

**EFFECTIVENESS OF MOBILE LEARNING PLATFORMS
FOR STUDY PROGRAM DELIVERY: A CLUSTERING
APPROACH TO ANALYSE STUDENT LEARNING
PATTERNS AND BEHAVIOUR**

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DECLARATION

I certify that this thesis is my own work and has not been submitted, in whole or in part, in any form for any other diploma or degree at any university or other institution. This thesis was prepared for the degree of Master of Science / Information Technology, by me under the guidance and supervision of Mr. Saminda Premaratne, Head, Department of Information Technology, and Senior Lecturer of the Faculty of Information Technology, University of Moratuwa. In respect of all the information taken from published or unpublished sources or authored by another person, due acknowledgment is made by citation in the text and inclusion in the list of references. .

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DEDICATION

This dissertation is dedicated to my beloved wife Wasanthi, daughter Thinara and son Thinura, who gave me endless courage and support to achieve my tasks whenever I discouraged.

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It is a great pleasure for me to express my sincere gratitude and thanks to all those, who helped me in various ways, to complete this study of research. First and foremost, my deepest gratitude goes to my Supervisor, Mr. Saminda Premaratne, Head, Department of Information Technology and Senior Lecturer, University of Moratuwa, Sri Lanka for his excellent inspirational academic support, meticulous care, kindness and generosity. His fruitful comments, guidance and insightful suggestions immensely helped me in carrying out the present study. He supported me in every possible way since the beginning of the research and without his guidance, excellent inspirational academic support and encouragement, my research would have never come out in the present form.

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ABSTRACT

The need for wide use of Mobile learning environments as an educational technology component in undergraduate education, has particularly arisen at present due to its vast potential for expansion. Use of online methods for education started to expand exponentially with the spread of devastating COVID19 since early 2020. Due to countrywide or regional wise long-term lockdowns, people are compelled to use online methods, particularly for learning. Mobile learning though makes it possible for students to learn and share their thoughts and views among each other as well as the academics can disseminate their knowledge with the student's community with the support of internet and technology improvements, it is evident that the solution is still suboptimal when compared to traditional teaching systems. Both the study behaviour of the students and the existing study patterns of Learning Management Systems (LMSs) in undergraduate studies seem to be responsible for this status of affairs. The objective of the study was to examine the present m-Learning study behaviour of undergraduate students and with the help of the outcome, to develop an improved LMS. Back-end data of the LMS for the period of five years was analysed to understand the factors that are under performing, and to use such findings to develop a better performing LMS. The study used Data Mining techniques in respect of the Database of the undergraduate LMS of the Faculty of Medicine, University of Colombo to test the research hypothesis. Various data mining algorithms, such as K Mean Clustering algorithm, Correlation Algorithm, Association algorithm etc have been used. The study found that there does exist only a mix of positive, negative and absence of relations between students' strong study behaviour and favourable study patterns, in the use of LMS. Distributions are not equal both among and in-between of attributes with LMS and therefore students are unable to realize full technical potential of the LMS delivery. LMS is acting as a limitation that keeps the online option at a suboptimal level. Students do not show a strong study behaviour and favourable study patterns in the use of LMS.

The conclusion is that there is a wide gap between the actual outcome and the full potential of the LMS. This pattern and behaviour indicates that the students have neither attempted questions or examinations nor use the benefits of an integration with social media via LMS mode. There are unutilized potential areas which can be used or utility can be enhanced without any technical expansion by only giving more opportunities to students. Findings provide technical solutions to develop the LMS comprehensively to meet today's online learning needs with further investments.

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Abbreviations

CRISP DM	-	Cross Industry Process for Data Mining
CSV	-	Comma-Separated Values
e-learning	-	electronic learning
GCE/AL	-	General Certificate of Education, Advanced Level
KDD	-	Knowledge Discovery in Database
LMS	-	Learning Management System
m-learning	-	mobile learning
MBBS	-	Bachelor of Medicine, Bachelor of Surgery
Moodle	-	Modular Object-Oriented Dynamic Learning Environment
NOC	-	Network Operating Centre
pdf	-	Portable Document Format
PHP	-	Hypertext Preprocessor
SQL	-	Structured Query Language
UK	-	United Kingdom

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Introduction

1.1 Background

The use of mobile learning is becoming a major area of development in the Sri Lankan education system. During the last decade, it has demonstrated a high potential for expansion. The mobile learning is a method of disseminating knowledge by using online electronic media especially to the geographically and physically distanced students of remote areas. This mode has also been introduced to the area of advanced learning in Sri Lanka. Use of online methods for education from primary level to post-graduate level expanded exponentially in Sri Lanka and the entire world with the spread of devastating COVID19 since early 2020. Countrywide or regional wise long term lockdowns confine people quite often to their homes compelling the use of online not only for learning but every other needs.

Sri Lankan undergraduate students are scattered in all parts of the island and by now mobile technology has reached to cover almost all parts of the country. Some of the students of the undergraduate programs are engaged in their learning while they are working. In spite of their difficulty in participating in classroom lecture sessions in the conventional delivery mode, the culture of mobile learning finds it very difficult to take root in society. As a result, realizing the potential of this technology is delayed which is disadvantageous to the individual learner as well as the country.

Currently, the education sector is facing a huge problem to enhance undergraduate education, with a large number of students passing the General Certificate of Education, Advanced Level (GCE/AL) or equivalent qualification, and eligible to enter into the University. However, the Sri Lankan universities are not adequately equipped to cater to current demands for the students due to limited availability of resources, especially space scarcity of the lecture halls, and other building requirements.

Above all, due to unexpected difficulties created by COVID19 Pandemic online methods of learning have become the only option for learning. COVID19 Pandemic related worldwide health restrictions require a minimum one-meter social distance, requiring substantial space to accommodate students in the conventional lecture-rooms. The requirement to maintain

social distances and conduct online lectures for all the lecture modules have become challenging tasks. Therefore, research to find solutions through improving decision support systems for mobile learning platforms to develop the LMS for conducting undergraduate online programs in the Universities has become a priority in today's context.

1.2 Problem statement

The traditional teaching system of universities is currently able to accommodate a very low percentage of 15-20 students who qualify to enter into university education annually. A similar percentage either attend private universities or go abroad for higher education. A substantial portion of students do not get an opportunity. The Education authorities have not explored the potential use of on-line teaching via the internet by expanding its student intake through this method. With the high literacy rates and wide use of online teaching provided a cost-effective method of expanding undergraduate programs. It is believed that the current study patterns and behaviors of the online studies acting as a limitation keeps the online option at a suboptimal level. Further there has not been any empirical work in this area to ascertain the factors that adversely affect progress. As a result of slow development in online teaching and not realising the full potential of new technology thousands of students who qualify to enter into universities are dropped out from realising full potential of their life while the country loses the contribution of such educated citizens to the country's economy. An entirely new challenge has been put forward by COVID 19 pandemic, making social distance mandatory and introducing long term lockdowns of the country or parts of it, leading online learning the only option. This situation has made the issue of online learning more relevant and critical in the present-day context.

