool that supports communication, collaboration, and access to learning resources in the digital era. In Economics education, it

provides students with opportunities to access current economic information, participate in academic discussions, and enhance their learning beyond the classroom. However, limited research has examined the educational use of social media among higher secondary school students, particularly with respect to demographic variables such as gender, locality, and medium of instruction. Therefore, the present study aims to investigate **the role of social media in Economics teaching in the present educational scenario among higher secondary school students in Dharmapuri District.**

Objectives of the Study

The present study was undertaken with the following objectives:

- To determine the level of social media usage in Economics teaching among higher secondary school students.
- To examine whether there is any significant difference in social media usage in Economics teaching between male and female students.
- To investigate whether there is any significant difference in social media usage in Economics teaching between rural and urban students.
- To find out whether there is any significant difference in social media usage in Economics teaching between Tamil medium and English medium students.

Hypotheses of the Study

The following null hypotheses were formulated for the present investigation.

- **H01:** There is no significant difference in social media usage in Economics teaching between male and female higher secondary school students.
- **H02:** There is no significant difference in social media usage in Economics teaching between rural and urban higher secondary school students.
- **H03:** There is no significant difference in social media usage in Economics teaching between Tamil medium and English medium higher secondary school students.

Methodology

The present study employed a quantitative research approach because it aimed to measure the extent of social media usage in Economics teaching among higher secondary school students and compare their perceptions across selected demographic variables. Quantitative research facilitates objective measurement and statistical analysis, thereby improving the reliability and validity of the findings.

Research Method

The present investigation adopted the Normative Survey Method. This method is appropriate for studying existing educational conditions, attitudes, opinions, behaviours, and practices without manipulating the variables under investigation. The normative survey method enables the researcher to describe the present status of social media usage among students and compare differences among various demographic groups.

Population of the Study

The population of the present study comprised all Higher Secondary School students studying Economics in Dharmapuri District, Tamil Nadu. Students from Government, Government-Aided, and Private Higher Secondary Schools offering Economics as a subject

constituted the target population. These students represented diverse educational, social, and geographical backgrounds, thereby providing an appropriate population for investigating the educational use of social media.

Sample of the Study

A sample of 120 Higher Secondary School students studying Economics was selected from various Higher Secondary Schools located in Dharmapuri District. The sample consisted of:

Demographic Variable	Category	Number
Gender	Male	55
	Female	65
Locality	Rural	71
	Urban	49
Medium of Instruction	Tamil	66
	English	54
Total		120

Sampling Technique

The investigator adopted the Simple Random Sampling Technique for selecting the respondents. This sampling technique provides every member of the population with an equal opportunity of being included in the sample and minimizes researcher bias. The selected respondents represented different schools across Dharmapuri District, thereby enhancing the generalizability of the findings.

Research Tool

Data were collected using the Social Media Usage Scale developed and standardized by the investigator. The instrument consisted of 52 statements covering various dimensions of educational social media usage in Economics teaching. The questionnaire was designed using a five-point Likert Scale with the following response categories:

- Strongly Agree (5)
- Agree (4)
- Undecided (3)
- Disagree (2)
- Strongly Disagree (1)

Positive statements were scored from 5 to 1, whereas negative statements were scored in the reverse order. The scale was developed after reviewing relevant literature, consulting experts in education and educational technology, and examining similar standardized instruments.

Reliability of the Tool

The reliability of the Social Media Usage Scale was established through a pilot study conducted among higher secondary school students who were not included in the final sample. Internal consistency reliability was estimated using Cronbach's Alpha, which indicated satisfactory reliability of the instrument for measuring students' educational use of social media. The obtained reliability coefficient confirmed that the scale was sufficiently reliable for collecting data in the main investigation.

Variables of the Study

- **Dependent Variable:** Social Media Usage in Economics Teaching
- **Demographic Variables:** Gender, Locality and Medium of Instruction

Statistical Techniques Used

The collected data were coded, tabulated, and analysed using the Statistical Package for the Social Sciences (SPSS). The following statistical techniques were employed:

- Mean and Standard Deviation
- 't' test

Analysis and Interpretation

Table 1 - Overall Mean and Standard Deviation of Social Media Usage

Variable	N	Mean	SD
Social Media Usage	120	143.14	24.02

The findings indicate that students demonstrate a moderately high level of social media usage for learning Economics. This suggests students frequently utilize digital platforms to access educational materials, share academic information, clarify doubts, and enhance their understanding of Economics concepts.

Gender-wise Comparison of Social Media Usage in Economics Teaching

Table 2 - Difference in Social Media Usage in Economics Teaching between Male and Female Higher Secondary School Students

Gender	N	Mean	SD	t-value	p-value	Result
Male	55	141.27	26.19	0.77	0.442	Not Significant
Female	65	144.72	22.10			

Table 2 presents the comparison of social media usage in Economics teaching between male and female higher secondary school students. The mean score of female students ($M = 144.72$, $SD = 22.10$) was slightly higher than that of male students ($M = 141.27$, $SD = 26.19$). However, the obtained t-value (-0.77) was not statistically significant at the 0.05 level ($p = 0.442$). Therefore, the null hypothesis stating that there is no significant difference between male and female students with respect to social media usage in Economics teaching is accepted.

Locality-wise Comparison of Social Media Usage in Economics Teaching

Table 3 - Difference in Social Media Usage in Economics Teaching between Rural and Urban Higher Secondary School Students

Locality	N	Mean	SD	t-value	p-value	Result
Rural	71	140.42	23.32	1.48	0.141	Not Significant
Urban	49	147.08	24.70			

Table 3 reveals the comparison of social media usage between rural and urban higher secondary school students. Urban students obtained a slightly higher mean score ($M = 147.08$, $SD = 24.70$) than rural students ($M = 140.42$, $SD = 23.32$). However, the calculated t-value (-1.48) was not statistically significant ($p = 0.141$). Hence, the null hypothesis is accepted. The findings suggest that locality does not significantly influence students' use of social media for learning Economics.

Medium of Instruction-wise Comparison of Social Media Usage in Economics Teaching

Table 4 - Difference in Social Media Usage in Economics Teaching between Tamil Medium and English Medium Higher Secondary School Students

Medium of Instruction	N	Mean	SD	t-value	p-value	Result
Tamil Medium	66	140.89	24.07	1.14	0.259	Not Significant
English Medium	54	145.89	23.89			

Table 4 shows the comparison of social media usage between Tamil medium and English medium students. English medium students obtained a marginally higher mean score ($M = 145.89$, $SD = 23.89$) compared to Tamil medium students ($M = 140.89$, $SD = 24.07$). Nevertheless, the obtained t-value (-1.14) was not statistically significant at the 0.05 level ($p = 0.259$). Therefore, the null hypothesis is accepted. The results indicate that medium of instruction has no significant influence on students' educational use of social media.

Discussion of the Findings

The findings of the present study indicate that higher secondary school students exhibit a moderately high level of social media usage for learning Economics, highlighting its growing importance as an effective educational resource. Social media enables students to access current economic information, engage in collaborative learning, and enhance their conceptual understanding beyond the classroom. The study further reveals that there are no statistically significant differences in social media usage with respect to gender, locality, and medium of instruction, suggesting that digital learning opportunities are equally accessible across different student groups. These findings imply that social media has become a widely accepted and inclusive learning platform that supports student engagement, independent learning, and technology-enabled Economics education in the contemporary educational scenario.

Major Findings

The major findings of the study are summarized as follows:

- Higher secondary school students exhibited a moderately high level of social media usage in learning Economics (Mean = 143.14; SD = 24.02).
- Female students obtained a slightly higher mean score than male students; however, the difference was not statistically significant ($t = -0.77$; $p = 0.442$).
- Urban students demonstrated marginally higher social media usage than rural students, but the difference was not statistically significant ($t = -1.48$; $p = 0.141$).
- English medium students recorded a slightly higher mean score than Tamil medium students; nevertheless, the difference was not statistically significant ($t = -1.14$; $p = 0.259$).
- The study concludes that gender, locality, and medium of instruction do not significantly influence students' educational use of social media in Economics teaching.

Educational Implications

The findings of the present study have several important implications for educational practice:

- Teachers should integrate social media platforms into Economics teaching to make learning more interactive and engaging.
- Educational administrators should organize professional development programmes to enhance teachers' digital pedagogical competencies.
- Curriculum planners should incorporate social media-based learning strategies into Economics education.
- Students should be guided in developing digital citizenship, ethical online behaviour, and critical evaluation of online information.

Recommendations

Based on the findings of the present study, the following recommendations are made to enhance the effective use of social media in Economics teaching:

- **Integrate Social Media into Classroom Instruction:** Teachers should systematically incorporate educational social media platforms such as YouTube, Google Classroom, WhatsApp, Telegram, and educational blogs to supplement classroom teaching and make Economics learning more interactive.
- **Promote Digital Literacy:** Schools should organize digital literacy programmes to enable students to identify authentic educational resources and effectively use social media for academic purposes.
- **Provide Professional Development for Teachers:** Regular training programmes should be conducted to enhance teachers' competencies in integrating social media and digital technologies into Economics teaching.

Conclusion

The present study concludes that social media plays a significant role in enhancing the teaching and learning of Economics among higher secondary school students. The findings indicate that students exhibit a moderately high level of educational social media usage, demonstrating its importance as a supplementary learning resource. The study also reveals that there is no significant difference in social media usage with respect to gender, locality, and medium of instruction, suggesting equal accessibility across different student groups. Social media promotes collaborative learning, improves access to current economic information, and supports

independent learning. Therefore, teachers, educational institutions, and policymakers should encourage the effective and responsible integration of social media into Economics education to foster meaningful learning experiences and develop the digital competencies required for the twenty-first century.

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Leadership in Educational Technology with Reference to School Heads

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Abstract

Educational technology has become a strategic component of contemporary school education, but technology adoption alone does not produce educational improvement. The quality of technology integration depends substantially on how school heads establish vision, build teacher capacity, allocate resources, manage change, use evidence, and protect equity, privacy, and digital well-being. This conceptual article reframes the broader educational-leadership discussion in the source document around the specific problem of leadership in educational technology with reference to school heads. Drawing on research on school technology leadership, digital leadership, instructional leadership, the UNESCO Global Education Monitoring Report, the National Education Policy (NEP) 2020, and international standards for education leaders, the article examines the changing role of school heads in technology-enabled school transformation. The discussion identifies seven interconnected leadership responsibilities: developing a shared digital vision; strengthening teachers' digital competence; leading instructional technology integration; ensuring digital equity and inclusion; governing data, privacy, ethics, and artificial intelligence; using technology for evidence-informed administration; and building a culture of continuous innovation and professional learning. The article argues that the school head should function not merely as a technology user or administrator but as a strategic digital learning leader who connects technology, pedagogy, people, policy, and school improvement. For the Indian context, this role is particularly relevant to the technology-related directions of NEP 2020, including the use of digital platforms, educational technology research, professional development, and equitable access. The paper concludes with a practical framework for strengthening school-head capacity in educational technology leadership.

Keywords: educational technology, digital leadership, school heads, technology leadership, school transformation, digital equity, instructional leadership, NEP 2020

Introduction

Educational technology has moved from being an auxiliary resource to becoming an important part of teaching, learning, assessment, communication, school administration, and professional development. Digital platforms, learning management systems, smart classrooms, online assessment, learning analytics, artificial intelligence, mobile technologies, and digital communication have expanded the range of possibilities available to schools. At the same time, technology introduces new leadership responsibilities concerning access, teacher preparedness, data governance, cybersecurity, ethical use, student well-being, and the quality of digital learning experiences. UNESCO's 2023 Global Education Monitoring Report cautions that the educational value of technology should not be assumed automatically; technology should be appropriate, equitable, evidence-based, and sustainable (UNESCO, 2023).

In this context, the role of the school head has changed. Traditionally, school heads were primarily associated with administration, discipline, personnel management, resource allocation,

and policy implementation. Contemporary school leadership requires these functions to be connected with instructional improvement and digital transformation. The school head must understand how technology can support learning while also recognizing its limitations and risks. Research by Anderson and Dexter (2005) demonstrated that technology leadership is an important condition for effective use of technology in schools, beyond the mere availability of infrastructure. More recent evidence similarly indicates that principals' digital leadership can influence teachers' technology integration (AlAjmi, 2022). For India, this issue has particular significance. The National Education Policy 2020 recognizes technology as a means of improving teaching-learning, assessment, teacher preparation and professional development, educational access, planning, management, and administration. It also envisages mechanisms such as the National Educational Technology Forum and emphasizes that technology interventions should be evaluated before being scaled up (Ministry of Education, Government of India, 2020). Consequently, school heads are increasingly required to lead technology strategically rather than simply permit or purchase technology.

Purpose of the Article

The purpose of this article is to examine leadership in educational technology with particular reference to school heads and to develop a research-based conceptual framework relevant to school education in India. The article extends the broader educational-leadership perspective of the source document by placing technology leadership at the centre of school improvement.

Conceptual Orientation: From Educational Leadership to Educational Technology Leadership

Educational leadership is fundamentally a process of influencing people and organizational conditions towards shared educational purposes. In technology-rich schools, this influence increasingly includes decisions about digital infrastructure, pedagogical integration, professional learning, data use, digital citizenship, and organizational change. Digital leadership may therefore be understood as the strategic use of leadership knowledge, digital competencies, organizational systems, and technology resources to improve teaching, learning, school operations, and stakeholder engagement. Technology leadership should not be equated with technical expertise. A school head does not need to be the school's most technically skilled person. Rather, the head needs sufficient digital literacy to ask informed questions, evaluate alternatives, establish priorities, support teachers, monitor implementation, and ensure that technology remains subordinate to educational purpose. The contemporary role is consequently both strategic and instructional.

Significance Educational Technology for School Heads Creating a Shared Digital Vision

Technology initiatives are more likely to become sustainable when they are connected to a clear educational vision. School heads need to answer fundamental questions: What learning problem is the technology intended to address? Which learners will benefit? What teacher competencies are required? How will impact be evaluated? How will equity be protected? A shared digital vision moves a school away from technology adoption for its own sake and towards purposeful technology integration. The ISTE Standards for Education Leaders identify visionary

planning, stakeholder engagement, strategic planning, and continuous evaluation as core elements of technology-oriented leadership (International Society for Technology in Education [ISTE], 2025).

Strengthening Teachers' Digital Competence

The effectiveness of educational technology depends heavily on teachers' confidence, pedagogical knowledge, and willingness to integrate digital tools meaningfully. School heads therefore have a responsibility to create sustained professional learning opportunities rather than treating one-time workshops as sufficient preparation. Professional development should address digital pedagogy, assessment technologies, digital content creation, learning analytics, accessibility, cybersecurity, artificial intelligence literacy, and responsible digital practice. School heads can also encourage peer mentoring, professional learning communities, demonstration lessons, collaborative planning, and teacher-led experimentation.

Leading Instructional Technology Integration

Technology leadership must remain closely connected with instructional leadership. The central question should be whether technology improves the quality, accessibility, personalization, efficiency, or inclusiveness of learning. School heads can support this process through classroom observations, professional dialogue, review of digital lesson plans, analysis of learner performance, and support for evidence-based instructional innovation. Technology should therefore be embedded within curriculum and pedagogy rather than treated as a separate administrative initiative.

Building Digital Infrastructure and Support Systems

School heads play a critical role in translating institutional priorities into infrastructure decisions. This includes connectivity, devices, digital platforms, technical support, maintenance, accessibility, and resource sustainability. Anderson and Dexter (2005) found that infrastructure is important but that technology leadership is particularly necessary for effective technology utilization. Thus, procurement without leadership, planning, training, and technical support is unlikely to generate sustained educational value.

Ensuring Digital Equity and Inclusion

Digital transformation can reproduce existing inequalities if differences in device ownership, connectivity, language, disability access, digital skills, or home learning environments are ignored. School heads must therefore consider technology access as an equity issue. NEP 2020 emphasizes accessible educational technology and digital resources, including support for learners in remote areas and learners with disabilities (Ministry of Education, Government of India, 2020). Technology leadership should consequently include equitable access, accessibility, multilingual resources, alternative modes of learning, and mechanisms for identifying digitally excluded learners.

Data Governance, Privacy, Cybersecurity, and Ethical Use

Digital schools generate substantial amounts of learner, teacher, and administrative data. School heads must establish a culture of responsible data use and ensure that staff understand privacy, consent, security, appropriate data sharing, and ethical digital practices. The emergence

of generative artificial intelligence makes these responsibilities more complex because schools must consider accuracy, bias, academic integrity, intellectual property, student privacy, and appropriate human oversight. The ISTE leadership standards explicitly include privacy and security, safe and ethical technology use, and digital citizenship as leadership responsibilities (ISTE, 2025).

Using Technology for Evidence-Informed School Administration

Educational technology can support attendance monitoring, communication, assessment, student progress tracking, scheduling, resource management, teacher professional development, and school reporting. School heads can use dashboards and other digital systems to identify patterns and support timely decisions. However, data should inform professional judgment rather than replace it. The value of learning analytics and digital management systems depends on data quality, interpretation, contextual understanding, and ethical use.

Developing a Culture of Innovation and Continuous Learning

Digital transformation is a process rather than a one-time project. School heads need to establish conditions in which teachers can experiment, reflect, share practices, and learn from failure. Sheninger (2014) emphasizes the relationship between digital leadership, school culture, communication, professional growth, and student engagement. A culture of innovation requires psychological safety, distributed leadership, professional trust, time for experimentation, and recognition of effective practice.

Major Competencies of a School Head as a Digital Learning Leader

Based on the literature reviewed, a technology-oriented school head can be conceptualized through seven interrelated competencies:

- **Digital vision and strategic planning:** formulating a shared technology vision aligned with curriculum, school improvement, and learner needs.
- **Digital-pedagogical leadership:** connecting technology use with instructional goals, assessment, learner engagement, and differentiated learning.
- **Teacher capacity building:** developing teachers' digital competence through sustained professional learning, mentoring, collaboration, and peer support.
- **Systems and resource management:** planning infrastructure, connectivity, devices, platforms, technical support, budgeting, and sustainability.
- **Equity, inclusion, and digital citizenship:** ensuring that technology benefits diverse learners and promoting safe, responsible, accessible, and inclusive digital participation.
- **Data, AI, privacy, and ethical governance:** establishing responsible practices for data use, cybersecurity, artificial intelligence, academic integrity, and digital well-being.
- **Change leadership and continuous improvement:** monitoring implementation, evaluating impact, learning from evidence, and adapting technology initiatives to changing educational needs.

Educational Technology Leadership in the Indian School Context

The Indian school system presents a distinctive context for technology leadership because schools vary considerably in geography, infrastructure, language, socioeconomic conditions,

institutional type, and access to professional development. A technology leadership model for India therefore needs to be context-sensitive. The National Education Policy 2020 explicitly recognizes India's scale, diversity, and complexity and proposes technology initiatives that support teaching-learning, assessment, teacher development, access, planning, management, and administration (Ministry of Education, Government of India, 2020). Platforms and initiatives associated with digital education provide opportunities for school heads to coordinate technology use across teaching and administration. However, the existence of a platform does not guarantee meaningful use. School heads must identify the actual needs of teachers and learners, support professional competence, ensure access, monitor quality, and encourage responsible use. This requires leadership capacity at the school level and alignment among policy, infrastructure, professional learning, pedagogy, and evaluation. The Indian context also makes digital inclusion a central leadership concern. A school head must consider not only whether a digital resource exists but whether students can access it, understand it, use it safely, and benefit from it. Language accessibility, disability inclusion, connectivity, device availability, and support for learners from disadvantaged backgrounds should therefore form part of school technology planning.

Challenges Faced by School Heads in Technology Leadership

- **Limited digital leadership preparation:** Many school heads have been promoted through conventional administrative pathways and may receive limited preparation specifically focused on digital transformation.
- **Infrastructure and connectivity constraints:** Unequal access to reliable internet, devices, electricity, maintenance, and technical support can restrict implementation.
- **Teacher readiness and resistance to change:** Teachers may differ substantially in digital competence, confidence, pedagogical beliefs, and willingness to change established practices.
- **Technology overload:** The rapid emergence of platforms, applications, artificial intelligence tools, and digital reporting systems can create fragmentation and additional workload.
- **Ethical and security risks:** Schools must respond to privacy, cybersecurity, misinformation, inappropriate content, data protection, algorithmic bias, and academic integrity concerns.
- **Evidence gap:** Technology decisions are sometimes driven by novelty, vendor claims, or policy pressure rather than by strong evidence of educational effectiveness. UNESCO (2023) specifically highlights the limited availability of robust evidence concerning the added value of digital technology in education.

Strategies for Strengthening Technology Leadership Among School Heads

- First, leadership preparation programmes should include a dedicated component on educational technology leadership. Such preparation should combine digital literacy with instructional leadership, change management, data governance, and ethical decision-making.
- Second, school heads should develop a technology roadmap linked to the school development plan. The roadmap should identify learning priorities, infrastructure requirements, teacher development needs, student access issues, implementation milestones, and evaluation indicators.
- Third, schools should establish distributed digital leadership teams. Subject leaders, technology coordinators, teachers, special educators, counsellors, and other relevant stakeholders can share responsibility for implementation. Distributed leadership reduces dependence on the school head while increasing organizational ownership.

- Fourth, technology initiatives should be evaluated systematically. School heads can use indicators such as teacher adoption, quality of technology-integrated lessons, student engagement, accessibility, learning outcomes, digital well-being, and cost-effectiveness. Evaluation should guide continuation, modification, or discontinuation of interventions.
- Fifth, professional learning should be continuous and practice-oriented. Instead of relying exclusively on lecture-based training, schools can use peer coaching, lesson study, professional learning communities, mentoring, classroom demonstrations, and action research.
- Finally, technology leadership should be explicitly connected to ethics and inclusion. School heads should establish clear expectations for responsible AI use, privacy, digital citizenship, cybersecurity, accessibility, and student well-being.

A Proposed Framework for School-Head Technology Leadership

The literature reviewed supports a school-head technology leadership framework with five mutually reinforcing domains: Vision, People, Pedagogy, Systems, and Ethics. Vision provides strategic direction; People focuses on teacher and learner capacity; Pedagogy ensures that technology serves learning; Systems address infrastructure, data, support, and administration; and Ethics ensures equity, privacy, safety, responsible AI use, and digital citizenship. These five domains operate within a continuous improvement cycle of planning, implementation, monitoring, evaluation, reflection, and adaptation.

Domain	Key school-head responsibilities	Expected school-level outcome
Vision	Shared digital vision; technology roadmap; stakeholder engagement	Strategic and coherent technology adoption
People	Teacher professional learning; mentoring; distributed leadership	Higher digital competence and professional ownership
Pedagogy	Instructional integration; assessment; learner-centred digital practices	More purposeful technology-supported learning
Systems	Infrastructure; technical support; data systems; resource management	Reliable and sustainable digital ecosystem
Ethics	Equity; privacy; cybersecurity; AI governance; digital citizenship	Safe, inclusive, responsible technology use

Implications for School Leadership and Teacher Education

The shift towards educational technology leadership has implications for school leadership preparation and teacher education. Leadership programmes should move beyond general management and include digital transformation, technology-supported pedagogy, data literacy, AI literacy, cyber safety, digital ethics, and innovation management. Teacher education institutions can also prepare prospective teachers for distributed digital leadership by developing collaboration, technology integration, reflective practice, and digital citizenship. For practising school heads, continuing professional development should be structured around authentic school problems. Instead of focusing only on how to operate particular software, professional learning should address how leaders decide whether technology is educationally appropriate, how they support teachers, how they evaluate impact, and how they manage the ethical and organizational consequences of digital transformation.

Conclusion

Leadership in educational technology is fundamentally a leadership-for-learning issue. The central responsibility of a school head is not to maximize the amount of technology in a school but to create the conditions in which technology contributes meaningfully to educational quality, equity, efficiency, and learner development. Research indicates that technology infrastructure alone is insufficient; leadership, teacher capacity, organizational conditions, and instructional purpose are critical to effective technology use (Anderson & Dexter, 2005). For Indian schools, NEP 2020 provides a strong policy rationale for technology-enabled teaching, professional development, assessment, planning, administration, and equitable access. School heads are therefore strategically positioned to translate national policy into school-level practice. Their role should encompass digital vision, instructional leadership, teacher capacity building, systems design, data-informed decision-making, ethical governance, and continuous improvement. The future-ready school head is consequently not merely an administrator who manages digital tools. The school head is a digital learning leader who connects people, pedagogy, technology, policy, evidence, and ethics. When technology leadership is embedded within a broader culture of collaboration and professional learning, schools are better positioned to use digital transformation as a means of improving teaching and learning rather than as an end in itself.

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Responsible Educational Technology Adoption in Higher Education: A Multi-Level Leadership Framework with Preliminary Student-Level Evidence

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ABSTRACT

The increasing adoption of emerging educational technologies in higher education has created a need for systematic decision-making before institutional implementation. Technologies such as artificial intelligence, learning analytics and adaptive learning can create educational opportunities while also introducing ethical, organisational, stakeholder and readiness-related concerns. This study investigates a multi-level leadership perspective for responsible educational technology adoption. Five decision dimensions are integrated: educational value, innovation potential, ethical risk, stakeholder interests and institutional readiness. The framework connects student, faculty, departmental and institutional leadership with an integrated learning environment in which classroom-based, digital and AI-enabled learning coexist, while academic and extracurricular/co-curricular learning operate as parallel lines. A descriptive survey of 677 higher-education students provides preliminary empirical evidence at the student-leadership level, with 303 respondents (44.8%) indicating willingness to undertake leadership roles. The survey does not empirically examine how established faculty, departmental or institutional leadership roles operationalise responsible technology adoption. Accordingly, the study does not claim complete empirical validation of the proposed framework; instead, it establishes a structured basis for broader multi-level investigation and evidence-informed decision-making.

Keywords: Educational Technology Adoption; Leadership Decision-Making; Responsible Innovation; Multi-Level Leadership; Ethical Risk; Institutional Readiness; Higher Education

1. Introduction

Educational technology adoption is more than an individual's decision to use a technological tool. Institutional adoption involves decisions concerning educational purpose, implementation, resources, governance, stakeholder acceptance and evaluation, making it a multidimensional organisational process rather than a purely technical choice (Chugh et al., 2023; Feng et al., 2025).

A technology may provide considerable educational value while simultaneously creating concerns related to privacy, data protection, algorithmic bias, transparency, accountability, academic integrity and equity.

A systematic review by Feng et al. (2025) identified performance expectancy, effort expectancy, social influence and facilitating conditions among important factors influencing educational technology adoption in higher education, while also highlighting challenges such as digital inequality, institutional resistance and inadequate support. Chugh et al. (2023) similarly described educational technology implementation as a complex process involving technologies, stakeholder perceptions, institutional contexts, frameworks and implementation measures. These findings indicate that adoption cannot be adequately explained through technical capability alone.

The emergence of AI further complicates technology-related decisions because AI systems can influence teaching, assessment, student services, research and administration while introducing questions concerning data governance, bias, transparency, accountability and academic integrity. Recent work on AI governance and strategic leadership similarly emphasises institutional readiness, stakeholder engagement, ethical governance and policy development, while UNESCO recommends human-centred, safe, equitable and meaningful approaches to AI in education (Jiang & Abdullah, 2026; Obied & Haj Ali, 2026; UNESCO, 2023).

Leadership in higher education is distributed across levels. Students can identify needs and lead activities; faculty members connect technology with pedagogy; departments coordinate implementation; and institutional leaders establish policy, resources, governance and strategic direction. Recent scholarship on anticipatory governance and ethical AI leadership also highlights the importance of stakeholder engagement, institutional capacity and forward-looking governance in higher education (Baroudi, 2026; Obied & Haj Ali, 2026). A responsible adoption decision may therefore require interaction among these levels rather than a single top-down decision.

