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# Mathematical Modelling and Big-Data Analytics for Student Performance

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**Abstract.** Mathematical Modelling and Big-data Analytics are playing a vital role in educational databases. The result of integrating technology to predict student performance along with Mathematical Modelling and Big-Data Analytics helps us to make better decisions about teaching and learning. Modelling involves formulating real-life situations or to convert the problems in mathematical explanations to a real or believable situation. However, Mathematical modelling are an essential enabler in Big-data and Developments in Big-data analytics require not only more computing, but also new advanced mathematical approaches. In this paper, our main aim to see how Mathematical Modelling and Big-Data analytics help in students' learning and how they relate to each other.

## Keywords

Mathematical Modelling, Big Data Analytics, Student Learning, Student performance, Educational Data Mining, Predictive Analysis, Predictive Modelling.

## 1. INTRODUCTION

In the 21st century, technology is playing an vital role in education. There are a lot of tools and techniques applied in in the Education industry. Here are a few examples:

- **Student Information System (SIS)** - This store and track all student information, including grades, attendance records, etc.
- **Learning Management Systems (LMS)** - This helps the teachers to track students' performance for each course along with the grades.
- **Attendance Management System (AMS)** - This helps the teachers to track the student's attendance.
- **Course Management System** - This helps the educators to develop the courses for students.
- **Enrollment and Admissions Management Systems** - This helps to track and monitor the enrollment process for the admission.

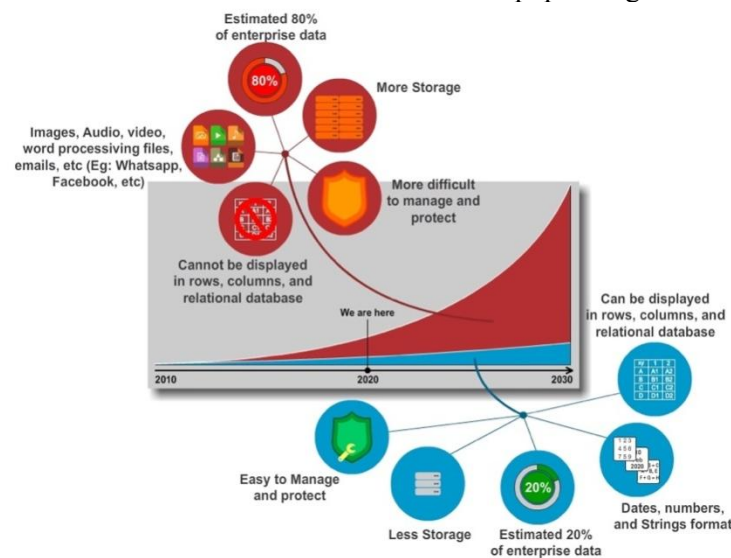
Apart from the above tools, teachers and administrators use many other management systems to improve the classroom, school, and campus operations. Recently, institutions have put into use mobile devices, online tests/evaluations, digital courses, education apps, and digital whiteboards to advance teaching and learning.



Data driven decision making is used in various businesses and other sectors widely now. Big Data, which be utilized in Data Driven Making technique, has become a very popular word now a days. Big Data and Analytics are utilized by different industries for decision making. The objective of this paper is to provide how Mathematical Modeling and Big Data Analytics to measure the student performance in Education.

**1.1 Big-Data**

Big Data is also a data but with a huge size. Big Data is a technology used to describe or interpret a collection of data that is very large and continuously growing exponentially with time. To put it in simple words, there exists no traditional data management tool that can store or process such large and complex data in an efficient manner. Now a days, data is populating from all the industries very fast. Big data can be classified as two major categories; that are Structured data and unstructured data. The following picture shows how structured and unstructured data is populating with clear picture.



**Figure 1. Big Data - Structured vs. Unstructured Data**

Big data has certain characteristics and hence is defined using 8 Vs namely.