1.3 Research Questions

- i. What are the students' study behaviours and study patterns of the Learning Management System (LMS) and current status of the use of mobile mode for undergraduate learning?
- ii. What are the factors affecting the realization of the full potential of mobile technology for mobile learning at undergraduate level?
- iii. How can a better performing decision support system for mobile learning platforms be developed based on the outcome of (i) and (ii) above and using the data mining concept?

1.4 Aim and Objectives

Aim:

The main aim of this study is to examine and analyse the students' study behaviour and the study patterns of the LMS in order to develop a decision support system for mobile learning platforms for conducting undergraduate programs.

Objectives:

- i. To examine, analyse and identify students' study patterns and study behaviours in the Learning Management System (LMS), at present.
- ii. To examine factors that influence students' study patterns and study behaviours in the Learning Management System (LMS) in order to develop a decision support system for mobile learning platforms .
- iii. To develop a better performing decision support system for mobile learning platforms for conducting undergraduate study programs.

1.5 Structure of the Thesis

The Structure of the thesis will distribute as follows.

The first chapter presented the background to the problem, the problem statement, research questions, research aim and objectives. The second chapter presents the underlying theory and a critical review of the literature on the research issue. This chapter therefore basically lays the foundation for the analysis of data, based on the body of knowledge on creating Decision support systems for mobile learning platforms for conducting undergraduate programs in Universities including the m-learning, Learning Management System (LMS), Use of Learning Management Systems (LMS) in Sri Lankan Universities and the existing gaps in research. The third chapter is about the methodology and technologies that were used to analyse data. The 4th to 7th Chapters presents various facets of the development of the new Decision Support System i.e., the fourth chapter is about the approach with users, inputs, outputs, process and features and the hypothesis. The fifth chapter is about the procedure of designing and implementing a system and to consider the top-level architecture design

(system design) of the solution. The chapter six is a discussion on the implementation process and in Chapter seven, the researcher evaluates the results in order to prove the accuracy of the solution. The last chapter will provide the conclusion for the research with recommendations for further development.

Theoretical Considerations and Review of Literature

2.1 Introduction

In this chapter, the theoretical aspects related to the research issue will be presented and available empirical evidence will be critically reviewed and presented. Also, a substantial body of knowledge on electronic learning (e-learning), mobile learning (m-learning) and Learning Management System (LMS) makes a part of both aspects of theory and empirical evidence. The remaining five sections of the chapter are organized as follows: Section-2.2 presents the evolution of theory and literature on E-learning and M-learning, while Section 2.3 is devoted to Learning Management System (LMS). Section 2.4 presents the existing knowledge on Data Mining, and Section 2.5 discusses the use of Learning Management Systems (LMS) in Sri Lankan Universities. Final Sections present gaps identified in the literature and a summary of the chapter respectively.

2.2 Underlying Theory and Review of Literature

2.2.1 E-learning and M-learning

With the advancement of information and communication technologies (ICTs), e-government has emerged as an effective means of delivering government services to citizens. In the recent past, e-government has become popular in many economically developing countries, yet there are numerous attempts to reinvent the wheel [1] according to Weerakkody et al, (2012) in their study on “Implementing e-government in Sri Lanka: Lessons from the UK,” The concept of e-government Mobile learning (M-learning) has become an important educational technology component in higher education and it also become a quite significant factor in higher education [2] as found by Klimova and Poulova, (2016) with regard to mobile learning in higher education.

The introduction of m- learning to the higher education sector of the country is set to exploit much of this opportunity, but there remains some doubt on the readiness of people toward this revolutionary distance learning method [3]. Gunawardana and Ekanayaka, (2009) in their study titled “An Empirical Study of the Factors That Impact Medical Representatives ”

support the prevailing doubt on the readiness of the people regarding the distance learning methods that challenges the hitherto practiced teaching and learning methods, focusing on attitudes towards the intention to use M-Learning for career development. While stating that M-learning can be considered as an intersection of online learning and mobile computing [4] Abou El-Seoud and El-Sofany, (2009) argue that this is a new stage to enhance higher education in the direction of towards the development of an M-Learning System. As per Fazeena and Hewagamage (2011), Mobile learning is one of the major developing areas in recent years in the educational field [5]and they argue for suitability of Mobile Learning to enhance English language learning . Their conclusion is based on a survey undertaken among students of University of Colombo, School of Computing.

In their investigation in higher education, Abu-Al-Aish and Love (2013) found factors influencing students' acceptance of m-learning that the Mobile learning (m-learning) environments provides a wide range of new and exciting learning opportunities supported by the wireless technology[6] M-learning makes it possible for students to learn, collaborate, and share ideas among each other with the aid of internet and technology development. However, M-learning acceptance by learners and educators is critical to the employment of M-learning systems [7] according to Al-Emran et al, (2015) who observed in their "Investigating attitudes towards the use of mobile learning in higher education". Integrating a secure short message service (SMS), into a learning management system (LMS) provides a facility for the trainers to communicate with students effectively [8] as found by Premadasa et al, (2013) in their study on the "Mobile learning environment with short messaging service," and it is treated as the m-learning.

Attitudes towards M-learning technology is an important factor that helps in determining whether or not learners and educators are ready to use M-learning [7] argues Al-Emran et al , (2015) in their investigation on attitudes towards the use of mobile learning in higher education. Through wireless devices e.g. such as mobile telephones, Personal Digital Assistants - PDAs, tablet PC, and laptops and wireless applications, M-learning supports an integrated access to Web content and services in education anytime and anywhere (Abou El-Seoud and El-Sofany, (2009) [4]. The use of mobile devices and wireless technology in the new learning environments allows students to achieve more in their educational process [6]. This has been identified as a factor influencing students' acceptance of m-learning, according to Abu-Al-Aish and Love,(2013). M- Learning facilitates a new mechanism of teaching and

learning process in order to enhance the learning and education experience of the students[6]. This has been another variable identified as a factor influencing students' acceptance of m-learning by the same authors Abu-Al-Aish and Love, (2013). There are challenges pertaining to e-learning skill development among course lecturers and students that include low digital bandwidth; expertise in e-learning; e-learning infrastructure; incentive packages for retaining skilled personnel; low budget, few funding for research on ODL; and costs of e-learning equipment's with its associated after sales contract adversely affects the implementation of e-learning [9]. These are relevant findings, based on a study on the experience of Tanzanian open university students conducted by Bakari et al, (2010) in their study on the "Implementing of e-learning in higher open and distance learning institutions in developing countries.

The advancement of technology and high mobile penetration rates in developing countries has broadened the horizon of education. One possibility to overcome the problems is the application of the concept of mobile learning (called m-Learning) [10], devices such as netbooks, tablets or smartphones that have become ubiquitous in the institutions of higher education for mobile learning, but these may be displaced by emerging technologies. These views are supported by Grimus et al ,(2012) who consider mobile learning as a chance to enhance education in developing countries, based on a study in Ghana. In addition, the most highly cited articles are found to focus on mobile learning system design, followed by system effectiveness. These findings of Wu et al, (2012) in their comprehensive review of trends from mobile learning studies based on a meta-analysis, may provide insights for researchers and educators into research trends in mobile learning [11]. Power of computers and laptops has changed the way learning happens and made it easier to access all materials and resources.