The present study develops a multi-level perspective while maintaining a clear empirical boundary. The complete framework includes student, faculty, departmental and institutional leadership, but the available empirical dataset consists of a student survey. Consequently, the present study uses the student-level findings as preliminary empirical evidence and does not claim to empirically examine how faculty, departmental or institutional leaders operationalise responsible technology adoption. Instead, it positions the student findings as an initial empirical entry point for a broader programme of multi-level research.

2. Aim of the Study

To investigate a multi-level perspective of leadership decision-making for the responsible adoption of emerging educational technologies in higher education, with particular empirical attention to the student-leadership level and a foundation for subsequent investigation of how faculty, departmental and institutional leadership operationalizes responsible technology adoption. We also tried to explore the stakeholder interests in adopting emerging technologies and responsible implementation

3. Academic and Extracurricular Learning Lines

3.1 Academic Learning Line

The academic learning line includes classroom teaching, digital learning, AI-supported learning, internal assessments, seminars, presentations, group activities, projects, ILM activities, practical learning, digital assessments, academic discussions and technology-supported assignments. These activities form the formal and structured learning component of the higher-education experience.

3.2 Extracurricular and Co-Curricular Learning Line

The extracurricular and co-curricular line includes student chapters, professional societies, innovation clubs, technical clubs, symposiums, conferences, workshops, competitions, hackathons, student-led events, lecture management, volunteering, sports, community activities and innovation or entrepreneurship initiatives. These activities can provide opportunities to practise communication, teamwork, leadership, creativity, decision-making and professional responsibility.

3.3 Interaction between the Two Lines

The academic and extracurricular lines are complementary rather than isolated. Academic learning provides disciplinary knowledge, while extracurricular and co-curricular engagement creates opportunities to apply, communicate and extend that knowledge. For example, a student may learn a technical concept in class, explore it using digital and AI-supported resources, develop an application through an innovation club, participate in a competition, lead a team and present the outcome at a symposium. The resulting learning experience emerges from the interaction of educational environments, activities and leadership support.

4. Multi-Level Leadership in Higher Education

The proposed framework recognises four interconnected leadership levels. These levels are analytical categories rather than a claim that all institutions use identical organisational structures.

4.1 Student-Level Leadership

Students can identify learner needs, suggest technological solutions, lead student activities, organise technical events, manage student chapters and professional societies, participate in innovation initiatives, provide peer support and communicate student perspectives. Student leadership therefore provides a bottom-up perspective on learning needs and implementation experience.

4.2 Faculty-Level Leadership

Faculty members connect technological possibilities with pedagogy. They can evaluate educational usefulness, design learning activities, mentor students, identify pedagogical limitations, monitor technology use and provide feedback on effectiveness and risk. UNESCO's AI competency framework for teachers similarly emphasises human-centred practice, ethics, AI pedagogy and professional learning, reinforcing the need for faculty capacity when AI is introduced into education (Miao & Cukurova, 2024).

4.3 Departmental Leadership

Departmental leadership can coordinate faculty practices, identify programme-level requirements, evaluate implementation feasibility, organise training, coordinate infrastructure and connect academic activities with student initiatives. Depending on institutional structure, this level may involve programme coordinators, heads of departments, deans or equivalent academic leadership.

4.4 Institutional Leadership

Institutional leadership provides the wider strategic and governance context for adoption. It can influence institutional technology policies, resource allocation, infrastructure, procurement, data governance, partnerships, training, institution-wide platforms and monitoring. Depending on the institution, this may involve senior academic and administrative authorities such as deans, registrars and other institutional decision-makers.

5. Five Dimensions of Responsible Technology-Adoption Decision-Making

5.1 Educational Value

Educational value refers to the extent to which a technology can improve teaching, learning, assessment, student support or educational outcomes. Relevant considerations include learning effectiveness, personalisation, accessibility, feedback, engagement and assessment enhancement.

5.2 Innovation Potential

Innovation potential refers to the capacity of a technology to create meaningful improvements or new possibilities in educational practice. Innovation is distinguished from novelty and may

include new learning processes, collaboration, assessment approaches, interdisciplinary opportunities or forms of student participation.

5.3 Ethical Risk

Ethical risk concerns possible negative consequences associated with technology use, including privacy, data security, algorithmic bias, fairness, transparency, accountability, student autonomy, academic integrity, surveillance, accessibility and digital inequality. These concerns are particularly relevant to AI-enabled education, where human agency, privacy, equity and responsible use require explicit attention (UNESCO, 2023; Jiang & Abdullah, 2026; Obied & Haj Ali, 2026).

5.4 Stakeholder Interests

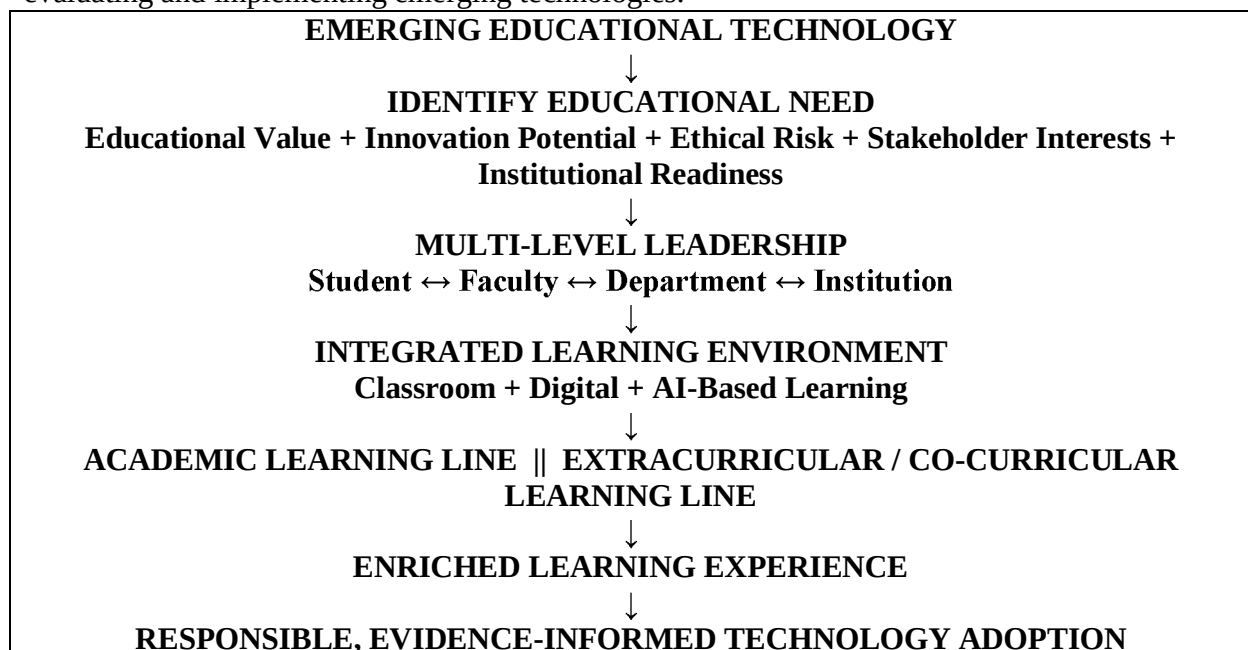
Stakeholder interests include the needs and concerns of students, faculty members, academic administrators, technical personnel, institutional management and other relevant groups. Their priorities may differ, making consultation important in responsible decision-making.

5.5 Institutional Readiness

Institutional readiness represents the capacity to implement and sustain a technology responsibly. It includes infrastructure, technical support, faculty competence, student digital literacy, training, financial resources, policies, data governance, leadership commitment and organisational culture. Reviews of educational technology implementation and recent work on AI governance indicate that institutional support, stakeholder engagement, capacity and governance conditions are important to successful and responsible implementation (Chugh et al., 2023; Baroudi, 2026; Obied & Haj Ali, 2026).

6. Conceptual Framework

The framework consists of two interconnected learning lines supported by three coexisting learning environments and connected through multi-level leadership. Classroom-based, digital and AI-based learning are treated as complementary environments. Academic learning and extracurricular/co-curricular learning operate in parallel and contribute to an enriched learning experience. Multi-level leadership links these learning activities with the institutional process of evaluating and implementing emerging technologies.



7. Methodology

The study adopts a conceptual-exploratory design supported by descriptive survey evidence. The conceptual component develops a multi-level framework for responsible educational technology adoption. The empirical component focuses specifically on the student-leadership dimension because the available dataset consists of student responses. The student survey provides preliminary evidence for one component of the framework and does not empirically validate faculty, departmental or institutional leadership levels. A survey of higher-education students produced 677 valid responses. The survey included questions relating to gender, academic branch, interest in leadership, existing skills, reasons for joining student organisations and preferred language. Personal identifiers were excluded from the analysis. The principal variable analysed in this study is students' expressed interest in undertaking leadership roles, categorised as Yes or No. Frequency and percentage calculations were used.

8. Results

8.1 Overall Student Interest in Leadership

Leadership Interest	Number	Percentage
Yes	303	44.8%
No	374	55.2%
Total	677	100%

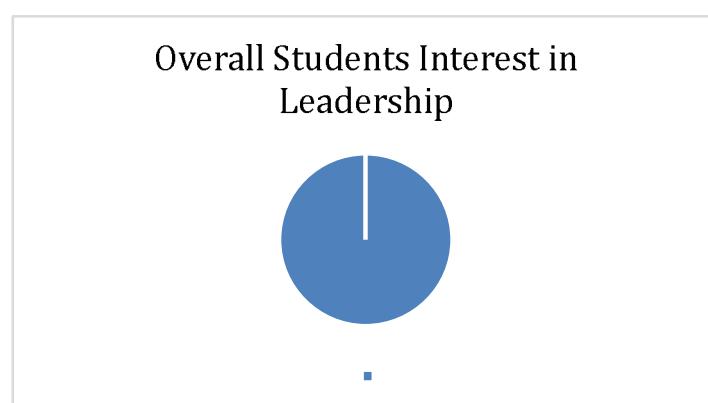


Figure 1 – Overall student Interest in Leadership

The more important implication is therefore structural. Student leadership can represent a bottom-up source of learner needs, implementation feedback and innovation ideas. Faculty leadership can connect those needs with pedagogy; departmental leadership can coordinate implementation; and institutional leadership can provide policy, resources, governance and strategic direction. The student survey does not empirically examine how these established leadership roles operate in technology-adoption decisions; such operational processes therefore require further empirical investigation.

8.2 Gender-Wise Leadership Interest

Gender	Total	Interested	Not Interested	Interest %
Male	490	209	281	42.7%
Female	187	94	93	50.3%
Total	677	303	374	44.8%

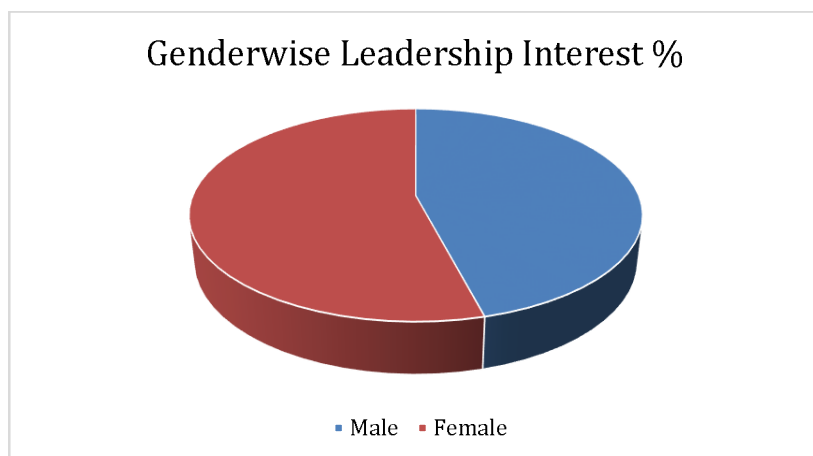


Figure 2 – Genderwise Leadership Interest %

Descriptively, 50.3% of female respondents expressed interest compared with 42.7% of male respondents. These values should not be interpreted as evidence of a statistically significant gender difference because inferential testing was not performed.

8.3 Branch-Wise Leadership Interest

Branch	Total	Interested	Not Interested	Interest %
CSE & AI	220	99	121	45.0%
CSE	97	34	63	35.1%
DS & AI	82	39	43	47.6%
ECE	79	43	36	54.4%
CSE DS	65	28	37	43.1%
IT	47	20	27	42.6%
CFIS	35	17	18	48.6%
BT	32	14	18	43.8%
BME	13	5	8	38.5%
MECH	4	2	2	50.0%
EEE	2	1	1	50.0%
CIVIL	1	1	0	100.0%

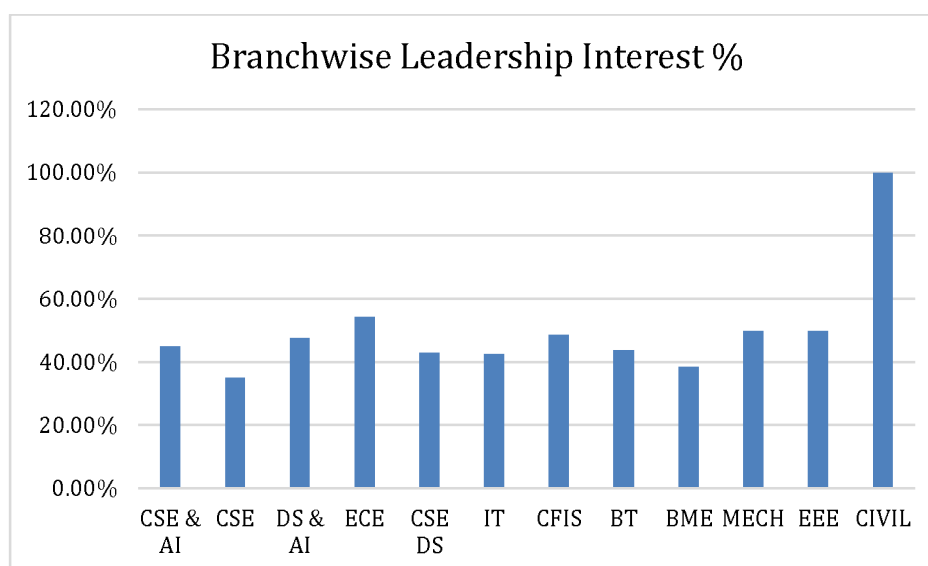


Figure 3 – Branchwise Leadership Interest %

The descriptive results show variation across branches. ECE recorded 54.4%, while CSE recorded 35.1%. Very small branch groups should not be interpreted independently because percentages based on extremely small samples can be unstable.

The present study should be understood as an initial empirical entry point into a broader multi-level research problem. The framework does not seek to establish that faculty, departmental or institutional officials are leaders; their leadership responsibilities are structurally embedded in higher-education governance. Responsible adoption therefore benefits from a two-way flow of information rather than a purely top-down model.

The below table shows responsible Technology Adoption Across Leadership Levels

Dimension	Student	Faculty	Department	Institution
Educational Value	Learner needs	Pedagogical value	Programme relevance	Institutional impact
Innovation Potential	Student ideas	New teaching practices	Academic innovation	Strategic innovation
Ethical Risk	User concerns	Classroom risks	Academic governance	Institutional governance
Stakeholder Interests	Student voice	Faculty needs	Department coordination	Institutional consultation
Institutional Readiness	Digital skills	Training	Infrastructure	Policy, finance and governance

The study makes three principal contributions. First, it integrates educational technology adoption with a multi-level leadership perspective rather than treating adoption as an isolated individual-use decision. Second, it connects classroom, digital and AI-enabled learning with parallel academic and extracurricular/co-curricular learning lines, emphasising coexistence rather than technological replacement. Third, it provides preliminary student-level empirical evidence and uses that evidence as a foundation for broader empirical examination of how established leadership roles operationalise responsible technology adoption across faculty, departmental and institutional levels.

as a foundation for broader validation of the proposed framework across faculty, departmental and institutional levels.

The study therefore contributes not by claiming a completed multi-level empirical model, but by defining a structured research problem and a framework through which subsequent empirical investigations can be conducted.

9. Practical Implications

Students can be provided with structured opportunities to participate in leadership, innovation and technology-related feedback.

The five-dimensional decision framework has not yet been empirically examined across all leadership levels, particularly with respect to how established leadership roles operationalise and balance these dimensions.

Departments can establish mechanisms for evaluating emerging technologies, collecting stakeholder feedback and coordinating implementation.

Future research should extend the study from the present student-level entry point to faculty, departmental and institutional levels. Separate instruments can be developed for students, faculty members, heads of departments, deans, academic administrators, technology coordinators and senior institutional leadership. The five dimensions can then be operationalised and compared across levels. This would directly address the present study's conceptual proposition without treating the existing student survey as evidence for higher-level decision-making.

Institutions can use pilot implementation and continuous evaluation before committing to large-scale adoption.

10. Conclusion

Emerging educational technologies are creating new opportunities for higher education, but responsible adoption requires more than identifying technologically capable tools. Institutions must consider educational value, innovation potential, ethical risk, stakeholder interests and institutional readiness while recognising that these considerations may compete with one another.

This study develops a multi-level perspective connecting these five dimensions with student, faculty, departmental and institutional leadership. It further places the decision-making process within an integrated learning ecosystem in which classroom-based, digital and AI-enabled learning coexist and complement one another, while academic and extracurricular/co-curricular activities provide parallel contexts for learning, application and leadership development.

The empirical evidence in the present study is intentionally limited to the student-leadership component. Among 677 respondents, 303 (44.8%) expressed interest in undertaking leadership roles. This finding provides preliminary evidence that student leadership represents a meaningful component of the proposed framework, but it does not validate the complete multi-level model.

The principal significance of the study is therefore its role as a foundation for broader investigation. By establishing a common framework and identifying the need to examine how educational value, innovation, ethics, stakeholder interests and institutional readiness are balanced across leadership levels, the study opens a pathway towards a more comprehensive empirical understanding of responsible educational technology adoption in higher education.

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Learner-Centred Approaches in Digital Education among B.Ed. Trainees

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Abstract

Learner-centred approaches have become increasingly important in digital education because they have learner centre of the teaching-learning process. Digital technologies provide to the B.Ed. trainees. The present paper examines the importance, characteristics and major forms of learner-centred approaches in digital education among B.Ed. trainees. These approaches help B.Ed. trainees develop critical thinking, creativity, communication, collaboration, digital literacy and independent learning skills. The paper also discusses the role of teacher educators in designing meaningful digital learning experiences and identifies challenges such as unequal access to technology, lack of digital competencies, Effective implementation of learner-centred digital education can contribute significantly to the professional development and academic achievement of B.Ed. trainees.

Keywords: Learner-centred learning, digital education, B.Ed. trainees, blended learning, digital literacy, collaborative learning, teacher education.

Learner-Centred Approaches in Digital Education among B.Ed. Trainees

Introduction

Digital technology has brought significant changes to the field of education. Traditional teacher-centred instruction is gradually being complemented by approaches that encourage learners to actively participate in constructing knowledge. Digital education provides a flexible environment in which learners can access educational resources at any time and from different locations for B.Ed. trainees, digital education is particularly significant because they are future teachers. They need not only subject knowledge and pedagogical knowledge but also the ability to integrate digital technologies effectively into classroom teaching. Learner-centred approaches provide opportunities for B.Ed. trainees to experience innovative teaching methods as learners and later apply them in their own classrooms.

Meaning of Learner-Centred Approach

A learner-centred approach is an educational approach in which the needs, interests, abilities, experiences and learning styles of learners are given importance. Instead of being passive recipients of information, learners actively participate in the learning process. In digital education, learner-centred learning can involve online discussions, interactive activities, digital projects, collaborative assignments, educational videos, simulations, quizzes and independent exploration of digital resources.

Digital Education and B.Ed. Trainees

Digital education refers to the use of digital technologies and resources to facilitate teaching and learning. B.Ed. trainees can use digital platforms to access learning materials, attend virtual classes, participate in discussions, complete assignments and receive feedback.

Digital education helps B.Ed. trainees:

- Develop digital teaching competencies.
- Access diverse learning resources.
- Learn at their own pace.
- Participate in collaborative activities.

- Develop independent learning skills.
- Practise digital assessment techniques.
- Understand innovative pedagogical practices.
- Prepare for technology-integrated classroom teaching.

Major Learner-Centred Approaches in Digital Education

❖ Blended Learning

Blended learning combines face-to-face teaching with online learning. B.Ed. trainees can attend classroom sessions and simultaneously use digital platforms for additional resources, assignments, discussions and assessments.

❖ Flipped Learning

In a flipped classroom, learners' study instructional materials such as videos, presentations or readings before attending the classroom session. Classroom time is then used for discussion, problem-solving, activities and application of knowledge.

❖ Collaborative Learning

Digital platforms allow B.Ed. trainees to work together on assignments, presentations and projects. Online discussion forums, shared documents and virtual meetings can facilitate peer learning and knowledge sharing.

❖ Problem-Based Learning

In problem-based learning, trainees are presented with authentic educational problems and encouraged to identify solutions. Digital resources can help them collect information, analyse evidence and present their solutions.

❖ Project-Based Learning

B.Ed trainees can undertake digital projects related to educational topics. They may prepare digital presentations, instructional videos, online learning materials or educational websites. This approach promotes creativity, research skills and practical application.

❖ Inquiry-Based Learning

Inquiry-based learning encourages trainees to ask questions, investigate problems, collect information and construct their own understanding. Digital resources provide access to a wide range of information that supports inquiry.

❖ Self-Directed Learning

Digital education supports self-directed learning by allowing trainees to select resources, manage their learning schedules and monitor their progress. Online courses and digital libraries can provide opportunities for continuous learning.

❖ Experiential Learning

Digital simulations, virtual laboratories, educational games and interactive activities can provide learning experiences that connect theory with practice. This is particularly useful for B.Ed. trainees who need opportunities to apply pedagogical concepts.

Role of the Teacher Educator

In learner-centred digital education, the teacher educator acts mainly as a facilitator, guide and mentor rather than simply transmitting information. The teacher educator should:

- Select appropriate digital resources.
- Design interactive learning activities.
- Encourage student participation.
- Provide timely feedback.
- Facilitate online discussions.
- Promote collaborative learning.
- Support trainees who face technological difficulties.

- Assess both learning processes and outcomes.
- Encourage ethical and responsible use of digital technology.

Benefits for B.Ed. Trainees

Learner-centred approaches in digital education can provide several benefits:

1. Active participation: Trainees become actively involved in learning activities.
2. Independent learning: Digital resources encourage trainees to learn independently.
3. Critical thinking: Problem-solving and inquiry activities promote analytical thinking.
4. Creativity: Digital projects allow trainees to develop innovative learning materials.
5. Collaboration: Online platforms facilitate interaction and peer learning.
6. Digital competency: Regular use of educational technologies improves digital skills.
7. Flexibility: Trainees can access learning resources according to their needs and schedules.
8. Personalised learning: Digital resources can support different learning needs and preferences.
9. Professional development: Trainees become familiar with technologies that they can later use in schools.

Learner-centred digital education faces several challenges:

- Unequal access to devices and reliable internet.
- Limited digital competencies among some trainees.
- Technical problems and connectivity issues.
- Lack of motivation for independent learning.
- Difficulty in maintaining meaningful interaction online.
- Inadequate digital learning resources.
- Distractions associated with digital devices.
- Concerns regarding privacy, academic integrity and responsible technology use.

Teacher education institutions therefore need to provide appropriate infrastructure, training and continuous technical support.

Suggestions for Effective Implementation

The following measures can strengthen learner-centred digital education among B.Ed. trainees:

- Provide regular digital competency training.
- Use a combination of online and face-to-face learning.
- Encourage collaborative digital projects.
- Provide accessible and high-quality learning resources.
- Use interactive assessments rather than relying only on examinations.
- Give regular and constructive feedback.
- Encourage trainees to create their own digital teaching materials.
- Promote digital citizenship and responsible technology use.
- Ensure accessibility for trainees with different learning needs.
- Provide adequate technological infrastructure and support.

Conclusion

Learner-centred approaches have considerable importance in the digital education of B.Ed. trainees. They transform trainees from passive recipients of information into active participants in the learning process. Approaches such as blended learning, flipped learning, collaborative learning, problem-based learning, project-based learning, inquiry-based learning

and self-directed learning can develop the knowledge, skills and attitudes required for effective teaching in the digital age. Since B.Ed. trainees are future educators, experiencing learner-centred digital learning can help them understand how technology can be integrated meaningfully into classroom practice. Effective teacher support, adequate infrastructure and continuous digital competency development are essential for successful implementation. Thus, learner-centred digital education can contribute significantly to the professional preparation of competent, creative and technologically proficient teachers.

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Automating Data Collection in the Introductory Physics Lab with the Raspberry Pi Pico

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Abstract

In Experimental Physics data taking is at the core of the experiment. While taking the data manually, helps the students in keenness of the observations and inculcate patience, it does not add to knowledge and consumes time. Time factor becomes significant, particularly in thermal experiments due to thermal response of the system, in achieving a specified temperature and when needed attaining steady state. Under such circumstances, automation of experiments is highly rewarding, releasing the time for the learner to focus on analysis and physics of the experiment, in this paper, our automation of measurements for the experiment on thermal diffusivity will be described. Our automation is implemented using very popular and inexpensive Raspberry pi Pico. Some aspects of the setup and physics will be discussed, including how we implemented thermal diffusivity measurements using thermistors and Raspberry pi Pico. Results obtained are presented in this paper. We have obtained a value of $0.28 \pm 0.01 \text{ cm}^2/\text{s}$ which compares very favorably with the literature value $0.3 \text{ cm}^2/\text{s}$. It will be emphasized that this is an apt example of automating the data collection process, leading to significant time savings, improving accuracy in experimental results and of immense educational value.

Keywords: laboratory automation; Raspberry Pi Pico; cognitive load; open-source instrumentation; physics education; thermal diffusivity; teacher professional development

1. Introduction

The laboratory is where physics is no more a set of statements moreover, a set of measurements. Reviews of practical work have nevertheless questioned how much of the learning laboratories are assumed to deliver actually occurs [1], and confirmatory laboratories appear to add little to conceptual understanding unless redesigned around reasoning rather than procedure [2]. With the National Education Policy 2020 placing experiential learning at the centre of Indian undergraduate science education [3], the question is practical for every physics department: given a fixed two-hour session, what is the student's time spent on?

In thermal experiments the answer is uncomfortable. The student spends much of the session waiting for a steady state, to take readings. Taking data by hand cultivates observation and patience, but transcription competes directly with the analysis and interpretation which the session must also accommodate. We automated that acquisition for thermal diffusivity by Angstrom's method using a Raspberry Pi Pico that logs to its own flash; thus using the time for learning physics rather than waiting for measurements.

2. Theoretical Framework

Cognitive load theory distinguishes the intrinsic load of the material, the extraneous load imposed by how the task is organised, and the germane load of constructing understanding [4]–[6]. Working memory is finite, so extraneous load displaces germane processing: clock-watching, reading two instruments in quick succession and copying numbers without error is a sustained demand unrelated to the physics under study.

What the learner does with the released capacity matters as much as the release. The ICAP framework orders engagement as passive, active, constructive and interactive, with gains rising along that order [7]. Copying a reading is active but not constructive, whereas fitting a decaying

sinusoid or arguing why lateral heat loss cancels are constructive. Automation moves the student up that ladder within the same session. TPACK [8] adds that an innovation demanding technological knowledge the teacher lacks will not be adopted, however sound its pedagogy, so software a teacher could run unmodified and adapt locally became a design constraint.

3. Methodology

In Angstrom's method [9] one end of a long rod is heated periodically and the thermal wave observed at two points, where it arrives attenuated and delayed. If the oscillation has angular frequency ω and the amplitudes and phases at two stations separated by Δx are A_1 , A_2 and ϕ_1 , ϕ_2 , the diffusivity is

$$\alpha = \omega (\Delta x)^2 / [2 \ln(A_1/A_2) \times (\phi_1 - \phi_2)] \quad (1)$$

Lateral heat loss affects attenuation and phase lag in opposite senses and cancels in the product, so no correction for radiation or convection is needed. The cost is that several heating cycles must be recorded with both stations read at closely spaced, accurately timed intervals manually, two thermometers across successive ten-minute cycles. The activity is clerical, and a single lapse corrupts the Fourier analysis.