**Figure 2. Big Data - 8Vs**

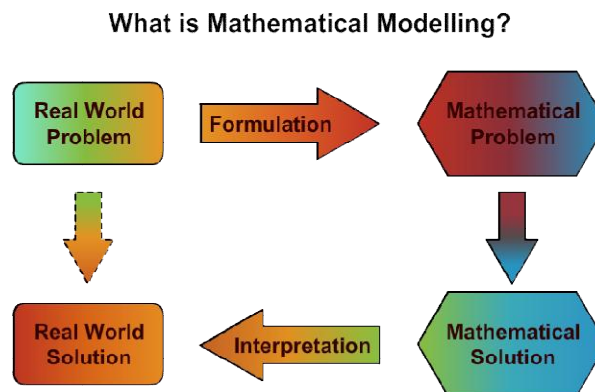
**1.2 Operations on Big-Data**

Three basic operations of big data are:

1. Transform big data to Information
2. Transform big data to Knowledge
3. Transform big data to Intelligence

### 1.3 Mathematical Modelling

Mathematical modeling is an art of decoding problems using mathematical formulations for both theoretical and numerical analysis to render appropriate solutions and guidance.



**Figure 3.** Mathematical Modelling

## 2. PRELIMINARIES

- **Learning or Data Analytics:** The process of measuring, investigating, and reporting of data about students to facilitate and optimize learning and studying the environment in which learning occurs.
- **Educational Data Mining:** The process where the techniques, tools, and research design is used for collecting meaning from repositories of data associated with student's learning activities in an educational setup.
- **Predictive Analytics:** Algorithms that assist analysts in predict behavior or events based on data.
- **Predictive Modelling:** The method of developing, testing, and authenticating a model to predict the possibility of an outcome.
- **Linguistic Variable:** It is the mathematical representation of variables stated in words. For example: “score” is a linguistic variable, which can take the values as “high”, “medium”, “low”, and so on.

## 3. ANALYTICS: A MATHEMATICAL ANALYSIS

For any  $x \in S$ ,  $x$  analytics is the discovery, interpretation, visualization, and communication of meaningful relationships, patterns, information, knowledge and intelligence in  $x \in S$ , where  $S = \{\text{data, information, knowledge, experience, wisdom, Google, Facebook, IBM, Adobe, Baidu, business, ...}\}$ .

This is the most general definition of analytics so far- 01 April 2019.

For example,

*If  $x = \text{data}$ , then we have data analytics,*

*If  $x = \text{big data}$ , then we have big data analytics*

*If  $x = \text{knowledge}$ , then we have knowledge analytics,*

*if  $x = \text{experience}$ , then we have experience analytics (Sun & Finnie, 2003)*

### Big Data Analytics: A Mathematical Analysis

*Big Data Analytics = Big Data  $\cap$  Mathematical Analytics*

Where  $\cap$  means integration and each as the other's scenario and application.