Herrington and Herrington, (2007) in their study titled "Authentic mobile learning in higher education," opined that the ready availability and uptake of devices such as mobile phones, personal digital assistants and mobile music players, have permeated the manner and means of human communication, socializing and entertainment on a large scale [12]. The results showed that four factors: performance expectancy, effort expectancy, social influence, and facilitating conditions had significant positive effects on students' mobile learning acceptance with performance expectancy being the strongest predictor [13]. These are found in two studies, viz Mtebe (2014) and Raisamo (2014) on students' behavioral intention to adopt

and use mobile learning in higher education in Tanzania and Finland,” respectively.

Cheon, et al (2012) in their investigation of mobile learning readiness in higher education based on the theory of planned behavior, have found that the college students’ acceptance of m-learning reasonably well. More specifically, attitude, subjective norm, and behavioral control positively influenced their intention to adopt mobile learning [14].

A review of some empirical literature on the current status of mobile learning that explores alternatives to help universities fulfil core functions of storage, processing, and disseminating knowledge that can be applied to real life problems, has been found in Rajasingham, (2011) in his study titled, “Will Mobile Learning Bring a Paradigm Shift in Higher Education?,” which is followed by an examination of the strengths and weaknesses of increased connectivity to mobile communication networks to support constructivist, self-directed quality interactive learning for increasingly mobile learners [15]. The advancement of technology and high mobile penetration rates in developing countries have broadened the horizon of education. One possibility to overcome the problems is the application of the concept of mobile learning (called m-Learning)[10] as recommended by Grimus et al,(2012) in their study “Mobile learning as a chance to enhance education in developing countries” taking Ghana as an example.

2.2.2 M-learning and Learning Management System (LMS)

Online learning is commonly accepted as a support tool for educators as well as a medium of delivery of any-time, anywhere content of a wide range of study programs to a widely dispersed learner community [16] according to Sandanayake and Madurapperuma, (2011) who recommend a novel approach for Online Learning through Affect Recognition. However, m-learning environments are a relatively new medium of learning to Sri Lankan universities. Mobile learning (M-learning) has become an important educational technology component in higher education. Today, M-learning makes it possible for students to learn, collaborate, and share ideas among each other with the aid of internet and technology development [7]. This is a finding of Al-Emran et al, (2015) in their investigation of attitudes in the use of mobile learning in higher education. However, M-learning acceptance by learners and educators is critical to the employment of M-learning systems. But the development of digital technologies has so far been limited to social communication and a

few persons have regarded mobile learning as a core pedagogical activity in higher institutions of learning [17] as revealed by El-Hussein and Cronje (2010), in their study of “Defining mobile learning in the higher education landscape.”

The emergence of revolutionary technologies has had a significant impact on educational technology. It has increased the potential of e-learning as a mode of delivery in education. The Learning Management System (LMS) is a software application for the administration, documentation, tracking, reporting, automation and delivery of educational courses, training programs, or learning and development programs. The learning management system concept emerged directly from e-Learning and m-Learning.

2.2.3 Learning Management System (LMS)

A LMS is a web-based software that facilitates the delivery and tracking of e-learning activities across an educational institution. It is an e-learning content management system or simply an e-learning system. In addition to delivering e-learning content, LMS can track learners’ activities, achievements and competencies, automate (supervisory and administrative functions, and operate as a repository for learning resources. The tools and functions of an LMS support teaching and learning processes, usually including course management tools, online group chat and discussion, homework collections and system applications in higher education has occurred in the recent past grading, and course evaluation essential tool in the delivery and management of teaching or training process with the improvement of the e-learning concept. A sudden increase in the use of learning management. Learning management systems are gaining interest as many universities are using LMS as a tool to help in disseminating materials to the learners. There is a trend in using LMSs to complement face-to-face classes with e-learning sessions. With the help of various features of an LMS, Lecture notes can be provided as PowerPoint presentations and PDF files. Other examples of tools include podcasts.

2.3 Data Mining

2.3.1 Data mining concept and Data Mining Paradigm

Data Mining is a technology to enable data exploration, data analysis and data visualisation of very large databases at a high level of abstraction. The purpose of data mining that helps analysts to recognise significant facts relationships trends patterns which might go unnoticed otherwise . -Data mining requires too much data and too little information. There is a need to extract useful information from the data and to interpret the data .The data mining tools are RapidMiner, Oracle data mining, orange, IBM SPSS Modeler, Weka, etc.

Data mining is a very interdisciplinary field and there are many different paradigms of data mining algorithms, such as Classification algorithms, Regression algorithms, Segmentation algorithms, Sequence analysis algorithms, Association algorithms that find correlations between different attributes in a dataset. Based on the said algorithms we can use Natural Networks, Bayesian Networks, Decision Trees, Support Vector Machines, Instance Based operators to Data Mining. The data mining paradigm (Figure -2.0).

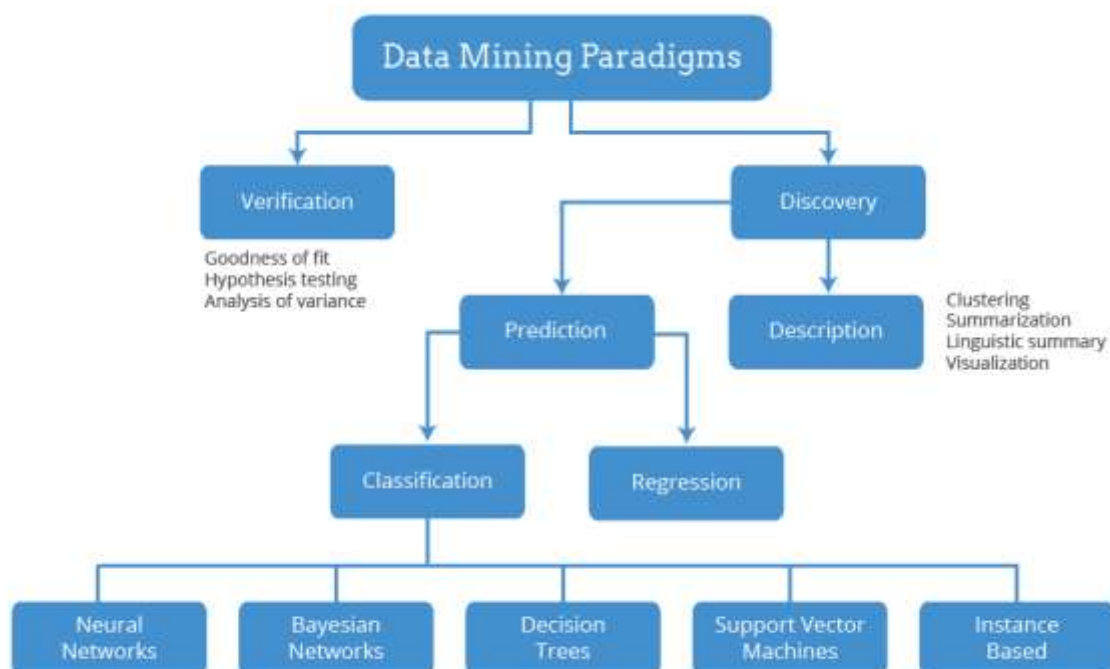


Figure 2.0 - The Data Mining Paradigm

2.3.2 Data Mining Process CRISP DM

CRISP is one of the data mining processes and there are many other data mining processes. The CRISP DM stands for Cross Industry Process for Data Mining and there are six-phases of the CRISP data mining process. They are business/problem understanding, data understanding, data preparation, modelling, evaluation and deployment (Figure -2.1).

