Analysis of E-Learning Data using Cooperative Decision Support System

By

Sadaf Jalil

NUST Fall 2015-MSIT15-00000119014

Supervisor

Dr. Shahzad Saleem

Department of Computer Science

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Information Technology

In

School of Electrical Engineering and Computer Science,

National University of Sciences and Technology (NUST),

Islamabad, Pakistan

Approval

It is certified that the contents and form of the thesis entitled "**Analysis of E-Learning Data Using Decision Support System**" submitted by **Sadaf Jalil** have been found satisfactory for the requirement of the degree.

Advisor: **Dr. Shahzad Saleem**

Signature: _____

Date: _____

Committee Member 1: **Mr. Fahad Ahmad Satti**

Signature: _____

Date: _____

Committee Member 1: **Dr. Muddassir Malik**

Signature: _____

Date: _____

Committee Member 1: **Dr. Asad Ali Shah**

Signature: _____

Date: _____

Certificate of Originality

I hereby declare that this submission is my own work and to the best of my knowledge it contains no materials previously published or written by another person, nor material, which to a substantial extent, has been accepted for the award of any degree or diploma at NUST SEECS or at any other educational institute, except where due acknowledgement has been made in the thesis. Any contribution made to the research by others, with whom I have worked at NUST SEECS or elsewhere, is explicitly acknowledged in the thesis.

I also declare that the intellectual content of this thesis is the product of my own work, except for the assistance from others in the project's design and conception or in style, presentation and linguistics which has been acknowledged.

Author's Name: **Sadaf Jalil**

Signature: _____

Acknowledgement

I pay my gratitude to Allah almighty for His blessings guidance without which I could not have completed this task. I am thankful to Dr. Shahzad Saleem for guiding and encouraging me to complete my thesis.

I am also thankful to Department of Computing, and the teachers for providing me with an academic base, which enabled me to complete this thesis.

I would like to thank my parents who have provided me every comfort of life and their utmost affection and support that made me reach where I am today.

Table of Contents

List of Figures

List of Tables

Abstract

In this digital era where the use of computers has become a part of learning as well as teaching; understanding the implications of technology inside education is important. It can be a powerful tool for learning or can be a source of distraction. Digital devices are given to the students with the purpose of having a worldwide source of information and guidelines so that every individual can learn with their own pace and at the same time teachers are required to track real time progress of individual students to know who may be struggling and lagging and need extra attention and motivation. Proposed solution to the problem; decision support systems have been developing since the last two decades, but the traditional approach is not enough for uncertain and complex situations where quick decision making is required. Therefore, a decision support system can serve to assist teachers via cooperation.

Chapter 1 Introduction

Learning is a process that starts with one's birth and continues throughout life. The learning process is both formal and informal[1]. Formally, learning takes place in an educational institute within the bounds of a classroom i.e. the traditional form of learning. A relatively new or developing form of learning is blended/online learning. E-Learning is an educational tool based on computers and internet, and it makes you able to learn at your comfort place without going anywhere and schedule time according own routine[2].

E-learning tools allow students to access educational curriculum outside traditional classrooms. It helps bridge geographical gaps and does not have any location or time restrictions. It enables students, who for any reason are unable to attend a traditional classroom, to earn online degrees[2]. The advancement of the technological era and widespread of the internet in the late 20th century made it feasible for virtual learning environments to become conducive. Sharing and access to information is possible in various formats i.e. video, slideshows and word documents etc.[3]. The reserves of online available information are surplus and virtual learning environments are thriving with people who get and benefit from e-learning opportunities[4].

Some of the E-learning practices are Learning Management System (LMS), MOOC (Massive Open Online Courses) and Virtual University[4].

Learning management system (LMS) remotely serves content to learners. It enables a teacher to create learning modules, upload files, and communicate with the learners, all in an online environment. LMS varies depending on the objective of the institution but it is widely used to deploy and track course content and progress[5].

MOOCs are courses which are offered at a massive scale to students with an open curriculum available online without any charges. MOOCs are a recent development in distance learning[6].

Virtual University broadcasts its lectures online and student-teacher interaction also happens over the internet. Exams are conducted in allotted centers all over Pakistan. Virtual University aims to provide widespread education at nominal costs[7].

The benefits of E-learning can be summarized as such that there is flexibility in schedules so that lectures can be accessed at any time. The availability and delivery of content are very easy as it can be

disseminated to students once at the start of the semester and they can access it again and again without any trouble[8]. There is no additional cost of hostels and conveyance, as it can be done through the comfort of your own home. There is also no issue of overcrowding of classrooms and thus, more students can be entertained in the courses of their choice[8].

E-learning is not perfect. Online learning requires more self-discipline and motivation, students are expected to be self-directed. Classroom learning is more disciplined and organized. It is hard to replicate the same discipline and organization in an online environment. While delivery of content may be more exhausting in a traditional classroom, it also gets instant feedback[9].

Teachers have an active role in traditional teaching where students are passive receivers of knowledge. Teachers pass information to students. When this information is loaded onto students without taking into consideration the attitude of students towards the subject, their motivations, and expectations from the course, they are encouraged in rote learning[10].

One-Way communication exists between teachers and students in a traditional classroom setting[9]. The use of computers is rapidly increasing in education and it is gaining importance. While classroom teaching has a major impact in developing students' interest in a course, their performance and eventually their final grading[1].

The huge amount of information collected from e-learning platforms can be nitpicked for meaningful trends which can show students' progress in a course[11]. There needs to be some more development in the monitoring tools for such platforms so that teachers can identify whether students need help in any aspect of the course content[12]. But unfortunately, there are no tools or applications which visual cues can to mark students who fail to develop an interest in their course or do not study regularly[13].

1.1 Background

Distance learning has become quite popular, which leads to an increase in the already existing data that is useful to predict what effect digitization has on this generation and the concurrent generation. Is it spoiling learners, or does it make learning more interesting for them? These questions need to be answered and subsequent decisions are needed to be made for students[6].

Every student is unique, and it is important to address problems tailored to the student in question. Performance-based focus is required. If students are not interested in studying their behavior must be

considered with reference to other students, educators, and educational institutions to facilitate educational decision making[14].

E-learning systems collect and hold a huge amount of information which is worth performing analysis of student behavior and determine the effectiveness of course designs to predict student performance[15]. This data can also be used to group students in a way which is most beneficial to students. The educational process can be improved greatly if this data is used appropriately. If teachers have access to relevant data and knowledge mined from the surplus data accumulated by online learning systems, the results will be more valuable and facilitate a better decision-making process[16].

E-Learning Platforms are constantly changing; they have transformed the everyday lives of teachers and students. In order to stay on top of the educational sector, countries are looking for new, smart platforms which can inculcate innovative training into the context of learning and teaching. Over the past decade, there has been a lot of evolution in the e-learning platforms[17].

Following are some of examples for e-learning, two things are common in all i.e. (i) learning and (ii) computers[6].

Table 1: E-learning Platforms

Platforms	**Concept focus**
Moodle (LMS, CMS)	Deliver course content to learners, supports blended learning (face-to-face + distance learning), implemented in educational institutes[5].
MOOCs (edx, udacity, course era)	Provide standalone course offerings with standardized sequence of topics covered for general audience. Facilitation of an true expert in that specific subject plus bundles of information and learning material made available online.[10].
Virtual University	Established by Government of Pakistan to promote distance education. It is known for the online lectures it facilitates and broadcasting thorough programs regardless of where the students are located physically. It is recognized by the Higher Education Commission (Pakistan)[18].
Khan Academy	Create a set of tools online for helping students to educate themselves. The acknowledged institute provides short lessons in the form of videos, including exercises to practice and studying materials[19].

Applications (games, videos)	Incorporating learning content/ activities to video and games enhance learning experience and self-motivation by engaging via knowledge checks, drag and drop tests, quizzes, or scenario-based video learning[20]. *"Games have the power to teach, train and educate"*[21].
Webinars (Web-based seminar)	Live, web-based video conference hosting to audience all over the world. Professionals give educational presentations to connect with their audiences in a much closer way[22].

1.2 **Motivation**

The physical component of a traditional classroom which allows teachers to keep some check on students is missing in E-learning platforms. Instructors face many challenges or obstacles in such platforms[9]. For all the benefits of distance learning, teachers lack visual cues which can signal students disinterest in the course[23]. While teaching online, instructors are less visible than traditional classroom instructors. This affects the authority of teachers and weakens the teacher-student connection[23]. Monitoring tools can be helpful to see if students were able to access course material and identify areas in need of improvement[24].

Statistics has a vital role in detailed analysis, while assessing and evaluating students; how they perform and how they behave in academic environments. This ability makes it be used by universities to measure student achievement levels[25], leading to better decisions regarding changes that are needed to be made to improve academic performances[26].

To help the class instructors' redesign/update their shared material for learning purposes and improving the arrangement of the course contents and categories, Learning Analytics (LA) and educational data mining (EDM) methods are among different approaches used to work on the problem of monitoring and appraising students learning progress. These methods can be adopted to predict and model an improved set of skills where data can be categorized into various factors that contribute to the learning process. It can serve as a guide about educational reform as well as intervention for students who need it[27].

Learning analytics is an ever-growing research area that is dedicated to tracking and finding modern solutions to the learning procedure that students follow when studying for their field[28]. The primary

reason to make use of data retrieved from learning platforms is so that the learning outcomes for students are drastically improved and become more tailored to their educational purpose[29].

LA can produce multi-purpose insights at a very instrumental level[30]. The system can help to identify students who are at risk and consequently help advisors to develop strategies which will help them stay on-course. Or if necessary, it also determines whether the student's selected major is in accordance with their academic inclination. Teachers can use LA to improve curriculum and assessments[31].

These analytics are governed by people termed as "educators" who track you while you navigate through the course or any learning activity online. In the age where students cannot learn something perfectly by following traditional educating methods. With a simulation at hand, and educators tracking it, better student development models can be created. Ultimately, this will provide students with the option of visualizing their learning progress in a more user-friendly and adaptable way in order to foster better self-regulation and self-motivation[32].

Educational Data Mining (EDM) is used to extract and analyze data from e-learning platform data stores in order to consider a set of questions regarding the quality and to aim at the optimization of educational process[33].

Data Mining is remarkably supportive in educational fields especially when there is a need to examine and evaluate conduct of students in the internet learning environments. It is because of the reason that the ability of data mining in decomposing and revealing the hidden data that is itself a tough and extremely tedious job if there is no automation and only work manually[34]. Numerous tools and techniques of data mining is adopted by many industries for the sake of generating business intelligence in order to improve and expand decision making process. In the educational fields, data mining techniques are used so that they can provide improved and better services with a lot more enhancement in the betterment of student performance.

Decision Support Systems (DSS) are a set of tools, manual or computer-based, which are used to assist in some decision making. People dealing with DSS perform a wide variety of functions, including cash flow analysis, concept ranking, multi-stage forecasting, product performance improvement, and resource allocation analysis[35].

Similar as every formal organization, school is truly a decision-making structure. Decision making is a major responsibility of educator and administrators, this process employs an optimizing strategy by seeking the best possible alternative to maximize the achievement of goals and object[36].

Educational Decision Support System (EDSS) can be used to create student profiles according to demographic information. To answer questions about why specific students are more likely to fail, profiles of students can be compared. Instructors can use this to know their students, understand their working habits, provide guidelines on how to make efficient use of course, where problems exist for them etc.[37]

Figure 1: education decision making flow chart

1.3 Challenges

The **challenges** that are faced when applying data mining/presentation techniques revolve around 3 major factors, amongst the many that may appear.

i. The first one is about how education-related data works in tandem with data-mining methods and tools. The relation between the two sectors being merged together is studied and is represented through diagrams, quantities and programs[38].
ii. The second challenge that must be efficiently battled is making sure that the desired learning outcome is achieved through an e-learning activity. The e-learning activity takes the help of different tools to record usage data[13].
iii. The third challenge is to be able to determine beforehand how the student will perform and what would be the predicted grade. The e-learning platform will make its prediction through the way students interact, access and use the platform given to them[39].

1.4 Problem Statement

"Analysis of data of learners' behavior in an e-learning environment is a challenging task where instructors may not have a clear vision about who their students are and what difficulties they face while learning."

The lack of visual aids for teachers to monitor the process and progress of students enrolled in their e-learning courses poses a challenge to the quality of education provided by institutions. Teachers cannot track where the students fail. If teachers have relevant data, they can predict the performance of students in a course and match students with courses where their aptitude lies. The performance of students can also be improved by identifying the areas where they face difficulties.

1.5 Solution

When taking the help of analytics for decision support systems, a pool of benefits open. When you enable an e-learning platform with intelligent tools and rich data, it proves itself to be profitable. The decision support systems will create student profiles according to demographic information, they will know the difference between a drop-out profile and the profile of a student who is successful, and they can help in finding out the questions which students are more likely to fail[40].

For instructors, the application of analytics to decision support system will be beneficial because they will know who their students are, how they will work, how they will make efficient use of the virtual course provided to them, where they find problems etc.[37]

The proposed solution is to develop an analytic tool which can be used to track data of users and evaluate their learning progress. A cooperative DSS is when data is collected, analyzed, and then given to a human who helps the system revise or refine it. Both a human and computer component join forces to facilitate the best solution. It allows for an interactive process between human and system towards the accomplishment of a common goal. The decision maker (or any of their advisors) can modify, complete, or refine the decision suggestions provided by the system, before sending them back to the system for validation[41]. In a similar manner, the system again improves, completes, and refines the suggestions of the decision maker and sends them back to them for approval.

A cooperative DSS will allow instructors to extract, transform and load factors which will help them analyze, modify and transform education policies if needed. It will also account for the opinions of multiple faculty members and will not be biased to the person who is running the analysis.

1.6 **Research Impact**

Pakistan is a developing country and education is one of those necessity that effects country's development like all developed countries around the world[42]. Pakistan's education system needs to be up to dated and improved in many ways to meet the global standards. Many universities in Pakistan have taken initiatives to use technology in assessments and evaluations of their students. LMS and CMS are used for content and information sharing; such as lectures, notes, grades and attendance. Any students can view their marksheets and can self-evaluate themselves that they need to improve[43].

It is a great effort, but still even if the course is very well-designed, some students may feel it boring similarly some instructors may face the same situations to get a clear vision of their students' progress.

Information systems produces series of data that can be useful to predict the impact of digitization on our coming generation/the posterity[42]. Hence, the question arises how much it can be benefitable. Are these changes making learning more enjoyable and interesting or is wasting students more time? Thus, critical decisions are needed to be taken for the students.

Learning analytics produce rich insights at a granular level, the system can flag students who are at risk and they can be provided with strategies by the advisors to help them get back to track academically or if necessary, make hard choice of whether a student's choice of his major fits his or her academic inclination. Faculty can help improve curriculum, pedagogy, and assessments[26].

1.6.1 Key Contributions

There are many benefits out of which some elaborated as under:

- Visualize learning analytics to guide decision making about educational reform and learner-level intervention for at-risk students.
- Improve teacher time and effort by providing information on which students need additional help, which students are candidates for mentoring others and which teaching processes are making the biggest impact.
- Observe and identify strategies used by the learners and find out the activities that are best used for learning.
- Helps to foresee performance of learners.
- Provides a personalized eLearning experience to the learners.
- Increased learners' retention rates.
- Allow non -technical people to deal directly with the computer.
- Provides an interface to visualize the information graphically like pie charts, bar charts and line charts.

1.7 Thesis Organization

The organization of the thesis is as follows:

1.7.1 Chapter 1: Introduction and Background

It provides brief overview of learning processes, idea of e-learning and challenges associated with them. Moreover, few e-learning platforms that have been evolved and enhanced over time have also been discussed.

1.7.2 Chapter 2: Literature Review

This chapter explains the work done so far which is related to e-learning and efforts put into gaining real analytics on user engagement with e-learning platforms. The formulation of the thesis and the

novelty of the thesis lie in identifying the research gap from the literature already published. The identification of the direction of research is also one of the sanctions of literature.

1.7.3 Chapter 3: Solution and Methodology

Our proposed analysis approach has been presented in this chapter. Moreover, features added to an existing LMS (skillpak - http://skillpak.com/)for automatic extraction of data, and plugins (high charts) used for visual presentations, are presented here. Furthermore, the input parameters required to drive the framework are also presented in this section.

1.7.4 Chapter 4: Deployment and Implementation

The functionality of our proposed framework implemented in a real environment (http://isdswat.org/lms/) is described.

1.7.5 Chapter 5: Results and Discussion

Results and visualizations obtained are all presented and discussed in this chapter.

1.7.6 Chapter 6: Conclusion and Future work

The conclusion of our work and the future work which is to be carried out is presented in this chapter.

Chapter 2 Literature Review

Learning is a self-development process. It is a process that involves making sense of your surrounding by observing, analyzing, reviewing relevant information, mentally reorganizing it, and connecting it with what an individual already know. Learning strengthens correct responses and weakens incorrect responses[44]. The process of learning has changed as the technology becomes widespread and as with time new technologies are rapidly developing[9]. To embrace the same phase, many educational institutions around the world are also integrating technologies and research knowledge so that the readers can access it according to their convenience anytime and anywhere they want[9].

2.1 Ways of Learning

In practice, there are three ways of learning; traditional method, blended method and virtual/ online method. All learning methods help a learner to upskill his/her knowledge. However, the question is which method demonstrates better outcome[45].

According to a case study by Prof. Christine A. Walsh in 2017, the following graph represents a relation between time spent on online learning vs use of technology of three fundamental ways of learning[46].