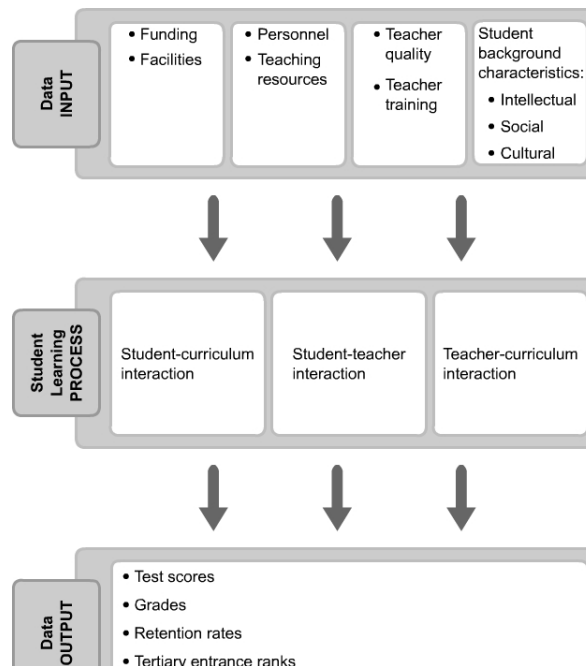
**Big Data analytics and computing**

- *Relation is Big Data analytics  $\cap$  Big Data computing*
- *Intelligent Big Data Analytics = AI + Big Data Analytics*  
*Intelligent is an operation, like +, - x, everyone knows*
- *Intelligent Big data analytics = Intelligent (Big data analytics)*  
*= Intelligent (Big data + analytics)*  
*= Intelligent big data + Intelligent analytics*
- *Intelligent Big data = Intelligent data collection + Intelligent data collection management*
- *Intelligent analytics = Intelligent Data analysis + Intelligent DW + Intelligent DM + Intelligent SM + Intelligent ML+ Intelligent Visualization + Intelligent optimization + AI*  
*Where DW = Data Warehouse, DM = Data Mining, SM = Statistical Modelling, ML = Machine Learning, AI = Artificial Intelligence*

**A Mathematical Modelling for Big Data**

The purpose of this section is to propose a mathematical modeling for big data. Once the mathematical structure and a basic structure is framed for the issue, it will be easy to develop a quality mathematical analytics. By applying discrete mathematics, two basic characteristics of big data can be recognized - the mathematical operator of being BIG, and the examining of the data. This will help create a mathematical model to search for big data.

The following is the example of how data is populated in Education. By using the following organizational framework steps in structuring, which consists of Population, Intervention Outcome, and Context.



**Figure 4.** How data is populated in Education Industry

**4. ADAPTIVE ASSESSMENT – ALGORITHM (UNIQUE MODEL FOR TESTING)**

- Step 1: Start the Assessment
- Step 2: Difficulty Level: Easy – Question 1
- Step 3: Check whether the answer is correct
- Step 4: Not correct? Go back to Step 2 (Question 2 should also be easy level)
- Step 5: If correct, Medium Level – Question 2
- Step 6: Check whether the answer is correct
- Step 7: Not correct? Reduce one difficulty level to Easy – then continue from Step 2
- Step 8: If correct, Hard Level – Question 3
- Step 9: Check whether the answer is correct
- Step 10: Not correct? Reduce one difficulty level to Medium – Then continue from Step 5
- Step 11: If correct, continue with hard level.
- ....
- Step k: If 5 questions are correct continuously, 6<sup>th</sup> question should be short answer type with Auto Grading. So that system will provide the result at the end of assessment. Short answer type questions should be consolidation of all the concepts covered from those 5 questions.
- ....
- Step n-2: Submit the Assessment
- Step n-1: Show Results
- Step n: End

Hence,

- IF Q1 (easy) ✓ then Q2 (medium), ELSE X Q2 (easy)
- IF Q2 (medium) ✓ then Q3 (hard), ELSE X Q3 (easy)
- IF Q3 (hard) ✓ then Q4 (hard), ELSE X Q4 (medium)
- IF Q4 (hard) ✓ then Q5 (hard), ELSE X Q5 (medium)

.....  
 .....

**Table format:**

Unit 1 / Lesson 1	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Q1	E	E	E	E	E	E
Q2	E	E	M	M	M	E
Q3	E	M	E	H	H	M
Unit 1/Lesson 2	E	M	E	M	H	E