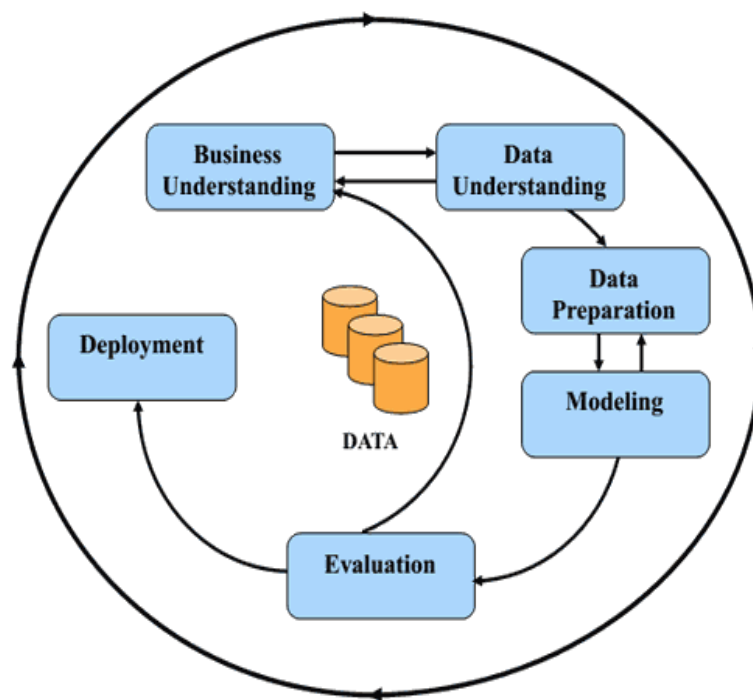


Figure 2.1 - Data Mining Process CRISP DM

The business/problem understanding- The business/problem understanding is to understand the problem to be solved. It really is an iterative process of discovery with the data understanding phase. In this stage initially determined the problem and objectives, 2nd assess the situation, which is really a detailed fact-finding exercise, 3rd determined data mining goals and finally 4th produced the plan. **The data understanding-** The data understanding stage before the researcher does anything with the data needs to understand the strengths and limitations of the data. Because rarely will the data exactly match the problem that the researcher is trying to solve, it's also important to recognize that data costs money and that some data may not be available, therefore the researcher needs to evaluate the costs

and benefits. In this stage are involved that is #1 collect initial data, #2 describe the data, #3 explore the data and #4 verify the quality of the data.

The data preparation- The data preparation is essentially analytics technologies and often requires that data be in a form that's different from how the data was initially provided. This data preparation includes #1 converting data to tabular format, #2 removing or inserting missing values, #3 converting data to different types and #4 scaling numerical values. This is the most time-consuming stage of this six-stage model . In this stage the specific steps are #1 select the data, #2 clean the data, #3 construct the data and #4 integrate the data. **Modelling-** The modelling stage is very important stage in the data mining, in this stage the specific steps are #1 select the modelling technique, #2 generate tests for model robustness, #3 build the model and #4 assess the model.

Evaluation stage- The evaluation stage the purpose of the stage is to assess the data mining results both from a quantitative and qualitative perspectives and have a keen attention to detail determine if the results are both justifiable infeasible. In this evaluation stage the model satisfies the original problem. In this stage the specific steps are #1 evaluate the results, #2 review the process and #3 determine . **The deployment stage-**The deployment stage where the results of the data mining are put into real use so that the problem can realise. In this stage the final outcome can pass in the working prototype to the development teams. Then they can be recorded for product for the production environment and oftentimes in the deployment stage.

2.4 Use of Learning Management Systems (LMS) in Sri Lankan Universities

Moodle open-source platform is used as the LMS in most state universities in Sri Lanka. It is a free web learning platform that can be used by educators to model effective online learning platforms. One of the main advantages is that it is an open source that any user can use, modify with programming knowledge and adapt the environment according to their wishes. It can be installed free of charge on any number of servers, and no maintenance costs are required to pay Moodle offers a more sophisticated and structured e-learning environment. It appears more like a set of tools sharing an effective and productive learning environment. These are some sounds for upgrades. Moodle's design is based entirely on socio-constructivist pedagogy

is to provide a set of tools that enable an online learning process based on inquiry- and discovery approach. The following are the reasons behind the wide range of uses in the context of Sri Lanka (i) Cost-effectiveness, (ii) interoperability and Flexibility, (iii) Support and Training, (iv) Ease of Use. (v) Scalability and (vi) Sustainability.

2.5 Gap identification

In this literature review, it has been observed that none of the researchers undertook any research on the students' study behaviour and students' study pattern of the Learning Management System (LMS) specially in the Sri Lankan context. Therefore, in this study the focus is on the present LMS in order to develop a better decision support system for mobile learning platforms for conducting undergraduate programs of studies in Universities.

2.6 Summary

This chapter provided a thorough description of the current measure of the particular matter in the focus and related literature was reviewed to get an idea to execute this research. It has discussed the related finding, e-learning, m-learning, learning management system (LMS), use of learning management systems (LMS) in Sri Lankan universities, gap identification. It delivered a clear idea to what technologies to use and possible ways to address this selected topic to enact a successful research.

Methodology

3.1 Introduction

This chapter presents the overall methodology used in the research. The chapter has five sections. The first section is about the research design while the second section presents various data sources for the study. Third section describes data collection methods while the fourth section presents as to how data was analysed. Data mining and other technological tools used in the stages of initial data analysis, implementation, evaluation etc. will also be discussed under this section. The last section will justify the use of the specific methodology for the intended research.

3.2 Research Design

The research method deployed is the case study method. The number of undergraduate/postgraduate student populations following their degree courses online in Sri Lanka make the population of the research. Students who follow undergraduate courses at the Faculty of Medicine have been taken as the sample while the Faculty of Medicine in the University of Colombo has been taken as the case for study. The justification for the selection of Faculty of Medicine as the case for the in-depth study of its online system is its high level of development as a teaching platform. This research design is essentially leading to a new system development to resolve the problems prevailing within the existing systems. As such by undertaking an in-depth study into an adequately developed system, research outcome is parallelly used to develop an improved version of a system.