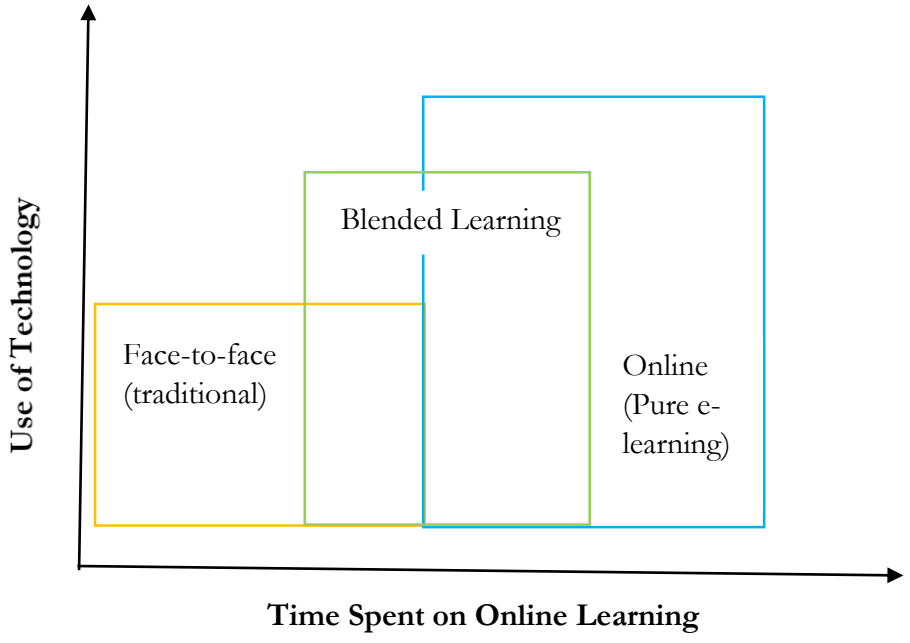


Figure 2: A graph demonstrating "Time spent on Online Learning VS Use of Technology"

2.1.1 Traditional Learning

The traditional way of learning or face-to-face learning is adopted in most of the educational institutes around the globe. In this method, an instructor is allocated for a course, where all the learning actions and strategies are arranged according to instructor's perspective. An instructor will be subjected to teach a group of students and access their learning capabilities by multiple assessments[47].

Another over facet of traditional learning is that the learner will be limited to an instructor's teaching material and guidance, and without considering the sequences of material and courses, individual student differences can hardly straight reflection of every person learning competences. As an effect, all students are similarly treated as if they are beginners and require to be given guided instructions but in fact some of them may already have learnt the subject material. For such students, the traditional method can be a time wastage and may it reduce their interest in learning and are less motivated[47].

2.1.2 Virtual Learning

A virtual learning is an approach to learn and teach by including computers and the Internet in a learning environment. The elements used are course curriculum mapped onto lecture material and assignments, students' identification, communication medium for teacher and students i.e. e-mail, threaded discussions, chat etc. [48]

Types of users are defined and credentials with reserved rights.

2.1.2.1 Examples

Virtual University provides a pure virtual learning environment (VLE)[7]. Similarly, MOOCs provide standalone course offerings with standardized sequence of topics covered for general audience. However, they lack the ability to provide credentials, which is essential for competing and improving while learning[8].

2.1.2.2 Case Studies

a. Every year technology advances, and many educational institutes adopt these technologies in their method of teachings. To investigate the effectiveness of electronic learning and traditional face-to-face learning, Richard K. Ladyshewsky in 2004 conducted a case study[49]. The study examined student (n = 1401) performance in nine units offered in both electronic learning and face-to-face learning for two years. The study also considered the effects of age

and gender. It was noted that students, on average, did better in the electronic learning. However, at the individual unit level the difference was minimal. Age and gender did not appear to moderate performance in any way except for those students under 33 who did better, on average, in the electronic learning.

b. Another case study conducted on university students; a total of 353 being divided into 2 groups each comprising of 12 courses. One group was enrolled in e-learning courses while the other in traditional physical courses. Results show the e-learning students to be more motivated, motivation measures are i) knowledge ii) completing tasks iii) practicing stimulation. Based on ethnicity, there were no motivational differences found among the test groups[45].

2.1.3 **Blended Learning**

Blended learning method has been adopted very rapidly by all educational institutions around the world. The reason of its rapid acceptance is "it allows the reservation of traditional forms of learning, shaped by centuries of pedagogical experience and enjoying a lot of human loyalty, despite the temptation of handing over many educational functions to new technologies"[50]. It permits the users to integrate new technologies into a teaching and learning process.

Many Authors have defined blended learning in their research papers which follows as:[51]

- According to Driscoll (2002), blended learning is the "intermixing of any instructional forms to achieve an educational goal"

- Garrison and Kanuka (2004) explain blended learning as "integrating classroom teaching with online experiences"

- Similarly, Singh (2003) understanding on blended learning is a "combining different delivery media to promote meaningful and motivating learning"

Almost all educational instructions in today's era have integrated bended learning in their teachings. Tools such as student's blackboard, social study groups, blogs, forums and webinars are typical examples[51].

2.1.3.1 **Demonstration of Blended Learning**

Christine A. Walsh, 2017 has demonstrated the relation of blended learning between traditional method or face-to-face learning and Virtual method in the following figure 3[46].

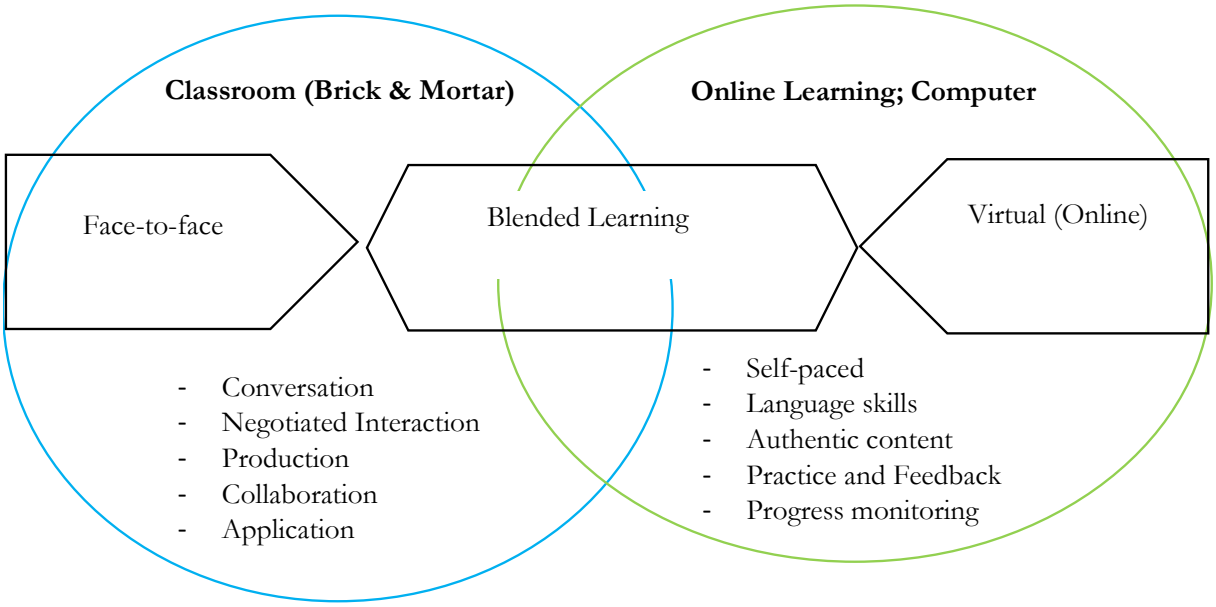


Figure 3: Relation between traditional and virtual learning

A model representing the relation between face-to-face classroom Vs Online classroom by Dr. Katie Holland in the following figure[46]:

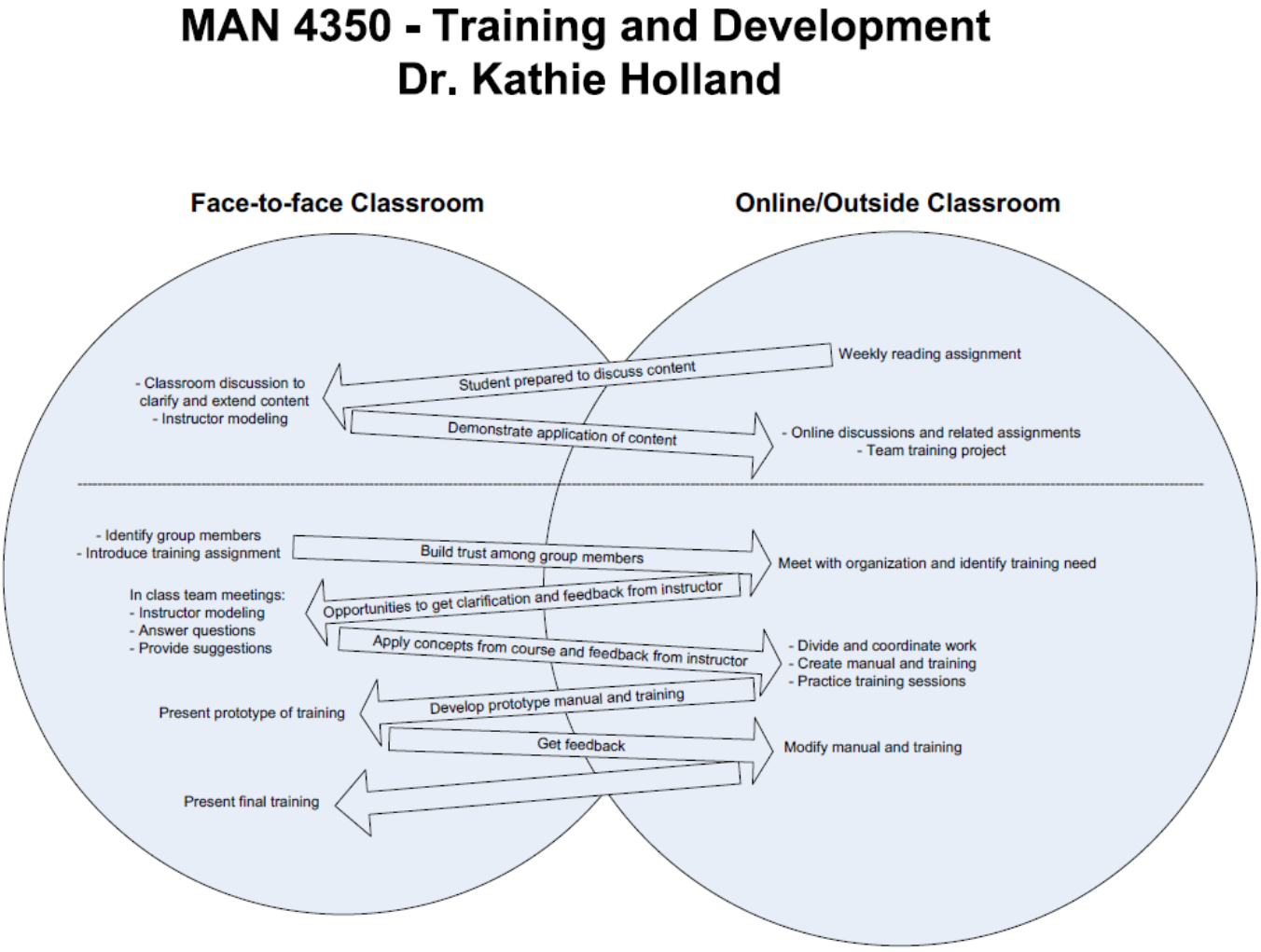


Figure 4: model representing the relation between face-to-face classroom V's Online classroom

We cannot completely switch to a new way of teaching and learning, and thus found a mid-way; giving birth to blended learning. Practical implications of blended learning are the management systems described in the next section.

2.2 E-Learning Systems used in Blended Learning

Depending on the functionalities and the goals of the e-learning platform LMS is a significant classification among many.

2.2.1 **Learning Management Systems (LMS)**

One of the most popular online education portals is the Learning Management System (LMS) which supports both learning and teaching processes. It is a flexible system where lectures can be accessed at any time[5]. Since the rapid development and adaption of internet, educational institutes have been pushed to enhance the learning process by attaching it to online platforms[52].

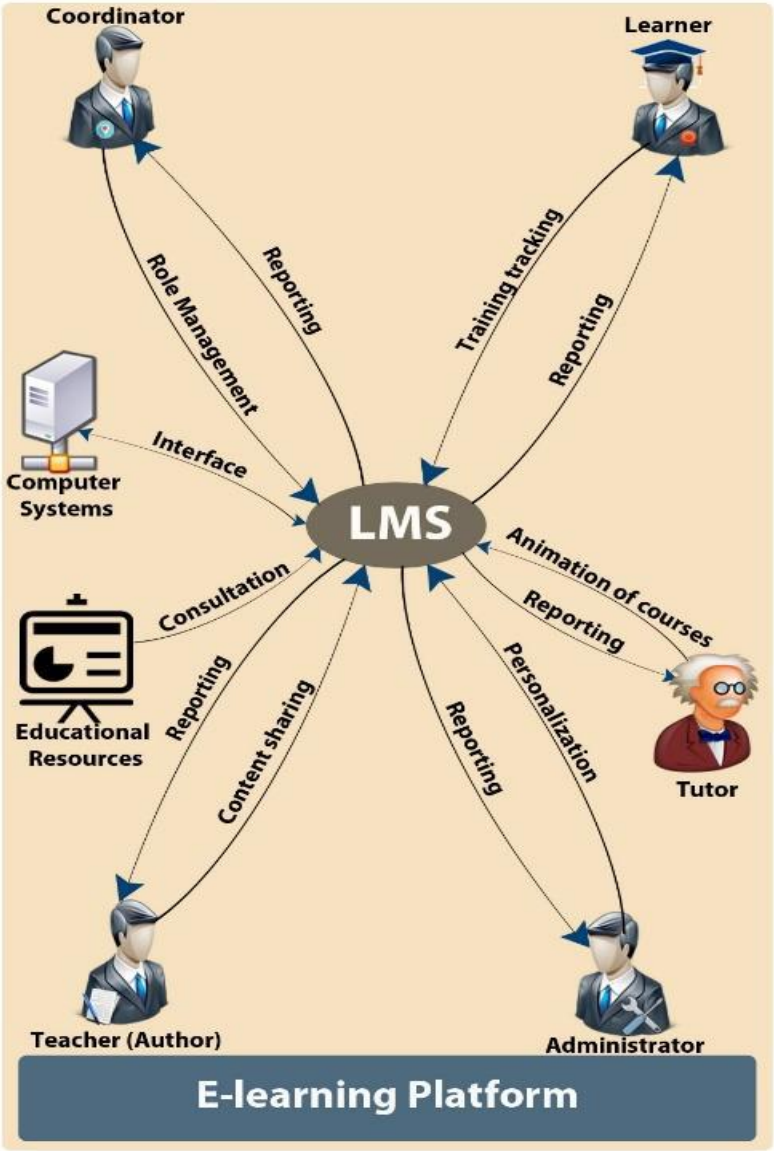


Figure 5: general architecture of an LMS[17]

We have multiple open source platforms. The most used platform for educational purposes is:

2.2.1.1 **Moodle**

Moodle is an open source course management system, which is also noted as (CMS). CMS software applications are designed using sound pedagogical principles. It helps educators to create effective online learning groups that are user friendly, low-tech browsing interface and can easily be installed on any platform, which supports PHP and demands single database[53].

Major features of Moodle are; adding and editing lectures, assignments, discussions, quizzes, grades, and suggesting online content. Quizzes may be of different types such as, multiple-choice, True-False, short questions etc. Six different users can be created i.e. administrator, course creator, teacher, non-editing teacher, student and guest[53].

Moodle is adopted by a lot of universities for the features Moodle offers. We can find surveys conducted on its effectiveness recently.

i. **Analyze the learning behavior of students**

   A research survey conducted on Learn@WU systems revealed that majority of students up to 70% use self-assessments to memories questions rather than focusing on given content. It was noted that students could easily solve exam questions that are copied from the original source but fail to do so, if the questions are modified. This showed that accomplishment rates in self-assessments are not beneficial for exam success. Furthermore, it was noted that space learning and the amount of time spent on learning also contribute optimistically on final exam results[54].

ii. **Analyze and discover learner's knowledge and ability through models**

   This research points towards the impacts of the digital revolution in education. The concept that it has made search easy as one can find tons of knowledge free and thus learning is not now dependent on classroom schedules and specific patterns, is tested. A group of 34 students with a tutor is considered for the study, focusing on learning by discovery and research skills. A group of exercises is designed by the tutor after which the students are expected to work on them, they are supposed to explore the criteria or rules needed to solve them. Techniques used in educational data mining are then practiced on the data obtained, results showed that 73% of them fulfilled every proposed activity

established in between the goal; 8-10 / 10. While 16% of the students fulfilled the minimum base of activities between the goals of 6-8 / 10. And 11% of students were below the expected goal and categorized among those who did not fulfill the minimum requirement in the certain activities[43].

iii. **Digging factors that influence a student's performance**

It poses an idea to predict student's performance in the next semester. Data is collected via multiple sources; regarding academic histories and demographics. Results highlights that a **student's attendance**, **3rd semester CGPA** and his/her **father's income** has an influence on his upcoming grades. All other parameters are found to be useless in case of effecting grades[55].

2.3 Evolution of E-Learning Platforms from Content to Activity Based Learning

With the passage of time, e-learning is no more an unheard term, not a trend[2]. It has become a mainstream being evolved from a basic system which was designed to share course and academic materials to complete online course offerings at universities[7].

One of the applications in e-learning specifically related Software Production Line (SPL) engineering is discussed in the study conducted by Pablo Sanchez[56]. The study mainly focuses on adaptability of auxiliary application across different e-learning platforms and among other auxiliary application. Although, the needs for inconsistent practice is inevitable due to application developer's strategy, platform of choice and environment, the consistency between applications can result in better teaching-learning experience for masses[3]. The inclusion of E-learning Web Miner to house different SPLs for which can be replicated to cater different e-learning platforms and applications. The purpose of the SPL engineering is to allow the regeneration and replication of code to automatically build new application as required based on specific need of a course, group, environment and other variables while keeping the cost as low and possible[57]. E-learning miner would rely on third party applications such as Weka, KNime and RapidMiner to perform Knowledge discovery from database (KDD) to perform data mining techniques and to build the understanding of the application requirements for a specific market segment[34].

2.4 The Triple E Framework: Engage, Enhance and Extend

Currently when media is everywhere, it is claimed more often that a source of technology may "revolutionize" the effect of learning and educating. Being realistic, it is not 100% correct. The triple E framework considers this illusion that the technology can be a magician in the learning processes, so it alarms the teacher to be more critical users of technology and be very alert in making wise choices while choosing tools and techniques for their support.

The framework is a practical approach developed by Professor Liz Kolb in 2011, at the University of Michigan, School of Education. The purpose was to measure the degree to which students are helped in their studies to learn anything by technology. It has 3 basic components; engagement, enhancement and extension of learning goals.[58].

The following table describes the Triple E framework:

Table 2: Triple E Framework

Extent Learning	It focuses on the idea of technology involved in learning, if it is capable enough to develop new skills in the students and help them in learning outside the traditional school?	**Instructional Strategies** **Tum & Talk** **Co-Use** **Gradual Release** **Interactive Modelling** **I Do, We Do, You Do** **Predicting** **Questioning** **Share-Aloud** **Think, Pair And Share** **Guided Practice** **Software Tour**
Enhance Learning	It examines if the technology creates a better path for the students to learn about the tools that they could not pick up easily in their typical learning classes?	
Engage Learning	Does the technology a better approach to keep students motivated and less distracted?	