4. The Automated System

Microcontroller platforms are well established in physics teaching [10], [11], with recent work extending them to distance laboratories [12] and using student-editable acquisition code to reduce the black-box character of instrumentation [13]. Here a single Raspberry Pi Pico is the whole measurement and control system (Figure 1). Two negative-temperature-coefficient thermistors clamped to the rod form the lower legs of 10 k Ω dividers across the 3.3 V rail, connected to GP26 and GP27, each decoupled by 100 nF; GP15 drives an opto-isolated relay module whose contacts switch the heater supply periodically. Thermistor non-linearity is handled in software, resistance being converted to temperature through the Steinhart–Hart equation, and the 12-bit converter is averaged sixteen times per reading to mask the differential non-linearity of the RP2040.

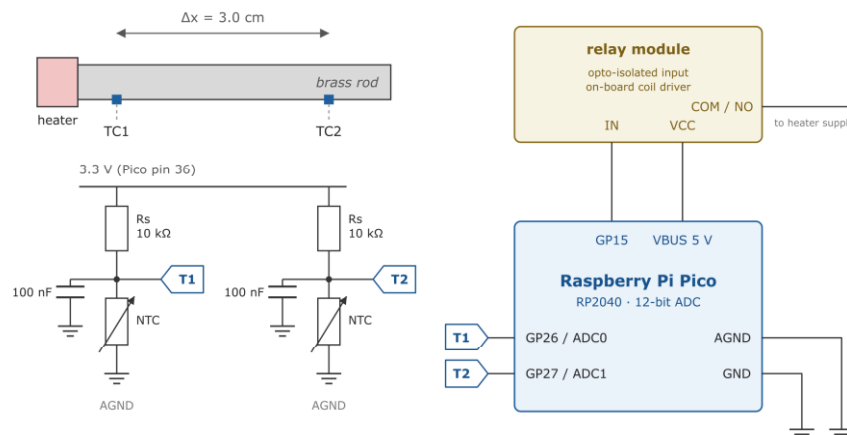


Figure 1. Front end. The two thermistor dividers run from the 3.3 V rail into GP26 and GP27; GP15 drives a relay module whose contacts switch the heater supply.

The firmware is a short MicroPython program saved as main.py, so it runs at power-up and can be read and edited on the board itself. Timing is non-blocking: the inputs are sampled every 5 s and the relay toggles every 300 s, giving a 600 s period, both held as named constants so that changing the driving period turns a fixed procedure into an investigable one. The Pico writes each run to its own filesystem as a plain CSV file, so acquisition needs no computer present and nothing is plotted while the run proceeds; the file is copied off afterwards and reduced through Equation (1). Because the record is plain text the reduction can be done in a spreadsheet or in a few lines of code, and every intermediate quantity stays visible to the student.

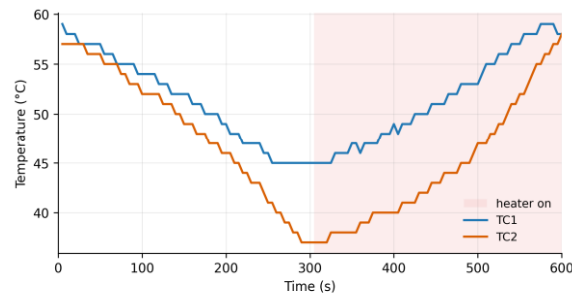


Figure 2. One 600 s cycle logged at 5 s intervals at the two thermistor stations, one of the four runs behind the reported value, recorded with the 10-bit predecessor of the front end described here.

5. Outcomes

Applied to a brass rod with the two stations 3.0 cm apart, and reducing each record over one 600 s period, the system gives $0.28 \pm 0.01 \text{ cm}^2/\text{s}$ the mean and standard deviation of four successive runs against the value of about $0.3 \text{ cm}^2/\text{s}$ commonly quoted for brass. The uncertainty is itself of pedagogical value. Since the acquisition is uniform and timestamped, repeat runs can be compared directly, and the scatter between them carries a meaning.

The shape of the session changes accordingly. Transcription, the dominant activity under the manual protocol, passes to the system; the waits through thermal transients become time for analysis; plotting and the Fourier reduction, routinely deferred to homework, are done in the session. Varying the driving period or the station separation becomes possible where it was not feasible earlier. Interpretation and error analysis becomes the principal activity in automated experiments.

The more interesting outcome is the possibility that can open up in the released time. Within one session a student can repeat the measurement at a different driving period and find the diffusivity unchanged while attenuation and phase lag both alter. Sensor separation can be varied and different rod materials can be compared which is constructive work in ICAP terms.

6. Discussion

One objection that comes up immediately is that automation takes away skill. But if we look closely, the student is still the one placing the thermistors, judging whether the contact is proper, and deciding when the oscillation has settled down. What has actually been removed is not the measurement, it is only the transcription.

Few design principles emerge here. To begin with, automate the clerical layer and leave the physical layer untouched. Then, pick sensors that the microcontroller can read on its own, without intermediate electronics. The instrument should also maintain its own record in an open format, so that no companion software is required to use it. Beyond that, keep the analysis inspectable rather than compiled, and expose the experimental parameters as named constants.

7. Conclusion

A standard Angstrom thermal-diffusivity experiment can be automated with a Raspberry Pi Pico, two thermistors and a relay module, logging to the board's own flash, reproducing the accepted diffusivity for brass consistent with commonly quoted values. The contribution we claim is automation of data acquisition as an instructional design decision, justified by the reduction of extraneous load and evaluated by what learners do with the time it returns.

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Student Engagement and Interactive Learning in the Digital Era: A Review and Technology-Enabled Framework

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Abstract

Student engagement is a multidimensional construct that strongly influences persistence, learning quality, academic achievement, and students' sense of belonging. The rapid adoption of learning management systems, mobile learning, gamification, learning analytics, adaptive platforms, virtual and augmented reality, and generative artificial intelligence has expanded the possibilities for interactive learning in higher education. However, technology availability alone does not guarantee meaningful engagement. This paper presents a structured narrative review of research on student engagement and interactive learning, with emphasis on technology-mediated higher education. The review synthesizes evidence concerning behavioral, cognitive, emotional, and social dimensions of engagement; active and collaborative learning; gamification; artificial intelligence; learning analytics; adaptive learning; and immersive technologies. A research gap is identified in the fragmentation between technology-specific studies and broader pedagogical models of engagement. To address this gap, the paper proposes a Technology-Enabled Interactive Learning Framework (TEILF) linking technology affordances to meaningful interaction, student engagement, learning experience, and learning outcomes, while treating teacher facilitation, learner characteristics, accessibility, equity, and ethical governance as cross-cutting conditions. The framework is intended to support educators and institutions in selecting technologies according to pedagogical purpose rather than novelty. The paper concludes with an implementation model and future research directions emphasizing longitudinal evidence, multimodal engagement measurement, responsible artificial intelligence, inclusive design, and discipline-specific evaluation.

Keywords: student engagement, interactive learning, higher education, educational technology, active learning, gamification, learning analytics, artificial intelligence, adaptive learning, immersive learning

1. Introduction

Higher education is undergoing a transition from predominantly content-delivery models toward learning environments in which students are expected to participate, collaborate, create, reflect, and solve authentic problems. Student engagement is central to this transition because learning is not determined only by exposure to instructional content, it is also shaped by the quality and intensity of students' behavioral, cognitive, emotional, and social participation. Engagement is therefore both an outcome of effective pedagogy and a mechanism through which learning occurs. Interactive learning extends this principle by deliberately creating opportunities for students to respond, discuss, investigate, practice, receive feedback, and apply concepts. Research on active learning has consistently challenged the assumption that extended passive listening is sufficient for deep learning. In science, technology, engineering, and mathematics, active learning has been associated with improved student performance and reduced failure rates compared with traditional lecturing [1], [2]. The ICAP framework further distinguishes passive, active, constructive, and

interactive cognitive engagement, suggesting that learning activities should progressively increase the cognitive work performed by learners [3].

Digital technologies have broadened the design space for such activities. Learning management systems enable asynchronous interaction; mobile devices support ubiquitous participation; gamification can introduce motivational structures; learning analytics can provide feedback; adaptive systems can personalize learning paths; immersive environments can support experiential learning; and generative artificial intelligence can provide conversational assistance and content generation. Systematic reviews, however, show that research remains fragmented, engagement is inconsistently defined and measured, and technology studies often focus on the tool rather than the pedagogical mechanism [4]–[7].

The central argument of this paper is therefore that educational technology should be evaluated through an engagement-oriented pedagogical lens. The objective is not to identify a single technology that produces engagement, but to establish a framework for aligning technology affordances, instructional design, interaction, student characteristics, and ethical conditions.

2. Review Approach and Research Questions

A structured narrative review approach was adopted rather than a full systematic review or meta-analysis. Peer-reviewed literature was identified from major scholarly publishers and indexing sources using combinations of terms such as student engagement, interactive learning, educational technology, higher education, gamification, learning analytics, adaptive learning, virtual reality, and artificial intelligence. Priority was given to systematic reviews, meta-analyses, and influential empirical or conceptual studies, with particular attention to evidence from 2018–2026. Foundational studies were retained where they provide widely used theoretical or pedagogical foundations.

Four research questions guided the synthesis: RQ1: What dimensions of student engagement are most relevant to interactive learning in higher education? RQ2: Which educational technologies provide strong opportunities for meaningful interaction and engagement? RQ3: What pedagogical, contextual, and ethical factors determine whether technology improves engagement? RQ4: How can these factors be integrated into a practical framework for technology-enabled interactive learning?

3. Student Engagement in Higher Education

Student engagement is commonly understood as multidimensional. Behavioral engagement concerns attendance, participation, effort, persistence, and completion of learning activities. Cognitive engagement concerns investment in understanding, self-regulation, critical thinking, and problem solving. Emotional engagement includes interest, enjoyment, belonging, and attitudes toward learning. Social engagement captures interaction with peers, instructors, and learning communities. Fredricks et al. established the widely used behavioral–emotional–cognitive model [8], while Kahu and Nelson positioned engagement at the educational interface where institutional and student factors interact [9].

Technology-mediated learning adds complexity because engagement can be visible through digital traces as well as direct observation or self-report. Henrie et al. noted the importance of combining

behavioral, affective, and cognitive measures rather than treating platform activity as a complete proxy for engagement [10]. Nkomo et al. similarly found substantial variation in definitions and measurement practices in research on engagement with digital technologies [5]. Consequently, a high number of clicks, logins, or discussion posts should not automatically be interpreted as meaningful learning.

Dimension	Typical indicators	Interactive learning mechanism	Potential evidence
Behavioral	Participation, effort, persistence	Quizzes, polls, simulations, tasks	Attendance, completion, activity logs
Cognitive	Elaboration, reasoning, problem solving	Case work, inquiry, peer instruction	Concept tests, solutions, reflective work
Emotional	Interest, enjoyment, belonging	Choice, feedback, authentic contexts	Surveys, interviews, sentiment indicators
Social	Dialogue, collaboration, co-construction	Discussion, peer review, group projects	Interaction networks, peer assessments

Table 1. Dimensions of student engagement and their relationship to interactive learning.

4. Interactive Learning and Educational Technology

4.1 Active and Collaborative Learning

Interactive learning is fundamentally pedagogical. Techniques such as think–pair–share, peer instruction, problem-based learning, project-based learning, collaborative design, formative questioning, and retrieval practice create opportunities for learners to perform cognitive work. Technology can scale these practices through live polling, shared digital workspaces, online discussion, automated feedback, simulation, and collaborative documents. Freeman et al.'s large-scale synthesis provides strong support for active learning in STEM, while Prince's review emphasizes the value of collaborative, cooperative, and problem-based approaches [1], [2].

4.2 Gamification and Game-Based Learning

Gamification introduces selected game elements such as points, badges, levels, challenges, progress indicators, feedback, and competition into non-game learning contexts. Systematic reviews and meta-analyses generally report positive effects, but the size and consistency of effects depend on design, learner characteristics, and the type of game element employed [11]–[13]. Recent work emphasizes tailoring game elements to learning objectives rather than simply adding rewards. Excessive competition or reward dependence may also shift attention from mastery toward extrinsic performance.

4.3 Learning Analytics and Adaptive Learning

Learning analytics can convert digital traces into information for learners and teachers. Dashboards may help identify students who require support, while predictive or descriptive analytics can support early intervention. Bergdahl et al. highlight the need to treat engagement in learning analytics as a multidimensional phenomenon rather than a single measurable variable [14]. Adaptive learning systems can adjust sequencing, difficulty, pacing, or feedback according to learner responses. Their value depends on the quality of personalization and on whether adaptation promotes productive cognitive effort rather than reducing challenge.

4.4 Artificial Intelligence and Generative AI

Artificial intelligence can support interactive learning through intelligent tutoring, automated feedback, recommendation, conversational agents, content generation, and learner analytics. Earlier reviews identified applications in assessment, profiling, prediction, intelligent tutoring, and adaptive systems [15]. Generative AI has expanded these possibilities by enabling dialogue-based explanation, brainstorming, coding assistance, simulation of alternative perspectives, and rapid formative feedback. Kasneci et al. describe substantial educational opportunities while also identifying concerns involving accuracy, bias, academic integrity, privacy, and over-reliance [16]. The educator therefore remains essential as a designer, verifier, facilitator, and ethical decision maker.

4.5 Virtual, Augmented, and Immersive Learning

Immersive technologies can support experiential learning where direct access to laboratories, industrial environments, hazardous processes, or rare phenomena is difficult. Virtual simulations allow students to manipulate variables and observe outcomes, while augmented environments can overlay contextual information on physical settings. Their strongest educational contribution occurs when immersion is connected to inquiry, reflection, feedback, and authentic tasks rather than used merely for visual novelty.

4.6 Mobile and Ubiquitous Learning

Mobile learning extends participation beyond the classroom and can support microlearning, field activities, instant polling, multimedia evidence collection, and location-independent collaboration. Its effectiveness depends on accessibility, connectivity, device availability, cognitive load, and purposeful activity design. Mobile access should therefore complement rather than replace inclusive institutional learning infrastructure.

4.7 Learning Management Systems and Digital Communities

Learning management systems remain the operational backbone of many technology-enabled courses. They provide content, assessments, discussion, announcements, feedback, and activity records. Their contribution to engagement is strongest when they are used as interaction environments rather than repositories of lecture files. Online participation theories emphasize that learning communities are formed through purposeful participation, dialogue, and shared meaning-making [17], [18].

5. Synthesis of Selected Literature

The literature suggests four broad conclusions. First, engagement is multidimensional and should not be reduced to platform activity. Second, active and interactive pedagogy is more fundamental than the technology itself. Third, technology affordances are most valuable when they increase meaningful cognitive and social interaction. Fourth, ethical, contextual, and human factors influence whether technological affordances translate into desirable outcomes.

Evidence area	Key finding	Implication	Representative sources
Engagement research	Definitions and measures vary substantially	Use multidimensional constructs and mixed evidence	[4], [5], [10]
Active learning	Participation and cognitive activity improve learning in STEM	Design interaction before selecting tools	[1]–[3]
Gamification	Generally positive but design-dependent effects	Align game elements with mastery objectives	[11]–[13]
AI in education	High potential with significant ethical and pedagogical risks	Keep human oversight and verification	[15], [16]
Learning analytics	Digital traces can support intervention but are incomplete proxies	Combine analytics with contextual evidence	[14]
Online learning	Participation and community are central	Design sustained dialogue and collaboration	[17], [18]

Table 2. Synthesis of selected literature and implications for interactive learning.

6. Proposed Technology-Enabled Interactive Learning Framework (TEILF)

Based on the synthesis, this paper proposes the Technology-Enabled Interactive Learning Framework (TEILF). The framework positions technology as an enabler rather than the primary driver of engagement. The central pathway is: Technology Affordance → Meaningful Interaction → Student Engagement → Learning Experience → Learning Outcome. Four cross-cutting conditions operate across the pathway: teacher facilitation, learner characteristics, accessibility and equity, and ethical governance.

Technology Affordance	Meaningful Interaction	Student Engagement	Learning Experience	Learning Outcome
AI / LMS / analytics / gamification / VR / mobile	Questioning / practice / collaboration / feedback	Behavioral / cognitive / emotional / social	Agency / relevance / reflection / confidence	Knowledge / skills / transfer / retention

Figure 1. Central pathway of the Technology-Enabled Interactive Learning Framework (TEILF). The first stage concerns affordances: what a technology makes possible. The second concerns interaction: whether learners actually use the affordance to perform meaningful actions. The third concerns engagement: the quality and intensity of behavioral, cognitive, emotional, and social participation. The fourth concerns the learning experience, including relevance, agency, feedback, reflection, and confidence. The final stage concerns learning outcomes, including knowledge acquisition, skills, transfer, retention, and problem-solving capability. Teacher facilitation is critical throughout the pathway. The teacher determines learning objectives, activity structure, prompts, feedback, grouping, assessment, and intervention. Learner

characteristics such as prior knowledge, motivation, digital literacy, self-regulation, and accessibility needs influence how technology is experienced. Accessibility and equity require attention to devices, connectivity, language, disability, cost, and alternative participation routes. Ethical governance includes privacy, transparency, bias mitigation, academic integrity, informed use of AI, and human oversight.

The framework therefore supports a simple design question for educators: What learning interaction do I want students to perform, and which technology provides the most appropriate support for that interaction? This reverses technology-first adoption and places pedagogy at the center.

7. Pedagogical and Ethical Challenges

Technology-mediated engagement has several limitations. The first is the engagement illusion: students may report feeling engaged or may generate visible activity without achieving deep learning. Deslauriers et al. demonstrated that students can perceive traditional instruction as producing more learning even when active-learning approaches produce greater actual learning [19]. Assessment must therefore distinguish engagement from learning.

The second challenge is cognitive overload and distraction. Multiple applications, notifications, interfaces, and multimedia elements can increase extraneous cognitive demand. Interactive learning should consequently use technology selectively and maintain a clear relationship between each digital activity and the intended learning outcome.

Third, unequal access can create an engagement divide. Students may differ in device quality, connectivity, digital literacy, language proficiency, and home learning environments. Institutions should provide accessible alternatives and avoid making expensive or high-bandwidth tools mandatory unless equivalent access is assured.

Fourth, analytics and AI introduce privacy, surveillance, bias, and transparency concerns. Student data should be collected for legitimate educational purposes, minimized, protected, and interpreted cautiously. Generative AI additionally creates risks of hallucinated information, inappropriate dependence, plagiarism, and reduced independent thinking. UNESCO's guidance emphasizes human-centered, safe, equitable, and responsible use of generative AI in education [20].

8. Recommended Implementation Model for Higher Education

A practical implementation model can be organized into six steps. Step 1—Define the learning outcome: specify the knowledge, skill, competency, or higher-order thinking target. Step 2—Define the desired interaction: decide whether students should explain, debate, design, simulate, practice, collaborate, critique, or reflect. Step 3—Select the minimum effective technology: choose the simplest technology that meaningfully supports the interaction. Step 4—Build feedback loops: provide rapid formative feedback through peers, instructors, simulations, analytics, or AI-assisted tools with verification. Step 5—Measure engagement and learning separately: combine participation evidence with assessments, observations, surveys, and student work. Step 6—Review inclusion and ethics: evaluate accessibility, privacy, workload, academic integrity, and unintended consequences.

For engineering education, the model can be implemented through virtual laboratories, FPGA/HDL simulations, collaborative design reviews, AI-assisted debugging with verification, industry case studies, digital twins, project-based learning, and low-cost mobile formative assessment. A useful course-level dashboard should therefore combine activity indicators with learning evidence instead of ranking students merely by the number of interactions.

9. Future Research Directions

Future studies should move beyond short-term technology evaluations toward longitudinal investigations of engagement and learning. Multimodal measurement combining self-report, classroom observation, learning analytics, assessment results, and student artifacts can provide a more robust picture. Research should also investigate how AI changes teacher roles, student agency, metacognition, and assessment practices.

Additional priorities include culturally responsive engagement models, inclusive design for students with disabilities, low-resource and low-bandwidth environments, discipline-specific frameworks for engineering and professional education, explainable adaptive learning, and ethical governance of learner data. Comparative research should examine not only whether a technology works, but for whom, under what pedagogical conditions, at what cost, and with what unintended effects.

10. Conclusion

Student engagement and interactive learning are inseparable from the quality of the educational experience in the digital era. The literature indicates that technology can expand opportunities for participation, personalization, collaboration, feedback, and experiential learning, but technology alone does not create engagement. Meaningful interaction, thoughtful instructional design, teacher facilitation, learner characteristics, accessibility, and ethical governance determine whether technological affordances translate into learning.

The proposed TEILF framework provides a practical way to connect technology choice with interaction, engagement, learning experience, and outcomes. Its principal contribution is a shift from technology-centered adoption toward pedagogy-centered design. For higher education institutions, particularly engineering institutions, this approach can support evidence-based integration of AI, analytics, gamification, simulation, immersive technologies, and collaborative platforms while preserving the central role of educators and learners.

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Teacher Professional Development: An Overview

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Abstract:

Professional development is a way for people and groups to broaden and/or enhance their pedagogical and subject knowledge. Formal lectures, seminars, and workshops are commonly referred to for professional development, which is sometimes abbreviated as PD. A teacher uses to improve his knowledge of teaching and further his career in education through professional development. Examples include attending conferences relevant to teaching and enrolling in online courses. Professional development can be pursued freely and occasion through funded programmes at the school, district, and state levels. In majority of the time, professional development for teachers focuses on introducing new methodologies, innovative techniques and procedures based on cutting-edge research, as well as implementation strategies. Pre-service and in-service teacher training programmes are the two main categories for teacher training programmes in India. Generally speaking, in-service training programmes for teachers are regarded as programmes for teacher professional development. This aspect of in-service teacher education was emphasized in many policy texts. In addition, "school complexes" will help with a nodal school in charge for all teachers' ongoing professional development, according to the Education Commission's (1964- 66) recommendation. As a result of these proposals, State Institutes of Education have been established in a number of States. According to the "Teacher and Society" report of the National Commission of Teachers-I (1983–1985), every teacher should participate in in-service training for three weeks once every five years and that it should be connected to career advancement. "Teacher education is a continuous process, and its pre-service and in-service components are interrelated," the National Policy of Education (NPE 1986/92) said explicitly. Numerous measures were suggested in the National Curriculum Framework for Teacher Education-2009 to improve in-service teacher education as a tool for professional growth. Index Terms - Professional development, Pre-service Teacher Training, In-Service Training.

Index Terms - Professional development, Pre-service Teacher Training, In-Service Training

Introduction

Every person's life is dynamically influenced by education, which has an impact on his or her physical, mental, emotional, social, and ethical growth. "The educational process is a constant process of adjustment, having as its main goals" every stage of development and additional capability for expansion is its goals. "Education involves reconstruction (or) restructuring of experience that adds to experience's meaning and that increases ability to affect the direction of following experiences," said Albert Camus. The third five-year plan for India highlights the importance of education in the following sentences. Education is the single most significant ingredient in achieving rapid economic growth and technical advancement, as well as in building a social order based on the principles of liberty, social fairness, and equality of opportunity. Education's objective is to mould people.

The paper starts by introducing the theoretical foundation that underpins this study. Thereafter, background information of teacher professional development is presented, its

definition and importance. The study then presents 21st Century skills. The following part discusses 21st Century skills teachers need to adopt. The last section is about teacher professional development in the 21st Century.

1. Focus on valued student outcomes

An important factor influencing whether professional learning activities have a positive impact on outcomes for students is the extent to which those outcomes form the rationale for, and ongoing focus of, teacher engagement. Such a focus requires teachers to understand the links between particular teaching activities, the ways different groups of students respond, and what their students actually learn. Further, success needs to be defined not in terms of teacher mastery of new strategies but in terms of the impact that changed practice has on valued outcomes. Because teachers work in such varied contexts, there can be no guarantee that any specific approach to teaching will have the desired outcomes for students. For this reason, it is important to keep progress towards the valued outcomes constantly in view. Professional learning opportunities that have little impact on student outcomes typically focus on mastery of specific teaching skills without checking whether the use of those skills has the desired effect on students. Outcomes and expectations Targeted outcomes for students may be relatively narrow, typically involving the learning of specific knowledge and skills. They also may be broad: comprehending text, learning how to learn, developing collaborative skills, or improving well-being. Whether narrow or broad, they must be clear to the teachers engaging in professional learning experiences. Otherwise, the teachers' engagement is not likely to make a difference for their students. Higher teacher expectations of students come from Professional learning experiences that focus on the links between particular teaching activities and valued student outcomes are associated with positive impacts on those outcomes. As they take more responsibility, and as they discover that their new professional knowledge and practice are having a positive impact on their students, they begin to feel more effective as teachers. Linking student learning issues to an expectation that teachers will address them is likely; however, to lead to blaming and a lack of learning unless teachers are confident that they will be given the support they need to develop more effective practices.

2. Worthwhile content

The popularity of particular professional development programmes is not necessarily matched by their impact on students. Professional knowledge and skills that do have a positive impact on student outcomes are consistent with evidence-based principles of teaching effectiveness. Some ineffective professional learning approaches also have been justified on the basis of "research" or "policy", but not research or policy that has been adopted by a professional body or that forms part of a wider programme of research and development. Fixed programmes versus context-specific approaches in some educational jurisdictions, professional development takes the form of fixed programmes designed to develop particular knowledge and skills that have been identified as effective. Context-specific approaches promote teaching practices that are consistent with the principles of effective teaching but also systematically assist teachers to translate those principles into locally adapted applications. By developing this kind of knowledge teachers can better solve identified issues about student outcomes in their particular teaching situations.

3. Integration of knowledge and skills

This principle is central to meaningful change. To establish a firm foundation for improved student outcomes, teachers must integrate their knowledge about the curriculum, and about how to teach it effectively and how to assess whether students have learned it. Teachers need knowledge and skills in assessment to maintain a student focus: the ability to identify exactly what students know and can do is a prerequisite for teaching that is responsive to each student's needs. But teachers cannot develop their assessment knowledge in isolation from their knowledge of pedagogical content, which is also vital as they focus their teaching on meeting the student needs they identify. Integrating theory and practice Theory and practice also need to be integrated. In effective professional development, theories of curriculum, effective teaching, and assessment are developed alongside their applications to practice. This integration allows teachers to use their theoretical understandings as the basis for making ongoing, principled decisions about practice. A skills-only focus does not develop the deep understandings teachers need if they are to change practice in ways that flexibly meet the complex demands of everyday teaching. In fact, without a thorough understanding of the theory, teachers are apt to believe they are teaching in ways consistent with the promoted practice when in fact the relationship between theory and practice is actually very superficial—and any changes they make have little impact on student outcomes.

4. Assessment for professional inquiry

To engage in professional inquiry that makes a difference for students, teachers need to learn how to identify the pedagogical content knowledge and skills they need to assist their students to achieve the valued outcomes. For professional inquiry to have an impact on outcomes, these elements are crucial. Teachers need sophisticated assessment skills if they are to identify

- (i) what their students know and can do in relation to valued outcomes and
- (ii) what further learning they themselves need if they are to assist their students in learning.

Assessment of this kind cannot take place outside of the teaching–learning process—it is integral to it. Teachers, therefore, need a variety of ways of assessing their students' progress, ways that include, but go beyond, standardised testing. These include interviews with students about their learning, systematic analysis of student work, and classroom observations. Developing self-regulatory learning skills It is essential that teachers learn how to identify the needs of their students and their own professional learning needs, but this is not the whole story. Teachers also need to develop the self-regulatory skills that will enable them to monitor and reflect on the effectiveness of changes they make to their practice. Prescribing sets of desirable behaviours or leaving teachers to develop better practice in the absence of clearly defined goals do not support the development of self-regulation. Indeed, traditional conceptions of assessment are not conducive to self-regulated inquiry: teachers are unlikely to participate in an inquiry process in an open and meaningful way if a less-than-desirable outcome puts their job, pay, or reputation at risk.