3.3 Technologies used for the tool

3.3.1 Data Source

The data pertaining to the m-Learning system of the Faculty of Medicine, University of Colombo has been used from 2017 to date. For the present research, the period from 2018 to 2020 has been taken into consideration. The total usage of the Learning Management System is 1695. The sample of research will consist of 234 students who followed online

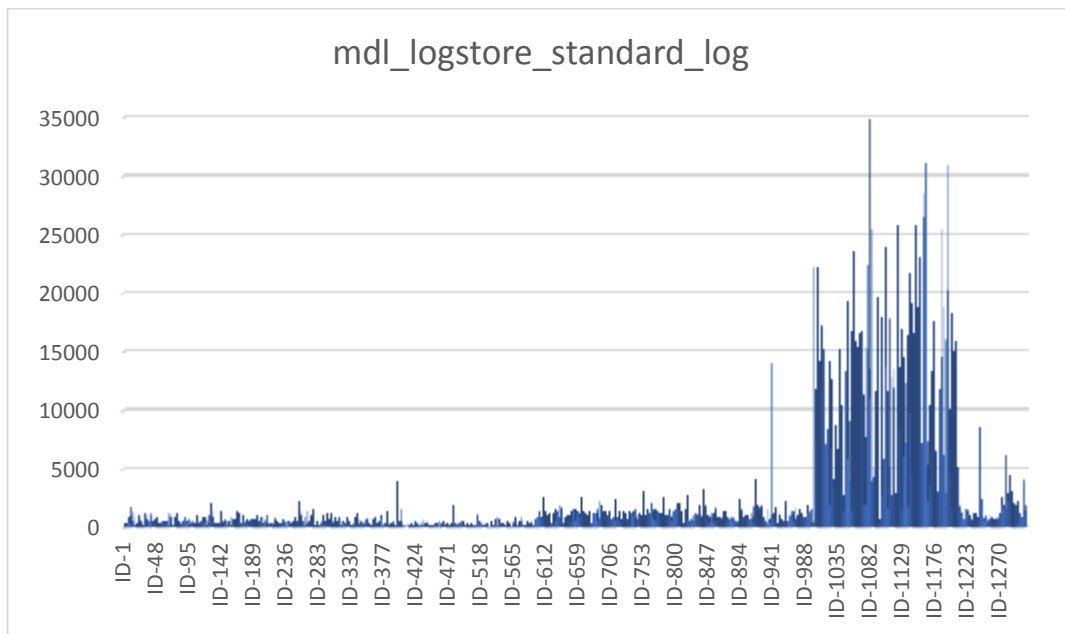
undergraduate courses of study during this period. The total usage of the Learning Management System is shown in Table 3.0

LMS User Summary

#	User Description	Population
1	Academics	175
2	System Administrators	6
3	Technical Team	15
4	Total Students	1499

Table 3.0 - The total usage of Learning Management System

The total user views and the usage of the Learning Management System is shown in Graph 3.0. As the other batch of the students are not using LMS fully, the 2018 batch has been taken for this research.



Graph 3.0 -Total User views of Learning Management System

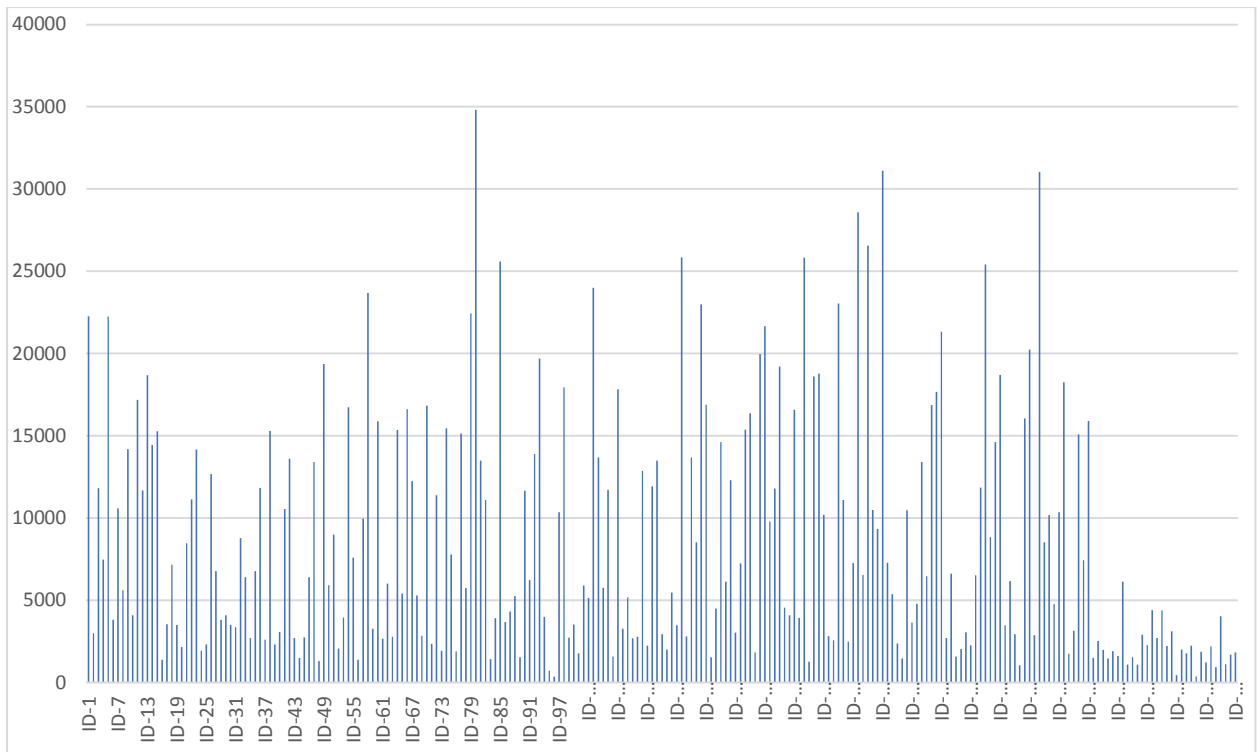
The sample of research will consist of 234 students who followed online undergraduate courses of study during this period. Using the data mining technology described below, information on various attributes relating to their interventions/ involvement with the system will be accessed through a back-end approach. All the secondary data recorded in the system will be taken for the analysis and quantitative type of data will be extracted for the purpose. The Data which were considered for this research are shown in Table 3.1.

Data Consider for this research

#	User Description	Population	Consider for this research
1	Academics	175	No
2	System Admin	6	No
3	Technical Team	15	No
5	2012 AL Batch	198	No
6	2013 AL Batch	200	No
7	2014 AL Batch	197	No
8	2015 AL Batch	194	No
9	2016 AL Batch	240	No
10	2017 AL Batch	236	No
11	2018 AL Batch	234	Yes

Table 3.1 - The total usage of the LMS and the sample considered for the research

The data which were considered for this research related to the 2018 AL batch. The user views of the entire 2018 batch, i.e. 234 students are shown in Graph 3.1



Graph 3.1 -Total User views of the 2018 AL batch, the sample of this research

3.3.2 The data preparation

The data preparation is essentially data mining and often requires it to be in a form that is different from how data was initially provided. This data preparation includes #1 converting data to tabular format, #2 removing or inserting missing values, #3 converting data to different types and #4 scaling numerical values. This is the most time-consuming stage of this six-stage model. In this stage the specific steps are #1 select the data, #2 clean the data, #3 construct the data and #4 integrate the data.

3.3.3 Data collection

The sample of research consists of **234** students who followed undergraduate courses of study during this period. Using the data mining technology described below, information on various attributes relating to their interventions/ involvement with the system were accessed through a back-end approach.