		Switcher Choo **Visible Thinking** **Routines** **Monitoring**

2.5 Gripping Approaches Towards Effective Online Learning

Online learning platforms, used in blended and virtual learning environments are aided/ embedded with some motivational elements to keep the students engaged and make the online learning more convincing, following are some that I could found in research:

2.5.1 Visuals

For learning anything in life it is necessary to have a visual image in mind, so it can make things much easier and clearer and helps in learning faster. Visualization is necessary for memory, dreaming and imagination[59].

Visualization is a graphical representation of information with the purpose of providing users a visual means of processing the information and for an effective visualization, it is necessary that it is based on the viewer's knowledge. If users have a strong knowledge and power of visualization they can perform in a much efficient manner as well as their ability to learn faster enhance more[60]. Using a visualization approach for the sake of effective learning increases the chances of success. Same is the case with e-learning systems for one reason that the visualization approach increases the critical thinking, enhances the communication skills in a person as well as an analytical approach towards numerous problems in everyday life[42]. Visualization plays an important role in effective learning because it is a very powerful and useful cognitive tool for problem-solving it is increasingly important in this information age[21].

2.5.1.1 Examples

In the context of second language, study conducted by Indy, the student learned Mandarin using a virtual environment and interact with learning objective. Virtual environment study was conducted in supermarket, kitchen and a zoom simulation[61]. Below is the picture of one of the virtual environments:

Figure 6: Virtual Zoo for word learning

2.5.2 Fun element

The approach called "game-based learning" usually targets young students, as basic education and awareness is a serious issue around the globe. Recently, efforts have been made on educational games development. For the respective purpose, keeping in mind the human cognitive processes, certain steps are followed defined in Anderson's taxonomy model[13];

i. Remembering
ii. Understanding
iii. Applying
iv. Evaluating
v. Analyzing
vi. Evaluating
vii. Creating

Anderson's taxonomy model is presented below[62]:

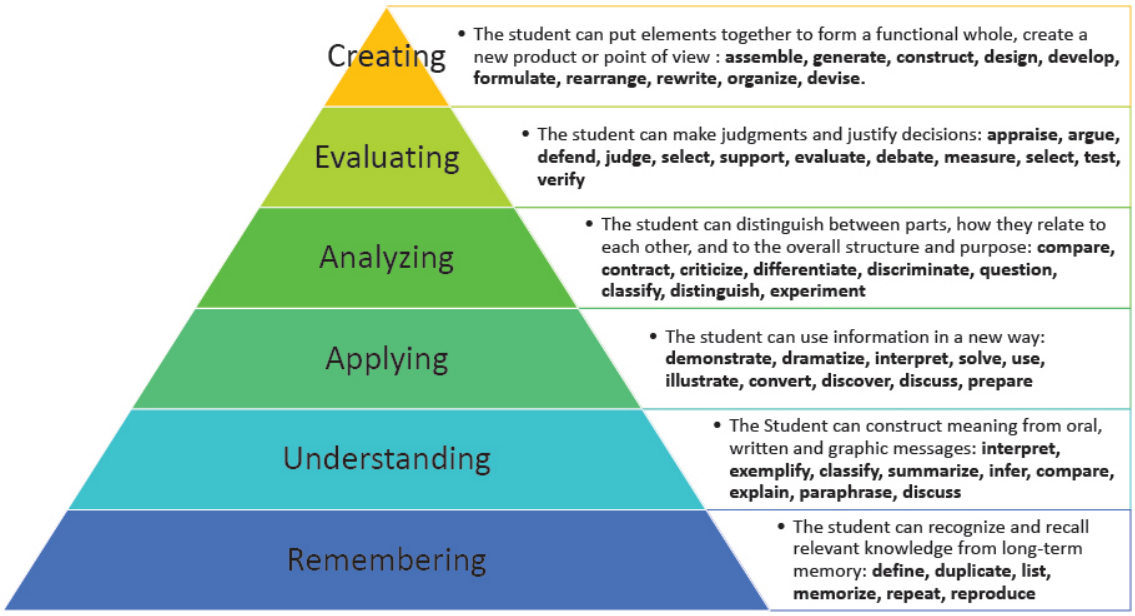


Figure 7: Andersons Learning Taxonomy Model

2.5.2.1 **Educational Games**

Regarding his research motivation, Minovic said that old-style methods of teaching are not suitable for the new students[13] Integrating educational goals into some activities in a game style is a precious idea by researchers, to which most of us agree and implement practically in our learning environments.

Games can be a great role player as a medium for knowledge transfer. They can hold their participants and keep them motivated in reaching their goals by understanding the requirements[21].

- **<e-Adventure>**

It is an educational game proposing an intelligent tool to create video games and story-driven educational games; it is primarily an educational tool for instructors. <e-Adventure> is an effort to make games part of learning process by integrating games in the educational environments to make learning interesting for students. Here the three components focused are: cut down the expense of developing an educational game, involve instructors in the loop of this process to enhance the educational value, and thus producing brilliant games using a Whitebox model[63].

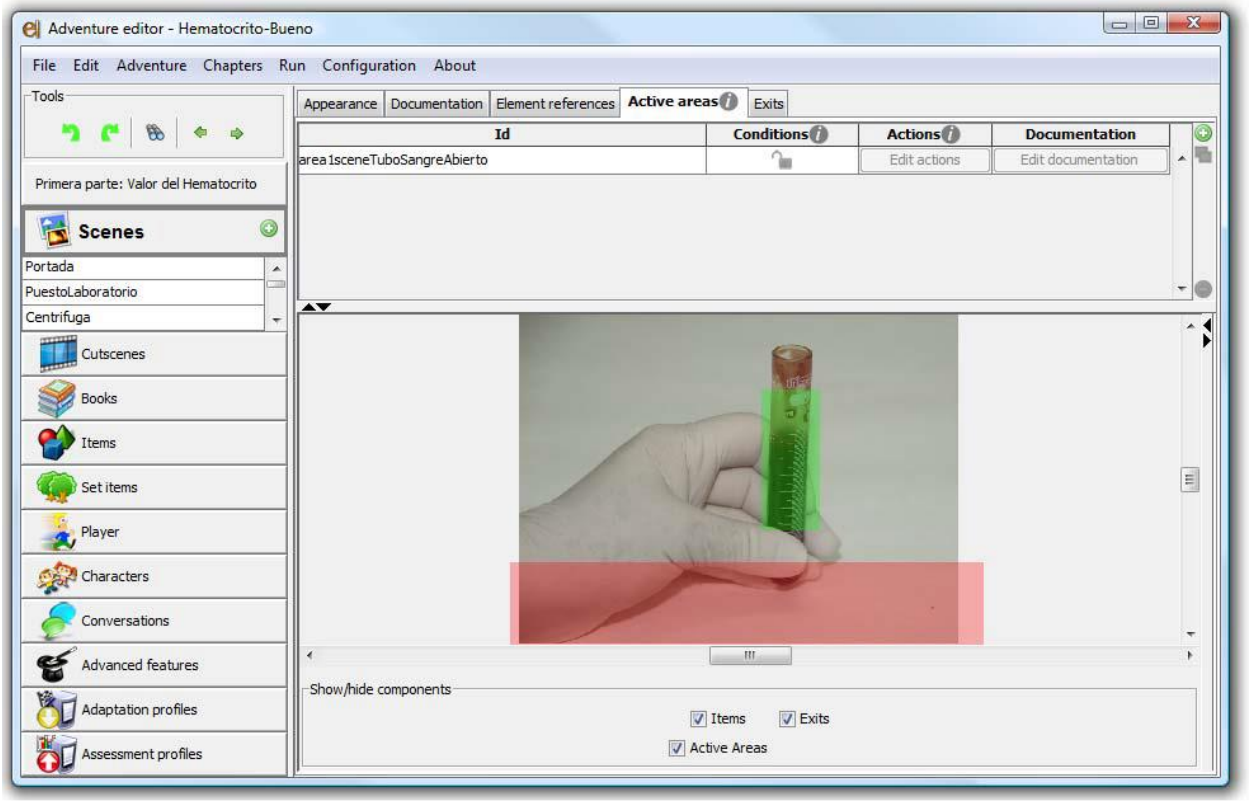


Figure 8: e-Adventure Platform

The respective model supports teamwork, allowing different role players to participate i.e. storywriters, programmers, artists, etc. with different technical skills and knowledge develop games. Non-technical staff is also one of the key stakeholders in this perspective, trying to make sure that "a good story never ends in a bad game"[63].

2.5.3 Interaction

Interaction among students and teachers while having a lecture/ discussion is important. It is usually a concern of teachers in a traditional classroom that every child should participate in class. For this reason, they often plan some activities where everyone will have an active role. Similarly, in e-learning environments, interaction is necessary for keeping every student on a right track[24].

2.5.4 Student Engagement and Evaluation (Monitoring)

There is a need for tools that are much more secure, reliable and efficient and students can easily access them and teachers at the same time easily track a student's progress report and hope this will be of great help to both of them in the future as well[64].

Proper visualization of progress tracking can help learners and teachers on individual and group level to compete. An example is quoted below:

The model, 'center of the circle', discussed in **Real-time learning analytics in educational game (Miroslav 2013)** aims to divide the competency in layers of rings. As the layers go deeper the level is divided further to show sub-category and the corresponding progress. Below is the figure from Miroslav's proposed model[13]:

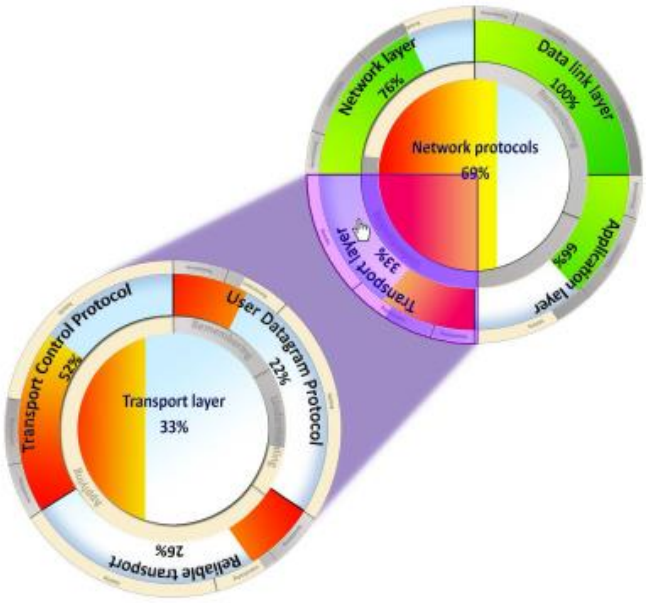


Figure 9: Visualization of student's knowledge and competency

2.6 Data Processing

Using the above approaches, we get loads of data that can be exploited to get useful information[34]. Also, we are in dire need of getting insights into whether the efforts are beneficial for the target users. Main idea is that instructors are unable to see real-time progress or other implications such as motivation level of students or confusion in the content being shared[63]. Instructors do not have adequate tools for monitoring and checking activities of students that would help them identify any problems faced by the students and fail to provide possible solutions for these problems[40]

Data produced in massive volumes are usually complex and unstructured[15] Since the fact that big data has the potential to become the main enabler of decision making by penetrating in all walks of our modern society including education, health, business etc., data processing tools and technologies are highly in demand in every field[15].

Data Processing is a cycle carried out to extract information from raw data by applying operations on data, especially by a computer, to retrieve, transform, or classify information. As shown below, data processing is done in four phases[15]:

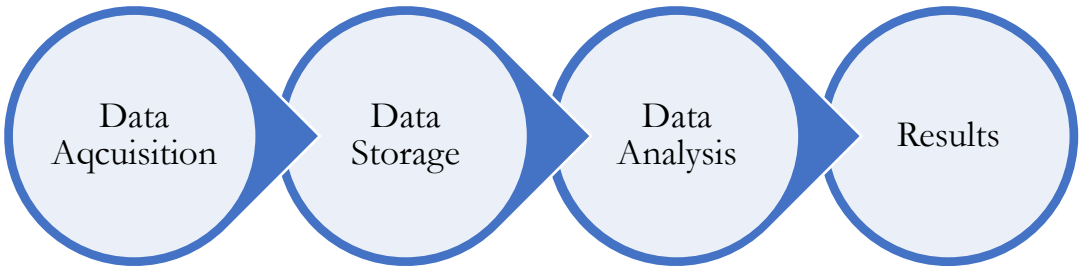


Figure 10: Data Processing Cycle

2.6.1 Data Acquisition

Data is acquired from different sources; from batch data sources where there is static data and from real-time data sources, where there is streaming data[65].

2.6.2 Data Storage

Data sets are stored in some storage area; disk or diskless for further processing[66].

2.6.3 Data Analysis

This phase uses various techniques and algorithms to process and analyze data[38].

2.6.4 Results

It includes the outcomes and results of analysis carried out in the proceeding phases[66].

2.7 Learning Analytics

Learning analytics (LA) can be easily understood in terms of collection, measurement, and analysis of the routine data of learners in their respective contexts in order to understand their learning patterns and to understand and optimize the learning environments[67]. It can also be understood in the context of educational data mining[32]. Traditional scholars suggest that learning analytics is basically an analysis of the learner's data with the sole purpose to predict and advice the learning of the people in respective fields[68]. Some scholars from late twentieth century focused on describing learning analytics as a tool to examine the data of the learners in order to use it in effective decision making with the sole purpose to improve the learning or education system especially when it comes to e-learning which was quite a new term for scholars from the late twentieth century[68].

The existing e-Leaning platforms pose a challenge to efficiently and effectively summarize, analyze and communicate the vast amount of data being gather throughout the learning and teaching process[34]. The data should be both historic and forward looking with easy to understand visual cue of gaps and at-risk areas. The problem is catered by using analytic approaches, learning analytics is the one being applied on educational data. Pointed by Diego Alonso, creation and development of intuitive visual tool should not require the teachers and students to select specific algorithms but still provide insightful analysis[69].

To gain insight into early indicators but not completely autonomous to the course, it's important to understand the behavioral pattern of students. The study conducted by Wang J. in Engineering Mechanics Experiment, focuses on analytics of early indicators such as landing behaviors analysis. Resource browsing, behavior influencing, online communication and so on[70]. The access level details data collected through e-learning platforms is the key component of this research. Access level time and frequency for each student is analyzed to understand the learning cycle of the entire group against individual student.

The concept of heterogeneous e-learning platform through open source learning analytics was explored by the **Society of Learning Analytics Research (SoLAR)**[67]**.** Benefits of learning data analytics is analyzed throughout the vertical chain of learning process and stakeholders involved to gain insights into teaching-learning effectiveness and efficiency. The proposal addressing the tackle the analytics through scenario analysis from the point of view of learners, educators, administrators and researchers[71]. The focus is to analyze the needs and wants for each stakeholder through data

driven scenarios. Learners are assisted through feedback of computational linguistics, lifelong learning inventory, relation to social network, embedded knowledge map and emotional dimension to keep them on course to succeed[72]. Educators are assisted through at-risk visual dashboards, self-reporting feedback, multiple application insights, cross course/university comparison and policy and environment analytics to have better knowledge of gaps at risk pertaining to students[73]. Finally, researches can provide their input simultaneously by refining platforms and applications using the meta-analysis and combinatorial analytics[71]

Well-known scholars from all over the world consider learning analytics as the most important aspect of e-learning to evolve the patterns of learning and ultimately bridge the gaps in the education system worldwide[74]. Learning analytics is very beneficial for students because it significantly improves the learning patterns and learning behaviors of the learners by effective decision making[75]. Following are some benefits of learning analytics[76]:

- Help to analyze and predict the performance of learners
- Personalize the web-based learning experience
- Increase the retention rates of the learners
- Improves the learning courses which learners need to enroll in future

2.8 Decision Support Systems

A decision support system is the one which has an integrated set of technological tools and allows people to interact directly with computers to get the required information which is useful for making decisions. It is a fundamental activity for decision making and consists of some steps like design, choice, implementation, and intelligence of the system[28]. There are some of the important factors which play a vital role in decision support system and helps in making the right decision. One of the most important aspects is the ease it provides to the people of all domains whether they are technical or non-technical they can handle it easily and in an efficient method. Another important feature which makes it unique is, it provides easy access to information to everyone either they are a part of an organization or not. Also, the decision support system should be highly adaptive by the people so they can quickly use and access the desired features of their choice[36].

Similar is the case with the e-learning system. Due to the lack of real-time interaction with one another distance learning has been introduced for the own convenience of the people[56]. But there are some of the drawbacks of using this blended learning technologies like administrations can face a real trouble sometimes knowing that who their students are, and also sometimes they can face difficulties knowing how their students are behaving in a virtual learning environment and many other factors come along like what are their chances to pass the paper and how fast they can pick up a concept taught to them and many other such come in the row[26].

So, in order to resolve all these and many other related issues and difficulties a decision support system is required which can be a solution to every problem discussed above. Choosing the right system for making the right decision can be of great help to the teacher and the students as well as it can better handle the teacher-student environment[33]. Also, one of the most important reasons behind using such a system is to interpret the real-time results and to take educational steps which are compulsory to take. The current information system feedback for the concerned parties doesn't incorporate the understanding from the utilization of data collection[74]. The presentation of existing feedback especially for teachers is both overwhelming and beyond the scope of their normal responsibilities. For instance, the two tools, TADA-Ed and Moodle Data Mining Tool, do provide functionalities to understand the data, however, teachers need to have certain knowledge in data mining to utilize them[39]. To address this concern and complement the utilization of existing platforms, a decision support system (DSS) can be deployed as and when needed to generate valuable insights and improving the learning and teaching journey for all stakeholders in the learning process[26]. A **Decision Support System (DSS)** can be defined as an information system used to support the decision-making process in the learning environment while analyzing structured and unstructured data collected from the existing learning platform. Decision support system basically emphasizes the ways in order to ensure the adaptability, reliability, capacity, and flexibility of the system to make effective changes as required from time with the sole purpose to improve the e-learning environment and to make the web-based learning systems more effective than before[77]. In the realm of e-Learning, DSS can be deployed as a module to existing platform to perform the needed analytics and provide value added feedbacks[78]. Haettenschwiler differentiates decision support systems into 3 categories; passive, active, and cooperative Decision support systems[79], described as follows:

2.8.1 Active Decision Support System

Active decision support system provides solutions and suggestions after properly analyzing the problem. Active decision support system analyses the problems by considering every aspect of the problem to recommend and suggest the best solution for the problem[79]. This involves active participation of the system to understand context, goals, intentions and automatically schedule and carry out the activities[80]. They are usually known to be "expert systems".