5. Multiple opportunities to learn and apply information

Changing practice and developing the skills of professional inquiry require in-depth understanding. For this reason, teachers need multiple opportunities to absorb new information and translate it into practice. Learning is cyclical rather than linear, so teachers need to be able to revisit partially understood ideas as they try them out in their everyday contexts. For substantive learning, such as that involved in improving their students' reading comprehension, mathematical problem solving, or scientific reasoning, teachers need extended time in which to learn and change. In such cases, it typically takes one to two years for teachers to understand how existing beliefs

and practices are different from those being promoted, to build the required pedagogical content knowledge, and to change practice. Given that teachers engaged in professional learning are simultaneously maintaining a teaching workload, and that many of their existing assumptions about effective practice are being challenged, it is not surprising that so much time is required. Time, however, is not a sufficient condition for change: teachers also need to have their current practice challenged and to be supported as they make changes. In the case of teachers' professional learning, participation is sometimes made voluntary as a way to minimise this problem. The circumstances that initially lead to participation bear a complex relationship to further engagement.

6. Approaches responsive to learning processes

Teachers are diverse in their understandings and assumptions about students and how they learn, what counts as valued knowledge, and how best to teach it. How these understandings and assumptions shape teachers' responses to new information depends on the extent to which they are consistent with, or dissonant from, the understandings that underpin the new knowledge and skills to be learned. Professional learning approaches that focus primarily on building new knowledge and skills are suitable when teachers' existing understandings are congruent with the new information and therefore can be integrated readily into their existing practice. But when teachers' personal theories about students, valued curricula, and effective teaching practices differ from those being promoted in the professional learning, a different approach is needed. In the case of mathematics and science, for example, existing curricula usually emphasise computational and factual knowledge while new curricula typically emphasise reasoning and problem-solving skills. This kind of change involves more than learning new knowledge and skills. It requires that teachers understand both the limitations of the current emphasis and the new ways of deciding what knowledge is valued. Change appears to be promoted by a cyclical process in which teachers have their current assumptions challenged by the demonstration of effective alternative practice, develop new knowledge and skills, make small changes to practice, and observe resulting improvements in student outcomes.

7. Opportunities to process new learning with others

Collegial communities have been promoted as a means of improving teaching, but research typically reveals only a weak relationship between participation in such communities and improved student outcomes. Yet findings from many studies suggest that participation in a professional community with one's colleagues is an integral part of professional learning that impacts positively on students. The resolution of this apparent contradiction appears to be that if teachers are to change, they need to participate in a professional learning community that is focused on becoming responsive to students, because such a community gives teachers opportunities to process new information while helping them keep their eyes on the goal. As is the case for all other areas of professional learning, the effectiveness of collegial interaction needs to be assessed in terms of its focus on the relationship between teaching practice and student outcomes.

8. Knowledgeable expertise

The engagement of expertise external to the group of participating teachers is necessary because substantive new learning requires teachers to understand new content, learn new skills, and think about their existing practice in new ways. Existing assumptions about curriculum or about what particular groups of students are able to learn can prevent teachers from examining how effective their own practice is in promoting student learning. External experts need to be able

to challenge assumptions and present teachers with new possibilities; challenge the social norms by which collegial groups operate, wherever these norms constrain professional learning; and keep the focus on students and their learning. Some professional developers treat teachers as technicians who can be taught a new set of behaviours and then be expected to implement them. This approach ignores the complexity of teaching and disregards the need for teachers to be responsive to the learning needs of their students.

9. Active leadership

In most educational jurisdictions, designated leaders have responsibility for promoting professional learning and development opportunities for teachers. Effective professional development may take place outside the school environment, but if it is site-based, it is important that leaders are actively involved. A vision of this kind can serve as a powerful catalyst for teachers to engage in new learning and to formulate specific goals for their learning. Establishing a vision in which new things are possible is best done through everyday activities, not decontextualized pronouncements. For example, the use of success stories to embed high teacher expectations of students is likely to contribute as much to the development of an alternative vision as the setting of targets or goals. One of the most powerful means of gaining teacher commitment is to provide proof, obtained through monitoring, of improved student progress towards identified goals. Professional development led by outside experts has limitations because these experts are not present in the school on a continuing basis. This means that it falls to site-based leaders to help teachers translate their new understandings into practice and to sustain the professional inquiry process.

10. Maintaining momentum

Regrettably, most efforts to improve student outcomes through professional learning and development are short-lived. For improvement to be sustained, short-term perspectives need to be extended to more distant horizons. The professional learning experience a sustained improvement in student outcomes depends firstly on teachers developing strong theoretical frameworks that provide them with a basis for making principled changes to practice in response to student needs. Teachers with these crucial self-regulatory skills are able to answer three vital questions: “Where am I going?”, “How am I doing?”, and “Where to next?” The answer to the “Where am I going?” question is sometimes referenced explicitly to national or state standards; more often it is found in, for example, improvements in students’ mathematical problem solving or text comprehension. The answer to the question, “How am I doing?” is a measure of how effective teaching is in terms of student progress. The answer to the “Where to next?” question is guided by a detailed and theoretically sophisticated knowledge of curriculum content and student progressions.

Conclusion

The ten principles discussed above do not operate independently; rather, they are integrated to inform cycles of learning and action. Given the varied contexts in which they work, there can be no guarantee that any specific activity will have the anticipated result. Once the experts withdraw their support, teachers need to be able to determine for themselves the effectiveness of their actions. For this reason, the extent to which they develop self-regulatory skills is one of the most powerful determinants of ongoing improvement.

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Teacher Professional Development

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Abstract:

Teacher Professional Development is an essential process for improving the knowledge, skills, attitudes, and professional competencies of teachers. In the changing educational environment, teachers are expected to adopt innovative teaching methods, digital technologies, inclusive practices, and learner-centred approaches. Professional development enables teachers to continuously update their subject knowledge, understand students' psychological and individual differences, and respond effectively to diverse learning needs. It includes various activities such as workshops, seminars, conferences, training programmes, peer learning, mentoring, action research, online courses, and reflective teaching practices. Effective professional development also helps teachers develop classroom management skills, communication skills, assessment competencies, technological skills, and professional ethics. A professionally competent teacher can create a positive learning environment and contribute to students' academic, emotional, and social development.

Keywords: Teacher Professional Development, Teacher Competency, Professional Ethics, Continuous Learning, Innovative Teaching, Teacher Education.

Introduction:

Teacher Professional Development is a continuous process of improving teachers' knowledge, skills, attitudes, competencies, and professional practices. In the modern educational environment, teachers are expected to respond to changing curricula, new technologies, diverse student needs, and emerging educational challenges. Therefore, professional development is essential for teachers to remain effective and confident in their profession. Professional development helps teachers improve their teaching methods, classroom management skills, understanding of student psychology, assessment techniques, ICT and AI competencies, communication skills, and professional ethics. It may take place through workshops, seminars, conferences, training programmes, mentoring, peer learning, action research, online courses, and reflective practices. A professionally developed teacher is not merely a transmitter of knowledge but also acts as a facilitator, mentor, guide, researcher, and role model. Continuous professional learning enables teachers to adopt innovative and learner-centred approaches and create a positive classroom environment. Thus, Teacher Professional Development plays a vital role in improving teacher competency, enhancing student learning, and ensuring the overall quality of education. It should be viewed as a lifelong process that supports both the professional growth of teachers and the holistic development of learners.

Meaning of Teacher Profession Development:

Teacher Professional Development is a continuous and systematic process of learning and improving the professional knowledge, skills, attitudes, and competencies of teachers to enhance the quality of teaching and students' learning.

Needs and Importance:

1. Needs of Teacher Professional Development

Teacher Professional Development is needed to help teachers continuously improve their professional knowledge, skills, and effectiveness.

Major needs include:

1. Updating subject knowledge – Teachers need to keep their knowledge current with new developments in their subjects.
2. Using educational technology – Professional development enables teachers to use ICT, digital tools, AI, and online learning resources effectively.
3. Managing diverse classrooms – It prepares teachers to support learners with different abilities, backgrounds, and learning needs.
4. Developing professional ethics – It promotes responsibility, honesty, fairness, respect, and commitment to the teaching profession.
5. Adapting to curriculum changes – Teachers need continuous training to implement new curricula and educational policies.
6. Promoting lifelong learning – It encourages teachers to become continuous learners and reflective practitioners.

2. Importance of Teacher Professional Development

1. Enhances teacher competency – Improves teachers' knowledge, skills, and confidence.
2. Improves quality of teaching – Helps teachers provide effective and learner-centred instruction.
3. Improves student learning – Better teaching practices contribute to better student achievement and development.
4. Promotes innovative teaching – Encourages creative methods, activities, projects, and technology-based learning.
5. Develops classroom management skills – Helps teachers create a positive and disciplined learning environment.
6. Strengthens professional ethics – Develops responsible and ethical professional behaviour.
7. Builds teacher confidence – Training and continuous learning increase teachers' confidence in handling classroom challenges.

Teacher Professional Competency

1. Subject Knowledge – Strong and updated knowledge of the subject.
2. Pedagogical Skills – Ability to use appropriate teaching-learning methods.
3. Lesson Planning – Ability to prepare effective lesson plans and learning activities.
4. Classroom Management – Maintaining a positive, safe, and effective learning environment.
5. Student Psychology – Understanding students' needs, interests, abilities, emotions, and individual differences.
6. Communication Skills – Communicating clearly and effectively with students, parents, and colleagues.
7. Assessment Competency – Using appropriate assessment and evaluation techniques.
8. ICT Competency – Using digital tools and technology to improve teaching and learning.
9. Inclusive Teaching – Supporting learners with diverse abilities and learning needs.

10. Professional Ethics – Demonstrating honesty, fairness, responsibility, respect, and commitment.
11. Reflective Practice – Evaluating one's own teaching and identifying areas for improvement.

Understanding Student Psychology:

1. Understanding individual differences – Students differ in their abilities, interests, learning styles, and personalities.
2. Understanding emotions – Teachers can identify students' emotional needs and provide appropriate support.
3. Improving motivation – Knowledge of psychology helps teachers motivate students to participate actively in learning.
4. Developing positive relationships – Psychological understanding helps teachers build trust and good relationships with students.
5. Supporting social development – Teachers can encourage cooperation, communication, empathy, and positive peer relationships.
6. Improving learning outcomes – When teaching responds to students' psychological needs, engagement and learning can improve.

Teaching and Classroom Management Skills

1. Teaching Skills

1. Lesson Planning – Preparing clear objectives, content, activities, and assessment.
2. Communication Skills – Explaining concepts clearly using appropriate language.
3. Questioning Skills – Asking meaningful questions to develop students' thinking.
4. Teaching Methods – Using suitable methods such as discussion, demonstration, project work, and collaborative learning.
5. Use of Teaching Aids – Using charts, models, multimedia, ICT, and digital resources effectively.
6. Assessment Skills – Evaluating students' knowledge, skills, and progress.
7. Feedback Skills – Giving constructive feedback to improve student learning.

2. Classroom Management Skills

1. Maintaining Discipline – Establishing clear and fair classroom rules.
2. Time Management – Using classroom time effectively.
3. Creating a Positive Environment – Developing a respectful and supportive classroom atmosphere.
4. Building Teacher–Student Relationships – Developing trust, respect, and cooperation.
5. Managing Diverse Learners – Responding to different abilities, backgrounds, and learning needs.
6. Encouraging Participation – Giving every student opportunities to participate.

Developing ICT and AI Skills in Education

1. Digital Teaching Skills – Teachers learn to use computers, smart boards, presentations, online platforms, and digital learning resources.
2. AI-Based Teaching – Teachers can use AI tools to support lesson planning, content creation, assessment, and personalized learning.

3. Online Learning – ICT helps teachers conduct virtual classes and provide digital learning materials.
4. Interactive Learning – Multimedia, educational apps, videos, and simulations make learning more engaging.
5. Personalized Learning – AI can help identify learners' needs and provide suitable learning support.
6. Digital Assessment – Teachers can use online quizzes, digital assignments, and technology-supported assessment.
7. Research and Information Skills – ICT helps teachers and students search, organize, analyse, and communicate information.
8. Digital Literacy – Teachers should develop skills to evaluate online information and use digital resources effectively.
9. Ethical Use of AI – Teachers should teach students about responsible AI use, privacy, plagiarism, bias, and academic integrity.
10. Continuous Professional Development – Teachers need regular training to keep pace with rapidly developing ICT and AI technologies.

Professional Ethics in Teaching

1. Respect for Students – Treat every student with dignity, respect, and care.
2. Fairness and Equality – Treat students equally without discrimination or favouritism.
3. Honesty and Integrity – Maintain truthfulness in teaching, assessment, and professional responsibilities.
4. Professional Responsibility – Perform teaching duties sincerely and responsibly.
5. Role Model Behaviour – Demonstrate good character, discipline, empathy, and responsibility.

Challenges and Strategies in Teacher Professional Development

A. Challenges

1. Lack of time – Teachers may have limited time for training and professional learning.
2. Heavy workload – Administrative and teaching responsibilities can reduce opportunities for development.
3. Technological challenges – Some teachers may lack adequate ICT and AI skills.
4. Lack of continuous training – Occasional training programmes may not be sufficient for professional growth.
5. Different student needs – Diverse abilities, learning styles, and backgrounds make classroom teaching challenging.
6. Classroom management difficulties – Managing student behaviour and maintaining engagement can be challenging.
7. Professional stress – Work pressure and multiple responsibilities can affect teachers' motivation.

B. Strategies

1. Continuous professional development programmes – Conduct regular workshops, seminars, training, and refresher courses.
2. ICT and AI training – Provide practical training in digital tools and responsible AI use.
3. Peer learning – Encourage teachers to share knowledge, experiences, and effective teaching practices.

4. Time management – Provide dedicated time for professional learning and reflection.
5. Collaborative learning – Promote teamwork, professional learning communities, and departmental discussions.
6. Institutional support – Educational institutions should provide resources, encouragement, and opportunities for professional growth.

CONCLUSION

Teacher Professional Development is a continuous and essential process for improving the quality and effectiveness of the teaching profession. A professionally teacher should continuously update subject knowledge, teaching skills, developed classroom management abilities, ICT and AI competencies, and understanding of student psychology. Professional development also promotes professional ethics, reflective practice, innovation, and lifelong learning. Although teachers face challenges such as workload, limited resources, technological changes, and diverse student needs, these can be addressed through regular training, workshops, mentoring, collaboration, action research, and institutional support. An effective teacher is not only a provider of knowledge but also a lifelong learner, guide, facilitator, and role model who contributes to the holistic development of students and the overall quality of education.

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Innovations in Teacher Professional Development and Emerging Educational Technology for the AI-Driven Classroom

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Abstract

Artificial intelligence (AI) is entering schools faster than teacher-preparation systems can adapt to instruct teachers on AI applications. Reviews of research on AI in education report that researchers are primarily focused on AI applications for students rather than the professional learning for teachers to use those AI applications effectively and ethically. A narrative review of the literature provides a synthesis of selective recent research between 2018 and 2026 on teacher professional development for AI classrooms from Scopus, Web of Science, ERIC, ScienceDirect (Elsevier), and Springer Nature. The narrative review methodology was preferred due to the embryonic nature, fluid terminology, and dispersed topics of research in teacher education, learning analytics, and human-computer interaction. Four themes are addressed: AI literacy and competency frameworks; TPACK extensions to address AI-specific and ethical knowledge; new technologies supporting teacher professional development; and trust, infrastructure, and policies. The review concludes with a call for more evidence to complement the many frameworks found in the literature, and four gaps are identified.

Keywords: *teacher professional development; artificial intelligence in education; AI literacy; Intelligent-TPACK; generative AI*

1. Introduction

Artificial intelligence has rapidly transitioned from a niche area of research into an integral part of classroom instruction. In a seminal, systematized review of artificial intelligence in higher education, Zawacki-Richter et al. (2019) commented on the absence of instructors in the research domain, noting the majority of authors were from computer science fields and few studies referenced pedagogical theory. This gap has reduced but not disappeared. A recent PRISMA review of 95 studies from 2015 to 2024 reported nearly two-thirds of the studies focused on the use of AI tools for teaching and less than one-third were about teachers, resulting in an imbalance between the supply and demand of professional development in AI applications (Tan et al., 2025).

The implications of the imbalance became more pronounced as large language models emerged for public use. Kasneci et al. (2023) emphasized that the benefits of such tools in education come with risks of bias, inaccuracy, and overuse, with the responsible actions of teachers being the foremost mitigations. Policy et al. has reflected this need, with UNESCO's newly released AI Competency Framework for Teachers outlining fifteen competencies in five areas — human-centred mindset, ethics of AI, AI foundations and applications, AI pedagogy, and AI for professional learning— at three levels of progression (Miao & Cukurova, 2024; Bai, 2025). But frameworks are not professional development. This review explores how the literature on AI and other educational technology is conceptualizing, providing, and proving professional development for AI-supported classrooms, and the implications thereof.

2. Review Methodology

To clarify, this is a narrative (i.e., an interpretive) review and not a systematic review or meta-analysis. A narrative review, unlike a systematic review, does not claim to be comprehensive, does not calculate effect sizes, and does not control selection bias by using a protocol. The reason we use narrative review here is that the construct of teacher competence for AI-mediated instruction in the two literatures is dissimilar, so a systematic review protocol based on keywords would lead to a much more limited set that is less comparable. Nevertheless, we provide a description of the search strategy below for the sake of transparency.

The search was primarily conducted using the databases Scopus, Web of Science, ERIC, ScienceDirect (Elsevier), Springer Nature Link, and Taylor & Francis Online, while backward and forward search was conducted on the most-cited papers on the framework, and I also searched for relevant policy documents from UNESCO. The search period was from 2018 to 2026, but I chose two works before 2018 for their authoritative use in my methodology (Desimone, 2009; Voogt et al., 2013).

Table 1
Search strategy and sources

Element	Specification	Rationale
Databases	Scopus; Web of Science Core Collection; ERIC; ScienceDirect; Springer Nature Link; Taylor & Francis	Coverage of both education and computing literatures
Search strings	("teacher professional development" OR "teacher education" OR "in-service training") AND ("artificial intelligence" OR "generative AI" OR "AI literacy" OR "learning analytics")	Bridges TPD and AIED vocabularies, which rarely co-occur
Window	2018–2026, plus retained pre-2018 conceptual anchors	Captures the pre- and post-LLM periods
Language / type	English; peer-reviewed articles, reviews, and institutional policy frameworks	Policy documents included because they drive national TPD design
Supplementary	Backward and forward citation chaining; hand-search of CAEAI, BJET, TATE, Computers & Education	Recovers work missed by unstable terminology

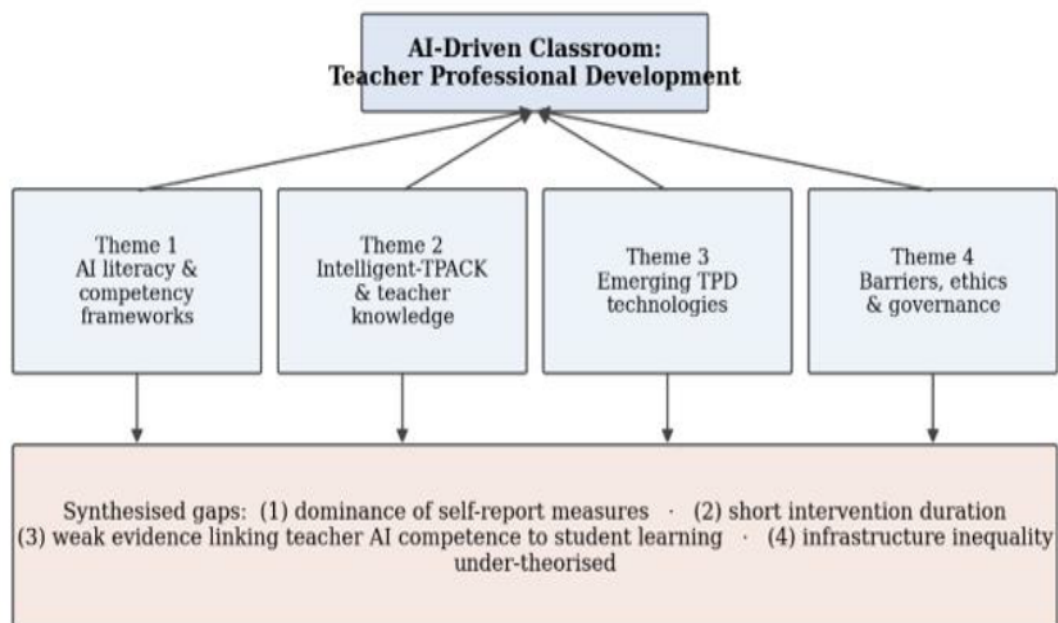
Table 2
Inclusion and exclusion criteria

Included	Excluded
Focus on teachers (pre-service or in-service) as learners or decision-makers	Studies of AI tools evaluated only on student outcomes with no teacher dimension
Explicit treatment of AI or advanced learning analytics	General ICT or digital-literacy TPD with no AI component
Empirical studies, validated instruments, systematic reviews, or competency frameworks	Opinion pieces, editorials and vendor white papers
Peer-reviewed, or issued by a recognised international body	Non-peer-reviewed preprints, unless no published equivalent exists

The screening was made by title and then by abstract, then by full text, with thematic coding being reviewed constantly. Codes were first derived from the dimensions of the UNESCO competencies and modified as the text was read. Four themes emerged, as represented in Figure 1. There is a lack of reflexivity here that should be acknowledged, as the partitioning of themes was done by one reader, and another coder would probably divide Themes 3 and 4 differently.

Figure 1

Thematic architecture of the review and the gaps derived from cross-theme synthesis.



3. Findings and Discussion

3.1 Theme 1 — Conceptualising AI literacy for teachers

The most cited conceptualisation of AI literacy in this field is by Ng et al. (2021), who proposed four facets of AI literacy — know and understand, use and apply, evaluate and create, and ethical issues — based on an exploratory review of thirty peer-reviewed articles. The authors later

developed the AI Literacy Questionnaire to measure affective, behavioural, cognitive, and ethical dimensions of AI literacy (Ng et al., 2024), providing a psychometrically supported instrument for measuring AI literacy where earlier authors resorted to makeshift instruments. In a similar vein, Ng et al. (2023) explored AI digital competencies of teachers in AI, mapping the competencies to twenty-first-century skills, while Casal-Otero et al. (2023) explored K-12 AI literacy efforts and curricula, focusing heavily on technical content with relatively little ethical or societal content. Kong et al. (2021) demonstrated that even a short, well-designed AI literacy course can shift understandings of AI among non-computing students — a background that is typical of in-service teachers. In China, the AI literacy of teachers was predicted more by the perceived usefulness of AI tools for teaching and school support than by the teachers' experiences with AI tools (Zhao et al., 2022).

3.2 Theme 2 — Extending TPACK to AI

For the past two decades, TPACK has been the dominant lens on teacher knowledge about technology (Voogt et al., 2013), but the introduction of AI adds a category of decisions not anticipated in the original framework, that of teachers evaluating the outputs of a system whose workings are not comprehensible. Celik (2023) responded to this need with the introduction of Intelligent-TPACK, which added an explicit ethical knowledge component and tested a scale for this knowledge. In a role like that of Mishra et al. (2023), Celik explained that technological knowledge is not enough because teachers are the orchestrator for any AI-mediated instruction and must evaluate decisions made for them by a recommendation from an algorithm that they may have to override. Mishra et al. (2023) argued that generative AI does not simply add a new tool to the technological corner of TPACK but muddies the boundaries between the technological, pedagogical, and content areas. Following their theoretical work, Kim (2024) shared results from a program in AI convergence education based on TPACK theory, and Celik et al. (2022) explored what was being offered in terms of AI for teachers and the promises along with recurring issues. A cautionary note about much of the work in this thematic area of TPACK and AI is that much of the research reported TPACK through self-reporting, and self-reporting is known to differ from performance, so the gains should be interpreted as gains in confidence as much as competence.

3.3 Theme 3 — Emerging technologies reshaping TPD delivery

In terms of TPD delivery rather than content, three developments can be identified, as summarised in Table 3. First, Generative AI is gaining a role as a reflective partner, with Albadarin et al. (2024) conducting a literature synthesis of empirical studies of ChatGPT in education and Lee and Palmer (2025) surveying instruction on prompt engineering as a key skill to be learned rather than a side note. Next, learning analytics for the teacher have evolved from descriptive reports to tools for professional learning, with Herodotou et al. (2019) demonstrating how predictive analytics changed the intervention choices of online educators, though in a subsequent study the uptake was mixed depending on perceived accuracy and cost of effort (Herodotou et al., 2021). A set of multi-modal dashboards bring learning analytics to face-to-face classrooms (Possaghi et al., 2025). The complementarity between humans and AI has now become a design objective (Echeverria et al., 2023), although a recent systematic review (Costache et al., 2026) found that most of these were still in prototype mode. Tammets et al. (2023) propose the AI-enhanced tools as feedback within the experiential learning cycle of a teacher's professional learning. Third, new delivery models for TPD are emerging, with both Fakhar et al. (2024) proposing an adaptive framework for AI-supported continuous professional development, and Ding et al. (2024) finding that the type of

case made a difference in the development of teacher AI literacy as part of a professional development programme, and Zhang (2024) reporting a lesson study model with a MOOC approach coupled with AI-supported assessment of EFL writing.

Table 3

Emerging technologies mapped to TPD function and strength of current evidence

Technology	TPD function	Representative work	Evidence strength
Generative AI (LLMs)	Lesson-plan co-design; reflective dialogue; prompt-engineering skill	Albadarin et al. (2024); Lee & Palmer (2025)	Emerging; mostly short-term, self-report
Teacher-facing analytics dashboards	Diagnostic reasoning; evidence-informed reflection	Herodotou et al. (2019, 2021)	Moderate; adoption uneven in practice
Multi-modal / affective dashboards	Real-time orchestration and awareness in K-12	Possaghi et al. (2025)	Early; feasibility-stage
Human–AI orchestration probes	Teacher–AI complementarity; role negotiation	Echeverria et al. (2023); Costache et al. (2026)	Prototype-dominated
Case-based online modules & PLCs	Sustained, collective, situated learning	Ding et al. (2024); Fakhar et al. (2024)	Promising; design variables rarely manipulated

3.4 Theme 4 — Barriers, ethics and governance

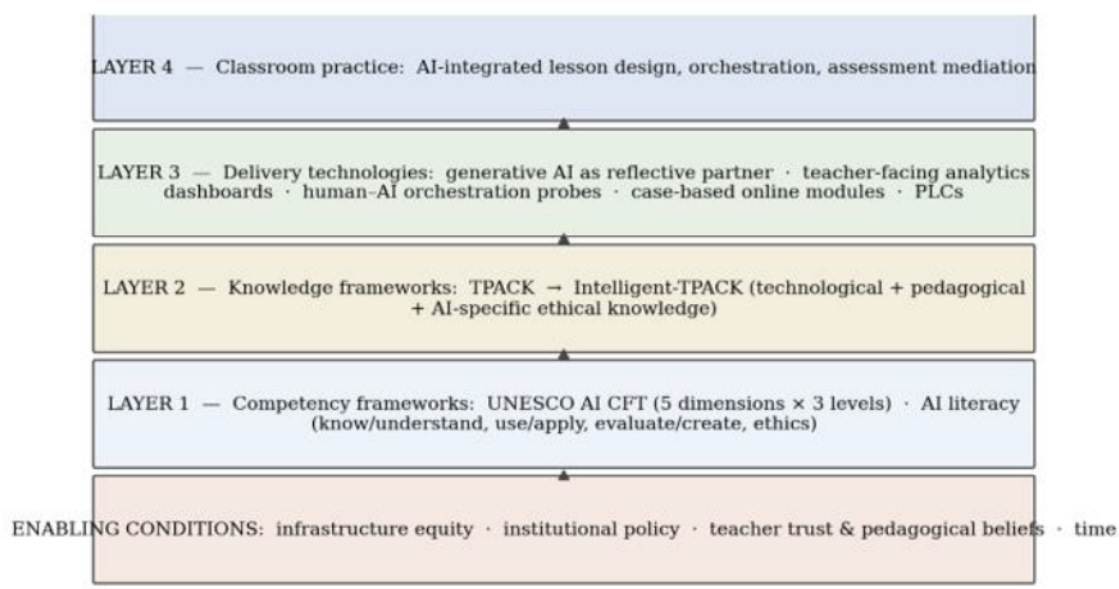
Adoption is not a matter of technology. Choi et al. (2023) show that pedagogical beliefs and perceived trust in educational AI tools have even more impact than technical familiarity in the acceptance process, which means that Training and Professional Development (TPD) focused on tool use may be lacking. School policy ideas include a framework for AI policy education (Chan, 2023), and a mapping study of generative AI and the open questions about academic integrity (Bahroun et al., 2023). Speculation about teacher replacement due to a shortage of teachers (Edwards & Cheok, 2018) now appears as a policy question. Inequities in infrastructure, lack of training, and ethical questions were among the barriers discussed in the research papers of the corpus that UNESCO is addressing with their framework through the alignment of educational policies (Miao & Cukurova, 2024).