Figure 5. Adaptive Testing in table format

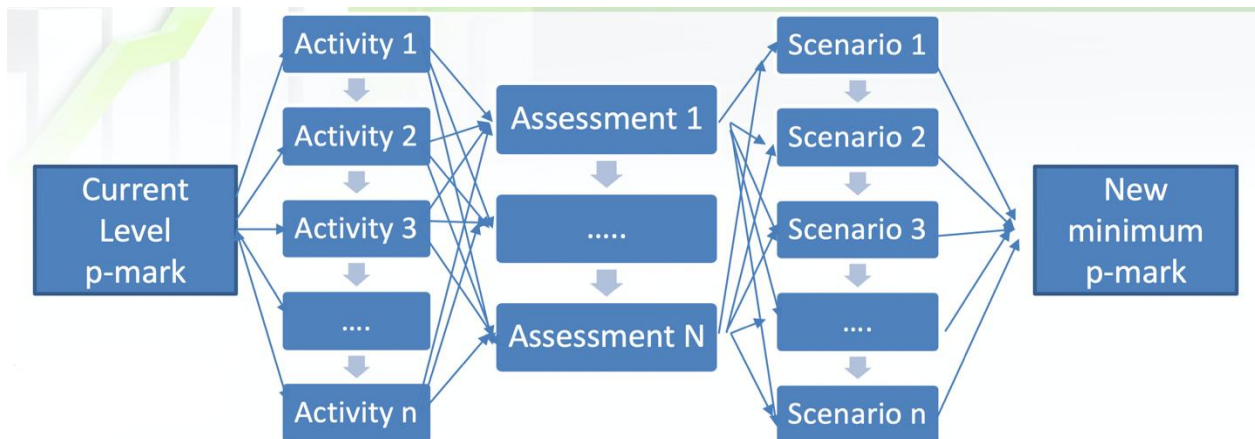
**5. Adaptive Testing in table format**

Continue the same logic for the second unit.

If the student answers the current difficulty level correctly, then increase the difficulty level.  
 If the student answers the current difficulty level wrongly, then decrease the difficulty level.

*IMPORTANT: For every unit, start with the same logic afresh.*

**5. ACTIVITIES AND WEIGHTAGE FOR CALCULATING P-SCORE**



<ul style="list-style-type: none"> <li>• a1 – Course Pretest</li> <li>• a2 – Theoretical Assignment</li> <li>• a3 – Class Test</li> </ul>	<ul style="list-style-type: none"> <li>• a4 – Unit Test</li> <li>• a5 – Projects</li> <li>• a6 – Course Posttest, etc...</li> </ul>
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After completing the assessment from all the activities defined by the teacher/administrator, the final performance score (p-score) will be calculated using the below formula.

$$p\text{-score} = a_1w_1 + a_2w_2 + a_3w_3 + \dots + a_nw_n$$

Where  $p$  is the participation or overall score

$a_1, a_2, a_3, \dots, a_n$  are the respective average score calculated for each activity

$w_1, w_2, w_3, \dots, w_n$  are the respective weights for each activity.

## 6. NUMERICAL DATA AND MODELLING

The following data modelling illustrates how the student learning progress improved every day/term with respect to all the learning activities. (Note: each dot represents a student)