2.8.2 Passive Decision Support System

The passive decision support system aids the process and does not provide any solutions and suggestions or recommendations to improve the process[39]. Passive DSS is generally the first step to understand the vast amount of data being collected on e-learning platform. The goal of such system is to provide insights to different stakeholders through pattern or models, so they can interpret and make educational decision accordingly. In order to achieve the required level of analysis, variables associated with behavioral pattern and study content pattern are analyzed using different type of algorithm such as regression classification algorithms. The data is accessed directly from the e-learning platform's data warehouse and modified using ETL processes[30]. The final product is in the form of visual representation of analysis that is concise and relevant for each stakeholder through static and parameter driven reports and KPI notification. The information between data warehouse and visual reports is accomplished through application integration API.

2.8.3 Cooperative Decision Support System

The cooperative decision support system is a review process which enables the decision maker to review and modify the solutions, suggestions, and recommendations provided by active decision support system before sending them to the computerized information system for proper validation[81] This cooperative approach allows for more intelligent decision making especially in complex situations where it's not possible for the DSS to make decision on its own and requires manual intervention by the user to reach joint resolution of a problem[41]. To tackle the customization, a collaborative intelligent decision support system (CIDSS) is used for an effective cooperation between user and machine for defined mutual assistance to reach a resolution[41]. Conceptually, the tasks are granulated to the lowest level of decision making and subsequently assigned to either a machine or a user to perform. Therefore, in a sequence of tasks there may be back and forth collaboration where some tasks and contingent on user and some on machine.

Chapter 3 Solution and Methodology

E-learning systems collect and hold a huge amount of information which is worth performing analysis of student behavior and determine the effectiveness of course designs to predict student performance. [24]. This data can also be used to group students in a way which is most beneficial to students. The educational process can be improved greatly if this data is used appropriately. If teachers have access to relevant data and knowledge mined from the surplus data accumulated by online learning systems, the results will be more valuable and facilitate a better decision-making process[16].

E-Learning Platforms are constantly changing; they have transformed the everyday lives of teachers and students. In order to stay on top of the educational sector, countries are looking for new, smart platforms which can inculcate innovative training into the context of learning and teaching. Over the past decade, there has been a lot of evolution in the e-learning platforms[17].

Learning management systems are used worldwide and at the same time teachers are required to track real time progress of individual students to know who may be struggling and lagging and need extra attention and motivation.

3.1 Monitoring and Evaluation:

To achieve the targeted goal, we have capitalized the idea of "monitoring and evaluating" (M&E) students accessing content on any e-learning platform. M&E is about[82]:

1. Collecting data
2. Storing data
3. Analyzing data
4. Visualizing data into a meaningful information

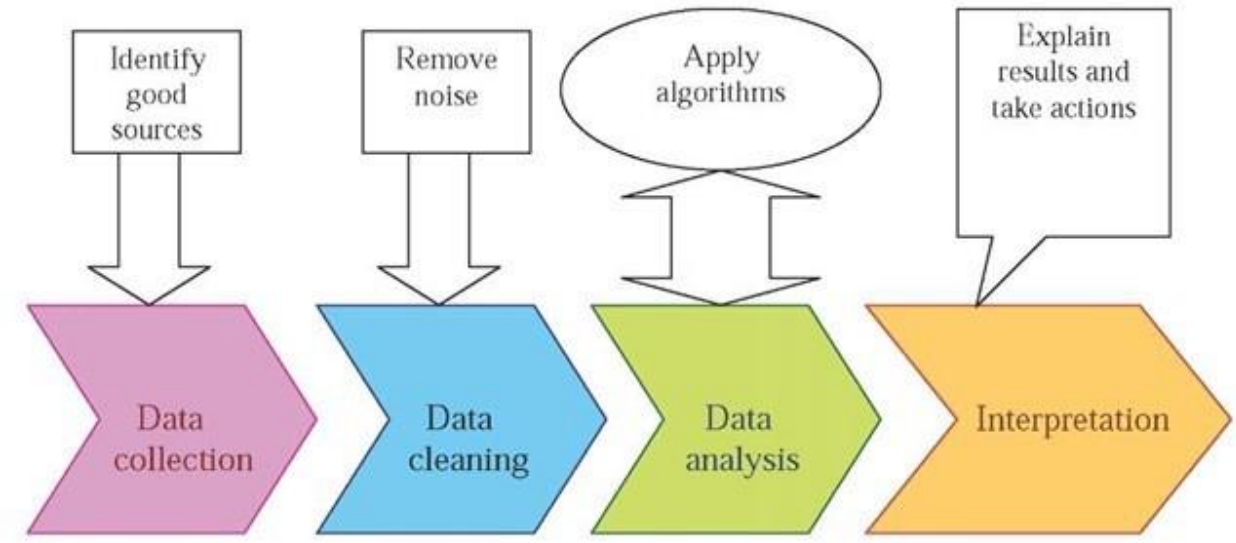


Figure 11: Data Analysis Cycle

3.2 Source for data collection

"skillpak" is taken as a use case for this research (http://skillpak.com/).

3.2.1 Functionalities:

It is developed by FYP students using Laravel PHP framework, having the following core functionalities:

1. Login
2. Content sharing; in PDF format, mp4 files and youtube videos
3. Online quiz (MCQs, true/ false, blanks)
4. Comments, if instructor wants to give any with a specific lecture

Students can enroll in a course, view and download lectures. They can take quizzes and know their score immediately.

The platform is enhanced to collect students' usage and access data. As it is primarily designed for 'teacher', details about how students interact with the courses, and how do they score in online quizzes are presented to him, numerically and graphically.

3.2.2 **Skillpak DB:**

The SkillPak database consists of several tables to store information pertaining to student, courses and instructors.

It stores users' credentials, course categories and modules, quizzes and all other particular related to course content and users.

The following screenshot shows all the tables:

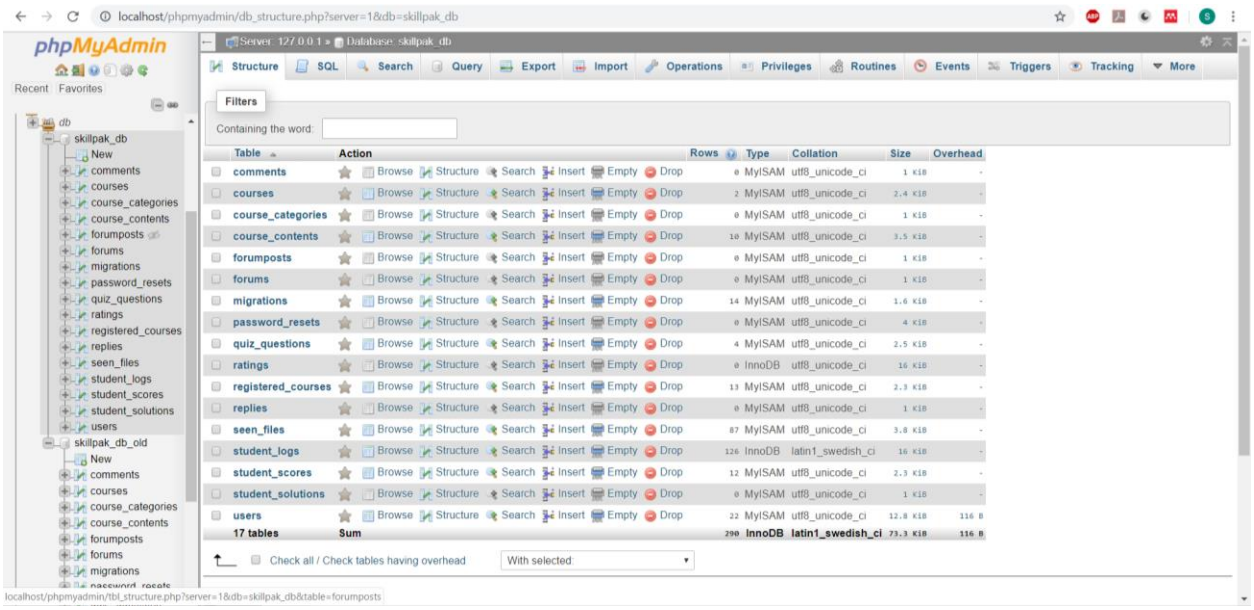


Figure 12: Skillpak Database

3.3 Data Extraction

Data collection tools are designed to automatically retrieve some quantitative values/ data from the valuable data stores that can lead to qualitative decisions/ results.

Values are selected for extraction from particular source, that can be measures for further variables needed for decisions to be taken.

For each user registered in the course, usage access data (arrangement of events and actions) is provided through the platform.

3.3.1 Storing Logs/ Data collection

Parameters

- Id
- Name
- Email
- Course
- Module (content named as quiz, lecture etc)
- Events
    - Clicks
    - Scrolls
    - Page loads

3.3.1.1 AJAX

AJAX technology is used for fetching the above variables from the platform, this is a new technology, which can be used in web applications to send and retrieve data from a server asynchronously (in the background) without interference in the GUI of the existing page.

Using AJAX, you can:

1. Update web page without reloading
2. Request desired set of data from a server, after loading the page
3. Receive desired data from a server, after loading the page
4. Direct data to server (in background)

Working of AJAX calls is shown below:

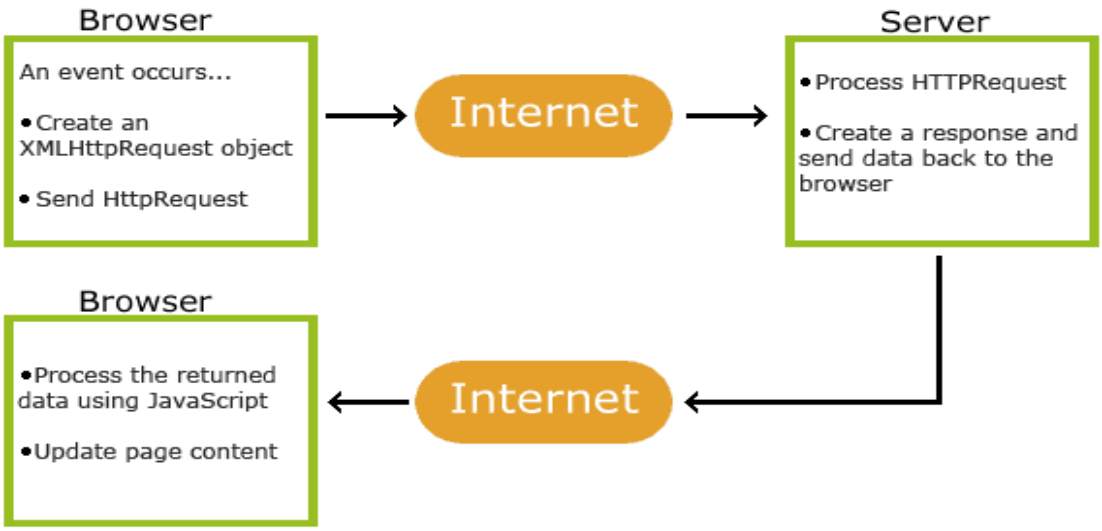
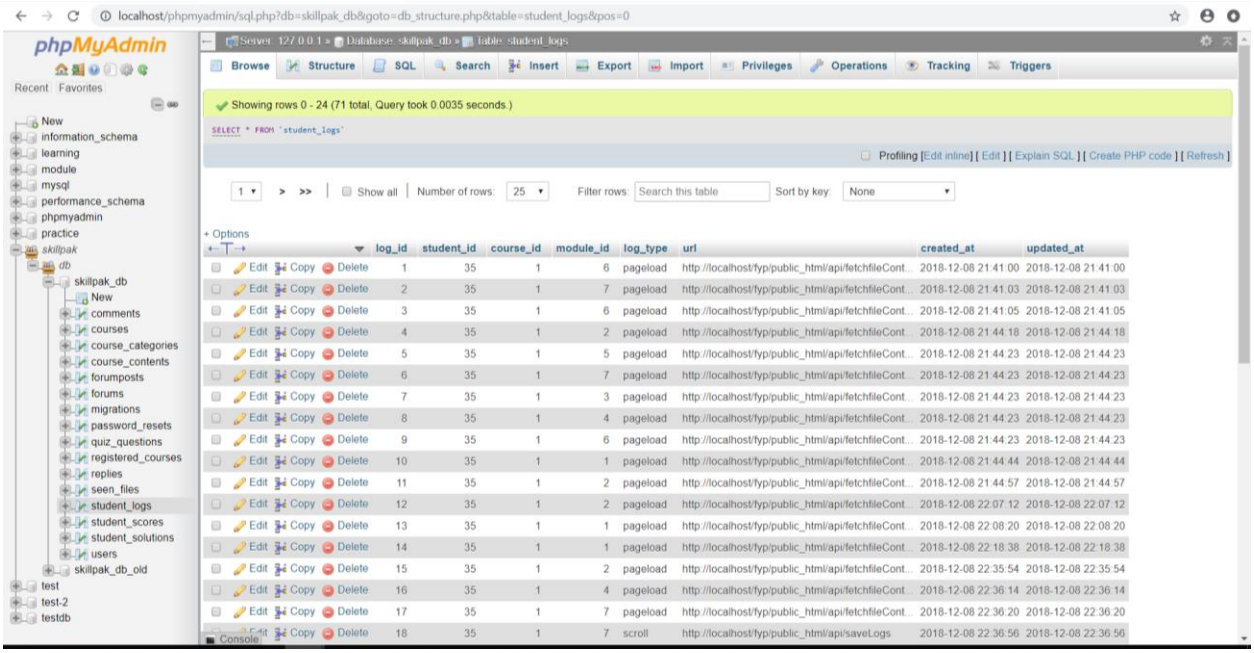


Figure 13: AJAX

A table is created to store the retrieved data. Each row of table defines a user to individual event and users ID, which follows as:

- The time imprint of all events one by one in a specific format such as (year-month-day) or (hr:min:sec)
- The category of event; "scroll", "click" & "pageload" in a character string variable. All likely activities of the user are captured such as viewing screen or skimming through reading content in a given course section
- The resultant data feature URL, which points to the location the action took place.

Table 3: Student log table



3.4 Application Design and Development

The instructor is the main user of this application. The extracted data helps the instructor when the designing of course platforms. As the functionalities needed, the application to support queries which filter the following bases: (a) students (individual/ multiple) (b) course

a. Each student or group of students' data can be requested to fetch all the desired data in relation to the use of material available on platform, gathered along all accessible material the users have accessed (in the known period).
b. When course is used as a key, all data should be gathered related to that specific course i.e. how the students interact with the course content, data is collected across material the users have accessed (within the known period).

Flow chart of the basic functionalities are shown below:

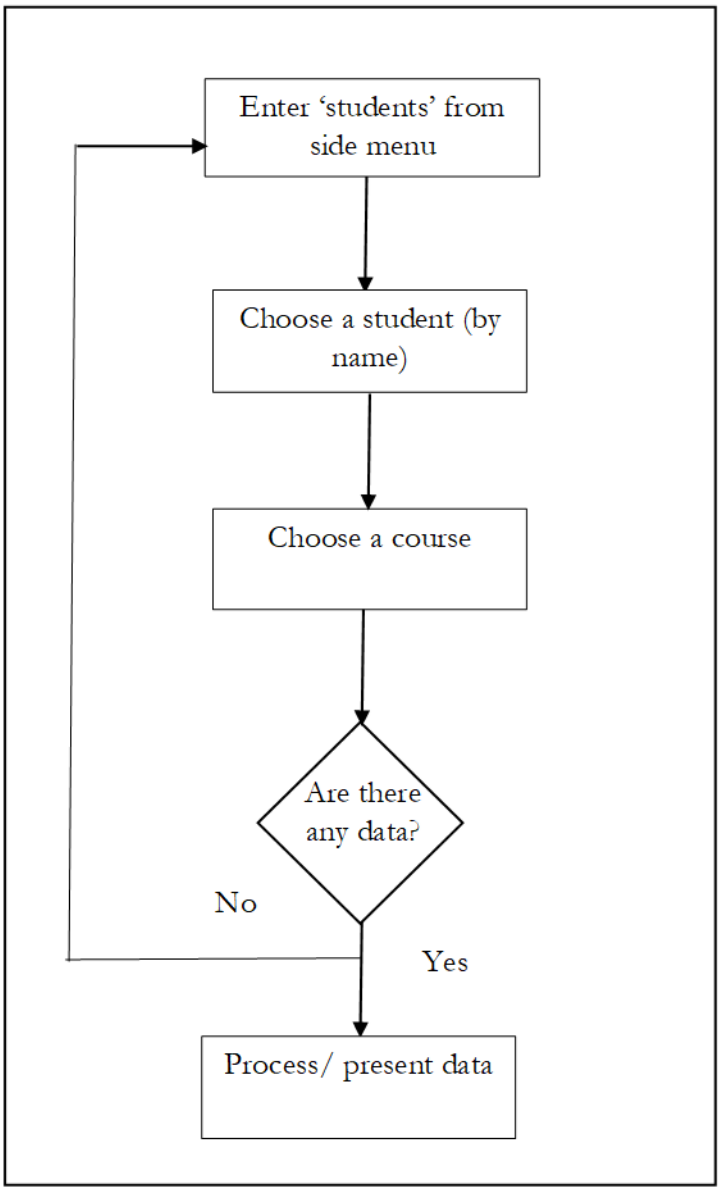


Figure 14: Flowchart of activities

The stats we further derive from above variables are used to focus:

1. **Activities/ performance of one or more students**

   The output from this application shows an instant approach to the instructor to screen his students' progress and provide correct guidance.

2. **Activities in a specific course**

   It is helpful if the instructor chooses re-structuring the knowledgeable material shared for learning with the students, after self-assessment process.

3.5 Data Processing

The data processing includes the following steps:

- The results are sorted in chronological sequence.
- The total number of events is equivalent to the number of rows.
- 'clicks', 'page loads' and 'scrolls' are acquired by calculating the table row according to type of event.
- 'Grade'
- 'Active Time' is calculated by taking time-stamp differences between every two events (table rows). A threshold empirically set to 5 minutes and adding them up. Intervals longer than 5 minutes, which contain no event or action, are ignored from Active Time computation. It is due to non-interaction with the platform and the material for more than 5 minutes is considered inactive. For instance, a student may have connected through the browser but left the context open while doing other things.

3.5.1 Date filter

Angular date filter is being used for showing the timestamp (in a specific format) of each activity; click, scroll and pageload which is an identification of a user being alive.