3.5 Cross-theme synthesis

Together, these four themes describe a layered system where competency frameworks set goals, knowledge frameworks describe what teachers should possess, delivery technologies put learning into action, and enabling conditions determine the extent to which any of this translates into practice (Figure 2). The structural weakness of the field is that these layers have evolved at different rates: the frameworks and instruments are now well specified, while evidence about practice change remains thin.

Figure 2

A layered model of teacher professional development for AI-driven classrooms, synthesised from the reviewed literature.

**Table 4**

Gaps identified and their implications for future research

Gap	Evidence in the corpus	Implication
Dominance of self-report outcome measures	Most TPACK and AI-literacy studies rely on validated but self-reported scales	Pair scales with independent classroom observation of AI-integrated lessons
Short intervention duration	Single workshops or semester units predominate	Conflicts with duration and collective participation as core TPD features (Desimone, 2009)
No link to student learning	Causal chain from teacher competence to student outcome is asserted, not tested	Requires downstream designs with student-level measures
Infrastructure inequality under-theorised	Named as a barrier but rarely built into sampling or analysis	Stratify by infrastructure tier; test measurement invariance across strata

4. Conclusion

There is clear consensus among these studies that competency frameworks for teacher use of AI have been sufficiently defined, along with improved measurement tools and promising delivery technologies for TPD on AI in teaching; but, the supporting evidence from these studies using TPD on teacher AI use is reported in general from short term interventions, self-reported data, and

prototype-stage tools. This means that, although this field is rich in conceptual frameworks, it is poor in research evidence. As a narrative review, this article cannot provide any measure of how much evidence is lacking; nor can it quantify how much the themes are related to one another. These are two limitations that could be addressed in a subsequent systematic review and/or meta-analysis of quantitative data. A key implication of this synthesis is that the research priorities shift from more conceptual development to more rigorously sustained studies using observational data with TPD on teacher AI use that incorporate ethical knowledge as a construct and vary sampling across infrastructure conditions. Without this shift, the TPD research on teacher AI use will continue to capture enthusiasm rather than competence.

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Teacher's Professional Development on Recent Trends in Education

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Abstract

The article explore is about the importance of lifelong learning for professional development. National professional standard for teachers has its own identity in national and international societies. Basically, Lifelong Learning is all about acquiring abilities, skills, knowledge and understanding from the early childhood stage to the post retirement age” The NPST emphasize Professional Learning as a key domain, highlighting the need for continuous growth, reflection, and skill enhancement. This paper reveals the role of professional learning in fostering teacher competency, improving student outcomes, and adapting to evolving pedagogical practices. NPST is related to the professional development. Teacher education and professional development are widely recognized as critical determinants of teaching quality, educational innovation, and improved student learning outcomes. In the context of rapidly evolving education systems and the growing demands of the 21st century, the role of teachers has expanded beyond content delivery to include facilitation of critical thinking, digital literacy, inclusivity, and lifelong learning. Consequently, continuous professional development (CPD) has emerged as an indispensable component of teacher effectiveness and institutional improvement. The article adopts by UNESCO, NCERT. These sources provide insights into global best practices as well as context-specific strategies relevant to the Indian education system. The paper analyzes how pre-service teacher education establishes core pedagogical competencies, professional values, and reflective dispositions, while in-service professional development sustains and enhances these competencies throughout a teacher's career. Particular attention is given to challenges in the implementation of effective professional development, including inadequate institutional support, fragmented training initiatives, limited access to resources, and insufficient alignment between policy and classroom realities. Emerging trends in teacher professional development are explored in detail, with a focus on digital pedagogy, reflective practice, collaborative learning communities, and lifelong learning. The paper concludes by proposing an integrated model of teacher education that views pre-service and in-service learning as part of a continuous professional continuum.

Introduction

Teacher education refers to the structured programs designed to prepare individuals for the teaching profession. It includes pre-service training (before entering the profession) and in-service training (for practicing teachers) to enhance their skills, knowledge, and professional competencies. The goal of teacher education is to develop educators who can effectively engage students, use modern pedagogical strategies, and adapt to the evolving needs of education systems. National Education Policy (NEP) 2020 Emphasizes 50 hours of CPD per year for teachers. NPST provides a assuring for teacher competencies. Guides global best essential part in teacher training UNESCO's Teacher Education Guidelines: Encourages competency-based teacher training programs” Effective teacher education and well-structured training programs are essential to enhance teaching quality and student learning outcomes. Education is universally

acknowledged as the cornerstone of national development, social progress, and economic growth. Nations that invest in quality education tend to experience higher levels of innovation, productivity, and social cohesion. Teachers are the most critical agents in translating educational policies into classroom practice and in shaping learners' cognitive, social, and emotional development. As Darling-Hammond (2000) emphasizes, teacher quality is the single most important school-based factor influencing student achievement. Similarly, Hattie's (2009) meta-analysis of over 800 studies identifies teacher effectiveness as having a significant impact on student learning outcomes, surpassing many structural and institutional variables. The effectiveness of education systems depends largely on the quality of teachers, which in turn is shaped by robust teacher education programs and sustained professional.

Teaching as a Profession

Teaching is reasoned one of the noblest professions globally and is associated with social ,physical ,psychological is a all-rounder progress. In ancient times a teacher was the most respected member of society, and most educated individuals were permitted to enter this profession. Teachers were the centre of the education system and were needed to transmit their knowledge, skills, and ethics optimally to the students. With the evolution in the education system and changing role of teachers, enhancing teacher quality becomes a task of almost importance for long-term and sustainable nation-building. As a form of social action and social inquiry, teaching is a deeply ethical and normative practice in which professionals need to care for students and love to be with them, honour students diversity, understand within social, cultural, and political contexts, develop sensitivity to their needs and problems and treat all students equally perceive studentss not as passive receivers of knowledge, augment their natural propensity to construct meaning, discourage rote learning, and make learning joyful, participatory, and meaningful. Critically examine curriculum and textbooks and contextualize curriculum appropriate to the local needs not to treat knowledge as 'given', embedded in the curriculum. organize learner-centered, activity-based, participatory learning experiences involving play, projects, discussion, dialogue, observation, visits, and learning to reflect on their practice. "Education and indeed the vision of education laid in the NEP 2020 emphasis on inclusive education and diversity in classrooms across all levels of school" "The NEP 2020 draws attention to many challenges to which teachers' pedagogical practices any other tasks should be responsive to (Principles of the Policy)"

Definitions of Key Terms

1. Professional Development

Professional development refers to ongoing learning activities that enable teachers to improve their instructional practices, update subject knowledge, and respond to educational reforms and learner needs. It may include workshops, mentoring, collaborative learning, action research, advanced study, and reflective practice. Professional development emphasizes continuous growth rather than one-time training.

2. Reflective Practice

Reflective practice is the process through which teachers critically examine their teaching experiences, instructional decisions, and classroom interactions to improve future practice. It involves self-evaluation, analysis of successes and challenges, and informed adjustments based on

evidence and theory. Reflective practice promotes professional autonomy, critical thinking, and adaptive expertise.

3. Lifelong Learning

Lifelong learning is the ongoing, voluntary pursuit of knowledge and skills throughout an individual's life. In the context of teacher education, it refers to the continuous professional growth of educators beyond formal training, ensuring they remain responsive to evolving educational research, technologies, and societal needs.

2.1 Professional Development

Professional Development (PD) refers to structured and informal learning opportunities that enhance teachers' professional knowledge, instructional practices, and commitment to the profession. Darling-Hammond, Hyler, and Gardner (2017) define effective PD as sustained, collaborative, content-focused, and classroom-embedded learning that leads to improved student outcomes. Research indicates that short-term workshops have limited impact on classroom practice, whereas long-term, collaborative PD initiatives significantly influence teaching effectiveness (Garet et al., 2001). Moreover, the OECD Teaching and Learning International Survey (TALIS, 2018) reports that teachers who actively engage in professional learning communities (PLCs) demonstrate higher self-efficacy and improved instructional practices. Guskey (2002) proposes a model of PD evaluation, suggesting that changes in teacher beliefs occur after improvements in student learning are observed. This highlights that PD must be results-oriented and evidence-based. Furthermore, Avalos (2011) emphasizes that professional development fosters teacher identity formation, professional autonomy, and reflective competence.

National Professional Standards for Teachers (NPST) "India's NEP 2020 is a transformative education policy designed to meet the evolving demands of the 21st century" It aims to revamp the education system by addressing the country's developmental needs. NEP 2020 represent the crucial role of teachers in national development and places them at the center of educational reforms. The policy focus on empowering teachers, attracting top talent, and ensuring holistic, high-quality education. Strengthening the teaching profession is seen as key to driving national progress. "A common guiding set of National Professional Standards for Teachers (NPST) will be developed by 2022, by the National Council for Teacher Education in its restructured new form as a Professional Standard Setting Body (PSSB) under the General Education Council (GEC), in consultation with NCERT, SCERTs, teachers from across levels and regions, expert organizations in teacher preparation and development, expert bodies in vocational education, and higher education institutions. The standards would cover expectations of the role of the teacher at different levels of expertise/stage, and the competencies required for that stage. It will also comprise standards for performance appraisal, for each stage, that would be carried out on a periodic basis. The NPST will also inform the design of pre-service teacher education programs. This could be then adopted by States and determine all aspects of teacher career management, including tenure, professional development efforts, salary increases, promotions, and other recognitions. Promotions and salary increases will not occur based on the length of tenure or seniority, but only on the basis of such appraisal. The professional standards will be reviewed and revised in 2030, and thereafter every ten years, on the basis of rigorous empirical analysis of the efficacy of the system [Para 5.20, NEP 2020]

2.2 Theoretical Perspectives

Schön's theory of reflective practice posits that professionals learn by reflecting "in action" and "on action." For teachers, reflection allows analysis of classroom experiences, enabling continuous improvement. Research by Zeichner and Liston (1996) supports the view that reflective practice enhances pedagogical decision-making and professional growth. Reflective journals, peer observations, and action research are widely recognized as tools for developing reflective competence. The constructivist perspective asserts that learning is an active, contextualized process of constructing knowledge rather than acquiring it passively. In teacher education, constructivist approaches encourage experiential learning, collaborative inquiry, and problem-solving (Vygotsky, 1978). Studies indicate that teachers participating in collaborative learning communities develop deeper pedagogical understanding compared to those in lecture-based training programs (Borko, 2004). Transformative learning theory emphasizes critical reflection as a means of transforming assumptions, beliefs, and professional perspectives. Mezirow argues that adult learners, including teachers, change their frames of reference through critical discourse and reflective analysis. Research shows that transformative professional development programs foster shifts in teaching philosophy, inclusivity practices, and student-centered approaches (Taylor, 2008). Collectively, these theoretical frameworks underscore that teacher learning is reflective, social, and transformative in nature.

2.3 Importance of Continuous Professional Development

Continuous Professional Development (CPD) is essential for maintaining instructional quality in dynamic educational contexts. Teachers engaged in regular professional learning demonstrate enhanced classroom management, innovative pedagogy, and effective assessment strategies. In addition to improving student achievement, CPD positively influences teacher motivation and retention. Ingersoll and Strong (2011) report that teachers who receive continuous mentoring and professional support are less likely to leave the profession. This is particularly important given global concerns about teacher shortages. CPD also fosters collaboration and knowledge sharing. Wenger's (1998) theory of Communities of Practice suggests that professional learning is strengthened when teachers engage collectively in shared inquiry and problem-solving. Furthermore, CPD ensures alignment between teachers' competencies and evolving curriculum reforms, technological integration, and policy changes. In rapidly changing educational environments, CPD serves as a mechanism for adaptability and innovation.

2.5 Challenges in Teacher Professional Development

Despite its recognized importance, teacher professional development faces several challenges. One major constraint is limited time within teachers' workload to engage in meaningful professional learning (OECD, 2018). Additionally, insufficient institutional support and lack of funding hinder sustained PD initiatives, particularly in developing countries. Research by Avalos (2011) indicates that many PD programs fail due to their lack of contextual relevance. One-time workshops, often detached from classroom realities, have minimal long-term impact. Guskey (2002) emphasizes that professional development must be ongoing, practical, and connected to student learning outcomes to be effective. In developing countries, challenges include inadequate infrastructure, limited access to digital technologies, and policy inconsistencies. According to UNESCO (2016), many low-income nations struggle to provide continuous, structured professional learning opportunities. Furthermore, resistance to change, lack of

motivation, and weak monitoring systems may impede the effectiveness of PD programs. Addressing these challenges requires systemic reform, including policy support, resource allocation, leadership commitment, and integration of school-based professional learning models.

Conclusion

Teacher education and professional development are central to improving educational quality. Grounded in theoretical perspectives such as reflective practice, constructivism, and transformative learning, effective teacher development programs promote continuous growth, collaboration, and instructional improvement. However, challenges related to implementation, sustainability, and contextual relevance must be addressed through comprehensive policy frameworks and institutional support. Strengthening teacher education systems is therefore essential for achieving long-term educational reform and national development goals.

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Digital Well-Being and Holistic Development among School Children: An Exploratory Study

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Abstract

Digital technology is now closely integrated into children's learning, communication and leisure. The present exploratory study examined digital-use patterns and their relationship with selected dimensions of holistic development among school children. A 25-item questionnaire covering mobile-phone use, social-media use, earphone habits, sleep, physical activity, concentration, family interaction, life skills and values was administered to 38 students from Classes VI–VIII. The analysis used the 38 collected responses only; no synthetic responses were generated or included in the statistical analysis. Responses were coded on a four-point health-oriented scoring framework and organised into seven dimensions. Descriptive statistics and Spearman rank correlations were used because the sample was small and the item responses were ordinal in nature. The findings indicate substantial digital exposure alongside concerns related to sleep, physical activity and concentration, while students also showed strong endorsement of holistic development and balanced technology use. The study supports a balanced rather than technology-free approach, with coordinated attention to sleep, physical activity, study habits, family interaction, values and responsible digital behaviour. Because the study is exploratory and questionnaire-based, the results should not be interpreted as evidence of causation or as diagnostic classifications.

Keywords: digital well-being; school children; mobile phone use; social media; sleep; physical activity; holistic development

1. Introduction

Digital well-being concerns the quality and balance of a person's relationship with digital technologies. For school children, digital technology can support learning and communication, but patterns of excessive or poorly timed use may compete with sleep, physical activity, concentration and face-to-face interaction. Contemporary digital-well-being resources for young people emphasise healthy digital habits, prosocial development and attention to mental, social and emotional well-being. (Digital Wellness Lab, 2026; Finch & Killion, n.d.)

The issue is therefore broader than screen-time duration alone. Children's development is multidimensional, involving physical health, learning, relationships, self-regulation, values and life skills. The present study adopts this holistic perspective and explores how digital-use patterns coexist with these developmental dimensions in a small group of school students.

The study is also grounded in a practical educational concern: schools and families need evidence that can guide children towards purposeful technology use without denying the legitimate educational and social benefits of digital media. The research is exploratory and does not attempt to establish cause-and-effect relationships.

2. Objectives

- To examine mobile-phone and social-media usage patterns among school children.
- To explore earphone use, sleep and outdoor physical activity in relation to digital well-being.
- To examine perceived effects of excessive mobile use on study concentration.
- To explore family interaction, responsibility, discipline and traditional-value orientation.

- To examine students' views regarding balanced technology use and holistic child development.

3. Methodology

Design and participants. An exploratory survey design was used. The participants were 38 school students from Classes VI–VIII. The dataset supplied for this paper contains 38 collected responses (S1–S38). The study is based exclusively on these collected responses; synthetic observations were not added to the analytical dataset.

Instrument. The questionnaire contained 25 multiple-choice items. The items addressed seven dimensions: (1) Mobile and Digital Exposure (Q1–Q6), (2) Earphone Health (Q7–Q8), (3) Sleep (Q9–Q10), (4) Physical Activity and Skills (Q11–Q12), (5) Study and Concentration (Q13), (6) Family and Life Skills (Q14–Q16), and (7) Values and Holistic Development (Q17–Q25). The questionnaire structure is consistent with the project's stated focus on mobile use, social media, earphones, sleep, physical activity, study, family and values.

Scoring. Responses were converted to 1–4 scores so that a higher score represented a healthier or more development-supportive pattern. Frequency/risk-oriented items were reverse-scored where appropriate. Construct-specific mappings were used for items whose answer choices were categorical rather than simple frequency scales (notably Q2, Q5, Q10, Q11, Q22, Q24 and Q25). Invalid or non-single-letter entries were treated as missing for scoring; the original raw responses were retained separately. Dimension scores were calculated as the mean of available item scores. An overall descriptive index was calculated as the mean of the seven dimension scores. The scoring is an exploratory research index and is not a clinical or diagnostic scale.

Data analysis. Frequencies and percentages were used for key questionnaire indicators. Means, standard deviations and medians were calculated for the seven dimension scores. Spearman's rank correlation was selected for exploratory associations because the underlying questionnaire responses are ordinal and the sample is small. No grade- or gender-based inferential comparison was attempted because the supplied response sheet did not contain a reliable grouping variable.

4. Results

4.1 Seven-dimension profile

Dimension	N	Mean	SD
Mobile & Digital Exposure	37	2.68	0.46
Earphone Health	37	3.09	0.61
Sleep	37	2.55	0.55
Physical Activity & Skills	37	2.34	0.75
Study & Concentration	36	2.39	1.08
Family & Life Skills	37	3.55	0.47
Values & Holistic Development	37	3.21	0.18

The seven-dimension profile shows variation across the different aspects of digital well-being rather than a single uniform pattern. The mean scores should be interpreted comparatively within this exploratory scoring framework, not against clinical cut-offs.

4.2 Key survey findings

Q1: 2+ hours mobile: 25/38 (65.8%).
Q3: daily social media: 28/38 (73.7%).
Q7: occasional/daily earphones: 26/38 (68.4%).
Q9: often/every night before sleep: 18/38 (47.4%).
Q10: <6 hours sleep: 8/38 (21.1%).
Q11: <30 min activity: 16/38 (42.1%).
Q13: affected concentration: 32/38 (84.2%).
Q24: holistic option: 37/38 (97.4%).
Q25: balance option: 36/38 (94.7%).

These findings suggest that digital exposure is substantial for a sizeable proportion of the participants, while sleep and physical-activity patterns identify areas requiring attention. At the same time, the responses show a strong orientation towards holistic development and balanced technology use. The project dataset independently reports the same headline counts for these key indicators.

4.3 Exploratory associations

Mobile & Digital Exposure and Sleep: Spearman $\rho = 0.38$, $p = 0.019$ ($n = 37$).
Mobile & Digital Exposure and Study & Concentration: Spearman $\rho = 0.04$, $p = 0.806$ ($n = 36$).
Mobile & Digital Exposure and Family & Life Skills: Spearman $\rho = 0.10$, $p = 0.573$ ($n = 37$).
Mobile & Digital Exposure and Physical Activity & Skills: Spearman $\rho = -0.06$, $p = 0.707$ ($n = 37$).
Sleep and Study & Concentration: Spearman $\rho = 0.10$, $p = 0.572$ ($n = 36$).
Physical Activity & Skills and Values & Holistic Development: Spearman $\rho = 0.02$, $p = 0.901$ ($n = 37$).

The correlations are exploratory and should be interpreted cautiously. A correlation does not establish that mobile use causes changes in sleep, concentration, activity or family interaction. The small sample also limits statistical power and generalisability.

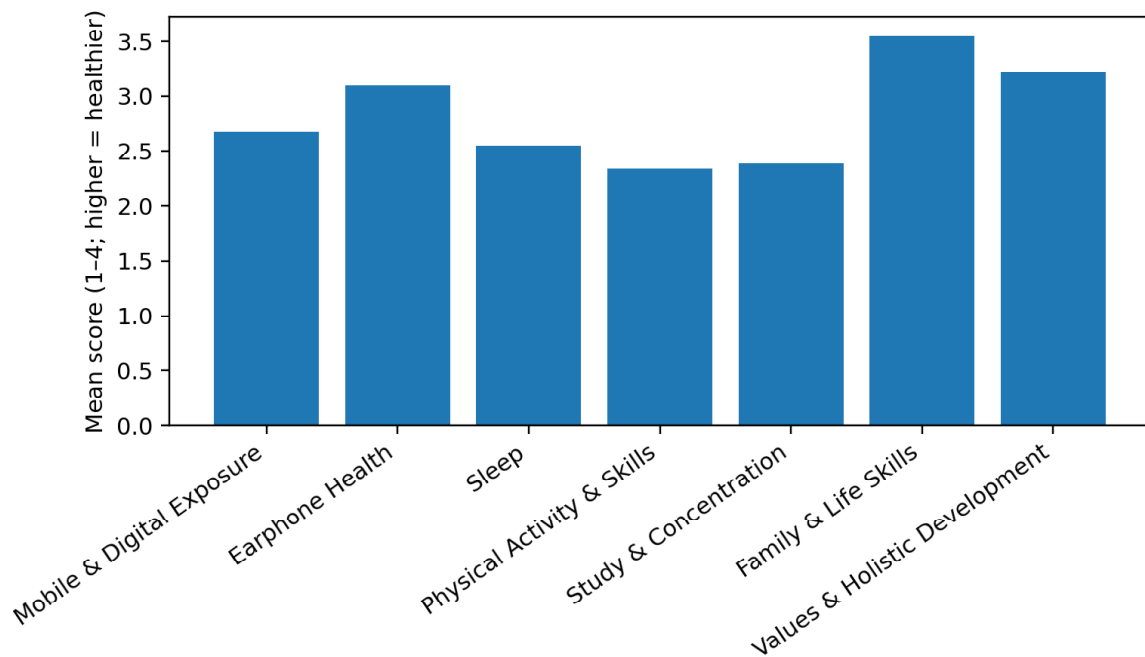


Figure 1. Mean scores across the seven dimensions.

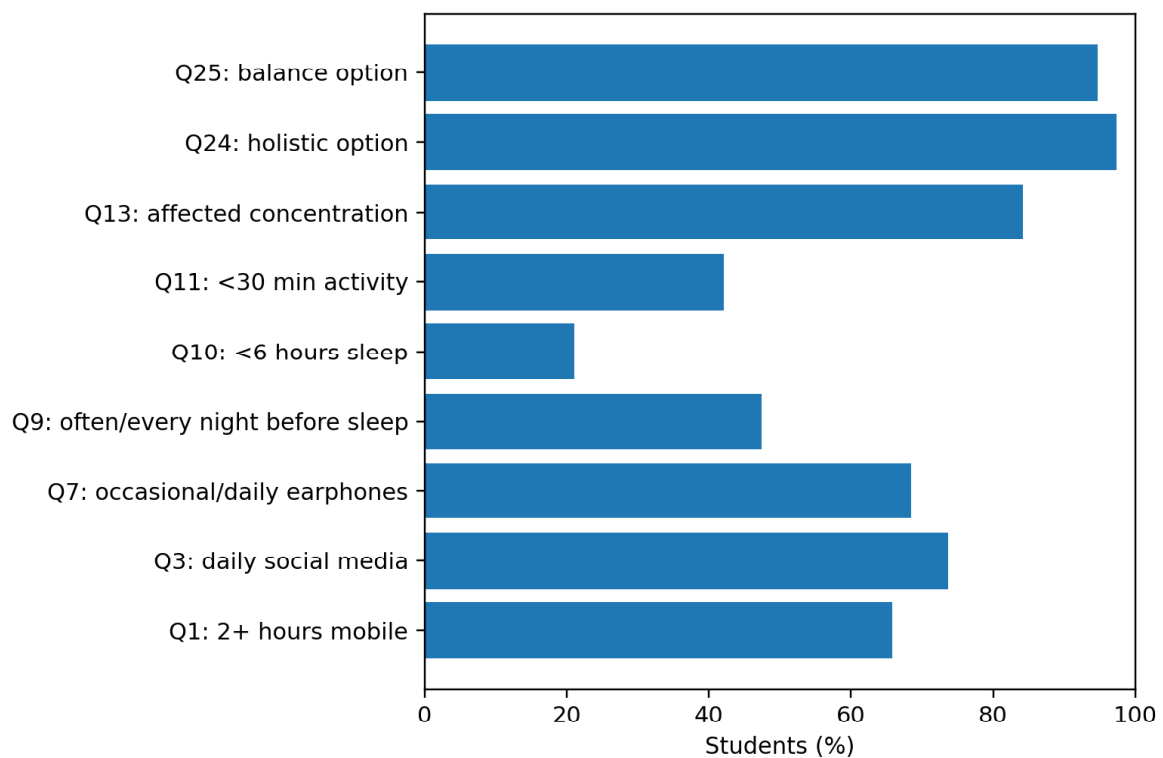


Figure 2. Selected indicators from the 38 collected responses.

5. Discussion

The findings present digital well-being as a balance problem rather than simply a question of whether children use technology. The observed levels of mobile and social-media exposure coexist with reported concerns about concentration, sleep and limited outdoor activity. This pattern is educationally important because children's development requires time and attention for both digital and non-digital activities. Guidance on digital wellness similarly emphasises balancing online activity with sleep, physical movement, family interaction and offline interests. (NCERT, 2024a, 2024b)

The strong endorsement of education, values, health, skills and responsibility indicates that participants themselves recognise a broader conception of development. The high preference for balancing technology with physical activity, values, skills and responsible parenting further supports the value of preventive school-based digital-well-being education. These responses suggest that interventions can focus on practical self-regulation, healthy routines and family-school partnership rather than framing technology as inherently harmful.

The study also illustrates why digital well-being should be interpreted contextually. Digital use can be purposeful and beneficial, especially for education, but the same device can become disruptive when use extends into meals, bedtime, study periods or replaces physical and social activities. The findings therefore support an intentional-use model: technology should serve learning and meaningful connection while boundaries protect sleep, movement, concentration and relationships.

6. Educational Implications

- Schools can conduct **age-appropriate digital-well-being awareness sessions** covering screen boundaries, notification control and purposeful use.
- Teachers can encourage device-free study intervals and active learning strategies that reduce unnecessary digital distraction.
- Schools and parents can promote consistent sleep routines, outdoor activity, sports, yoga, arts and other offline skills.
- Family discussions can address responsible technology use, patience, self-discipline and respectful digital behaviour.
- Digital-well-being education should emphasise balance rather than complete avoidance of technology.

7. Limitations

The study has several limitations. The sample is small ($n=38$) and was obtained from a limited school-student group, so the results cannot be generalised to all children. Responses are self-reported and may be affected by recall or social-desirability bias. The questionnaire is exploratory and the seven-dimension scoring framework has not been presented as a validated psychometric instrument. Some responses in the supplied raw sheet contained non-standard entries; these were preserved in the raw file and treated as missing during scoring. Finally, the cross-sectional survey design cannot establish causal relationships.