3.3.4 Data mining

The Data Mining technology has been used for data exploration, data analysis and data visualization from the database at the NOC at a high level of abstraction. The data mining helps the analysis to recognize relationships, significant trends and patterns which might go unnoticed usually. Data mining is needed to extract useful information from the data and to construe the data. From various data mining tools available, such as RapidMiner, Oracle data mining, orange, IBM SPSS Modeler, Weka, etc. the tool, RapidMiner has been used in this research

3.3.5 Data mining tool

Data mining is a very vast field and there are many different paradigms of data mining algorithms. In the data mining to find and examine the correlations, association and different relationships, etc between different attributes in a dataset, the Clustering algorithm, Correlation Algorithm, Association rule data mining algorithms, Classification algorithms, Segmentation algorithms, Regression algorithms, Sequence analysis algorithms, etc is take part and immensely use. The most common application of this kind of algorithm is for creating association rules. Based on the said algorithms Natural Networks, Bayesian Networks, Support Vector Machines, Decision Trees, Instance Based operators etc. could be used for Data Mining.

3.3.6 Knowledge Discovery Process

The Knowledge Discovery in Database (KDD) process consists of several stages that is “data cleaning, data Integration, data Selection, data transformation, data mining, pattern evaluation and knowledge representation” and its graphical representation is shown in Figure 3.0 [18] according to Janosik (2005) in his article titled, “Data mining and Knowledge Discovery Hand”.

Repossessing knowledge (knowledge discovery) from data is an essential task for decision making in any circumstance and data mining is the key part of Knowledge Discovery in Database (KDD) process[19] as per Zaïane’s (1999) Introduction to Data Mining.

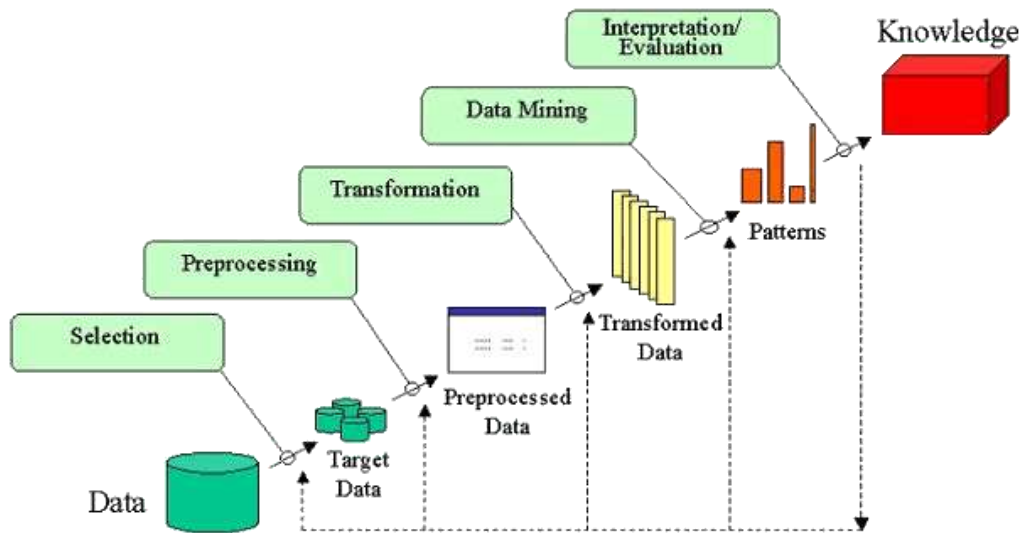


Figure 3.0 - Knowledge Discovery Process

3.3.7 Data mining tool- RapidMiner

RapidMiner Studio is one of the widespread and most used open-source data mining solutions. RapidMiner is licensed under the GNU Affero General Public License version 3 and currently available in version 9.8. Java programming is used to write the RapidMiner. The researcher used a free version of RapidMiner for this research, but the commercial version is readily available with more functions and features. The RapidMiner caters to data mining including data loading, data transformation, data pre-processing, data visualization, predictive analytics, statistical modelling, evaluation etc. The Open window of the RapidMiner Studio 9.8 is shown in Figure 3.1.

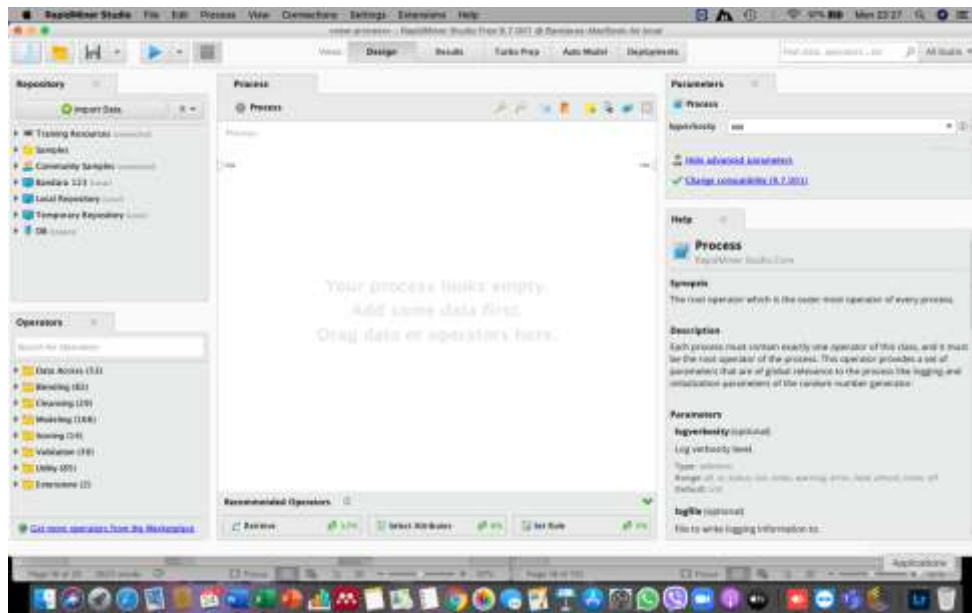


Figure 3.1 - The open window of the RapidMiner Studio 9.8

3.3.8 PhpMyAdmin

The PhpMyAdmin is written in PHP and it is an open-source free software. PhpMyAdmin is web based and supports MySQL database. MySQL is the most popular open-source database. The researcher executed the SQL queries on the PhpMyAdmin cPanel.

3.3.9 MySQL

The researcher used MySQL queries for the development of the database. MySQL is free and it is a freely available open source. The researcher took a backup from the Moodle live environment and hosted it on a local server and published it. The researcher perused all the log details and wrote several queries to obtain the research data set.

3.3.10 CSV files (Comma-Separated Values)

The CSV files (Comma-Separated Values) used to handle the dataset as it involved a large number of logs. The CSV file has been used for projects to organize and format the data sets. As this researcher involved a larger number of data sets and also as csv is compatible with the RapidMiner CSV used to organize and format the dataset.

3.4 Justification of methods

As stated earlier this research design is essentially leading to a new system development to resolve the problems prevailing in the existing systems. As such by undertaking an in-depth study into an adequately developed system, research outcome is used to develop an improved version of a system.

3.5 Summary

In this chapter, research methods used in the study have been presented. In the data analysis section, the use of the data mining tools to derive research objectives was elaborated. In this chapter, technologies used for the tool for data mining were discussed. Further data Mining Process CRISP DM the data understanding, the data preparation, modelling during the evaluation and the deployment stage were considered. The Knowledge Discovery Process, data mining paradigms and also data mining tools- RapidMiner, MySQL, CSV files (Comma-Separated Values have also been discussed.