3.5.2 Calendar

Calendar is used when an instructor wants to retrieve data in some specific time period, as is shown below:

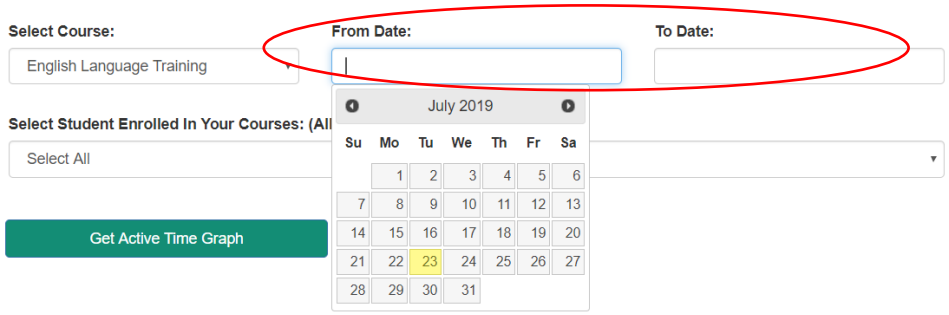


Figure 15: Calendar

3.5.3 AngularJS Filter by Dropdown Value

It is used to have options one can choose among multiple courses, where he (teacher) wants to see his students working/ not working. Also it gives option to choose an individual student. The following screen shows how it works:

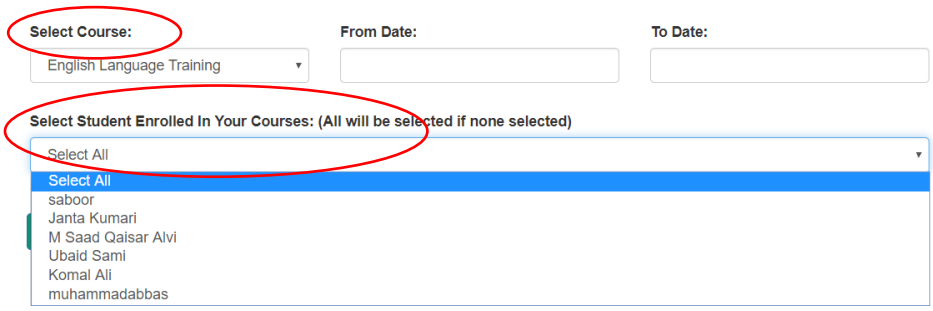


Figure 16: Dropdown Filter for courses and students

3.6 Data Presentation

The results obtained are displayed in the form of **table or graph**.

3.6.1 Tabular Presentation

It displays the list of all events in the screen, row-wise, in chronological order. Including User ID, total events, clicks, scrolls, page loads, event timestamps and active interval. Following figure shows the respective table.

Table 4: Tabular Presentation

Show 10 entries Search:

#	Course	Module	Student Name	Email	Actions	Date	Time	Active Time
1	Course Testing 01	Quiz 01	Zoha Rehman	zee56.zr@gmail.com	click	Saturday 8th of December 2018	10:53 PM	0 minute
2	Course Testing 01	Quiz 01	Zoha Rehman	zee56.zr@gmail.com	click	Saturday 8th of December 2018	10:53 PM	--
3	Course Testing 01	Quiz 01	Munazza	munazzaamirza@gmail.com	scroll	Saturday 8th of December 2018	10:53 PM	0 minute
4	Course Testing 01	Quiz 01	Munazza	munazzaamirza@gmail.com	click	Saturday 8th of December 2018	10:53 PM	--
5	Course Testing 01	Quiz 01	Sadaf	sadaf@gmail.com	click	Saturday 6th of April 2019	10:40 AM	5 minutes
6	Course Testing 01	Quiz 01	Sadaf	sadaf@gmail.com	click	Saturday 6th of April 2019	10:39 AM	--
7	Course Testing 01	Quiz 01	Sadaf	sadaf@gmail.com	pageload	Saturday 6th of April 2019	10:39 AM	--
8	Course Testing 01	Youtube Lecture 2	Sadaf	sadaf@gmail.com	click	Friday 1st of February 2019	06:57 AM	--
9	Course Testing 01	Youtube Lecture 2	Sadaf	sadaf@gmail.com	pageload	Friday 1st of February 2019	06:57 AM	--
10	Course Testing 01	Introduction	Sadaf	sadaf@gmail.com	click	Friday 1st of February 2019	06:57 AM	--

3.6.2 Graphical Presentation

It shows the content usage in form of events and time spent (active time).

3.6.2.1 Highcharts

Highcharts is a registered library being written in JavaScript. It offers to add interactive graphs/charts for your website/ web applications. Options available are: line, spline, area, column, bar, pie, scatter, error bars, funnel, waterfall and polar chart types.

I have used the "basic line" chart, a demo for dummy data is shown below:

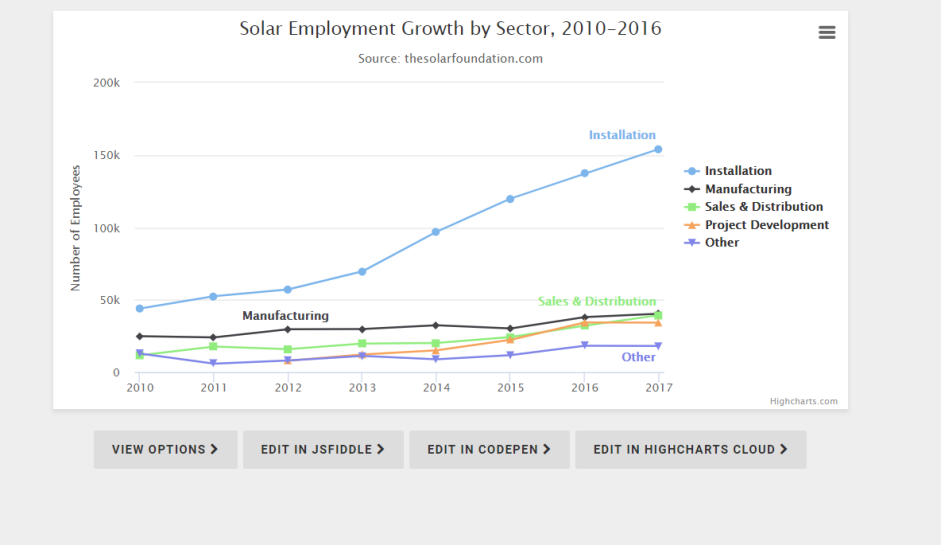


Figure 17: dummy line graph

3.6.2.2 Chart.js

It is another way to plot a data set. For representing active time, I have used chart.js canvas in graphs form. Following is an example:

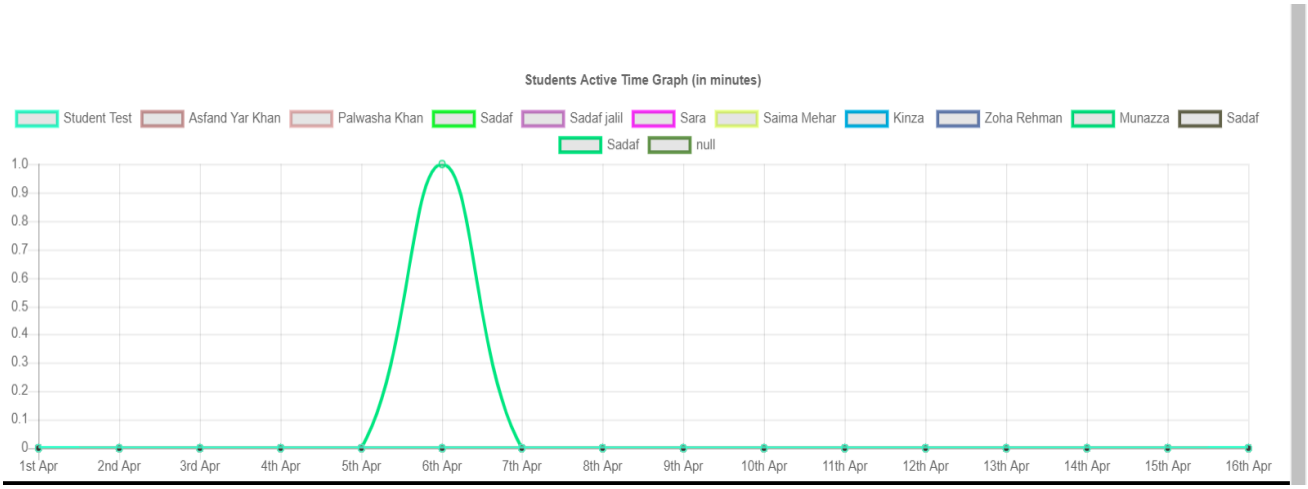


Figure 18: plot created via chart.js

3.7 Data Driven Decision Making

There are some rules to progress towards an educational decision, so the process goes successful.

First set "**goals**", they are the decisions we want to obtain in form of outputs. **Goals = objectives (research questions)**

Then decide input and output parameters.

"**input**" are the variables/ data sets we have; used to gain output via some calculations. Functions are applied on these variables.

"**output**" is the result obtained; it is affected by values of input. They are values to the goals set.

Output=research answers

Finally implement the process to see results.

Among multiple approaches; Data-Driven, Model-Driven, Knowledge-Driven, Document-Driven, and Communications-Driven, I have chosen data-driven decision making which involves using hard data instead of only observations or models.

3.7.1 Steps of Data-Driven Decision Making

1. Formulate Hypothesis (an idea that can be tested which has data, no data means no hypothesis)
2. Find the right test; though which the hypothesis is tested for if it is true or false
3. Execute the test chosen
4. Make a decision

3.7.1.1 Formulate Hypothesis

Our hypothesis is "More is the time spent by the students on learning a subject, more is the score gained". Before testing and verifying hypothesis, find out the relationship between the two effecting variables through **correlation** (time spent, score).

3.7.1.1.1 Categorization

Categorize data applying AND operator on both variables, thus obtaining a sample set of students, which we claim are good performers among the whole population; called ***focused students.***

3.7.1.2 Find a Right Test

As our data is normally distributed, choose from relevant hypothesis tests;

- **Z-test**

Z-test is performed if the data on which test is performed, is normally distributed. It is calculated on parameters: "population mean" and "population standard deviation" being known and it is applied to confirm if a hypothesis where the sample is already a part of the population. Here, the sample size is larger than 30 (n>30).

Null Hypothesis: When mean (sample) is equal to "population mean"

Alternate Hypothesis: It says mean (sample) is unequal with the "population mean"

According to z-statistic, score is calculated as per equation:

$$z = (x — \mu) / (\sigma / \sqrt{n}), \text{ where}$$

x= sample mean

μ = population mean

$\sigma / \sqrt{n}$ = standard deviation

If the test result gives a score that is less than the critical value, the hypothesis is accepted otherwise rejected

- **T-test**

The t-test is applied on two sample sets of data which is normally distributed and required to compare their means.

It is performed where the respective parameters; "mean" and "standard deviation" are unknown.

The t-statistic calculates t-score as follows

$$t = (x1 — x2) / (\sigma / \sqrt{n1} + \sigma / \sqrt{n2}), \text{ where}$$

x1 = sample 1 mean

x2 = sample 2 mean

n1 = sample 1 size

n2 = sample 2 size

- **F-test**

F-test (or ANOVA), is also called: "analysis of variance", is performed if comparison of multiple samples is desired within an individual test.

To measure the significance via F-statistics. The resultant value is obtained using formula

$$F= ((SSE1 — SSE2)/m)/ SSE2/n-k, \text{ where}$$

SSE = sum squares of residual

m = restrictions count

k = independent variables count

- **Chi-Square Test**

Chi-square test performed on categorical variables. It tests whether the sample selected is match able to the population, i.e. Goodness of fit test.

- If the chi-square measures a smaller value, it concludes that data fits the population
- And if chi-square measures a larger value, it concludes that data doesn't fit the population.

To measure the significance through a chi-square statistic. The resultant value is obtained using formula

$$X2 = \Sigma [(Or,c — Er,c)2 / Er,c], \text{ where}$$

Or, c = observed frequency count at level r of Variable A and level c of Variable B

Er, c = expected frequency count at level r of Variable A and level c of Variable B

3.7.1.2.1 Choice

Z-test is most suitable among all, because we have a sample size larger than 30 and, we have to test a hypothesis when the sample to be tested belongs to the same population.

3.7.1.3 Execute the Test

For executing Z – test, variance is known for both population and sample. Start from the hypothesis that needs to be tested:

Claim: a student set (x=focused students) performs well while using more e-learning material.

H_0: μ=71 (accepted fact)

H_1: μ>71 (claim)

Level of significance: α= 0.025

$$Z = (x - \mu)/ \sigma$$

3.7.1.4 Make a Decision

Always the null hypothesis is tested, so if the test statistic is lower than the critical value (from the z-table against the z-value), accept the hypothesis or else reject the hypothesis.

Chapter 4 Deployment and Implementation

Web developers and designers' final steps after done with developing their website and test if it works, is the deployment. Deployment of a software is a process that makes the website available for use. There are multiple steps, every step contains a specific action/s that is performed as part of the deployment process.

4.1 Preparation

When finalizing a website, few things are required to consider which depend upon the type of deployment that will be going to complete.

4.1.1 General Scenarios of a Website Deployment

There are three general scenarios one should categories his project deployment into are:

1. The client has no host i.e. this is their first website
2. The client already has hosting and the website will be deployed on server
3. The client already has hosting, but moving to a new server

4.1.2 Reserving Resources

When deployment scenario is worked out, we can better prepare resources needed in order to carry out a smooth process to make our website live and available to use.

While working with scenario 1, requirements are to register the **domain name** and purchase **web hosting**.

Scenarios 2 and 3 require some information i.e. **domain management credentials** for the existing web host so that we can manage our website. Usually, the client doesn't know what these are or where to get them, so you will need to do as much as you can before you approach your client.

4.1.3 cPanel

cPanel is a hosting control panel that is web based. Several hosting providers provides the cPanel host control to the clients who own their websites, they allow them to manage their websites via a web-

based interface. The graphical user interface is given to the users to handle and control everything in their website on server.

4.1.4 Web portal

Make a folder for the project for deployment, containing all files and database that are required.

4.2 Preparation Steps for Skillpak Deployment

4.2.1 Scenario

We are dealing with scenario 2; having a hosting and the website will be deployed on server.

4.2.2 Domain and Subdomain

We are using cPanel for managing our website, domain already we have is the "isdswat.org" and the subdomain for the website is "lms.isdswat.org".

4.2.3 File Manager

To manage our website, cPanel file manager is accessed which offers multiple important options to easily manage your things over the website, the options are available openly within the interface. Option are; create, modify, remove and upload files and folders. Another important feature it gives is the trash/recycle bin, so we can recover if needed after deleting any file.

Go into the files section, to find "file manager".

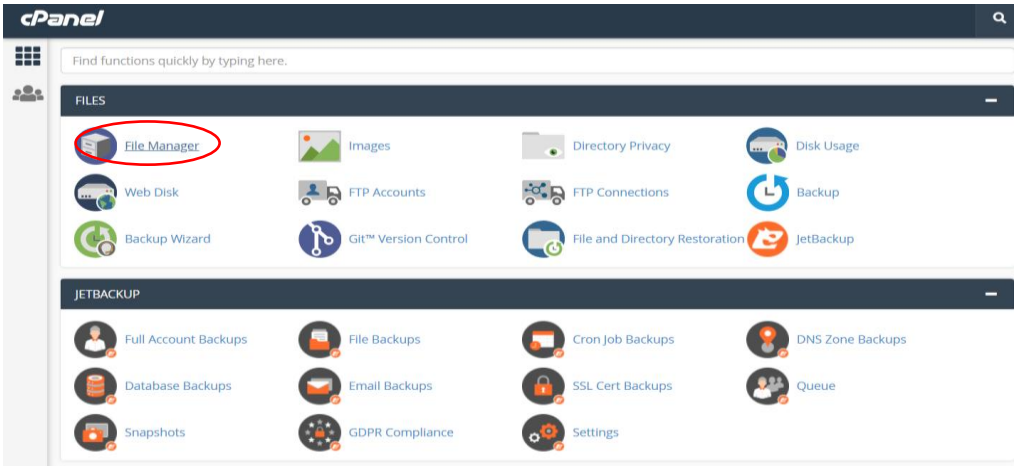


Figure 19: cPanel Home/ file manager

4.3 Deployment Process

4.3.1 Upload the project

Upload the project folder in file manager

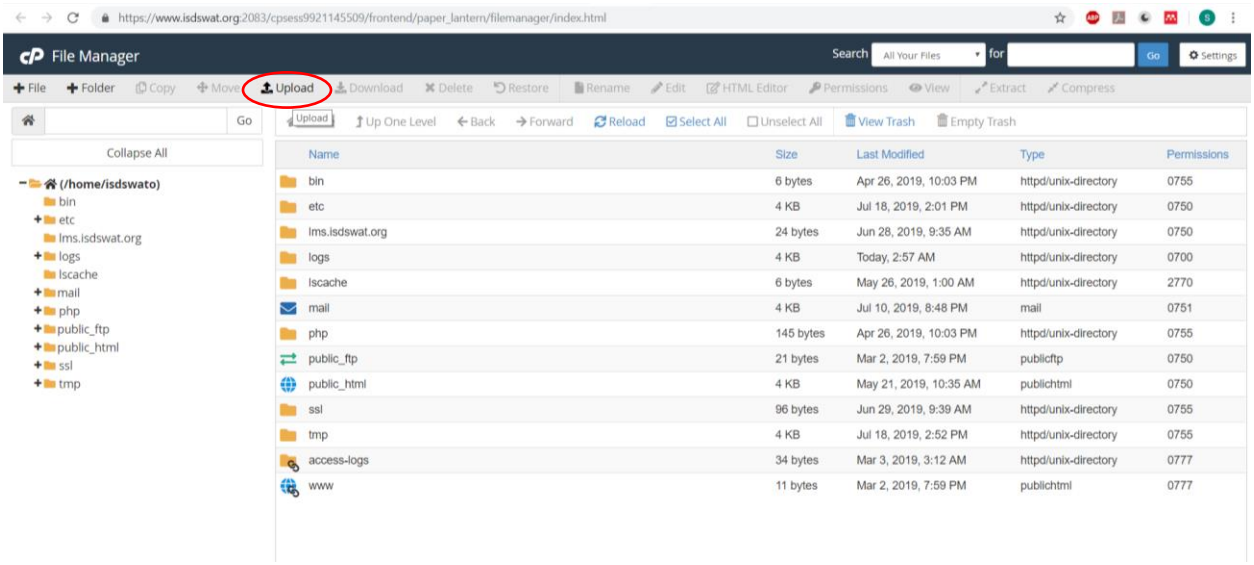


Figure 20: file manager/ upload

4.3.2 Configuration of database

Create a database and import tables from your own database, check the .env file for username password.