8. Conclusion

This exploratory study of 38 school children indicates that digital well-being is closely connected with a wider pattern of childhood habits and developmental priorities. The collected responses show notable exposure to mobile and social-media use, alongside concerns involving bedtime

phone use, sleep, physical activity and study concentration. At the same time, students strongly endorse holistic development and balanced technology use. The central educational message is therefore one of balance: children need digital competence together with healthy sleep, physical activity, concentration, family interaction, values, responsibility and life skills. Schools and families can use such findings to develop practical, age-appropriate digital-well-being programmes. Larger studies with validated instruments and demographic/grouping variables are needed to test these patterns more rigorously.

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Appendix A. Questionnaire scoring note

The complete item-level codebook, response mappings and the 38-row scored dataset are supplied as separate files in the accompanying research package. The raw response file preserves the collected answers. The analysis file contains only derived scores from those 38 responses.

Fostering 21st-Century Skills through Innovative Learning Activities: A Conceptual Framework

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Abstract

The rapidly changing educational landscape demands a shift from traditional knowledge transmission towards learning experiences that prepare students to respond effectively to complex personal, social, academic, and professional challenges. In the 21st century, learners require not only subject knowledge but also critical thinking, creativity, communication, collaboration, problem-solving, digital literacy, adaptability, and self-directed learning. Innovative learning activities provide opportunities for learners to actively construct knowledge, work collaboratively, solve authentic problems, use digital resources, and apply their learning in meaningful contexts. The present conceptual paper explores the role of innovative learning activities in fostering 21st-century skills and proposes a conceptual framework linking innovative pedagogical practices with the development of these competencies. The framework integrates activity-based, experiential, collaborative, inquiry-based, project-based, problem-based, technology-enabled, and reflective learning approaches. It proposes that carefully designed learning activities, supported by learner-centred pedagogy and appropriate assessment, can create meaningful opportunities for developing 21st-century skills. The paper also discusses the role of teachers, technology, learning environments, and assessment in strengthening this process. The proposed framework may serve as a guide for teachers, teacher educators, curriculum designers, and educational institutions in designing learning experiences that prepare learners for the demands of the 21st century.

Keywords: 21st-century skills, innovative learning activities, learner-centred pedagogy, experiential learning, digital literacy, critical thinking, creativity, collaboration, communication

1. Introduction

Education in the 21st century is undergoing significant transformation due to technological advancement, globalisation, changing employment patterns, increased access to information, and the growing complexity of social and environmental challenges. Learners today have access to enormous amounts of information, but access to information alone does not guarantee meaningful learning. They need to be able to evaluate information, think critically, generate creative solutions, communicate ideas effectively, collaborate with others, and adapt to changing circumstances. Consequently, the role of education is gradually moving from “**what to learn**” towards “**how to learn, how to think, and how to apply learning.**” This transformation requires learning environments in which students are active participants rather than passive recipients of information.

Innovative learning activities can provide such environments. Activities such as project work, inquiry, problem-solving, debates, simulations, digital storytelling, design challenges, collaborative tasks, peer teaching, and community-based projects enable learners to connect theoretical knowledge with practical situations.

Therefore, fostering 21st-century skills requires a systematic integration of innovative learning activities into classroom practice rather than treating these skills as additional or separate learning outcomes.

Traditional classroom practices often emphasise memorisation, teacher explanation, textbook-based learning, and examination-oriented assessment. Although these approaches may support knowledge acquisition, they may provide limited opportunities for students to practise higher-order thinking, collaboration, creativity, communication, and real-world problem-solving.

Innovative learning activities can address this limitation by providing learners with opportunities to:

- actively participate in learning, investigate authentic problems,
- generate and evaluate ideas, collaborate with peers,
- communicate their understanding, use technology meaningfully,
- reflect on their learning and apply knowledge in unfamiliar situations.

Thus, there is a need for a conceptual framework that explains how innovative learning activities can contribute systematically to the development of 21st-century skills.

Understanding 21st-Century Skills

21st-century skills refer to a broad range of competencies that enable learners to function effectively in rapidly changing educational, social, technological, and professional environments. For the purpose of the proposed framework, these skills can be grouped into the following dimensions:

1. Critical Thinking and Problem-Solving - Learners should be able to analyse information, identify problems, evaluate alternatives, make reasoned decisions, and develop appropriate solutions.

Possible activities:

- case studies, problem-based learning, inquiry tasks, puzzles, real-life problem-solving, decision-making scenarios.

Creativity and Innovation - Creativity involves generating original ideas, exploring alternatives, experimenting, and developing innovative solutions.

Possible activities:

- design challenges, brainstorming, invention projects, creative writing, story creation; STEM challenges, “What if?” activities.

2. Communication - Communication involves expressing ideas clearly through oral, written, visual, and digital forms and listening effectively to others.

Possible activities:

- debates, presentations, storytelling, digital storytelling, group discussions, interviews, student podcasts.

3. Collaboration - Collaboration involves working effectively with others, sharing responsibilities, negotiating ideas, resolving conflicts, and achieving common goals.

Possible activities:

- group projects, peer teaching, cooperative learning, team challenges, collaborative research, role play.

4. Digital Literacy - Digital literacy involves the ability to access, evaluate, create, and communicate information using digital technologies responsibly and effectively.

Possible activities:

- digital presentations, multimedia projects, online research, digital storytelling, educational videos, collaborative digital documents, virtual simulations.

Innovative Learning Activities for 21st-Century Skills

The following activities can be integrated across different subjects and age groups.

Innovative Activity	Major Skills Developed
Project-Based Learning	Collaboration, creativity, problem-solving
Problem-Based Learning	Critical thinking, decision-making
Design Thinking Challenges	Creativity, innovation, empathy
Digital Storytelling	Creativity, communication, digital literacy
Debates and Discussions	Communication, critical thinking
Role Play and Simulation	Communication, collaboration, decision-making
Inquiry-Based Learning	Critical thinking, curiosity, problem-solving
Peer Teaching	Communication, collaboration, leadership
Gamification	Problem-solving, collaboration, motivation
STEM/STEAM Challenges	Creativity, innovation, problem-solving
Community-Based Projects	Collaboration, social responsibility
Reflective Journaling	Self-directed learning, metacognition
Multimedia Presentations	Communication, digital literacy
Case-Study Analysis	Critical thinking, decision-making

Conceptual Framework

The framework consists of **five interconnected components**.

Component 1: Learner-Centred Pedagogy - The framework begins with a shift from teacher-centred instruction towards learner-centred pedagogy. The teacher functions as a facilitator, guide, mentor, and learning designer.

Component 2: Innovative Learning Activities - Teacher's design activities that require learners to investigate, create, collaborate, communicate, and solve problems rather than merely recall information.

Component 3: Active Learning Processes - The activities engage learners in three interconnected processes:

Exploration → Collaboration → Reflection

Learners explore information and problems, collaborate with others to construct knowledge, and reflect on their experiences and learning.

Component 4: Development of 21st-Century Skills - Repeated participation in meaningful activities provides opportunities for learners to practise critical thinking, creativity, communication, collaboration, problem-solving, digital literacy, adaptability, and self-directed learning.

Component 5: Future-Ready Learner - The ultimate outcome is the development of learners who are capable of applying knowledge creatively, working with others, using technology responsibly, solving unfamiliar problems, and continuing to learn throughout life.

Role of the Teacher

The success of innovative learning activities depends significantly on the teacher's role.

The teacher should:

- design meaningful and authentic learning experiences, provide opportunities for student choice, encourage questioning and exploration, facilitate collaborative learning, integrate appropriate technology, provide constructive feedback;
- encourage reflection, assess both learning outcomes and skill development and create an inclusive classroom environment.

The teacher therefore becomes less of a “**knowledge transmitter**” and more of a “**learning facilitator and designer**.”

Role of Technology

Technology can strengthen innovative learning when it is used purposefully rather than merely as a replacement for traditional teaching.

Digital tools can facilitate:

- collaborative learning; multimedia creation; virtual simulations, digital storytelling,
- online research, interactive presentations, communication beyond the classroom and
- personalised learning.

However, technology should support pedagogical objectives rather than become the objective itself.

Challenges in Implementing Innovative Learning Activities

Despite their potential, several challenges may affect implementation:

- Lack of teacher training, limited classroom time; large class sizes.
- inadequate technological resources; examination-oriented educational systems;
- limited access to digital infrastructure; difficulty in assessing 21st-century skills;
- resistance to pedagogical change; and unequal learner access to learning resources.

These challenges highlight the need for institutional support, professional development, flexible curriculum planning, and appropriate assessment systems.

Implications for Education

For Teachers- Teachers should receive professional development in activity-based, project-based, inquiry-based, and technology-enabled pedagogies.

For Teacher Educators - Teacher education programmes should provide opportunities for trainee teachers to design and implement innovative learning activities.

For Curriculum Designers - Curricula should provide sufficient flexibility for collaborative projects, inquiry, creativity, and authentic learning experiences.

For Educational Institutions - Schools and colleges should create learning environments that support experimentation, collaboration, technology integration, and interdisciplinary learning.

For Policy Makers - Educational policies should recognise 21st-century skills as integral learning outcomes rather than supplementary competencies.

Conclusion

The development of 21st-century skills requires a fundamental transformation in the way learning experiences are designed and implemented. Innovative learning activities provide learners with opportunities to move beyond memorisation towards exploration, creation, collaboration, communication, reflection, and problem-solving.

The conceptual framework proposed in this paper positions **innovative learning activities as an important pedagogical pathway for developing 21st-century skills**. Project-based learning, problem-based learning, inquiry, design thinking, digital storytelling, collaborative activities,

simulations, gamification, and community-based learning can create meaningful contexts for learners to practise and demonstrate these competencies.

However, the effectiveness of such activities depends on purposeful instructional design, teacher facilitation, appropriate technology integration, supportive learning environments, and assessment practices aligned with 21st-century competencies.

Ultimately, education should not merely prepare learners to **remember what is already known**, but should empower them to **think critically, create innovatively, collaborate effectively, communicate confidently, use technology responsibly, and continue learning throughout life**. Innovative learning activities can therefore serve as a powerful pathway towards developing **future-ready learners**.

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Secondary School Teachers' Awareness about Digital Literacy and 21st Century Skills

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Abstract

The rapid development of digital technologies has transformed the educational process and created new expectations for teachers and learners. Digital literacy and 21st century skills have become essential for effective teaching, learning, communication, collaboration, problem-solving, and responsible participation in a technology-oriented society. Teachers play a central role in helping students develop these competencies because their own digital knowledge, attitudes, and classroom practices influence students' opportunities to use technology meaningfully. The present study focuses on the awareness of secondary school teachers regarding digital literacy and 21st century skills. The study adopts a descriptive survey design and considers a model sample of 100 secondary school teachers. Data are proposed to be collected using a self-developed questionnaire covering digital literacy, information and media literacy, communication and collaboration, critical thinking, creativity, problem-solving, digital citizenship, and technology-integrated teaching. Based on the model distribution, 8% of teachers demonstrate excellent awareness, 18% possess above-average awareness, 62% possess average awareness, and 12% fall under the below-average category. No teacher is placed in the poor-awareness category. The findings indicate that although most teachers possess a basic understanding of digital literacy and 21st century skills, further professional development is necessary to strengthen their practical application in classroom teaching. The study recommends continuous digital-skills training, technology-integrated pedagogy, collaborative learning, critical-thinking activities, digital citizenship education, and institutional support for teachers.

Keywords: Digital Literacy, 21st Century Skills, Digital Competence, Secondary School Teachers, ICT in Education, Critical Thinking, Creativity, Collaboration, Digital Citizenship

Introduction

The 21st century has brought significant changes to education, employment, communication, and social life. Digital technologies such as computers, smartphones, online learning platforms, educational applications, artificial intelligence tools, digital libraries, and multimedia resources have become increasingly important in education. As a result, teachers are expected not only to possess subject knowledge but also to develop the digital and transferable skills required for effective teaching and learning.

Digital literacy refers to the ability to access, understand, evaluate, create, communicate, and share information through digital technologies in an effective, responsible, and safe manner. It goes beyond the ability to operate a computer or smartphone. A digitally literate person should be able to search for reliable information, evaluate online sources, communicate appropriately, create digital content, protect personal information, and use digital technologies responsibly.

The concept of **21st century skills** encompasses a range of competencies needed for successful participation in contemporary society. These include critical thinking, creativity, communication, collaboration, problem-solving, digital literacy, information literacy, media literacy, adaptability,

and responsible citizenship. These competencies enable learners to apply knowledge to unfamiliar situations rather than merely memorizing information.

Teachers are important agents in developing these skills among students. A teacher who is confident in using digital resources can provide students with opportunities to conduct online research, collaborate through digital platforms, create multimedia presentations, solve problems, evaluate information, and communicate their ideas effectively.

In the Indian educational context, initiatives such as the **National Education Policy (NEP) 2020** emphasize the importance of technology, digital learning, critical thinking, creativity, communication, and holistic development. Therefore, strengthening teachers' awareness of digital literacy and 21st century skills has become an important educational priority.

Need and Significance of the Study

Digital transformation has changed the way knowledge is produced, accessed, communicated, and shared. Schools therefore need teachers who can effectively use digital technologies and develop 21st century competencies among learners.

Teachers are expected to perform several roles in the digital age. They act as facilitators of learning, guides for online information, designers of digital learning experiences, and role models for responsible technology use.

The present study is significant in the following ways:

1. Teacher Professional Development

The study can identify areas in which teachers require additional training in digital technologies and 21st century competencies.

2. Effective Technology Integration

Greater awareness can help teachers integrate digital tools with appropriate teaching strategies rather than using technology merely as a replacement for traditional methods.

3. Development of Student Skills

Teachers with stronger awareness can create learning experiences that promote critical thinking, creativity, communication, collaboration, and problem-solving.

4. Digital Citizenship

Teachers can guide students towards safe, ethical, responsible, and respectful use of digital technologies.

5. Information and Media Literacy

Teachers can help students identify reliable information, evaluate online sources, recognize misinformation, and use digital resources appropriately.

6. Inclusive Education

Digital resources can provide flexible learning opportunities for students with different learning needs when appropriately designed and implemented.

7. Curriculum Development

The findings can help curriculum planners integrate digital literacy and 21st century competencies across different school subjects.

8. Improving Teaching and Learning

Digital competence can support interactive, collaborative, learner-centred, and inquiry-based teaching practices.

9. Preparing Students for the Future

Schools have an important responsibility to prepare students for higher education, employment, citizenship, and lifelong learning in a rapidly changing society.

Review of Literature

Digital literacy and 21st century skills have received considerable attention in educational research because technological development has changed the knowledge and competencies required by learners and teachers.

The **UNESCO ICT Competency Framework for Teachers** emphasizes that teachers need competencies for using ICT to support teaching, learning, assessment, professional development, and educational innovation. It views teacher digital competence as an important component of effective technology-integrated education.

The **European Commission's DigComp framework** describes digital competence in areas including information and data literacy, communication and collaboration, digital content creation, safety, and problem-solving. The framework demonstrates that digital literacy involves a broad range of knowledge and skills rather than simply operating digital devices.

The **OECD Learning Compass 2030** highlights competencies such as student agency, transformative competencies, knowledge, skills, attitudes, and values. It emphasizes the ability of learners to respond effectively to complex and changing environments.

The **Partnership for 21st Century Learning (P21)** identifies critical thinking, creativity, communication, and collaboration as major learning and innovation skills. These are commonly described as the **4Cs of 21st century learning**.

Redecker (2017), through the European Framework for the Digital Competence of Educators, emphasizes that teachers need digital competence not only for their own professional activities but also for improving teaching, assessment, learner empowerment, and students' digital competence. The **National Education Policy 2020** emphasizes the integration of technology in education and promotes critical thinking, creativity, communication, problem-solving, and holistic development. It also recognizes the importance of preparing learners for a rapidly changing technological environment.

Research Questions

1. What is the level of awareness among secondary school teachers regarding digital literacy?
2. How aware are teachers of information and media literacy?
3. What is the level of teachers' awareness regarding communication, collaboration, creativity, critical thinking, and problem-solving?
4. How aware are teachers of digital citizenship, online safety, and responsible technology use?
5. What is the role of teachers in developing 21st century skills among secondary school students?
6. What strategies can be adopted to improve teachers' awareness and practical application of digital literacy and 21st century skills?

Objectives of the Study

1. To assess the level of digital literacy awareness among secondary school teachers.
2. To examine teachers' awareness of information and media literacy.

3. To assess teachers' awareness of communication and collaboration skills.
4. To examine teachers' awareness of critical thinking, creativity, and problem-solving skills.
5. To identify teachers' awareness of digital citizenship and online safety.
6. To examine teachers' understanding of their role in developing 21st century skills among students.
7. To identify the need for professional development in digital literacy and technology-integrated teaching.
8. To suggest strategies for improving teachers' digital literacy and 21st century skills.

Methodology

The present study adopts a **descriptive survey design** to examine the level of awareness of secondary school teachers regarding digital literacy and 21st century skills.

Sample

For the purpose of the model study, a sample of **100 secondary school teachers** were considered. The participants may be selected using **stratified random sampling** to obtain representation from different types of secondary schools.

Tool Used for Data Collection

Data may be collected using a **self-developed Digital Literacy and 21st Century Skills Awareness Questionnaire**.

The questionnaire may consist of the following sections:

1. Demographic Information
2. Awareness of Digital Literacy
3. Information and Media Literacy
4. Communication and Collaboration
5. Critical Thinking, Creativity and Problem-Solving
6. Digital Citizenship and Online Safety
7. Teachers' Role in Developing 21st Century Skills

The awareness section may consist of **25 objective items**.

Each correct response may be awarded **one mark**, while an incorrect response receives zero marks.

The maximum possible score is **25**.

Scoring Procedure

Score Level of Awareness

- 0–5 Poor Awareness
- 6–10 Below Average Awareness
- 11–15 Average Awareness
- 16–20 Above Average Awareness
- 21–25 Excellent Awareness

Procedure of Data Collection

The researcher may first obtain the necessary permission from the concerned educational institutions.

The purpose of the study should be explained to the participating teachers. Teachers should be informed that participation is voluntary and that their responses will be kept confidential.

The questionnaire may be administered through both online and paper-based formats according to the accessibility of the participants.

The questionnaire consists of demographic questions followed by items measuring awareness of digital literacy and 21st century skills.

The researcher provides appropriate instructions before administration and clarifies doubts regarding the questionnaire without influencing the participants' responses.

Results and Discussion

Level of Digital Literacy and 21st Century Skills Awareness Among Secondary School Teachers

Table 1

Sl. No.	Level of Awareness	Number of Teachers	Percentage
1	Excellent	8	8%
2	Above Average	18	18%
3	Average	62	62%
4	Below Average	12	12%
5	Poor	0	0%
Total		100	100%

Interpretation

The model findings indicate that **62% of secondary school teachers possess an average level of awareness** regarding digital literacy and 21st century skills.

About **18%** of teachers demonstrate above-average awareness, while **8%** demonstrate excellent awareness.

A further **12%** of teachers fall within the below-average category.

Importantly, none of the respondents are classified under the poor-awareness category.

The findings suggest that most teachers possess a basic understanding of digital literacy and 21st century skills, but a considerable proportion may require additional support to develop advanced knowledge and practical competence.

Discussion

1. Majority at Average Awareness Level – 62%

The finding that 62% of teachers fall within the average-awareness category suggests that most teachers have a basic understanding of digital technologies and 21st century competencies.

They may be familiar with common digital tools such as search engines, email, online learning platforms, presentations, video resources, and digital communication.

2. Above-Average Awareness – 18%

About 18% of teachers demonstrate above-average awareness.

These teachers may have greater familiarity with educational technology and may be more confident in using digital tools for teaching, communication, assessment, and professional development.

3. Excellent Awareness – 8%

Only 8% of teachers demonstrate excellent awareness.

This relatively small percentage suggests that advanced digital competence may still require further development among many teachers.

Teachers with excellent awareness can potentially serve as resource persons or mentors for other teachers and contribute to technology-based innovation within schools.

4. Below-Average Awareness – 12%

The presence of 12% of teachers in the below-average category highlights the need for targeted professional-development programmes.

5. Absence of Poor Awareness

The absence of teachers in the poor-awareness category is encouraging.

It indicates that basic awareness of digital technologies and contemporary educational skills has reached most teachers to some degree.

Major Components of Digital Literacy and 21st Century Skills

1. Information and Data Literacy

Teachers should be able to search for information, evaluate its credibility, organize information, and use reliable sources.

Students should also learn to distinguish trustworthy information from misinformation and misleading online content.

2. Digital Communication

Digital platforms provide multiple opportunities for communication through email, learning-management systems, video conferencing, discussion forums, and other online tools.

Teachers should understand appropriate and respectful digital communication.

3. Collaboration

Collaboration involves working effectively with others to achieve a common goal.

Digital platforms can facilitate group projects, peer learning, online discussions, and collaborative content creation.

4. Critical Thinking

Critical thinking enables learners to analyse information, examine evidence, identify assumptions, compare perspectives, and make reasoned decisions.

Teachers can promote critical thinking through inquiry-based questions, problem-based learning, debates, case studies, and evaluation of online information.

5. Creativity

Creativity involves generating new ideas and developing innovative solutions.

Digital tools can support creativity through presentations, videos, digital storytelling, graphics, animations, coding, and multimedia projects.

6. Problem-Solving

Problem-solving is the ability to identify problems, analyse possible solutions, evaluate alternatives, and implement appropriate solutions.

Digital technologies can provide students with opportunities to solve authentic and complex problems.

7. Digital Content Creation

Digital literacy includes the ability to create and modify digital content.

Teachers and students can create presentations, videos, infographics, podcasts, digital stories, and other educational materials.

8. Digital Citizenship

Digital citizenship refers to responsible, ethical, respectful, and safe participation in the digital environment.

Students should understand issues such as privacy, digital footprints, copyright, responsible communication, and online safety.

Role of Teachers in Developing 21st Century Skills

Teachers have a major role in developing students' 21st century competencies.

1. Facilitator of Learning

The teacher should move beyond transmitting information and facilitate active and independent learning.

2. Promoter of Critical Thinking

Teachers should encourage students to question information, examine evidence, compare ideas, and develop reasoned conclusions.

3. Encourager of Creativity

Students should be provided with opportunities to generate ideas, design projects, create digital content, and find alternative solutions.

4. Promoter of Collaboration

Group activities, projects, peer learning, and digital collaboration can help students develop teamwork skills.

5. Digital Role Model

Teachers should demonstrate responsible, ethical, and safe use of digital technologies.

6. Information Guide

Teachers can help students identify reliable sources and critically evaluate information obtained from the internet.

Educational Implications of the Study

The findings have important implications for teacher education, professional development, curriculum planning, school administration, and classroom teaching.

1. Digital Literacy Training

Schools and teacher education institutions should organize regular programmes to strengthen teachers' digital literacy.

2. Continuous Professional Development

Teachers should receive continuous training rather than one-time technology workshops.

3. Technology-Integrated Pedagogy

Training should focus not only on operating digital devices but also on integrating technology with effective teaching methods.

4. Development of 4Cs

Teaching should provide opportunities for students to develop:

- Critical thinking
- Creativity
- Communication
- Collaboration

5. Digital Citizenship Education

Students should be educated about responsible and ethical technology use, privacy, online safety, and digital footprints.

6. Information and Media Literacy

Teachers should help students evaluate online information and identify misinformation and unreliable sources.

7. Digital Assessment

Teachers should be trained to use appropriate digital assessment tools and provide meaningful feedback through technology.

8. Collaborative Learning

Digital platforms can be used to facilitate group activities, peer learning, discussions, and collaborative projects.

9. Responsible Use of Emerging Technologies

Teachers should develop awareness of emerging technologies, including artificial intelligence, while considering issues such as accuracy, privacy, ethics, bias, and responsible use.

Recommendations

Based on the findings, the following recommendations are suggested:

1. Regular digital-literacy training programmes should be organized for secondary school teachers.
2. Teacher education programmes should give greater importance to digital competence and 21st century skills.
3. Professional-development programmes should focus on practical classroom applications of technology.
4. Teachers should be trained in information and media literacy.
5. Schools should promote critical thinking, creativity, communication, collaboration, and problem-solving across subjects.
6. Teachers should be encouraged to use digital tools for interactive and learner-centred teaching.
7. Schools should provide adequate digital infrastructure and technical support.
8. Teachers should be trained to evaluate the credibility of online information and digital resources.

Conclusion

The present study focuses on secondary school teachers' awareness of digital literacy and 21st century skills. The model findings indicate that **62% of teachers possess average awareness, 18% possess above-average awareness, 8% demonstrate excellent awareness, and 12% fall within the below-average category**, while none are classified under poor awareness.

The findings suggest that teachers generally possess basic awareness of digital technologies and contemporary learning competencies. However, there is considerable scope for strengthening their advanced digital knowledge and their ability to integrate technology effectively into classroom teaching.

Therefore, schools and teacher education institutions should adopt a systematic approach involving **digital-literacy training, technology-integrated pedagogy, development of the 4Cs, digital**

citizenship education, information literacy, collaborative learning, and continuous professional development.

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Secondary School Teachers' Awareness of Gender Equality and Gender Issues in Education

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Abstract

This study investigates secondary school teachers' awareness of gender equality, gender roles, gender stereotypes, gender discrimination, gender rights, and gender-related issues in education. Gender awareness is an essential component of an inclusive and equitable educational system because teachers play a significant role in shaping students' attitudes, values, and perceptions regarding gender. Although education has the potential to challenge traditional gender norms and promote equality, teachers may sometimes reproduce gender stereotypes through classroom practices, language, curriculum interpretation, and interaction with students. Using a descriptive survey design, the present study examines the level of gender awareness among 100 secondary school teachers in Malappuram district. Data were collected using a self-developed Gender Awareness Questionnaire covering major dimensions such as basic concepts of gender, gender roles and stereotypes, gender equality and rights, gender issues in education, and the role of teachers in promoting gender equality. The findings, based on the model distribution, indicate that 72% of teachers possess an average level of gender awareness, 13% possess above-average awareness, 6% demonstrate excellent awareness, and 9% fall under the below-average category. No respondent was classified under poor awareness. The findings suggest that although teachers possess a basic understanding of gender-related concepts, deeper awareness and effective integration of gender-sensitive practices into classroom instruction require further attention. The study recommends gender-sensitization programmes, teacher professional development, gender-responsive curriculum practices, inclusive classroom strategies, and institutional policies to promote gender-equitable education.

Keywords: Gender Awareness, Gender Equality, Gender Roles, Gender Stereotypes, Gender-Sensitive Education, Secondary School Teachers, Inclusive Education

Introduction

Gender is an important social and educational concept that influences the opportunities, experiences, expectations, and participation of individuals in society. Gender refers not merely to biological differences between males and females but also to socially constructed roles, behaviours, expectations, relationships, and norms associated with being male, female, or belonging to diverse gender identities. Education has a significant role in shaping these perceptions because schools are important spaces where children learn social values, attitudes, behaviours, and expectations.

Gender awareness refers to the understanding of gender as a social and cultural construct and the ability to recognize gender-based inequalities, discrimination, stereotypes, and unequal opportunities. A gender-aware individual is able to identify how social expectations

influence the lives and educational experiences of different genders and supports equal opportunities and rights for all.

Teachers occupy a central position in promoting gender equality in educational institutions. Their attitudes, language, classroom interactions, allocation of responsibilities, expectations, teaching materials, and responses to gender-related issues can influence students' understanding of gender. Gender-sensitive teachers can challenge stereotypical beliefs, encourage equal participation, provide equitable opportunities, and create a safe and inclusive classroom environment.

Gender stereotypes can influence students from an early age. For example, assumptions that boys are naturally better at mathematics and science while girls are more suitable for language, arts, or caring activities may affect students' subject choices and confidence. Similarly, assigning leadership, physical, technical, or disciplinary responsibilities predominantly to boys while assigning organizing or decorative activities predominantly to girls can reinforce traditional gender roles.