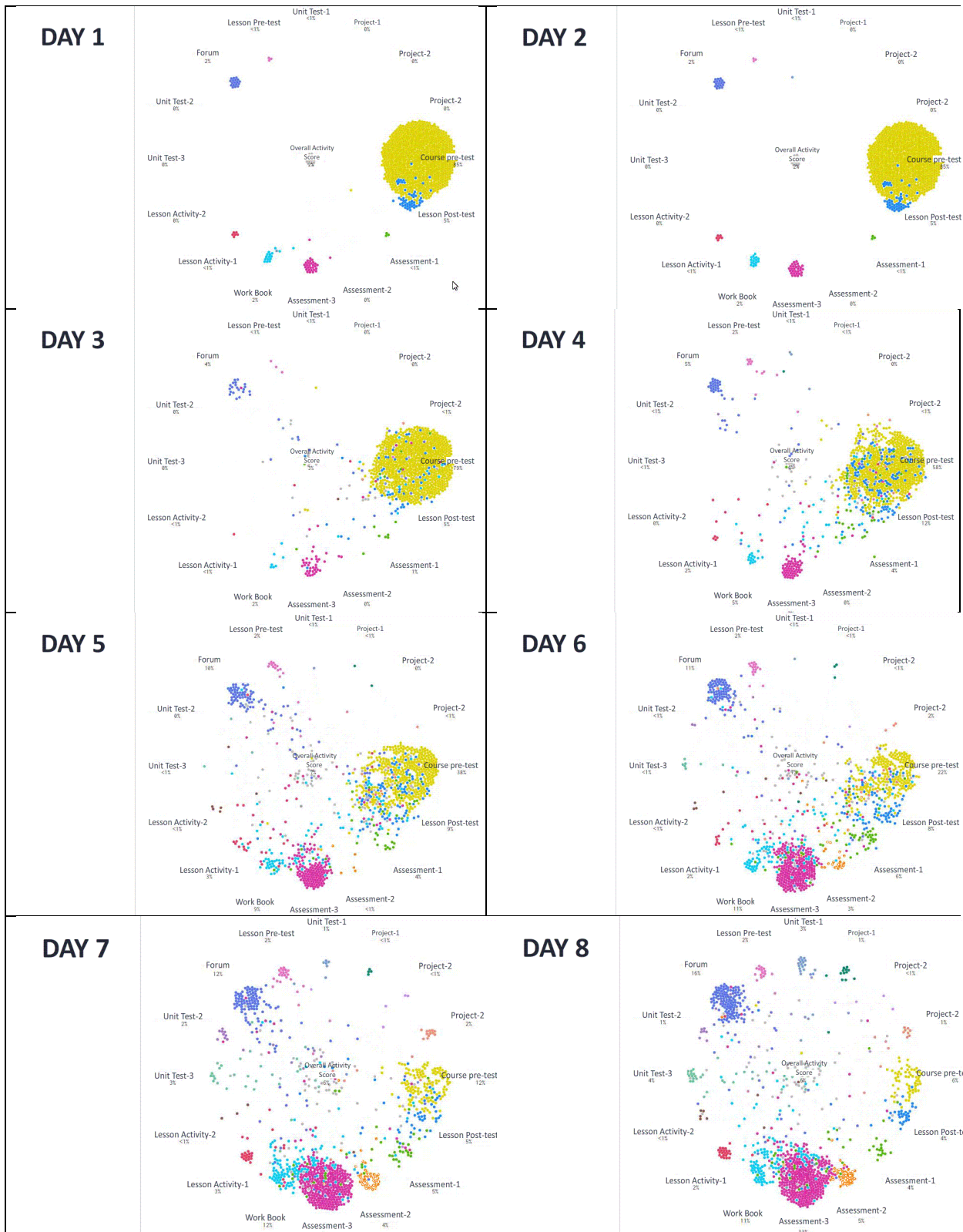
Measurement: Day 1, Day 2, Day 3,.. This can be a week or specified number of days for each activity. To explain better, measurement Day 1, Day 2,.. is used here.

**Day 1:** All the students starts from the course pretest - This assessment predicts the student’s level at the beginning of the course.

**Day 2:** After completing the course pretest, students individualized learning plan will be generated according to the student’s performance on the course pretest. From this moment, students will have their own goals to complete the course activities.

**Day 3 - Day 15:** Student completes the assessment or activity for the respective day and move to another activity.

**Day n:** All the students must have completed with a minimum mastery score for each activity and eligible for next grade or promotion.