Data Analysis and Results – The Approach

4.1 Introduction

In the previous chapter, methods used in different aspects of the research were discussed together with technological tools used to analyse and develop new systems to solve the research problem. This chapter describes the selected approach for analysis of factors influencing students, their study behaviour and the patterns of the prevailing Learning Management System.

4.2 Hypothesis

The research hypothesis was that there will be a students' strong study behaviour and favorable study patterns in the use of the Learning Management System (LMS). In order to test the hypothesis Data Mining techniques of the Learning Management System (LMS) have been used in respect of the Database of the Undergraduate Faculty of Medicine, University of Colombo. Various classified technologies have been used in data mining.

4.3 Process Model

The development of the proposed approach has involved mainly four steps of data gathering, data pre-processing, data mining, and data visualization. In the proposed approach, the data set was found from the LMS Moodle database and SQL queries were written to develop the dataset. Once the dataset is developed, the pre-processing has been carried out, as the real data sets are incomplete, inconsistent and contain many errors. In this preprocessing stage, several steps have been undertaken viz data cleaning, data integration, data selection, data transformation, data reduction, data discretization, evaluation and knowledge representation.

Data cleaning has been used to remove noise missing data or irrelevant data as generally data cleaning improves the data quality. **Data integration** is merging of data from multiple data stores; careful integration helps to reduce redundancies and inconsistencies in the resulting data set and this step improves accuracy and speed. The next step was data **selection**, in this step, data relevant to the analysis task, was selected from the database for

further processing. During the data transformation stage, data transformation routine converts the data into appropriate ways. It involves aggregation, normalization and generalization. **Data reduction** techniques have been applied to obtain a reduced representation of the data set that is much smaller in volume but still contains critical information. **Data discretization** involves the reduction of a number of values of a continuous attribute by dividing the range of attribute intervals. The **evaluation and knowledge representation** in this step visualisation and knowledge representation techniques have been used to present find knowledge to the users.

In summary, the data preprocessing is a data mining technique. In this preprocessing stage raw data are transforming into the understandable format. At this stage RapidMiner has been used in order to mine data or analyse data for data mining activities. There are several advantages of using this RapidMiner tool. Key important advantage about choosing RapidMiner is that when the research data set size is small or medium this is useful. The above reason is given for the use of RapidMiner for the pre-processing data on this research.

Clustering algorithm, Correlation algorithm and Apriori algorithm have been used in this research as it involves the use of machine learning models to analyse data for patterns, or co-occurrence, in a database and then finally picked up the most accurate classifying techniques based on data model which was developed for the research.

4.4 System overview

The proposed process commences with the data collection from the Moodle database of the live Learning Management System (LMS). Thereafter backup is stored in the different server environment and the said database is published. Then by using SQL queries a proposed data set has been developed. The next step is the process of the pre-processing. Thereafter modelling and design the data mining process takes place. Next process analysed the dataset using a data mining algorithm and finally presented the final outcome, shown in Figure 4.0.

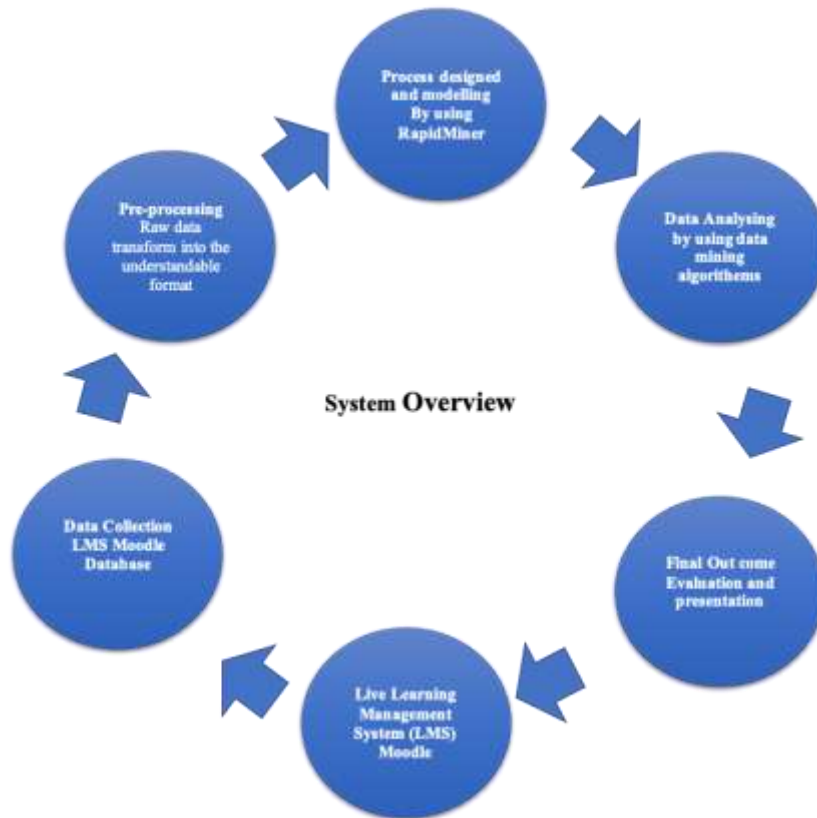


Figure 4.0 - The System Overview

4.5 Raw Data Presentation & inputs

The researcher developed a dataset by writing queries using the Structured Query Language (SQL) to the published Moodle database. The executed SQL queries to develop the dataset is shown in Code Snippet 4.0.

The SQL Query executed to prepare research data set

```

select id as user,
(SELECT COUNT(userid) FROM
mdl_stats_user_daily where userid=user ) as
'mdl_stats_user_daily',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%dashboard_viewed') as
'dashboard_viewed',

```

```

(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%course_viewed') as
'course_viewed',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%course_module_viewed') as
'course_module_viewed',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%course_category_viewed') as
'course_category_viewed',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%content_page_viewed') as
'content_page_viewed',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%attempt_viewed') as
'attempt_viewed',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%user_profile_viewed') as
'user_profile_viewed',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%report_viewed') as
'report_viewed',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%blog_entries_viewed') as
'blog_entries_viewed',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%message_viewed') as
'message_viewed',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%notification_viewed') as
'notification_viewed',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%question_viewed') as
'question_viewed',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%discussion_viewed') as
'discussion_viewed',

```

```

(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%message_sent') as 'message_sent',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%notification_sent') as
'notification_sent',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%discussion_created') as
'discussion_created',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%message_contact_added') as
'message_contact_added',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%user_password_updated') as
'user_password_updated',
(SELECT COUNT(userid) FROM
mdl_forum_discussions where userid=user ) as
'mdl_forum_discussions',
(SELECT COUNT(userid) FROM
mdl_chat_messages where userid=user ) as
'mdl_chat_messages',
(SELECT COUNT(userid) FROM
mdl_question_attempt_steps where userid=user ) as
'mdl_question_attempt_steps',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%question_answered') as
'question_answered',
(SELECT COUNT(userid) FROM
mdl_quiz_attempts where userid=user ) as
'mdl_quiz_attempts',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%assignment_submissions') as
'assignment_submissions',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%email_failed') as 'email_failed',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%user_login_failed') as
'user_login_failed',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%webservice_login_failed') as
'webservice_login_failed',