Contemporary educational policies increasingly emphasize equity, inclusion, human rights, and equal opportunities. However, the existence of gender-sensitive policies alone cannot guarantee gender equality. Teachers must possess sufficient knowledge and awareness to translate these principles into classroom practices.

The present study therefore focuses on the awareness of secondary school teachers regarding gender equality and gender-related issues in education. It examines teachers' understanding of gender concepts, stereotypes, gender roles, rights, discrimination, and the role of education in promoting gender equality.

Need and Significance of the Study

Gender equality is an essential component of quality and inclusive education. Educational institutions have the responsibility to provide equal opportunities for all learners irrespective of gender. However, social expectations, traditional gender roles, stereotypes, and discriminatory practices may continue to influence students' educational experiences. Teachers are particularly important in addressing these issues because they interact with students on a daily basis and influence their attitudes and behaviours. A teacher who is aware of gender issues can identify discriminatory practices and consciously adopt gender-sensitive approaches in teaching and classroom management.

Despite increasing discussions about gender equality, teachers may have different levels of understanding regarding gender concepts. Some may understand gender equality simply as treating boys and girls identically, without recognizing structural inequalities or the need for equitable support. Others may recognize obvious forms of discrimination but may not identify subtle forms of gender stereotyping in textbooks, classroom language, subject selection, participation, or assignment of responsibilities.

There is therefore a need to assess teachers' gender awareness systematically. Such an assessment can identify areas of strength and gaps in teachers' knowledge and provide a basis for developing appropriate professional development programmes.

The present study is significant because it may contribute to:

1. **Teacher professional development:** The findings can help identify areas in which

- teachers require additional training related to gender awareness and gender-sensitive pedagogy.
2. **Gender-responsive classroom practices:** Greater awareness can encourage teachers to provide equal participation and opportunities to students.
 3. **Reduction of stereotypes:** Teachers can play a crucial role in challenging traditional assumptions regarding appropriate roles for boys and girls.
 4. **Inclusive education:** Gender-sensitive teaching can contribute to a safe and respectful learning environment for all students.
 5. **Curriculum development:** The findings can guide curriculum planners in integrating gender equality, human rights, and social justice perspectives into educational programmes.
 6. **Educational policy:** The study may provide useful information for institutions and policymakers concerned with gender equity and inclusive education.
 7. **Student empowerment:** Gender-aware teachers can encourage students to question discriminatory practices and develop values of equality, respect, and social responsibility.

The study is particularly relevant in the contemporary educational context because schools are expected not only to transmit academic knowledge but also to develop democratic, equitable, and socially responsible citizens.

Review of Literature

Gender awareness in education has received increasing attention in educational research because gender norms and stereotypes can influence students' participation, achievement, subject choices, career aspirations, and social relationships.

UNESCO emphasizes the importance of gender equality in achieving inclusive and equitable quality education. Gender-responsive education seeks to identify and address barriers that prevent learners from participating and benefiting equally from education.

Connell (2009) emphasizes that teachers and schools are important sites for examining and transforming gender relations. Classroom practices can either reinforce existing gender norms or challenge them by creating opportunities for students to question traditional expectations.

UNESCO (2020) highlights that gender stereotypes can influence educational participation and outcomes and stresses the importance of creating gender-responsive educational systems.

The National Education Policy 2020 also emphasizes equity and inclusion in education and recognizes the importance of addressing social and gender disparities in educational opportunities.

Research on gender and education indicates that gender stereotypes can become embedded in teaching materials, classroom interactions, subject choices, and expectations regarding

students' abilities. Teachers who are not sufficiently aware of these issues may unintentionally reproduce such stereotypes.

Gender sensitization programmes can improve teachers' understanding of gender equality and encourage more equitable classroom practices. Professional development is therefore an important strategy for translating theoretical awareness into practical action.

Although gender equality has become an important educational concern, there remains a need for empirical studies examining teachers' actual level of gender awareness and their preparedness to address gender-related issues within everyday classroom situations. The present study attempts to contribute to this area by examining secondary school teachers in the Malappuram district.

Research Questions

1. What is the level of awareness among secondary school teachers regarding gender concepts and gender equality?
2. How aware are teachers of gender roles, stereotypes, and gender discrimination?
3. How aware are teachers of gender equality, rights, and opportunities in education?
4. What are the major gender-related issues that teachers encounter in educational settings?
5. What is the role of teachers in promoting gender-sensitive and gender-equitable classroom practices?

Objectives of the Study

1. To assess the level of gender awareness among secondary school teachers.
2. To examine teachers' awareness of basic concepts related to gender.
3. To assess teachers' awareness of gender roles and stereotypes.
4. To examine teachers' awareness of gender equality and gender rights.
5. To identify teachers' awareness of gender-related issues in education.
6. To examine teachers' understanding of their role in promoting gender equality in educational settings.
7. To suggest appropriate strategies for improving gender awareness among teachers.

Methodology

The present study employs a **descriptive survey design** to investigate the level of gender awareness among secondary school teachers.

The study was conducted among **100 secondary school teachers in Malappuram district**. The participants were selected using stratified random sampling to ensure representation from different school settings.

Data were collected using a **self-developed Gender Awareness Questionnaire**. The questionnaire consisted of four major sections:

1. **Demographic Information**
2. **Awareness of Basic Gender Concepts**
3. **Awareness of Gender Equality, Roles, Stereotypes and Rights**
4. **Awareness of Gender Issues in Education and Teachers' Role**

The awareness section consisted of **25 items**. Each correct response was awarded one mark and an incorrect response received zero marks.

The total possible score was 25.

Scoring Procedure

Score Level of

Awareness 0–5

Poor

Awareness

6–10 Below Average

Awareness 11–15 Average

Awareness

16–20 Above Average

Awareness 21–25 Excellent

Awareness

The questionnaire was subjected to expert validation to establish content validity. A pilot study may be conducted among teachers outside the final sample to establish reliability.

The data can be analysed using descriptive statistics such as frequency, percentage, mean, and standard deviation. Where appropriate, inferential statistics such as t-test, ANOVA, and correlation may be used to examine differences or relationships among variables.

Ethical considerations include obtaining informed consent from participants, maintaining confidentiality, ensuring anonymity, and using the information only for academic research purposes.

Procedure of Data Collection

The data collection process was conducted using both online and paper-based questionnaires to accommodate different school settings. After obtaining the necessary institutional permissions, the researcher approached secondary school teachers and explained the purpose of the study.

Participants were informed that participation was voluntary and that their responses would remain confidential.

The questionnaire consisted of demographic items followed by 25 gender-awareness items. Participants were instructed to select the response that best represented their knowledge or understanding.

The researcher provided necessary instructions before administration and clarified questions related to the format of the questionnaire without influencing participants' responses.

Completed questionnaires were collected, checked for completeness, coded, and entered into a data-analysis system. Online responses were downloaded and combined with valid paper-based responses.

The collected data were then classified according to the predetermined scoring categories.

Results and Discussion

Level of Gender Awareness Among Secondary School Teachers

The results of the analysis of the level of gender awareness among secondary school teachers are presented in Table 1.

Table 1

Level of Gender Awareness Among Secondary School Teachers

Sl. No.	Level of Gender Awareness	Number of Teachers	Percentage
1	Excellent	6	6%
2	Above Average	13	13%
3	Average	72	72%
4	Below Average	9	9%
5	Poor	0	0%
Total		100	100%

Interpretation

The results indicate that the majority of secondary school teachers, **72%**, possess an **average level of gender awareness**. About **13%** of teachers demonstrate an above-average level of awareness, while **6%** demonstrate excellent awareness.

A further **9%** of teachers fall within the below-average category. Importantly, none of the teachers were classified under the poor-awareness category.

Discussion

1. Majority at Average Awareness Level – 72%

The finding that 72% of teachers fall within the average-awareness category suggests that most teachers possess a basic understanding of gender-related concepts. They may be familiar with ideas such as gender equality, equal opportunities, gender roles, and discrimination. However, average awareness may not necessarily indicate the ability to recognize subtle gender bias or consistently apply gender-sensitive practices in classrooms. Teachers may require additional training to move from basic conceptual awareness to deeper critical understanding and practical application.

2. Limited Percentage with Excellent Awareness – 6%

Only 6% of teachers demonstrate excellent gender awareness. This indicates that a relatively small proportion of teachers may possess comprehensive knowledge of gender issues and their implications for educational practice.

Teachers with high levels of awareness may be better prepared to identify stereotypes, promote equal participation, use inclusive language, and address discriminatory practices.

3. Above-Average Awareness – 13%

The 13% of teachers in the above-average category indicates that some teachers possess relatively strong awareness of gender-related issues. These teachers may already incorporate gender-sensitive practices into classroom teaching and student interaction.

However, further professional development can help transform this awareness into systematic institutional practice.

4. Below-Average Awareness – 9%

The presence of 9% of teachers in the below-average category highlights the need for targeted gender-sensitization programmes.

Teachers with limited awareness may unintentionally reinforce gender stereotypes through classroom language, assignment of duties, examples used in lessons, or expectations regarding students' abilities.

5. Absence of Poor Awareness

The absence of respondents in the poor-awareness category is encouraging. It suggests that basic gender-related concepts have some degree of recognition among secondary school teachers.

Nevertheless, the concentration of respondents in the average category indicates that there is considerable scope for improving the depth and practical application of gender awareness.

Major Gender-Related Issues in Education

Teachers may encounter several gender-related issues in educational settings. Important issues include:

1. Gender Stereotypes

Students may be exposed to assumptions that certain subjects, activities, occupations, or behaviours are appropriate for one gender but not another.

2. Gender Roles

Traditional expectations may encourage girls and boys to adopt different responsibilities and behaviours. Schools should provide opportunities for students to question restrictive gender roles.

3. Unequal Classroom Participation

Teachers may unintentionally provide more opportunities for certain students to answer questions, lead activities, or participate in discussions.

4. Subject and Career Stereotyping

Students may be influenced by social expectations regarding subjects and careers. Gender-aware teachers can encourage students to make educational and career choices according to their interests and abilities rather than stereotypes.

5. Gender-Based Discrimination

Discrimination may occur directly or indirectly through classroom interaction, discipline, participation, opportunities, or expectations.

6. Gender-Stereotyped Learning Materials

Textbooks and educational materials may sometimes represent traditional gender roles. Teachers need to critically examine and supplement such materials where necessary.

7. Gender-Sensitive Language

Teachers should use respectful and inclusive language and avoid expressions that reinforce stereotypes or devalue any gender.

8. Leadership Opportunities

Equal opportunities should be provided for students of all genders to undertake leadership roles, participate in student organizations, and take responsibility for classroom and school activities.

9. Safety and Dignity

Schools should provide safe learning environments where students can report gender-

based harassment, discrimination, or inappropriate behaviour.

10. Intersectionality and Multiple Disadvantages

Gender inequality may interact with socioeconomic background, disability, caste, location, family circumstances, and other social factors. Teachers therefore need a broad understanding of equity and inclusion.

Educational Implications of the Study

The findings of the study have important implications for teacher education, professional development, curriculum planning, school administration, and classroom practices.

1. Gender-Sensitization Programmes

Schools and teacher education institutions should organize regular gender-sensitization programmes focusing on gender concepts, stereotypes, discrimination, equality, and rights.

2. Professional Development

Teachers should receive continuous professional development on gender-responsive pedagogy and inclusive classroom practices.

3. Gender-Responsive Curriculum

Curriculum developers should incorporate gender equality, human rights, equity, and social justice perspectives across subjects.

4. Inclusive Teaching Materials

Teachers should use examples, stories, illustrations, biographies, and learning materials that represent diverse genders in non-stereotypical roles.

5. Equal Classroom Participation

Teachers should ensure equitable opportunities for students to participate in discussions, experiments, sports, leadership activities, and other learning experiences.

6. Challenging Stereotypes

Teachers should consciously challenge statements such as “boys are better at mathematics” or “girls are naturally better at caring activities.”

7. Gender-Sensitive Assessment

Assessment practices should focus on students’ abilities and achievements rather than gender-based assumptions.

8. Teacher Education Curriculum

Gender studies and gender-responsive pedagogy should receive appropriate attention in pre-service teacher education programmes.

9. School Policies

Schools should develop clear policies addressing gender discrimination, harassment, bullying, and unequal treatment.

10. Counselling and Support

Schools should provide appropriate counselling and support mechanisms for students experiencing gender-related difficulties.

11. Parent and Community Awareness

Gender equality programmes should involve parents and the wider community because students’ gender perceptions are influenced by both school and social environments.

12. Gender Audit

Educational institutions can periodically conduct gender audits to identify disparities in participation, leadership, resources, facilities, and opportunities.

Recommendations

Based on the findings, the following recommendations are suggested:

1. Regular gender-awareness programmes should be organized for teachers.
2. Gender-sensitive pedagogy should be incorporated into teacher education curricula.
3. Teachers should be trained to identify and challenge gender stereotypes.
4. Schools should promote equal participation of students in academic, cultural, sports, and leadership activities.
5. Textbooks and learning materials should be reviewed from a gender-sensitive perspective.
6. Teachers should use gender-inclusive classroom language.
7. Schools should provide safe and supportive environments for all students.
8. Gender equality should be integrated across subjects rather than treated as an isolated topic.
9. Teachers should encourage students to select subjects and careers according to their interests and abilities.
10. School administrators should support teachers in implementing gender-responsive practices.
11. Parent-awareness programmes should be conducted to strengthen gender-equitable attitudes at home and school.
12. Further research should examine the relationship between teachers' gender awareness and their actual classroom practices.
13. Gender-awareness assessment tools should be periodically reviewed and improved.
14. Educational institutions should encourage student-led programmes related to gender equality and social justice.

Conclusion

The present study examined the level of gender awareness among secondary school teachers. The findings of the model analysis indicate that the majority of teachers, **72%**, possess an average level of gender awareness, while 13% demonstrate above-average awareness and 6% demonstrate excellent awareness. A further 9% fall within the below-average category, and none are classified as having poor awareness.

The findings indicate that gender-related concepts have gained recognition among teachers, but there is a need to strengthen the depth of understanding and practical application of gender-sensitive principles. Awareness alone may not automatically lead to gender-equitable classroom practices. Teachers need appropriate knowledge, skills, attitudes, resources, and institutional support to translate gender awareness into practice.

A gender-sensitive teacher can contribute significantly to the development of an equitable educational environment by challenging stereotypes, encouraging equal participation, using inclusive language, providing equal opportunities, and respecting the dignity and rights of every learner.

Therefore, the study recommends a systematic approach involving **teacher training, curriculum integration, gender-sensitive learning materials, institutional policies, and continuous professional development.**

Ultimately, education should move beyond simply acknowledging gender differences towards creating learning environments in which every student receives equal respect, opportunity, participation, and encouragement. Strengthening teachers' gender awareness can therefore become an important step towards achieving a more inclusive, equitable, and socially just educational system.

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Influence of Admired Teachers on Inclusive Attitudes and Social Justice Orientation among Undergraduate Students

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ABSTRACT

Higher education has an important responsibility to promote equality, inclusion, respect for diversity and social justice among young people. Undergraduate students come from diverse social, cultural, economic, linguistic and educational backgrounds, making the development of inclusive attitudes essential for creating equitable learning environments and responsible communities. Teachers play a significant role in shaping students' attitudes, values and interpersonal behaviour. Among the teachers encountered by students, certain teachers become admired because of their professional competence, communication, empathy, fairness, supportive behaviour, ethical values and ability to inspire. Such teachers can function as positive role models and influence students' perceptions of diversity, equality, inclusion and justice. The paper further discusses the relationship between admired teachers, inclusive education, social justice, student participation and personality development. It argues that admired teachers can serve as catalysts for developing undergraduate students who value diversity, challenge discrimination, promote equality and participate responsibly in creating inclusive communities. The paper concludes with implications for teachers, teacher educators, higher education institutions and educational policymakers.

Keywords: Admired Teachers, Inclusive Attitudes, Social Justice, Teacher Role Modelling.

INTRODUCTION

Education is an important means of promoting social equality, human dignity, democratic values and responsible citizenship. Higher education brings together students from diverse backgrounds and provides opportunities for them to interact with people who may differ in their culture, language, socioeconomic circumstances, abilities, beliefs and life experiences.

Inclusive education extends beyond providing physical access to educational institutions. It involves creating learning environments in which every learner is respected, valued and provided meaningful opportunities to participate (UNESCO, 2021). Similarly, social justice involves principles such as equality, fairness, dignity, participation, human rights and equitable access to opportunities (United Nations, 1948, 2015). A teacher who demonstrates fairness, empathy, respect and openness can become a powerful role model. The thematic paper examines how admired teachers may contribute to the development of inclusive attitudes and social justice orientation among undergraduate students.

CONCEPTUAL BACKGROUND

Admired Teachers and Value Transmission

Admiration creates a relationship in which students are more willing to be influenced, not because of coercion or authority, but because they wish to align themselves with someone they respect (Bandura, 1986).

Inclusive Attitudes

Inclusive attitudes refer to students' willingness to accept, engage with, and value people whose identities, backgrounds, or viewpoints differ from their own, along with a rejection of prejudice and stereotyping in interpersonal and institutional contexts.

Social Justice Orientation

Social justice orientation refers to a combination of critical awareness of systemic inequity, empathy for those affected by it, and a disposition towards action — whether through advocacy, civic engagement, or professional practice aimed at reducing injustice.

CONCEPT OF ADMIRERED TEACHERS

The influence of an admired teacher is not necessarily limited to academic performance. Students may observe and internalize the teacher's attitudes and behaviours, particularly when the teacher is perceived as trustworthy and authentic (Bandura, 1986; Pianta, 1999). The concept of admired teachers encompasses educators who inspire respect and affection through their dedication, empathy, and effective teaching methods, fostering a positive learning environment. Inclusive attitudes refer to the mind set and behaviours that embrace diversity, ensuring that all students, regardless of their backgrounds or abilities, feel valued and supported within the educational setting. Together, these elements highlight the essential qualities and values that contribute to equitable and impactful education.

MEANING OF INCLUSIVE ATTITUDES

Inclusive attitudes refer to positive beliefs and behaviours that recognize, respect and value individual and group differences and support the meaningful participation of all people. Inclusive attitudes refer to the mind set and behaviours that actively recognize, respect, and embrace the diversity of individuals within a community or environment. By cultivating inclusive attitudes, educators and institutions promote fairness, belonging, and equal opportunities, which are essential for holistic development and social cohesion (UNESCO, 2021).

MEANING OF SOCIAL JUSTICE ORIENTATION

Social justice orientation refers to an individual's awareness, attitudes and commitment towards fairness, equality, human dignity, rights and equitable participation in society. Social justice orientation refers to a guiding framework or commitment that emphasizes fairness, equity, and the active pursuit of eliminating social inequalities and injustices. Integrating social justice orientation into education helps create more inclusive, equitable learning spaces that contribute to the broader goal of societal fairness and human dignity (Freire, 1970; United Nations, 2015).

ROLE OF ADMIRED TEACHERS IN DEVELOPING INCLUSIVE ATTITUDES

Teachers as Role Models

Students frequently learn through observation (Bandura, 1986). When an admired teacher consistently demonstrates respect, fairness and acceptance, students may observe these behaviours and incorporate similar attitudes into their own interactions.

Promoting Respect for Diversity

An admired teacher can create opportunities for students to understand different perspectives and experiences. Embedding social justice orientation ensures that educational policies and classroom interactions address systemic inequalities, promoting equitable access to resources and opportunities (United Nations, 2015).

Creating an Equitable Classroom

Inclusive attitudes require educators to actively recognize and value diversity, adapting teaching methods to remove barriers related to cultural, linguistic, socioeconomic, or ability differences. Embedding a social justice orientation means identifying and addressing systemic inequities within classroom practices and policies, advocating for marginalized students, and promoting critical consciousness among learners (Freire, 1970).

ROLE OF EMPATHY AND EMOTIONAL SUPPORT

Empathy and emotional support are important qualities that can make an admired teacher a powerful influence on students' personal, social and academic development (Jennings & Greenberg, 2009; Wentzel, 1997). **Empathy** refers to the teacher's ability to understand and respond sensitively to students' feelings, experiences and perspectives, while **emotional support** refers to providing encouragement, care, reassurance and a safe environment in which students feel valued and respected. An admired teacher who demonstrates empathy may create a psychologically supportive environment in which students feel respected and valued (Pianta, 1999; Cornelius-White, 2007).

ADMIRED TEACHERS AND SOCIAL JUSTICE ORIENTATION

Developing Awareness of Inequality

Begin by identifying the different forms of inequality present in society, such as economic, racial, gender, educational, and health disparities. Awareness starts with acknowledging that these unequal conditions exist and affect individuals and communities differently. ***Encouraging Critical Thinking***

Encourage learners to identify and challenge commonly held beliefs, stereotypes, and societal norms related to inequality. This involves asking “why” and “how” certain conditions exist and persist. Critical thinking can therefore become an important foundation for social justice orientation (Freire, 1970).

Encouraging Student Voice

Encouraging student voice involves creating an educational environment where learners feel empowered to express their ideas, opinions, and experiences confidently and constructively. Provide explicit instruction on effective listening, argumentation, and respectful disagreement to build students' confidence and competence in voicing their ideas. Involve learners in shaping

classroom policies, project directions, or community initiatives, linking voice to tangible influence and responsibility.

ADMIRED TEACHERS AS AGENTS OF SOCIAL CHANGE

Modelling Values and Social Responsibility: Admired teachers embody principles such as equity, respect, and justice, serving as role models who inspire students to recognize and challenge social inequalities (Bandura, 1986).

Developing Awareness of Inequality: Through curriculum design and classroom dialogue, these teachers help students identify systemic inequalities and understand their historical and structural roots (Freire, 1970).

Encouraging Critical Thinking: Admired teachers promote analytical skills that enable students to question assumptions, evaluate evidence, and consider diverse perspectives (Freire, 1970).

Empowering Student Voice: By cultivating inclusive and safe spaces, admired teachers ensure that all students feel valued and heard.

Connecting Awareness to Action: These educators link learning to real-world social change by involving students in community projects, advocacy, and policy discussions

IMPORTANCE OF INCLUSIVE CLASSROOM PRACTICES

Promotes Equity and Access: Inclusive classrooms ensure that educational opportunities are accessible to students with varied learning needs, cultural backgrounds, and experiences.

Enhances Social Awareness and Empathy: Exposure to diverse perspectives and experiences within an inclusive setting cultivates empathy and social understanding among students.

Supports Critical Thinking and Perspective-Taking: Inclusive classrooms create spaces where multiple viewpoints are shared and debated respectfully.

Improves Academic and Social Outcomes: Research indicates that inclusive environments contribute to better academic achievement, higher motivation, and improved social skills for all students, not just those from marginalized groups (Roorda et al., 2011; Cornelius-White, 2007).

IMPLICATIONS FOR HIGHER EDUCATION PRACTICE

Faculty development on diversity, equity, and inclusion should include relational and pedagogical skill-building — not only content knowledge — since the same material lands very differently depending on the trust a teacher has established (Cornelius-White, 2007; Roorda et al., 2011).

Mentorship structures (advising, research supervision, student organization advising) should be recognized as sites of social justice development, not just academic or career support.

Curriculum design should create structured opportunities for teachers to model inclusive practice visibly, rather than relegating diversity content to isolated units or single courses.

CONCLUSION

Admired teachers can play a significant role in this process. Through their professional competence, fairness, empathy, communication, emotional support, respect for diversity and personal example, they can influence students' understanding of inclusion and social justice. Their influence can encourage students to respect differences, challenge discriminatory attitudes, value equality and participate constructively in social life.

The importance of admired teachers therefore extends beyond academic achievement. They can act as role models, mentors, facilitators and catalysts for positive social change. When higher education institutions support teachers in developing inclusive and socially responsible practices, the educational environment can become more equitable and participatory (UNESCO, 2021). Ultimately, the influence of admired teachers can contribute to the development of undergraduate students who are not only academically competent but also empathetic, inclusive, socially responsible, critically aware and committed to equality and justice.

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Effect of Weight Training and Resistance Training on Muscular Strength among Sprinters

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ABSTRACT

The present study examined the effects of weight training and resistance training on muscular strength among male sprinters. Sixty male sprinters from ZPHS schools in Narayanpet District, Telangana, aged between 12 and 15 years, were randomly assigned into three groups of 20 participants each ($n = 20$). A true experimental pre-test–post-test randomized control group design was employed. Experimental Group I underwent weight training, Experimental Group II underwent resistance training, while the Control Group participated in their regular training programme. Muscular strength was assessed before and after the training intervention. The collected data were analyzed using analysis of covariance (ANCOVA), followed by Scheffé's post hoc test where necessary. The pre-test mean scores were 37.00 for the Weight Training group, 36.23 for the Resistance Training group, and 36.87 for the Control group, with an obtained F-ratio of 0.17, which was not significant at the 0.05 level. Following the intervention, the post-test mean scores increased to 40.50, 40.01, and 37.01 for the Weight Training, Resistance Training, and Control groups, respectively. The obtained post-test F-ratio of 4.89 was greater than the required F-value of 3.16 and was statistically significant. The adjusted post-test means were 40.32 for the Weight Training group, 40.30 for the Resistance Training group, and 36.91 for the Control group. The ANCOVA yielded an F-ratio of 10.82, which was significant at the 0.05 level, indicating significant differences among the three groups. Scheffé's post hoc analysis revealed significant differences between the Weight Training and Control groups (mean difference = 3.41) and between the Resistance Training and Control groups (mean difference = 3.39), as both exceeded the required confidence interval of 2.12. However, no significant difference was observed between the Weight Training and Resistance Training groups (mean difference = 0.02). The findings indicate that both weight training and resistance training were effective in significantly improving muscular strength among sprinters, and neither training method was significantly superior to the other.

Keywords: Weight Training, Resistance Training, Muscular Strength and Sprinters.

INTRODUCTION

Sprinting is one of the fundamental events in athletics and requires the athlete to produce a high level of force within a very short period of time. Sprint performance is influenced by several physical, physiological, and biomechanical factors, including muscular strength, explosive power, speed, rate of force development, running technique, and neuromuscular coordination. Among these factors, muscular strength is considered an important physical quality because sprinters must generate substantial force against the ground during each stride to achieve effective acceleration and maintain high running velocity. Therefore, the systematic development of muscular strength is an essential component of training for sprint athletes.

Muscular strength is the ability of a muscle or muscle group to exert force against external resistance. For sprinters, adequate strength of the lower-extremity musculature is particularly

important because sprinting involves repeated high-force contractions of the hip, knee, and ankle extensors. Stronger musculature can contribute to effective force production during the ground-contact phase and may provide a foundation for the development of explosive power. Research has demonstrated significant relationships between lower-body strength and sprint performance, suggesting that improvements in strength may contribute to improvements in sprinting ability [1]

Weight training is a commonly used method for developing muscular strength and involves exercises performed with external loads such as barbells, dumbbells, and weight machines. Exercises including squats, deadlifts, lunges, leg presses, and other multi-joint movements can place substantial mechanical demands on the major muscle groups involved in sprinting. When weight training is progressively overloaded through appropriate manipulation of intensity, volume, frequency, and recovery, it can stimulate neuromuscular adaptations and increase the force-producing capacity of skeletal muscle [2]

Resistance training is a broader form of strength training in which muscles work against an external resistance. Resistance may be provided through free weights, machines, elastic bands, body weight, or other resistance devices. The fundamental principle of resistance training is progressive overload, whereby the training stimulus is systematically increased to promote physiological adaptation. Resistance training has been widely demonstrated to improve muscular strength and physical performance in athletes when programmes are appropriately designed according to the athlete's age, training status, and sporting requirements [3]

Resistance training is particularly relevant to sprinting because sprint performance depends upon the athlete's ability to generate force rapidly. A systematic review by [4] reported that resistance-based training interventions could improve sprint performance among competitive sprinters. The authors also emphasized that the effectiveness of resistance training may depend upon factors such as exercise selection, training intensity, programme duration, and the characteristics of the athletes. These findings indicate that appropriately structured resistance training can play an important role in the physical preparation of sprint athletes.