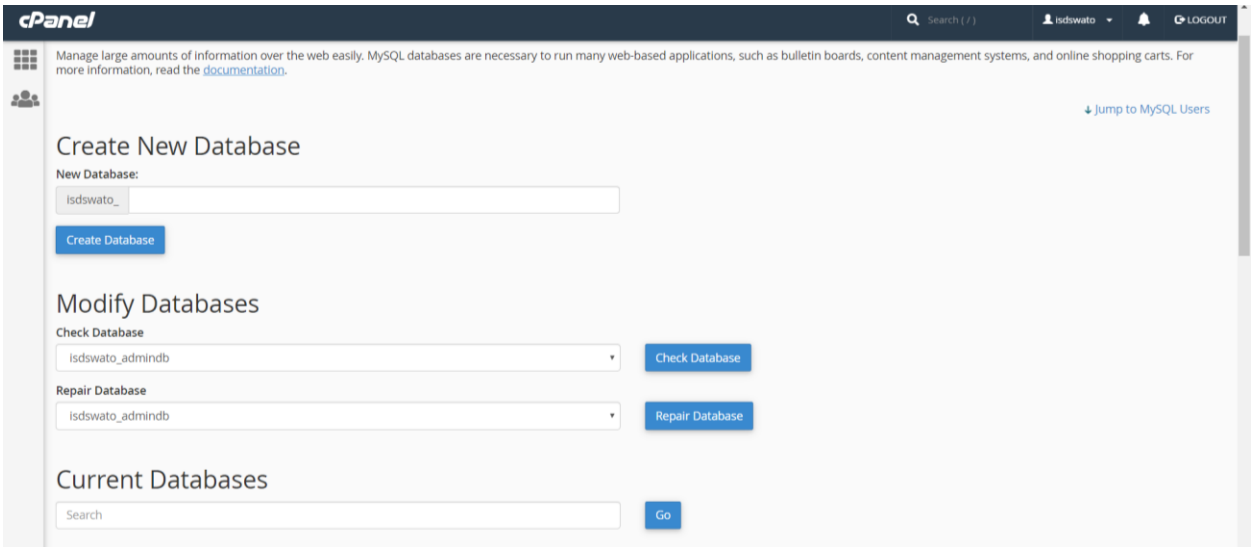


Figure 21: cPanel/ mySQL databases

4.3.3 Deploy

A domain pins a specific folder, whenever we write its URL it is live.

4.4 Implementation

The functionality of our proposed framework is deployed and can be accessed on http://isdswat.org/lms/. The following screenshot shows implementation of the deployed project:

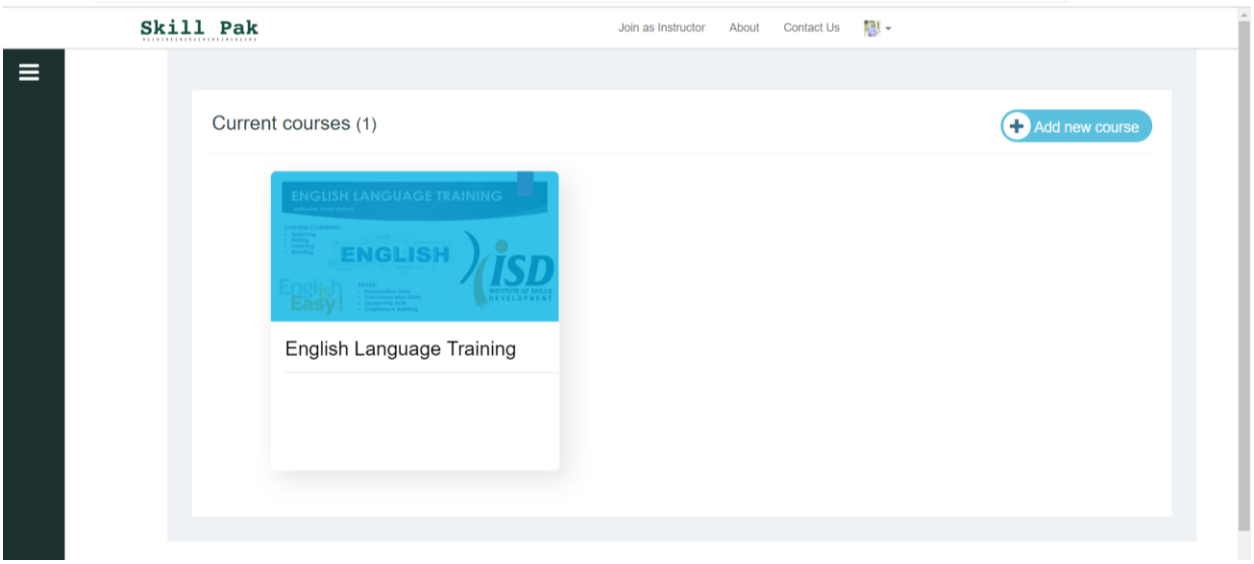


Figure 22: Course uploaded by the ISD

A course has been uploaded by a registered instructor and being used by their students.

4.5 Export the dataset

As our data set is small, so I took an anonymized e-learning data from Kaggle (https://www.kaggle.com/), for which average time calculated from clicks was required.

Export the table "student_log" from database, convert it from SQL to CSV and find the mean time spent from 'clicks' only.

We Filter the data by log_Type, module to clicks, course ID, created date (see the difference between update time). We analyze a sample of 10 students from the extracted data and determine the mean for clicks per min as shown in the following table.

Table 5: average clicks per minute

Average Click per min		
Students	Clicks per min	Overall mean
1	2.27	**2.72**
2	1.99	
3	4.11	
4	3.07	
5	3.55	
6	5.04	
7	2.44	
8	1.20	
9	1.57	
10	1.95	

Clicks per mins of 10 Samples

Chapter 5 Results and Discussion

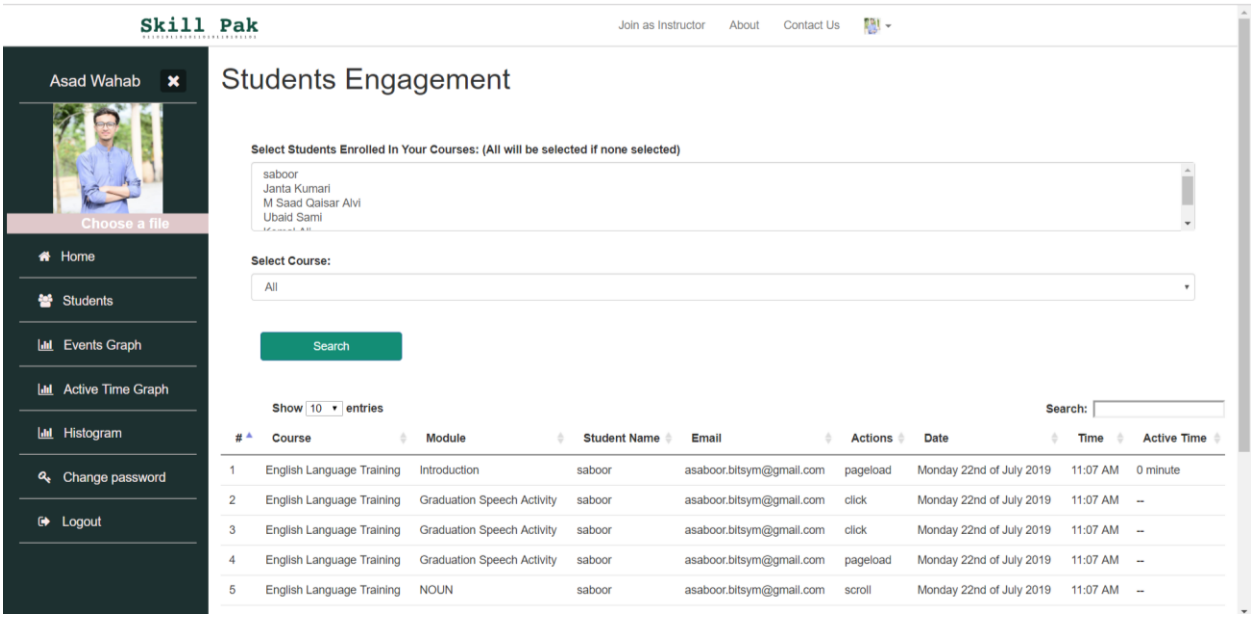
5.1 Results

5.1.1 Results from Online Platform Used to Extract and Visualize Data

"skillpak" is taken as a use case and deployed on server by Institute skills development (ISD Swat). It can be accesses on "http://isdswat.org/lms/"

5.1.2 Tabular Data Presentation

Table 6: Tabular data of an individual chosen student



The data extracted as expected be viewed by the instructors. The application support queries, that filter data according to constraints: 1) **students (individual/ multiple)** 2) **course (choose one only)**

a. Request submitted for a **single student or multiple students** retrieves all the data while the interaction of a user or may be multiple, with the platform and material (during the defined time period).
b. If **course key** is used for extraction, all data against the specific course and the enrolled students is displayed (during the defined time period).

5.1.3 Graphical Data Presentation

Primary target here is the frequency of usage i.e. how often a course/ module is visited. The other target is the active time; it means how much time a student spends on a course module. Below are the screenshots of results gained by ISD instructor.

5.1.3.1 Frequency of a Course Being Accessed

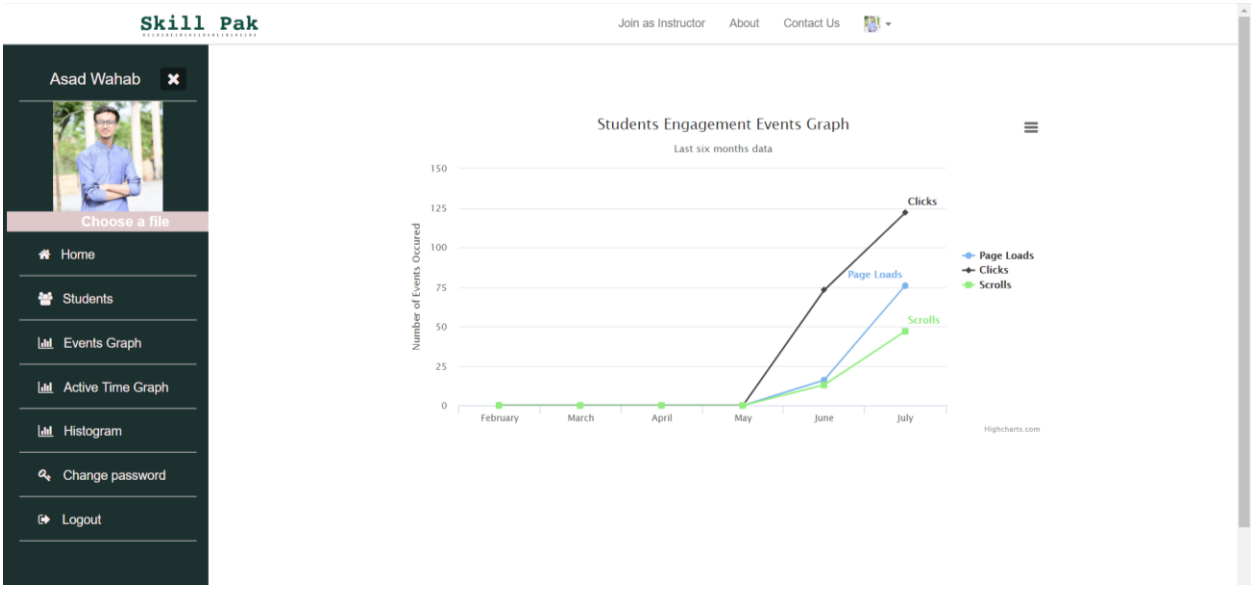


Figure 23: Usage Frequency Graph for the Specific Course

We can see how the curves move up after May, in June i.e. students have been visiting the course after enrolled in it. It may vary with time, if it drops while the course is still taught actively and content being shared frequently but access is limited, its point out the students are losing interest and motivation.

For the admin it works for assessing teacher's performance, they may interpret if a course is used less than other courses (i.e. less than average frequency of an active course), the instructor is required to put more effort or change teaching strategy which is more suitable for the respected group of students.

5.1.3.2 Active Time of Students

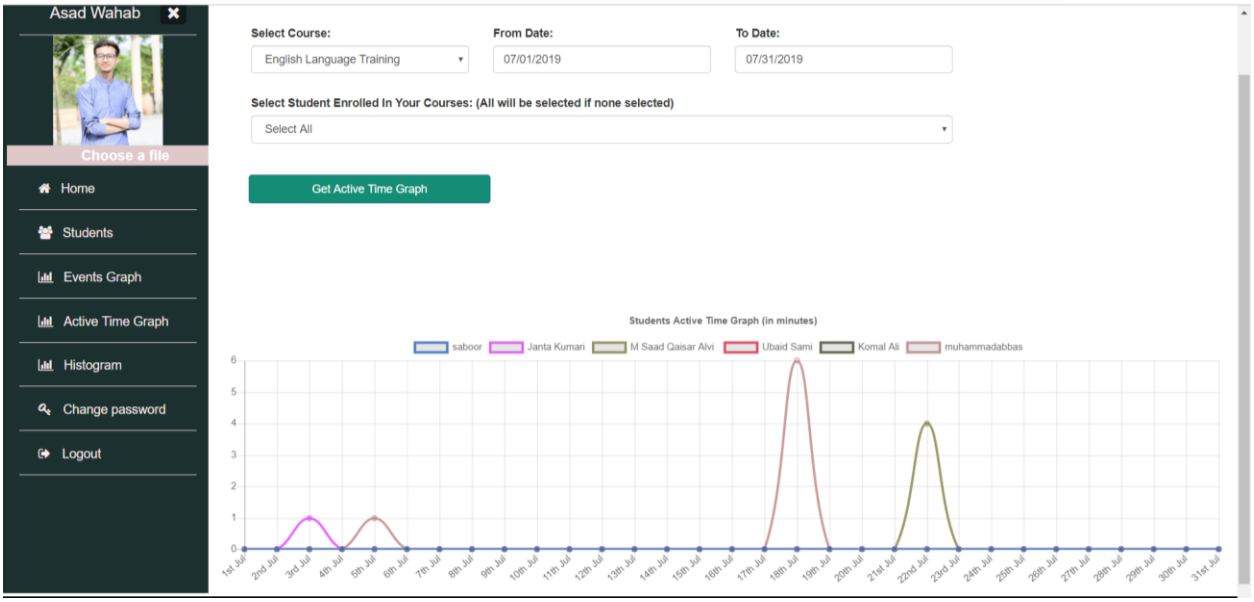


Figure 24: Active time measure

This feature gives multiple option to proceed with, we can see in the above screen the time period can be limited as well as it can be extended according to what data the instructor wants to see, he can skip extra time and zoom in results to get quick and clearer view.

Being more flexible, a single student can also be chosen if it is the required case and it can be viewed if he has been active in a certain time period or remained absent.

Choosing course/ subject is mandatory, at a time only one course can be scanned for results by an instructor.

It also shows the enrolled students' strength with names with the plots gained from their activities on the platform within a course.

5.2 Hypothesis Test

Before we test our hypothesis, it is important to make sure if our data is normally distributed, normality test has been performed in excel:

5.2.1 Normal curve graph

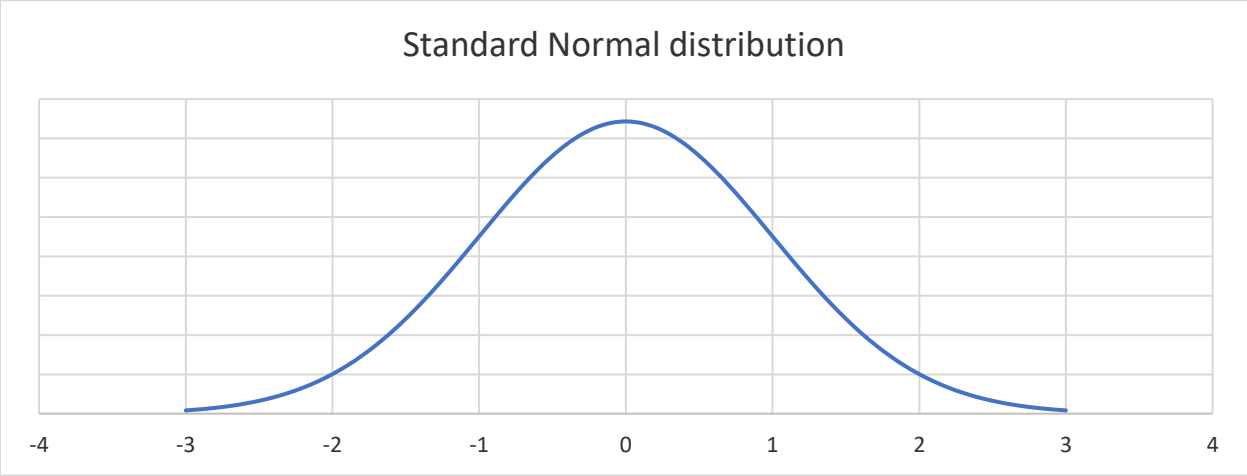


Figure 25: Standard Normal Distribution Curve

5.2.2 Input Data

We have arranged and organized (clean) a decent size input data of n > 3000 to perform analysis.

5.2.3 Experimentation

Process of execution has been shown in the model using Analytica (figure 28) and implement in Microsoft Excel to generate results and run the hypothesis.