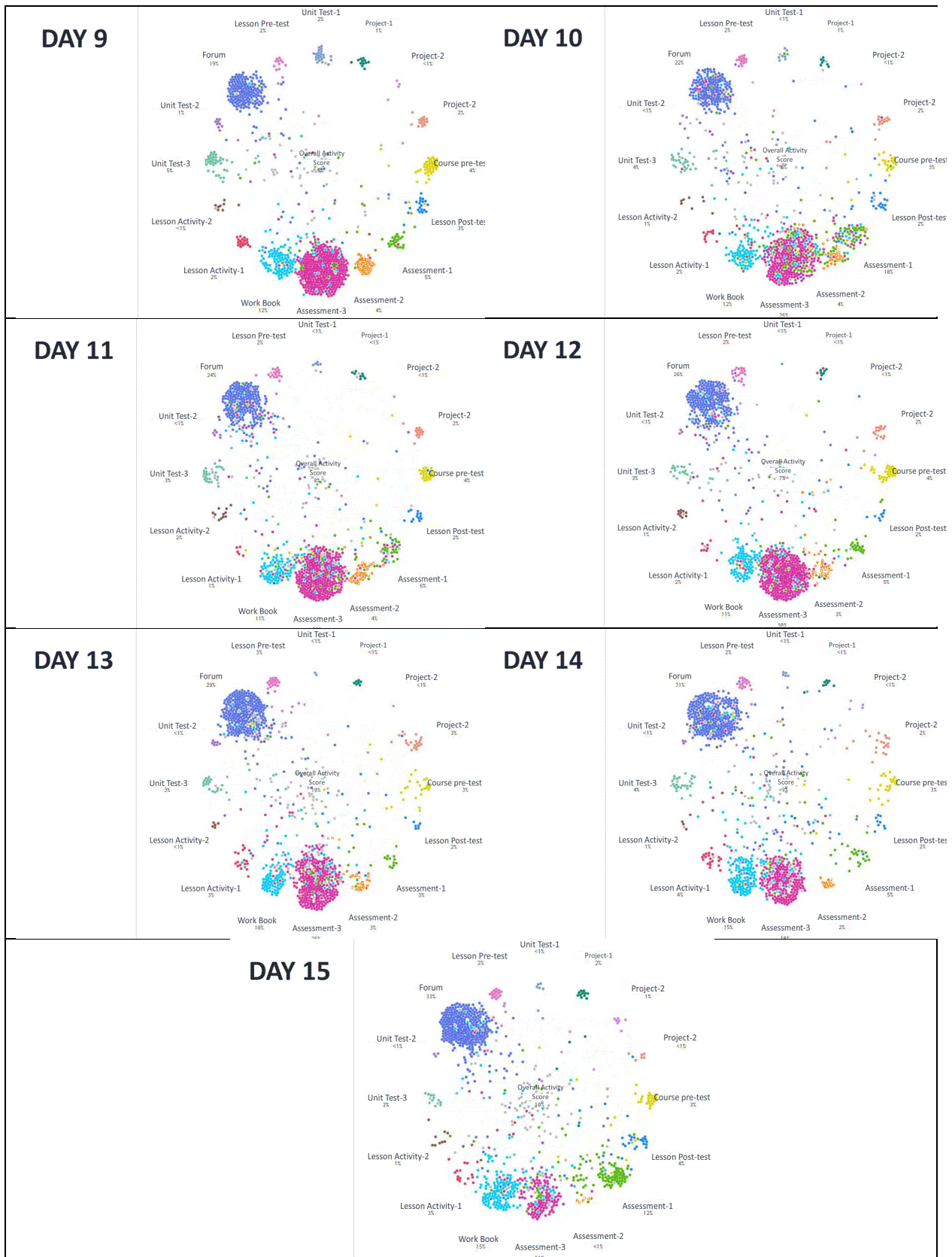


Figure 6. Data flow based on course completion for each day/term.

## 7. CONCLUSION

Assessing the student's performance is mostly useful to help teachers and administrators to improve their teaching methodology as well as students' learning goals/processes. This will help the educational system to monitor the students' performance in a systematic way using current technology. As per the student progress data flow based on activity completion for each day/term, students performance will be measured at each and every activity, lesson, unit term or semester, and for the whole course. At the end, all the students will be acquired the required skills for completing the course. In conclusion, the adaptive testing model is used to assess the students' performance at the beginning of the school year. If schools conduct this kind of assessment for each term (3 to 4 tests per year is suggested), they can easily improve students' learning process as well as teachers' teaching methodology. Hence, comparison of all the 3 to 4 tests, will give the accurate measure of the student performance based on the activity completion for each course.

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