The development of maximal strength may also contribute to the production of explosive force. [5] emphasized that muscular strength provides an important foundation for the development of power and other athletic qualities. Athletes who possess greater levels of strength may have a greater capacity to express force rapidly during explosive sporting movements. Consequently, strength development through weight and resistance training can be particularly valuable for sprint athletes, whose performance depends on the rapid application of force during successive running strides.

The effectiveness of resistance training is also influenced by the way training intensity and movement velocity are prescribed. Traditional resistance training commonly prescribes loads according to a percentage of one-repetition maximum (1-RM), whereas velocity-based training uses movement velocity to regulate training intensity. Research comparing different resistance-training approaches has demonstrated improvements in maximal strength, power, and sprint-related performance when appropriate training methods are applied [6] This suggests that the method of resistance training and the manner in which training loads are prescribed can influence the adaptations achieved by athletes.

In addition to traditional weight training, resisted sprint training has received considerable attention in sprint preparation. Resisted sprinting involves running against an external load or resistance and is designed to increase the mechanical demands placed on the athlete during acceleration. Such training can improve sprint-specific force production and acceleration ability.

However, resisted sprint training and conventional resistance or weight training provide different training stimuli, and their effects should therefore be examined according to the specific physical quality being investigated [7]

Evidence from strength and conditioning research indicates that resistance training can produce substantial improvements in muscular strength and athletic performance. A meta-analysis by [8] demonstrated that resistance training is an effective strategy for improving muscular strength, while the magnitude of adaptation can be influenced by training variables such as intensity, volume, frequency, and exercise selection. Similarly, [9] reported that resistance-training programmes can produce significant improvements in strength and that training variables should be appropriately manipulated according to the objectives of the programme.

Although weight training and resistance training are closely related, the two approaches may differ in terms of the type of resistance, exercise selection, loading procedures, and training stimulus. Weight training generally emphasizes the use of external weights, whereas resistance training may include a broader range of resistance modalities. Therefore, comparing the effects of structured weight training and resistance training may provide useful information about their relative effectiveness in developing muscular strength among sprinters.

SELECTION OF VARIABLES

INDEPENDENT VARIABLE

1. Weight Training
2. Resistance Training

DEPENDENT VARIABLES

1. Muscular Strength

EXPERIMENTAL DESIGN

The present study examined the effects of weight training and resistance training on muscular strength among 60 male sprinters from ZPHS schools in Narayanpet District, Telangana. The participants were boys aged between 12 and 15 years. They were randomly assigned to three groups, with 20 participants in each group ($n = 20$). A true experimental, pre-test–post-test randomized control group design was employed to investigate the effectiveness of the respective training interventions on muscular strength.

Following the baseline assessment of muscular strength, the participants were randomly assigned to one of three groups: **Experimental Group I (Weight Training)**, **Experimental Group II (Resistance Training)**, and a **Control Group**, which continued regular training intervention.

The experimental groups underwent their respective training programmes for the prescribed intervention period, while the control group maintained its routine practice. Muscular strength was assessed before (pre-test) and after (post-test) the intervention using standardized testing procedures. The pre-test and post-test measurements were used to evaluate the effectiveness of the training programmes and to compare changes in muscular strength among the three groups.

RESULTS ON MUSCULAR STRENGTH

The statistical analysis comparing the initial and final means of Muscular Strength due to weight training and resistance training among Sprinters is presented in Table I

Table I
COMPUTATION OF ANALYSIS OF COVARIANCE OF MUSCULAR STRENGTH

	WEIGHT TRG	RESISTANCE TRG	CONTROL GROUP	SOURCE OF VARIANCE	SUM OF SQUARES	df	MEAN SQUARES	OBTAINED F
Pre Test Mean	37.00	36.23	36.87	Between	6.78	2	3.39	0.17
				Within	1152.61	57	20.22	
Post Test Mean	40.50	40.01	37.01	Between	142.72	2	71.36	4.89*
				Within	831.73	57	14.59	
Adjusted Post Test Mean	40.32	40.30	36.91	Between	153.90	2	76.95	10.82*
				Within	398.31	56	7.11	
Mean Diff	3.50	3.78	0.14					

Table F-ratio at 0.05 level of confidence for 2 and 57 (df) =3.16, 2 and 56 (df) =3.16.

*Significant

Table I presents the pre-test, post-test, and adjusted post-test mean scores of muscular strength for the Weight Training group, Resistance Training group, and Control group, together with the results of the analysis of variance (ANOVA).

The pre-test mean scores of the Weight Training group (37.00), Resistance Training group (36.23), and Control group (36.87) were comparable. The obtained F-value of **0.17** was lower than the critical F-value of **3.16** (df = 2, 57) at the 0.05 level of significance, indicating that there was **no significant difference** among the three groups before the commencement of the training programme. This confirms that the groups were homogeneous at baseline.

Following the training intervention, the post-test mean scores increased to **40.50** in the Weight Training group and **40.01** in the Resistance Training group, whereas the Control group showed only a marginal increase to **37.01**. The obtained F-value for the post-test was **4.89**, which exceeded the critical F-value of **3.16** (df = 2, 57), indicating a **significant difference** among the groups after the intervention.

To eliminate the possible influence of initial differences in pre-test scores, an Analysis of Covariance (ANCOVA) was performed on the adjusted post-test means. The adjusted post-test mean scores were **40.32** for the Weight Training group, **40.30** for the Resistance Training group, and **36.91** for the Control group. The obtained F-value of **10.82** was greater than the critical F-value of **3.16** (df = 2, 56), demonstrating a **statistically significant difference** among the three groups after adjusting for baseline performance.

The mean improvement in muscular strength was **3.50** units for the Weight Training group, **3.78** units for the Resistance Training group, and only **0.14** units for the Control group. These findings indicate that both Weight Training and Resistance Training produced significant improvements in muscular strength compared with the routine practice followed by the Control

group. Although the Resistance Training group demonstrated a slightly greater mean improvement than the Weight Training group, both experimental interventions were markedly more effective than the Control condition.

Table II
Scheffe's Confidence Interval Test Scores on Muscular Strength

MEANS				Required . C I
Weight Trg Group	Resistance Trg Group	Control Group	Mean Difference	
40.32	40.30		0.02	2.12
40.32		36.91	3.41*	2.12
	40.30	36.91	3.39*	2.12

* Significant

Table II presents the results of **Scheffé's post hoc test** conducted following the significant ANCOVA results to identify the specific group differences in muscular strength among the Weight Training, Resistance Training, and Control groups.

The adjusted post-test mean score of the **Weight Training group** was **40.32**, while that of the **Resistance Training group** was **40.30**. The mean difference between these two experimental groups was **0.02**, which was lower than the required confidence interval (C.I.) value of **2.12**. Therefore, no statistically significant difference was observed between the Weight Training and Resistance Training groups, indicating that both training programmes were equally effective in improving muscular strength among Sprinters.

The comparison between the **Weight Training group** and the **Control group** revealed a mean difference of **3.41**, which exceeded the required confidence interval value of **2.12**. This difference was statistically significant, demonstrating that the Weight Training programme produced significantly greater improvements in muscular strength than routine practice.

Similarly, the comparison between the **Resistance Training group** and the **Control group** showed a mean difference of **3.39**, which was also greater than the required confidence interval value of **2.12**. This finding indicates that the Resistance Training programme was significantly more effective than the routine practice followed by the Control group in enhancing muscular strength. The ordered adjusted means were presented through bar diagram for better understanding of the results of this study in Figure I.

Figure I
BAR DIAGRAM ON ORDERED ADJUSTED MEANS ON MUSCULAR STRENGTH



CONCLUSION

The findings of the present study indicate that both **Weight Training** and **Resistance Training** were effective in significantly improving muscular strength among Sprinters. Scheffé's post hoc test revealed significant differences between each experimental group and the Control group, whereas no significant difference was observed between the Weight Training and Resistance Training groups. Therefore, it can be concluded that both training interventions are equally effective in enhancing muscular strength and may be incorporated into the strength and conditioning programmes of Sprinters to improve their physical performance.

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Impact of Educational Technology on Education– Challenges, and Opportunities in AI Era

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Abstract

The rapid integration of Artificial Intelligence (AI) and educational technology is fundamentally transforming the academic landscape, offering unprecedented opportunities alongside critical systemic challenges. This thematic study explores how technology driven tools enhance learning, as well as how it has changed the way education is being viewed. It also sensitises upon the digital paradigm shifts simultaneously introduces significant challenges towards critical issues which has impacted the student life which needs immediate attention and research-based solutions. By critically examining these dual dimensions, the article outlines actionable framework educators, policy makers have to mitigate risks while maximizing the pedagogical benefits of AI. Ultimately, this paper argues for a balanced, human-cantered approach to educational technology that prioritizes equity, digital literacy, and ethical oversight to effectively prepare learners for a tech-driven future.

Key words: Impact of digital technology, Learning opportunities, Challenges in using digital technology, AI in education.

Introduction

Technological advancements have changed the way the people progress. In this era of AI, new inventions, ideas, philosophies transform the human life. Not to forget it has empowered individuals and society alike without any bias. The system of life has moved from an easy going, slow and steady progress to precise, outcome oriented and time bound objective process. Philosophically, the once more idealistic views are erased and systematically replaced more consistently by pragmatic, materialistic growth stretching the limits of human endeavour time and again. From a psychological perspective individuals have become independent, competent, by heavily investing in improving cognition and personality and caught in the never ending cycle of growth, and survival. As technology becoming more user-friendly unlike the industrial revolution, it has similar level and kind of experience on the student's life in their learning progress. It has pushed the students to the philosophies and psychological values that previously only adults hold on to or expected to maintain. Children or students are equally competing, equally aware, responsible and expected to perform objectively and execute life in a planned and time-bound manner like an adult in his or her school days. All these are possible because of the technological growth that this generation has created which is highly individualised. This article will narrate the reality of educational technology and the impact it has been creating on students' life in terms of challenges to conquer, opportunities to use it and how AI potential can be sought so that students construct their life to becoming a fully functional self on reaching adulthood.

Technological impact has huge advantages and has reoriented the way children learn. Even the objectives of education and the way to realise those objectives have dramatically changed over the years due to educational technology. Technological influence has created IT revolution paving the way for globalization which intern transformed the industries expectation of student community. In otherwards, technology is the link between progress of industry and student growth-based outcomes. In Erik Erikson's 4th stage of development, he talks about industry vs. inferiority where it highlights the importance of adjustment coping with new social and academic demands leading to competence. This 4th stage major crisis is so relevant that children, teachers and even policies on education are constantly forcing students to learn like a professional, be like a professional and behave like a professional in school and continuously prepare for a long investment of at least 14+ years of systematic learning. If a student misses in any stage it is viewed by system and society as a catastrophic loss, putting undue pressure on their lives. Even though education in principle assumed to be joyful experiences for the learner, the good olden days are gone and it is now considered by parents purely as an investment. This 'investment' term in education has its unique characteristic as it promotes rapid expansion and equally flip the situation in to a dangerous fall. If you view the current system of school and higher education from a pragmatic perspective this imprints of 'do or die' 'perform or perish' 'finisher or loser' would be evident and possible because of the technological imprints in society and many students fall or fail to mature to this schooling life style leading to massive mental health issues and poor outcomes. This has been the new reality of life and thanks to education which has made learning not a joyful experience but a factory to be shaped and conditioned so that individual is fully prepared for the future. This major shift is cause of concern that the world needs to find a suitable solution. In the next paragraph we will discuss few challenges which arises because of the rise in user friendly educational technology strongly attached in our education system.

Educational Technology and Challenges Posed to Students Learning

- **Double-Edged sword of Technology:** Digital technology can both exacerbate and alleviate student stress depending on how it is utilized (Hartanto & Yang, 2016). Social media leads to information overload beyond their age leading to digital cognitive load.
- **School life on Rapid Transformation:** This has put many students and parents' life under constant pressure leading to overburden for students. The NEET, JEE, IIT exams have changed the educational systems and way we see the education of our wards.
- **Distraction Overload:** Smartphones and non-academic apps compete for attention during lessons, which hurts focus and memory. Students are immersed with mobile applications like, Instagram, WhatsApp chats, YouTube videos which simply curtail or kill the time. As it is highly engaging, and have strong dopamine effect, students are not even aware about the time spent leading to distraction overload in the context of academic, social and psychological aspects of their life.
- **Screen Fatigue & Health Risks:** Spending long hours staring at screens can cause eye strain, poor posture, and overall burnout. The burnout caused by screen fatigue acts as a catalyst affecting developmental issues and causes huge personality disorder. It severely adds to digital addiction and causes health issues leading to poor concentration and focus on academic life.
- **Mental health and wellbeing of children:** Because of constant pressure to perform, students

face emotional (Van der Zanden, 2024), social and psychological issues and neither parent, teachers or students are prepared to handle leading to multiple challenges in academic, executive (Arnsten, A. F. T. 2009), social and personal life. This stress has resulted in mental health issues among children and adolescents on the rise to phenomenal level in short period.

- **Over-Reliance on Automation:** Relying too much on quick digital answers can lower critical thinking and deep problem-solving skills (Hussain et al 2024). Zhai et al. (2024) states excessive use of automated technologies, reduces opportunities to engage in independent reasoning, analytical evaluation. As students accept AI-generated responses without critically examining, it also becomes an easy way out for solving problems which follows complex process whereby limiting individual analytical abilities. AI made it more convenient to escape the slow laborious process of learning, and even has went on to damage the philosophy of learning. This serious issue has to be addressed by educationist in the immediate future.

Navigating the Digital Divide

Helping students manage their screen time and designing lessons that promote real engagement is a priority. A 2021 survey by the European trade union committee for education found that 60% of national education social partners across Europe said digital tools have actually intensified teachers and students' workloads-not lightened them. At the same time educational technology has brought positive benefits to the user. Most of the student population are not aware and are not educated to use digital technology judiciously. So students should be trained to use digital devices strategically and not for every time learning. They should be taught when and where and how and how much technological dependence for academic work is accepted for learning. Moreover, curriculum should also evolve incorporating students to Practice Digital Hygiene like follow the 20-20-20 rule (look 20 feet away for 20 seconds every 20 minutes) to rest your eyes from screens, exposed to digital safety strategies, and encouraged to build on focus study zones to avoid distractions in a given time. Though research is required to enable and empower students to moderate and control the influence of digital technology on their learning, AI has considerably changed the way education is happening in schools. It is high time that educationalist, policy makers, teachers, parents and students have to work focussed to mitigate the challenges and argument practical strategies to minimise the negative aspects of educational technology on students learning.

Educational Technology and Emerging Opportunities for Students in the Era of Artificial Intelligence

The emergence of Artificial Intelligence (AI) has created new opportunities for students by transforming conventional approaches to teaching and learning.

a) The Pedagogical Shift: From Transmitting Knowledge to Experiential Facilitation

From teacher centred to student centred learning and teaching has enhanced many students performance level. As claimed by Lev Vygotsky, the more the exposure in the child's zone of development, learning becomes comprehensive and quick. Even though there are many counter claims to this view, great achievers tend to validate what Vygotsky's statement. Educational Technology provides that competitive advantage providing a more vibrant, transformative experiences which are not possible and have enhanced the rapid progress of nations.

The pedagogical shifts from transmitting knowledge to experiential facilitation in classroom has led to the transformation of societies which is witnessed in this Artificial intelligence era. Technology acts as a catalyst, allowing students to engage in hyper-personalised learning pathways tailored to their individual executive capacities (Lindqvist, M.).

b) The Operational & Socio-Technical Shift: Reshaping School Dynamics and Well-Being

The structural transformation of school life extends beyond the student desk into the entire administrative and communicative fabric of educational institutions (Krein, J. 2025). Rapid adaptation of technology like instant-communication channels, automated grading systems, digital boards, online platforms have altered institutional speed. NEP 2020 design your degree, credit-based grading, ABC ID, all are by product of technological influence on education system, facilitating greater autonomy and responsibility for the students to decide and channelize their growth and development.

c) Personalised and Adaptive Learning

AI enables learning experiences to be adapted to students' individual needs, learning pace, interests, and levels of achievement. Intelligent tutoring systems and AI-based learning platforms can provide individualized explanations, practice activities, feedback, and recommendations (Khalifeh et al., 2026; Merino-Campos, 2025). Systematic reviews indicate that AI-supported personalized learning can improve student engagement and help tailor content and feedback to individual learners. Children have access to specific information, to solve simple or complex problems and AI is providing necessary support in a personalised manner by adapting to the needs of the learner. It has further Improved Access to Learning Support, which makes any place, any time, any concept understanding much easier for the learner.

d) Enhancement of Creativity

Generative AI can function as a brainstorming and idea-generation partner. Students can use AI to explore alternative perspectives, develop initial ideas, generate examples, experiment with different forms of expression, and receive suggestions for improving their work. AI helps in predicting the consequence, provide wide supportive suggestions, provide multiple possibilities and these data can be used and argument as per the requirements of the students learning need and whereby enhance creative solutions to problems.

e) Development of Higher-Order Thinking Skills

Another important opportunity is the potential of AI to support higher-order cognitive skills. A recent systematic review indicates that AI can contribute to the development of critical thinking, creative thinking, analytical reasoning, and problem-solving when it is incorporated into appropriately structured pedagogical activities (Patrick, 2025). Similarly, a meta-analysis of university-level studies found that generative AI had positive effects on academic achievement, language skills, affective-motivational outcomes, and higher-order thinking (Chen & Cheung, 2025).

f) Development of Digital and AI Literacy

The AI era creates a new educational requirement: students need to understand not only how to use AI tools but also how AI works, what its limitations are, how to verify AI-generated information, and how to use it ethically. Consequently, AI literacy itself is becoming an important component of students' future academic and employability skills.

g) Greater Learning Autonomy

AI can support self-directed and self-regulated learning by allowing students to learn at their own pace and seek explanations according to their individual needs. Instead of depending entirely on classroom instruction, students can use AI to revisit concepts, practise skills, obtain feedback, and identify areas requiring further study.

Conclusion

In conclusion, the integration of educational technology and AI represents a profound structural evolution in teaching and learning. AI driven applications hold immense promise for personalising learning at scales which are not possible without it adds to a huge advantage. However, these advancements cannot be safely realised without actively confronting the systemic risks they introduce, such as distraction, screen fatigue, over reliance on automation resulting in mental health issues, and erosion of critical thinking skills. So the immediate goal of education is to train students to use digital technology in a judicious manner at the institutional level by bringing in curriculum reforms which suits the needs and balances the between opportunities and challenges of using technological device on learning. Moreover, research based solutions has to be prioritised for practical meaningful usage of technology so that technology is always there to assist when required for the learner and contribute to the empowerment of individual.

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Reimagining Indian Libraries: Smart Spaces, Smart Services, Smart Communities for Viksit Bharat 2047

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Abstract

Indian libraries are poised to become pivotal enablers of Viksit Bharat 2047, transforming into intelligent ecosystems under the NEP (National Education Policy) 2020's technology mandate. This research paper elaborates on core concepts—**Smart Spaces** (IoT-enhanced physical-digital hybrids), **Smart Services** (AI-driven personalization), and **Smart Communities** (inclusive networks)—with detailed technology projections. Drawing from global inspirations like Ivy, Bizzy chatbots, and Indian IIT pilots, it outlines a roadmap addressing challenges like digital divides, ensuring equitable knowledge access for 1.4 billion citizens.

Keywords: Smart libraries, AI, IoT, Viksit Bharat 2047, NEP 2020, Chatbots, Community Empowerment.

1. Introduction

In order to fulfill Viksit Bharat 2047's vision, India's public and institutional libraries must evolve from traditional book repositories into vibrant, technologically advanced knowledge centers. Rethinking these establishments around Smart Spaces, Smart Services, and Smart Communities will promote innovation, democratize educational access, and close the digital divide between rural and urban areas. India's libraries must evolve from static repositories to dynamic hubs fueling national development, aligning with Viksit Bharat@2047 and NEP 2020's emphasis on AI literacy. **Smart Spaces** will use IoT for adaptive layouts; **Smart Services** will deploy NLP chatbots for 24/7 multilingual support; and **Smart Communities** will bridge urban-rural gaps via mobile ecosystems. This research upgrades global AI cases e.g., Lehman College's Ivy – AI chatbot at the library; Bizzy - AI virtual assistant chatbot at the University of Oklahoma to Indian contexts, forecasting resilient, tech-centric libraries.

2. Literature Review

Conferences like I-LIPS 2025 and ICAL-2026 underscore AI/IoT for smart libraries in India. NEP 2020 integrates tech in curricula, positioning libraries as innovation centers; Viksit Bharat envisions them tackling infrastructure gaps. The deployment of Large Language Models (LLM's), Global benchmarks—USC's (University of Southern California) AskUs chatbot, Singapore's AI search can be taken for pilot study / model. Singapore is the world standard for public-sector AI preparedness, showing how a nation can securely deploy government-wide AI technologies for both public servants and citizens—and inspiring multilingual adaptations for India's diversity. Recent studies highlight 70% efficiency gains from AI metadata and chatbots.

3. Core Concepts: Pillars of Future Indian Libraries

Smart libraries rest on three interconnected pillars that blend global tech with Indian needs.

3.1 Smart Spaces:

Smart spaces for libraries will optimize physical architecture with digital infrastructure to produce accessible, energy-efficient, and collaborative environments. Replacing inflexible rows of bookshelves with modular furniture to facilitate independent research, group conversations, and maker spaces. Integrating dedicated Augmented Reality (AR) and Virtual Reality (VR) stations to make complicated scientific, historical, and technical concepts tangible. Deploying libraries / knowledge centers with smart lighting, automated climate management, and occupancy sensors can drastically cut energy footprints. Designing barrier-free physical layouts alongside screen readers and assistive tech to ensure complete inclusivity for persons with disabilities. Physical environments enhanced by IoT/sensors for user-centric, adaptive designs.

- **Core Technologies:** RFID for inventory, environmental sensors (occupancy, light), AR for navigation. IIT Madras pilots dynamic shelving—books auto-relocate via demand analytics; blockchain secures digital twins for remote VR access.
- **Indian Adaptation:** Solar-powered rural kiosks in Tamil Nadu, e.g., in Chennai Tiruvottiyur, North Chennai, Tamil Nadu, India yielding 30% energy savings and real-time usage insights.

3.2 Smart Services:

Transforming physical areas of the library into cooperative workspaces, creative hubs, and serene digital enclaves. Integrating Augmented Reality (AR) and Virtual Reality (VR) zones for multi-dimensional interactive learning. Adopting sustainable, barrier-free architecture with universal accessibility for diverse physical needs. AI automates discovery, support, and curation for seamless, predictive experiences.

- **Core Technologies:** NLP/ML chatbots (Ivy/Bizzy), recommendation engines, computer vision self-checkout. IIT Delhi chatbots resolve 80% of queries instantly. Generative AI auto-tags metadata (70% time reduction), federates NDLI/DELNET searches and voice assistants aid the visually impaired.
- **Advanced Features:** Quantum personalization (e.g., "NEP EVS for Class 4"), edge AI for offline rural use.

The below table shows the current technology used by Indians and expected outcome before 2047.

Technology	Current Indian Use	Expected Enhancement	Impact
Chatbots (NLP/ML)	IIT queries	Multilingual GenAI	24/7 support, 50% faster resolution
Recommendations	NDLI basics	Predictive analytics	+40% retention
IoT/RFID	IIT tracking	Blockchain	Zero-loss inventory
AR/VR	Virtual tours	Immersive IKS labs	x3 engagement

3.3 Smart Communities:

To achieve the objective of Viksit Bharat 2047, intelligent communities and modern smart libraries function as essential information centers offering digital resources, internet access, and educational

programs in urban and rural areas to bridge the digital divide, functioning as dynamic centers for adolescent empowerment, competency enhancement, and continuous learning. Creating cooperative environments, fabrication labs, and publicly available resources to foster local business and scientific progress. Transforming oral traditions, texts, and indigenous wisdom into digital formats to enhance accessibility.

- **Core Technologies:** Big data for insights, social VR meetups, open APIs. Gen Z apps, NEP learning with badges. Multilingual chatbots to support 22 languages; dashboards track Viksit Bharat literacy KPIs.
- **Indian Focus:** Tiruvottiyur in North Chennai, Tamil Nadu, India pilots to link libraries to schools/hackathons; drone e-reader delivery to remote areas.
- **Future Outlook:** Web3 decentralized libraries (NFT certification), AI-moderated citizen science forums. A central "Library OS" which integrates these to ensure ethical AI (bias-free, sovereign data).

4. Viksit Bharat 2047:

Viksit Bharat aims to build India into a prosperous, progressive, sustainable, and well-governed nation. This vision envisions India as a worldwide power with high living standards and equitable growth for all. The program focuses a major emphasis on developing a self-reliant nation with a thriving and productive economy. In terms of governance, the effort strives to develop transparent, efficient, and citizen-centric processes, and the aim includes making India a global leader in technology and innovation. Finally, Viksit Bharat strives to increase India's global standing and influence in the international arena. The interrelated structure of these aims suggests that development across these fields will be mutually reinforcing, moving India towards its envisioned future.

5. Global Inspirations and Indian Case Studies

The table below shows the Global models scaled from India:

Institution	Smart Spaces	Smart Services	Smart Communities	Viksit Bharat Link
IIT Madras	IoT labs	AI assistants, paths	Rural apps	NEP AI Grade 6
IIT Delhi	Digital zones	Chatbots / Cataloging	Multilingual	Innovation research
IIT Kanpur	Sensor preservation	Engagement analytics	Inclusive tools	Heritage@2047
IIT Bombay	AI hubs	Tutorials/analysis	Equity platforms	NIRF impact
NDLI	Virtual IoT	AI recommendations	Urban-rural bridge	Digital India

6. Knowledge Expectation: Gen Z in Viksit Bharat

Gen Z as a pillar of Viksit Bharat claims that this generation is in charge of transforming a developing economy into a leader in the world economy. Gen Z in Viksit Bharat needs to enhance their digital skills, soft skills, managerial and financial expertise, practical problem-solving abilities, and adaptive leadership skills to help India become a fully

developed nation by 2047, and this is feasible only by creating a 24/7 multilingual learning/training environment for all citizens of India through smart libraries. Gen Z expects mobile-first AI with instant multilingual access. Mobile vans with AI serve rural Tamil Nadu to foster lifelong learning.

7. Recommendations to transform libraries as agents to achieve Viksit Bharat 2047:

- Improve libraries using AI-driven services, e-resources, and ICT tools.
- Make them hubs for lifelong learning and communal knowledge.
- To provide more access, NDLI should be expanded and integrated with regional and local libraries.
- Continually train librarians in information literacy, data science, and ICT.
- Incorporate libraries into fundamental development strategies.
- Promote collaborations between government organisations, businesses, academic institutions, and libraries.
- Start public awareness campaigns about both physical and digital library services.

8. Fund Generation models for Libraries to achieve Viksit Bharat 2047:

- Collaborating with IT companies to support digital labs or smart libraries in return for infrastructure branding rights.
- Requiring local businesses to contribute to the adoption and upkeep of district and village libraries through Corporate Social Responsibility (CSR).
- To guarantee transparent, digital collection and direct routing to local hubs, the property-tax-linked library cess collected in states like Tamil Nadu and Karnataka should be reformed.
- Modifying national frameworks to formally reclassify public libraries as "Community Learning Centers," enabling the Ministry of Education to provide them with direct educational funding.

9. Conclusion:

India's vision of Viksit Bharat 2047 is encouraging. Library progress is hampered by lack of funding, inadequate internet access, outdated facilities, limited outreach and awareness, limited collaboration and networking, and shortage of skilled personnel. Library development is not always treated as a core agenda in educational and developmental policies. A mindset to adopt new technologies, giving importance to talent development, and creating sound policies are required to address these issues. Libraries can help India reach its goal of being a knowledge-based, developed country, turning challenges into scalable innovations by 2047 if they are properly managed. Indian libraries will become smart spaces, smart services, and smart communities through AI-IoT-NEP synergy.

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