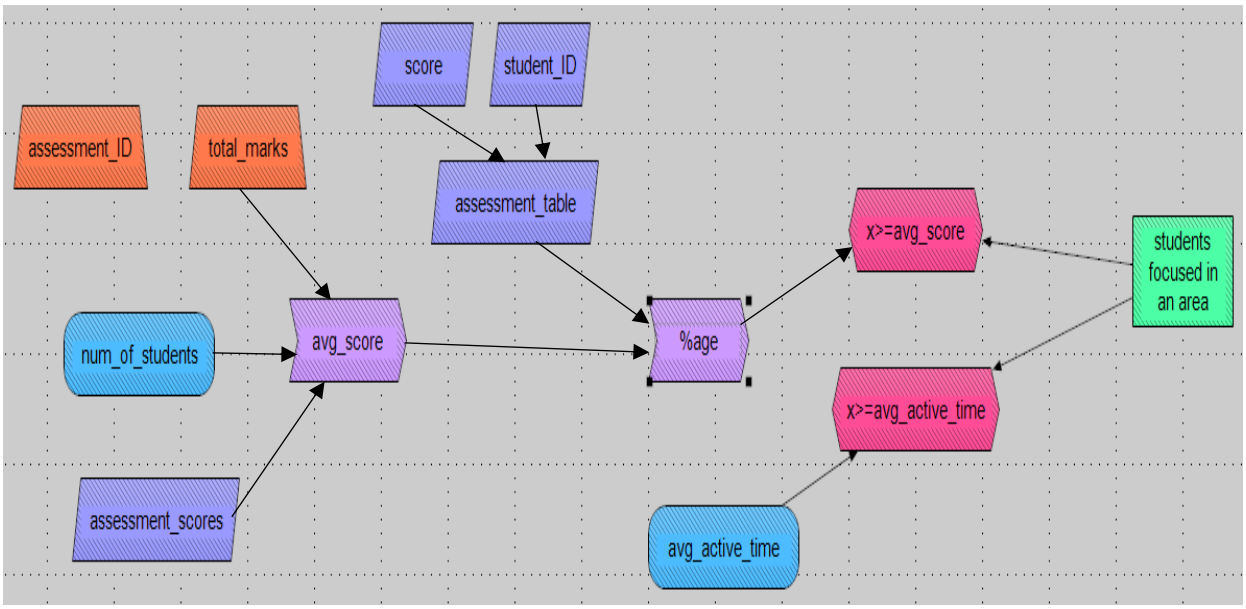


Figure 26: Percentage of students in an area or topic of study

5.2.3.1 Steps of Experiments

1. Data Categorization

Data was organized in 10 modules as shown in the following table.

Table 7: modules

code_module	id_assessment	Counts
AAA	1752	359
BBB	1753	342
CCC	1754	331
DDD	1755	303
EEE	1756	298
FFF	1758	337
GGG	1759	316
HHH	1760	304
III	1761	280
JJJ	1762	278

2. Experiment

Once the data was organized for all the modules, I determine the focused students for each module and find the correlation between time spent during the assessment and obtained score.

a. Correlation result:

Population Correlation: among time spent and scores	0.928

Correlation shows dependency of time spent and scores gained.

To gain a sample from population and proof our hypothesis, apply a condition with a loop across students individually on both the affective variable inputs; time spent and score:

If x.score>=mean_score && x.time>=mean_time

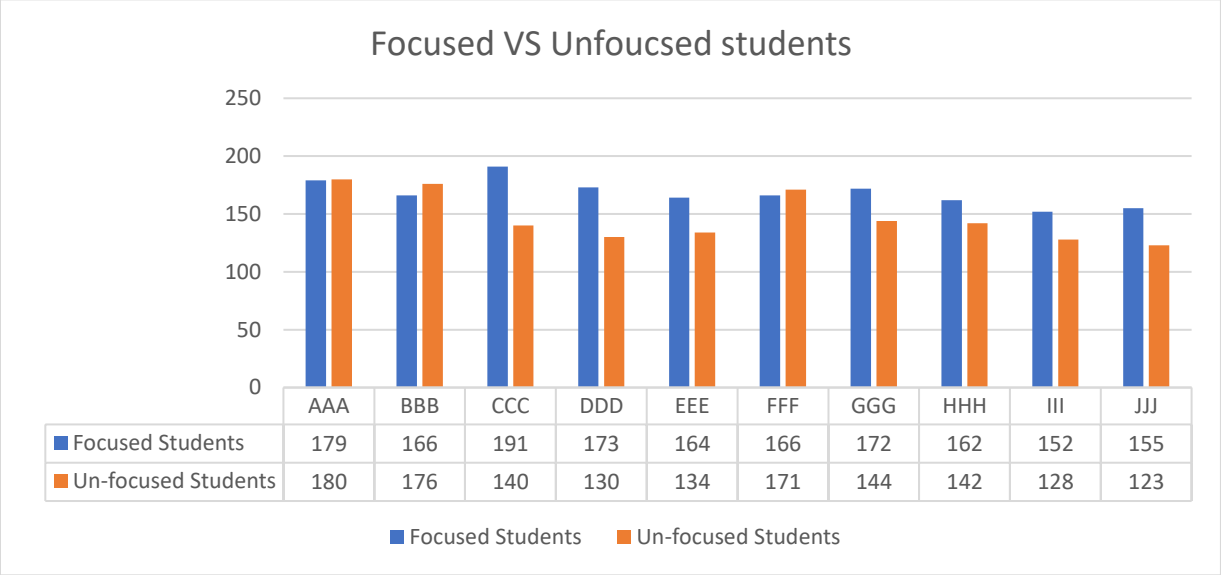
Then x=focused students

Else x=unfocused students

It gives us a group of focused students; sample data to run our hypothesis.

b. Focused Students

Table 8: graph for both categories of students



c. Hypothesis Z-Test

From the analysis it was determined that module DDD is better course, compare to other modules. It was noted from the following graph that an average score achieved from module DDD student is 79.60. Claiming that a set a student has achieved a desirable score using e-learning material.

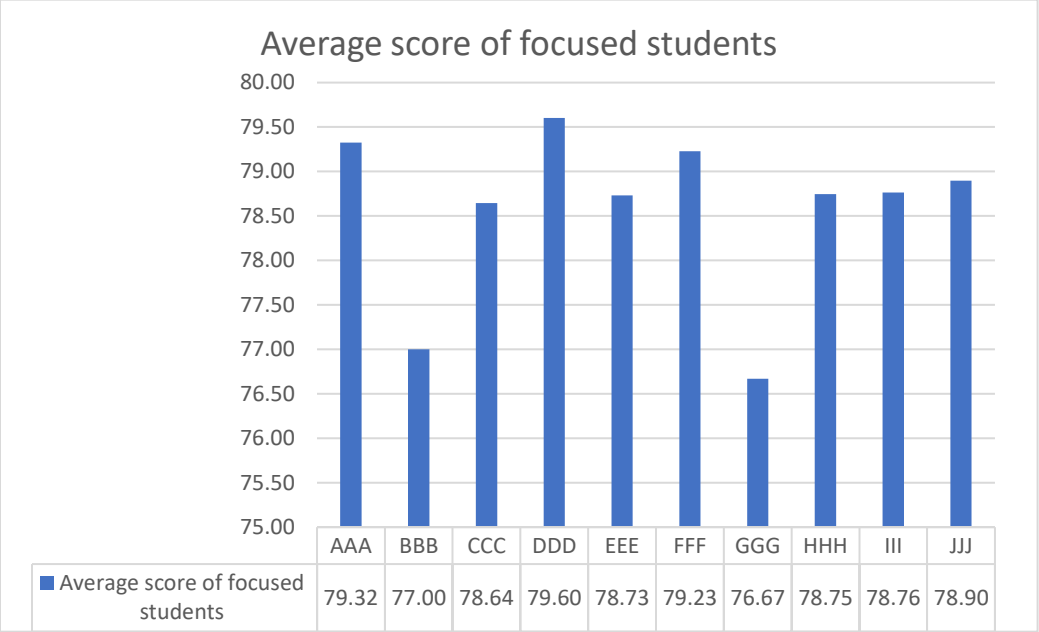


Figure 27: focused students

We further tested the result of Module DDD by performing Z-hypothesis method. The data for module DDD is shown in following table.

Table 9: module DDD summary table

	Population Average Time	38.72	min
	Population Average Score	70.57	
TOTAL	**Focused Students**	173	
TOTAL	**Un-focused Students**	130	
	Clicks per min	2.72	From click per min spreadsheet
	Correlation: among time spent and scores	0.93	

Population	303
Mean (FS)	79.38
Stand Dav (FS)	5.37
Z_Score	1.641

Z_score = (x — μ) / (σ / √n)

Where:

x= sample mean

μ = population mean

σ / √n = sample standard deviation

d. Calculation as below:

H_0: μ=70.57

H_1: μ>70.57

$Z = \frac{x-\mu}{\sigma}$

X=79.38

μ=70.57

Z= 1.641

Once the Z score was calculated we than find probability from z-table as shown below.

Table 10: z-table

STANDARD NORMAL DISTRIBUTION: Table Values Represent AREA to the LEFT of the Z score.

Z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.50000	.50399	.50798	.51197	.51595	.51994	.52392	.52790	.53188	.53586
0.1	.53983	.54380	.54776	.55172	.55567	.55962	.56356	.56749	.57142	.57535
0.2	.57926	.58317	.58706	.59095	.59483	.59871	.60257	.60642	.61026	.61409
0.3	.61791	.62172	.62552	.62930	.63307	.63683	.64058	.64431	.64803	.65173
0.4	.65542	.65910	.66276	.66640	.67003	.67364	.67724	.68082	.68439	.68793
0.5	.69146	.69497	.69847	.70194	.70540	.70884	.71226	.71566	.71904	.72240
0.6	.72575	.72907	.73237	.73565	.73891	.74215	.74537	.74857	.75175	.75490
0.7	.75804	.76115	.76424	.76730	.77035	.77337	.77637	.77935	.78230	.78524
0.8	.78814	.79103	.79389	.79673	.79955	.80234	.80511	.80785	.81057	.81327
0.9	.81594	.81859	.82121	.82381	.82639	.82894	.83147	.83398	.83646	.83891
1.0	.84134	.84375	.84614	.84849	.85083	.85314	.85543	.85769	.85993	.86214
1.1	.86433	.86650	.86864	.87076	.87286	.87493	.87698	.87900	.88100	.88298
1.2	.88493	.88686	.88877	.89065	.89251	.89435	.89617	.89796	.89973	.90147
1.3	.90320	.90490	.90658	.90824	.90988	.91149	.91309	.91466	.91621	.91774
1.4	.91924	.92073	.92220	.92364	.92507	.92647	.92785	.92922	.93056	.93189
1.5	.93319	.93448	.93574	.93699	.93822	.93943	.94062	.94179	.94295	.94408
1.6	.94520	.94630	.94738	.94845	.94950	.95053	.95154	.95254	.95352	.95449
1.7	.95543	.95637	.95728	.95818	.95907	.95994	.96080	.96164	.96246	.96327
1.8	.96407	.96485	.96562	.96638	.96712	.96784	.96856	.96926	.96995	.97062
1.9	.97128	.97193	.97257	.97320	.97381	.97441	.97500	.97558	.97615	.97670

Confidence level probability (CL) =0.94950 for module DDD

In order to determine the critical range probability, we will subtract 1 from CL

Therefore,

1- 0.94950 = 0.05050 (probability of null hypothesis)

We set our rejection area as Alpha = 5%

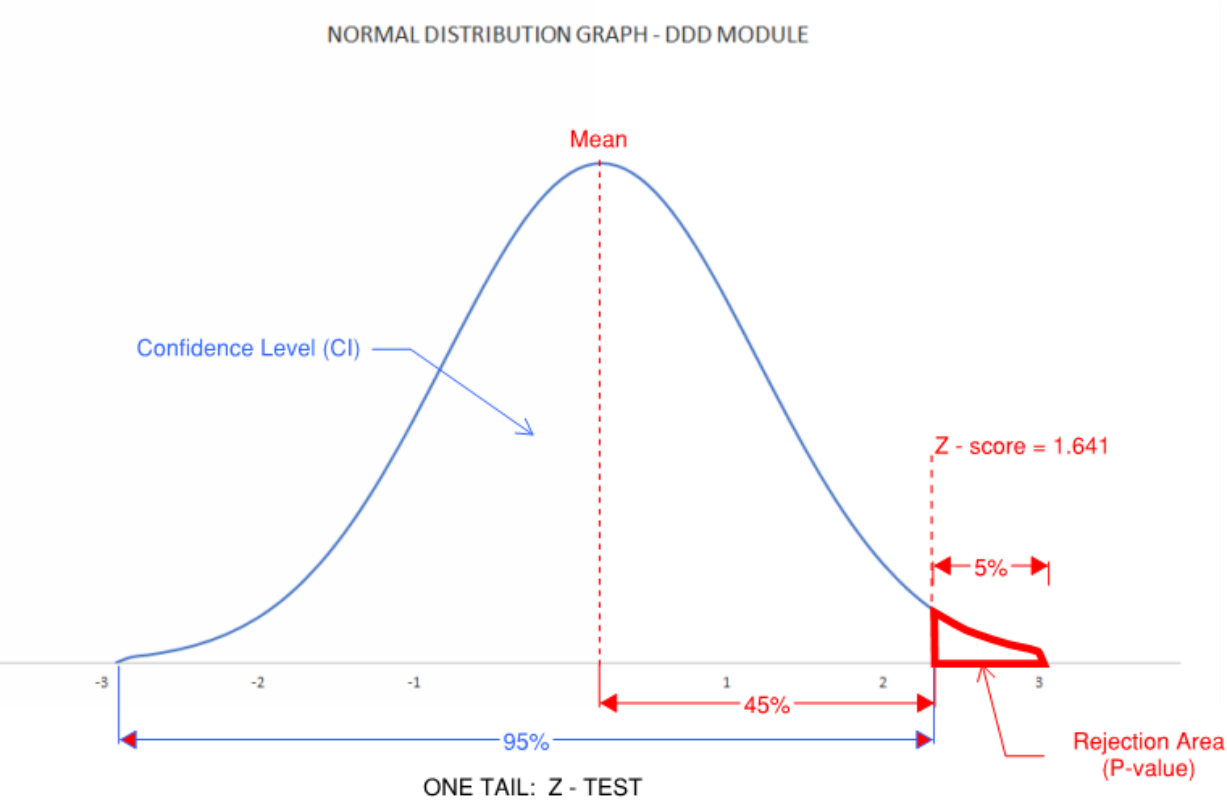


Figure 28: bell curve

Since Z-score result's value lies in rejection area, and we know if z>=critical value, the hypothesis is rejected. i.e. Null hypothesis (H_0) is rejected and alternate hypothesis(H_1) is accepted.

It concludes that our claim that the students who are active more on their learning platforms have greater chances to score more.

5.2.4 Overall Summary

Table 11: summary

Summary Table										
Code Module	**AAA**	**BBB**	**CCC**	**DDD**	**EEE**	**FFF**	**GGG**	**HHH**	**III**	**JJJ**
Population Average Time	45.51	40.59	42.07	46.12	36.99	42.06	37.32	37.41	34.78	34.54
Population Average Score	70.31	66.80	70.44	70.57	69.13	69.26	66.36	68.87	69.54	69.22
Focused Students	179	166	191	173	164	166	172	162	152	155
Un-focused Students	180	176	140	130	134	171	144	142	128	123
Population	359	342	331	303	298	337	316	304	280	278
Clicks per min	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72	2.72
Correlation: time spent and scores	0.932	0.915	0.914	0.928	0.920	0.909	0.931	0.933	0.897	0.926
Average score of focused students	79.32	77.00	78.64	79.60	78.73	79.23	76.67	78.75	78.76	78.90
Stand Dav of focused students	5.42	5.52	4.86	5.48	5.59	5.35	6.65	6.04	5.34	6.05
Z Score	1.665	1.848	1.688	1.641	1.717	1.864	1.549	1.635	1.719	1.600
Confidence Level probability				0.94950	From Z table					
Rejection probability				0.05050						

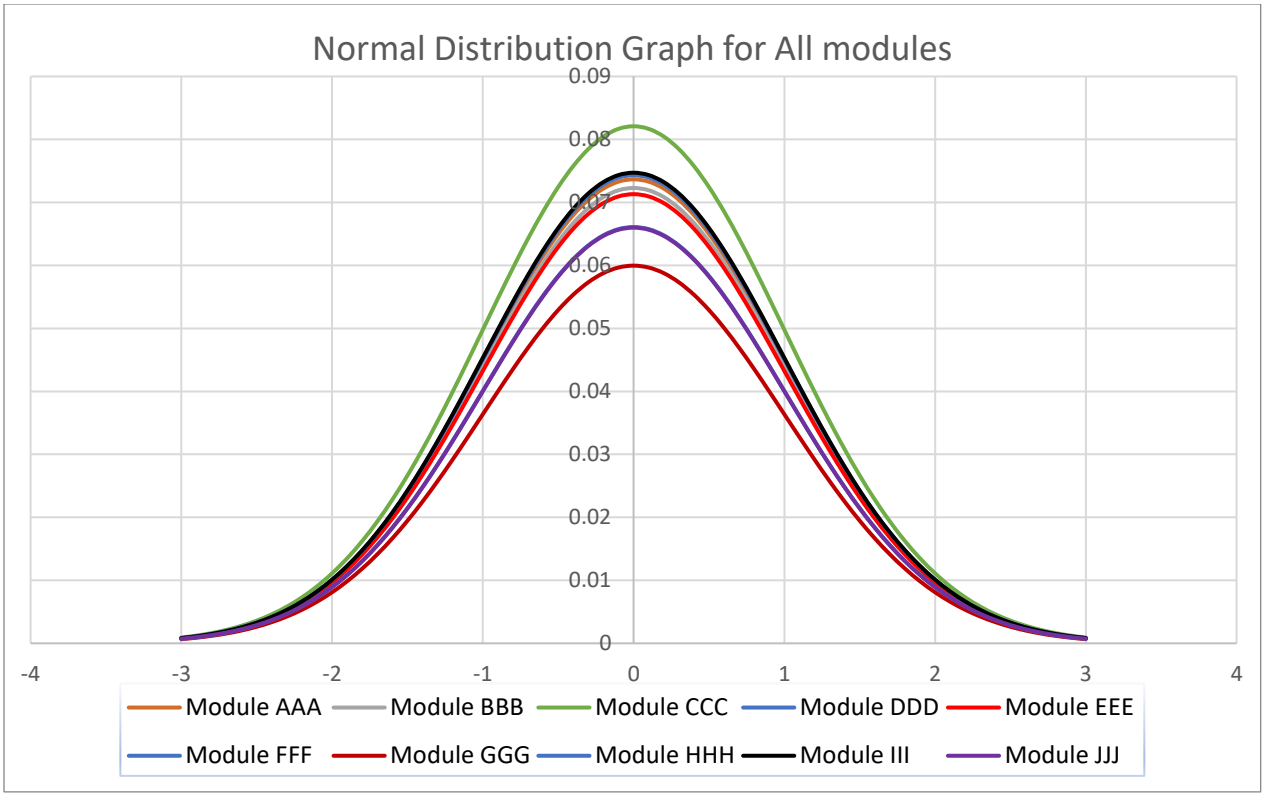


Figure 29: distribution graphs

5.3 Discussion

Motivation behind the study is the fact that in e-learning environments teachers are required to track real time progress of individual students to know who may be struggling and lagging and need extra attention.

Aims and requirements of this research were:

1. Introduce a data collection tool that should be automatic; it should always show an updated view of students' activities within the online course
2. Allow a graphical representation, to have a quicker view
3. Interpret decisions regarding course content and students from the presented data
4. Analyze and verify decisions, interpreted via time spent and scores gained

We have integrated database learning logs with the visuals/ plots to enable evaluation of learners' behaviors when they interact and access course modules and lectures. Till now, some functionalities have been implemented in the platform based on data collected using an auto data collection tool in order to answer education-related questions.

The visual tool allows the educator to examine and observe a much better involvement into the students' online course usage. Information we get as a result is helpful in making useful decisions for students who may be lagging; the group of highlighted unfocused students. "Events graph" is referred to in this case, while the "active time" contributes to both course wise and student wise activities.

The proposed solution contributes in enhancing the effective use e-learning systems used by institutes who offer blended learning environments. Helps the stakeholders (teachers, students and administration) to see working on a course online, leading to important decisions related to the teaching strategies if they need to be changed or modified to keep the students motivated. Also, it helps them to deal with their students in a much better way to improve their learning.

One limitation of this exploratory research work is the number of students and courses, that is not enough to conclude a rigid decision. Another is the limited time period given to conduct a detailed survey and could perform a real analytic result based on comparison of plots and scores.

Although we did take another set to test out hypothesis that comes out to be true.

Chapter 6 Conclusion and Future Work

6.1 Conclusion

Data collection in today's era is growing exponentially across more variable than ever before, from both qualitative and quantitative aspects across timeseries. Technology has adopted simultaneous by moving away from traditional analysis tool and moving towards the development of tools that can mine big data on cloud servers with optimized performance and processing power capabilities. Being able to make sense of data through data analysis and analytics with the capabilities to perform predictive analytics is imperative to justify the increasing cost and investment in IT infrastructure. In the realm of e-learning through LMS platforms, the data captured is valuable to gain tremendous insights into the very fabric of learner-teacher behavior. Unraveling these behavior patterns is essential to make the online learning environment more effective. From student's perspective they can check the progress, track their activities, engagement in course content, rectify their study patterns and improve grades. From teacher/s perspective, they would be in a better position to monitor the performance of all the students, their study patters, progress over time, provide value feedback, focus on students who are lagging and predict adverse results. To make it simpler, the feedback in the form of visualization, which is easy to navigate, bridges the competency gaps of students and teacher, and allow them to focus on the results instead of analyzing the data themselves.

The medium and context used by teachers can be modified as per the feedback received by the group and/or student engagement behavior pattern. Algorithm driven decision support system can be utilized for scalability, consistency and adaptability to the audience and course for effective feedback analysis. These DSS have capabilities from rule based to being complement autonomous with reinforced learning. Emerging learning environments such as visual learning can be optimized by understanding effective learning patters and to mold and reinforce these through learning patterns.

6.2 Future Work

The present study combines tools for data visualization and database from learning logs to evaluate learners' behaviors while they are interacting and accessing course content. Up to now, a set of functionalities has been implemented in the platform based on data collected using an auto data collection tool in order to answer education-related questions. The next phases will be to conduct extended data analysis by introducing new functionalities, including standard data mining approaches (linear regression and clustering) and to evaluate the validity of new functionalities and data.

Further by adding intelligence to e-learning platforms, distance instructors can be helped to 'zoom in' into their online courses and their students thus improving the existing learning techniques to provide better learning experiences. Consequently, various dimensions of learning techniques can also be explored which are required for next generation learning.

Chapter 7 Bibliography

[1] K. S. Kashinath, "Introduction :," no. February 2013.

[2] S. College and H. Kentnor, "Digital Commons @ DU Distance Education and the Evolution of Online Learning in the United States," *Recomm. Cit. Curric. Teach. Dialogue*, vol. 17, 2015.

[3] E. Llc, "e-learning Concepts, Trends, Applications."

[4] D. Weaver, C. Spratt, and C. S. Nair, "Academic and student use of a learning management system: Implications for quality," *Australas. J. Educ. Technol.*, vol. 24, no. 1, pp. 30–41, 2008.

[5] D. Palova, "Experience with usage of LMS moodle not only for the educational purposes at the educational institution," *2016 39th Int. Conv. Inf. Commun. Technol. Electron. Microelectron. MIPRO 2016 - Proc.*, pp. 901–906, 2016.

[6] M. Aparicio, F. Bacao, and T. Oliveira, "An e-Learning Theoretical Framework An e-Learning Theoretical Framework," no. January, 2016.

[7] "Virtual University of Pakistan." [Online]. Available: https://en.wikipedia.org/wiki/Virtual_University_of_Pakistan.

[8] J. L. Moore, C. Dickson-Deane, and K. Galyen, "E-Learning, online learning, and distance learning environments: Are they the same?," *Internet High. Educ.*, vol. 14, no. 2, pp. 129–135, 2011.

[9] C.-H. L. C.-H. Liu, "The comparison of learning effectiveness between traditional face-to-face learning and e-learning among goal-oriented users," *Digit. Content, Multimed. Technol. its Appl. (IDC), 2010 6th Int. Conf.*, pp. 255–260, 2010.

[10] M. Aparicio, F. Bacao, and T. Oliveira, "An e-learning theoretical framework," *Educ. Technol. Soc.*, vol. 19, no. 1, pp. 292–307, 2016.

[11] G. Sykamiotis, A. Charitopoulos, M. Rangoussi, and D. Koulouriotis, "Extraction and presentation of access and usage data from an e-learning platform (moodle) Design and development of a software application," no. April, pp. 1020–1026, 2017.

[12] M. E. Zorrilla and E. Álvarez, "MATEP : Monitoring and Analysis Tool for e-Learning

Platforms," pp. 611–613, 2008.

[13] M. Minović and M. Milovanović, "Real-time learning analytics in educational games," pp. 245–251, 2013.

[14] T. N. C. Vo, H. P. Nguyen, and T. N. T. Vo, "Making kernel-based vector quantization robust and effective for incomplete educational data clustering," *Vietnam J. Comput. Sci.*, vol. 3, no. 2, pp. 93–102, 2016.

[15] R. Casado and M. Younas, "Emerging trends and technologies in big data processing," *Concurr. Comput.* , vol. 27, no. 8, pp. 2078–2091, 2015.

[16] D. Zhao and W. Jia, "Design and implementation of university educational decision support system on the students satisfaction survey," *IFCSTA 2009 Proc. - 2009 Int. Forum Comput. Sci. Appl.*, vol. 3, pp. 428–430, 2009.

[17] M. Ouadoud, M. Y. Chkouri, A. Nejjari, and K. E. El Kadiri, "Studying and comparing the free e-learning platforms," *Colloq. Inf. Sci. Technol. Cist*, no. March 2018, pp. 581–586, 2017.

[18] VU, *About VU*. VU Press release.

[19] "Khan Academy." [Online]. Available: https://en.wikipedia.org/wiki/Khan_Academy.

[20] "The 4 Biggest Myths Of Video Learning." [Online]. Available: https://elearningindustry.com/4-biggest-myths-video-learning.

[21] S. Vandercruysse, M. Vandewaetere, and G. Clarebout, "Game-Based Learning," *Handb. Res. Serious Games as Educ. Bus. Res. Tools*, no. February 2014, pp. 628–647, 2012.

[22] "Here's how webinars are changing the way we connect and learn." [Online]. Available: https://www.lifewire.com/what-is-a-webinar-3486257.

[23] J. L. Guzman, S. Dormido, and M. Berenguel, "Interactivity in education: An experience in the automatic control field," *Comput. Appl. Eng. Educ.*, vol. 21, no. 2, pp. 360–371, 2013.

[24] F. Mödritscher, M. Andergassen, and G. Neumann, "Dependencies between E-Learning Usage Patterns and Learning Results," no. May 2014, pp. 1–8, 2013.

[25] P. K. Udupi, P. Malali, and H. Noronha, "Big data integration for transition from e-learning to smart learning framework," *2016 3rd MEC Int. Conf. Big Data Smart City, ICBDSC 2016*, pp.

268–271, 2016.

[26] D. D. Lumley, "Participation in Educational Decision Making.," *Educ. Horizons*, vol. 57, no. 3, pp. 123–125, 1979.

[27] R. Bansal, A. Mishra, and S. N. Singh, "Mining of educational data for analysing students' overall performance," *Proc. 7th Int. Conf. Conflu. 2017 Cloud Comput. Data Sci. Eng.*, pp. 495–497, 2017.

[28] Y. V. N. Acevedo, C. E. M. Marin, P. A. G. Garcia, and R. G. Crespo, "A proposal to a decision support system with learning analytics," *IEEE Glob. Eng. Educ. Conf. EDUCON*, vol. 2018-April, pp. 161–168, 2018.

[29] H. Luo, S. Rocco, and C. Schaad, "online course," vol. 1, 2015.

[30] J. Allen, T. Cavanagh, M. Gunkel, and J. Witmar, "Developments in Learning Analytics," *Educause*, vol. July, 2017.

[31] H. Y. Sung, P. H. Wu, G. J. Hwang, and D. C. Lin, "A Learning Analytics Approach to Investigating the Impacts of Educational Gaming Behavioral Patterns on Students' Learning Achievements," *Proc. - 2017 6th IIAI Int. Congr. Adv. Appl. Informatics, IIAI-AAI 2017*, pp. 564–568, 2017.

[32] A. Manohar, P. Gupta, V. Priyanka, and M. F. Uddin, "Utilizing Big Data Analytics to Improve Education," *2016 ASEE Northeast Sect. Conf.*, 2016.

[33] Y. Xue, W. Guo, and X. Gu, "Research on educational decision supporting system of compulsory education policy," *Proc. - IEEE 16th Int. Conf. Adv. Learn. Technol. ICALT 2016*, pp. 421–422, 2016.

[34] R. K. Lomotey and R. Deters, "Unstructured data extraction in distributed NoSQL," *IEEE Int. Conf. Digit. Ecosyst. Technol.*, pp. 160–165, 2013.

[35] E. Daniati, "Decision support system to deciding thesis topic," *Proc. - 2017 Int. Semin. Appl. Technol. Inf. Commun. Empower. Technol. a Better Hum. Life, iSemantic 2017*, vol. 2018-Janua, pp. 52–57, 2018.

[36] J. Cosgrave, "Decision making in," *Disaster Prev. Manag.*, vol. 5, no. 4, pp. 28–35, 1996.

[37] "Stories of learning and leading." [Online]. Available: https://georgecouros.ca/blog/archives/tag/educational-decision-making.

[38] A. Charitopoulos, M. Rangoussi, and D. Koulouriotis, "Educational data mining and data analysis for optimal learning content management: Applied in moodle for undergraduate engineering studies," *IEEE Glob. Eng. Educ. Conf. EDUCON*, no. April, pp. 990–998, 2017.

[39] M. Zorrilla, D. García, and E. Álvarez, "A decision support system to improve e-learning environments," no. June 2014, p. 1, 2010.

[40] W. Zhang and S. Qin, "A brief analysis of the key technologies and applications of educational data mining on online learning platform," *2018 IEEE 3rd Int. Conf. Big Data Anal. ICBDA 2018*, pp. 83–86, 2018.

[41] A. Adla and P. Zarate, "A cooperative intelligent decision support system," *Proc. - ICSSSM'06 2006 Int. Conf. Serv. Syst. Serv. Manag.*, vol. 1, pp. 763–769, 2007.

[42] F. Kanwal and M. Rehman, "Factors Affecting E-Learning Adoption in Developing Countries-Empirical Evidence from Pakistan's Higher Education Sector," *IEEE Access*, vol. 5, pp. 10968–10978, 2017.

[43] "Analysis of data mining techniques applied to LMS for personalized education," *2017 IEEE World Eng. Educ. Conf.*, pp. 85–89, 2017.

[44] R. Clark, "eLearning and the Science of Instruction." [Online]. Available: http://theelearningcoach.com/learning/10-definitions-learning/.

[45] A. Rovai, M. Ponton, M. Wighting, and J. Baker, "A comparative analysis of student motivation in traditional classroom and e-learning courses," *Int. J. E- …*, vol. 6, no. 3, pp. 413–432, 2007.

[46] P. C. A. Walsh, "Blended Learning." .

[47] "face-to-face learning." [Online]. Available: https://www.colleges.co.za/face-to-face-learning.

[48] "VLE." [Online]. Available: https://whatis.techtarget.com/definition/virtual-learning-environment-VLE-or-managed-learning-environment-MLE.

[49] R. K. Ladyshewsky, "E-learning compared with face to face : Differences in the academic

achievement of postgraduate business students," vol. 20, no. 3, pp. 316–336, 2004.

[50] A. L. Nazarenko, "Blended Learning vs Traditional Learning: What Works? (A Case Study Research)," *Procedia - Soc. Behav. Sci.*, vol. 200, no. October, pp. 77–82, 2015.

[51] A. A. Okaz, "Integrating Blended Learning in Higher Education," *Procedia - Soc. Behav. Sci.*, vol. 186, pp. 600–603, 2015.

[52] Linawati, N. Dewi Wirastuti, G. Sukadarmika, I. M. A. Suyadnya, and D. C. Krishne, "Adaptive online learning design using moodle," *2016 Int. Conf. Smart Green Technol. Electr. Inf. Syst. Adv. Smart Green Technol. to Build Smart Soc. ICSGTEIS 2016 - Proc.*, vol. 4, no. October, pp. 98–101, 2017.

[53] H. C. Guenaneche, "Communication Software Laboratory," 2008.

[54] M. Andergassen *et al.*, "The evolution of e-learning platforms from content to activity based learning: The case of Learn@WU," *Proc. 2015 Int. Conf. Interact. Collab. Learn. ICL 2015*, no. January 2018, pp. 779–784, 2015.

[55] S. Angra, "implementation of data mining algorithms on students' data using rapid miner," 2017.

[56] P. S. Barreiro, D. García-Saiz, and M. E. Z. Pantaleón, "Building families of software products for e-Learning platforms: A case study," *Rev. Iberoam. Tecnol. del Aprendiz.*, vol. 9, no. 2, pp. 64–71, 2014.

[57] G. Neumann, "Wirtschaftsinformatik 2003/Band I," *Wirtschaftsinformatik 2003/Band I*, no. May, 2011.

[58] "The Triple E Framework." [Online]. Available: https://www.tripleeframework.com/about.html.

[59] "Information Visualization." [Online]. Available: https://www.interaction-design.org/literature/article/information-visualization-who-needs-it.

[60] M. Patwardhan and S. Murthy, "Computers & Education When does higher degree of interaction lead to higher learning in visualizations ? Exploring the role of ' Interactivity Enriching Features ,'" *Comput. Educ.*, vol. 82, pp. 292–305, 2015.

[61] I. Y. T. Hsiao, Y. J. Lan, C. L. Kao, and P. Li, "Visualization Analytics for Second Language Vocabulary Learning in Virtual Worlds Visualization Analytics for Second Language Vocabulary Learning in Virtual Worlds," no. January, 2017.

[62] B. Bloom, "Bloom ' s Taxonomy," p. 1956, 1990.

[63] J. Torrente and Á. Del Blanco, : "Introducing educational games in the learning process," *Educ.* …, vol. 127, no. 10, pp. 1121–1126, 2010.

[64] S. Del Barrio-García, J. L. Arquero, and E. Romero-Frías, "International Forum of Educational Technology & Society Personal Learning Environments Acceptance Model: The Role of Need for Cognition, e-Learning Satisfaction and Students," *Source J. Educ. Technol. Soc.*, vol. 18, no. 3, pp. 129–141, 2015.

[65] "Data Acquisition." [Online]. Available: https://subscription.packtpub.com/book/big_data_and_business_intelligence/9781785885655/5/ch05lvl1sec35/data-acquisition.

[66] "Data Engineering." [Online]. Available: https://www.toptal.com/data-science/data-engineering-guide-to-storages.

[67] G. Siemens, D. Gasevic, C. Haythornthwaite, S. Dawson, S. B. Shum, and R. Ferguson, "Open Learning Analytics : an integrated & modularized platform Proposal to design , implement and evaluate an open platform to integrate heterogeneous learning analytics techniques," 2011.

[68] K. Mangaroska, M. Giannakos, and S. Member, "Learning analytics for learning design : A systematic literature review of analytics-driven design to enhance learning," no. September, 2018.

[69] O. Access, "We are IntechOpen , the world ' s leading publisher of Open Access books Built by scientists , for scientists TOP 1 %."

[70] N. Aeronautical, "Application of Educational Data Mining on Analysis of Students' Online Learning Behavior," pp. 1011–1015, 2017.

[71] P. Long and G. Siemens, "Penetrating the Fog: Analytics in Learning and Education," 2011.

[72] S. B. Shum and R. Ferguson, "Social Learning Analytics - KMi Technical Report (2011)," vol. 15, no. June 2011, p. 2330616, 2012.

[73] "desire to learn." [Online]. Available: https://en.wikipedia.org/wiki/D2L.

[74] A. Datenbanken, "A comparison of HTML-aware tools for Web Data extraction," pp. 1–84, 2008.

[75] J. A. Ruipérez-valiente, P. J. Muñoz-merino, D. Leony, and C. Delgado, "Computers in Human Behavior ALAS-KA : A learning analytics extension for better understanding the learning process in the Khan Academy platform," vol. 47, pp. 139–148, 2015.

[76] B. Dietz-uhler and J. E. Hurn, "Using Learning Analytics to Predict (and Improve) Student Success: A Faculty Perspective Beth Dietz-Uhler & Janet E. Hurn," vol. 12, no. 1, pp. 17–26, 2013.

[77] B. E. V. Comendador, A. M. Sison, and R. P. Medina, "Adoption of Feature Selection and Classification Techniques in a Decision Support System," *Int. J. Inf. Educ. Technol.*, vol. 7, no. 11, pp. 809–813, 2017.

[78] S. L. Alter, "Decision Support Systems: Current Practice and Continuing Challenge," *Reading, MA Addison-Wesley*, p. 82, 1980.

[79] "DSS Taxonomies." [Online]. Available: https://en.wikipedia.org/wiki/Decision_support_system#Taxonomies.

[80] "An Extended Taxonomy." [Online]. Available: https://www.lumina.com/blog/decision-support-systems-an-extended-taxonomy.

[81] D. Torregrossa, O. Engineer, and J. Hansen, "Decision Support Systems VIII: Sustainable Data-Driven and Evidence-Based Decision Support," vol. 313, no. May, 2018.

[82] "Monitoring and Evaluation (M&E)." [Online]. Available: https://en.wikipedia.org/wiki/Monitoring_and_evaluation.