```

```
(SELECT COUNT(userid) FROM
mdl_logstore_standard_log where userid=user ) as
'mdl_logstore_standard_log'
FROM mdl_user ORDER BY `user` ASC
```

Code Snippet 4.0 - The SQL Query executed to prepare research Data set

The SQL query executed in the *PhpMyAdmin* is shown in **Figure 4.1**

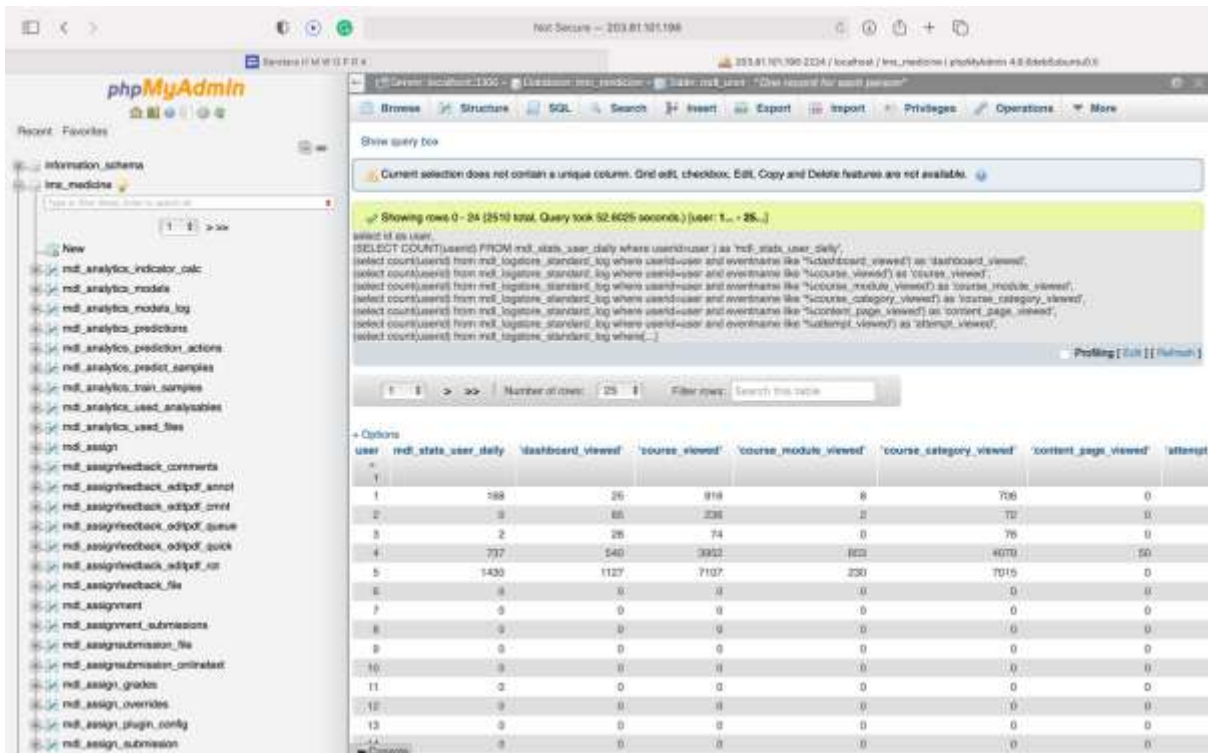


Figure 4.1 - The SQL query executed in the PhpMyAdmin

The researcher developed the dataset by writing SQL queries to the published Moodle database. The developed Dataset is shown in Table 4.0

user #	mdl_stash_urls_videodaily	'dashboards_videowedd'	'coursemodulery_videowedd'	'coursecatalogory_videowedd'	'content_page_videowedd'	'atttempt_videowedd'	'user_profile_videowedd'	'report_videowedd'	'blog_entries_videowedd'	'messages_videowedd'	'notification_videowedd'	'question_videowedd'	'discussion_videowedd'	'messagessession_videowedd'	'discussions_create_videowedd'	'message_content_added_videowedd'	'user_password_updated_videowedd'	mdl_forum_discussions_videowedd'	mdl_quiz_attempts_videowedd'	'question_answer_templates_videowedd'	mdl_quiz_submission_videowedd'	'assignment_submission_videowedd'	'user_login_failed_videowedd'	'webserver_loginfailed_videowedd'	mdl_logstore_standard_log	
42	1633	6197	1236	214	10	41	11	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	25	00	690
189	799	148	622	121	0	11	10	00	00	00	00	14	00	17	00	00	00	00	6	0	10	00	00	10	00	368
202	14	916	19	2	0	00	00	00	00	00	00	00	00	00	00	00	10	00	00	00	00	00	00	90	00	68
203	46	189	345	4	0	14	10	00	00	00	00	00	00	00	00	00	10	00	00	30	0	10	00	20	00	158
204	129	1001	143	6	0	14	10	00	00	00	00	30	00	00	00	00	10	00	00	45	0	10	00	70	00	402
205	70	352	693	4	0	14	00	00	00	00	00	00	00	00	00	00	10	00	00	45	0	10	00	36	00	311
206	145	1054	129	16	0	15	10	00	00	00	00	00	00	00	00	00	10	00	00	45	0	10	00	80	00	577
207	188	4148	2498	82	0	36	00	00	00	20	00	00	20	00	00	00	10	00	00	45	0	10	00	19	00	858
208	61	4604	1147	2	0	00	20	00	00	00	00	00	10	00	00	00	10	00	00	00	00	00	00	90	00	371
209	264	16935	4934	85	14	16	14	00	00	10	00	61	11	00	10	20	00	00	30	0	10	00	21	14	00	1684
210	187	1283	2827	357	12	68	20	00	00	00	00	00	10	00	00	00	20	00	90	0	20	00	00	62	00	1070
211	71	114	815	17	0	20	00	00	00	10	00	00	00	00	00	00	10	00	46	0	10	00	00	10	00	299

**Table 4.0 - The developed Dataset by executing SQL query, the full data set –
Appendixes**

4.6 Output

By using data mining algorithms, the hypotheses have been tested that students' study behaviour and study pattern in the learning management system (LMS) and finally a decision support system has been developed.

4.7 Stakeholders of the solution

The stakeholders of the solution are system developers of the Learning Management System, academics, decision makers, mentors and finally students.

4.8 Features of the solution

The Features of the solutions are user friendly, with learnability and security

4.9 Summary

In this chapter, the approach of the research i.e., how to adopt the technology to solve the research problem has been discussed. The analysis and design of the solution will be discussed in the next chapter.

Analysis and design of the solution- Implementation

5.1 Introduction

In this chapter, the approach to develop the solution by using data mining technology has been described. The overview of the overall architecture of the proposed solution and the Analysis and Design Implementation of the proposed Solution is examined in this chapter.

5.2 Top Level Architecture Design (System Design) of the solution

The purpose of this section is to describe the overall architecture of the research and the proposed solution. The development of the dataset and RapidMiner analytic engine have processed and given the output for students' study behaviour and the students' study patterns of the LMS. The overall overview of top-level architecture design (system design) of the solution architecture is displayed in Figure 5.0.

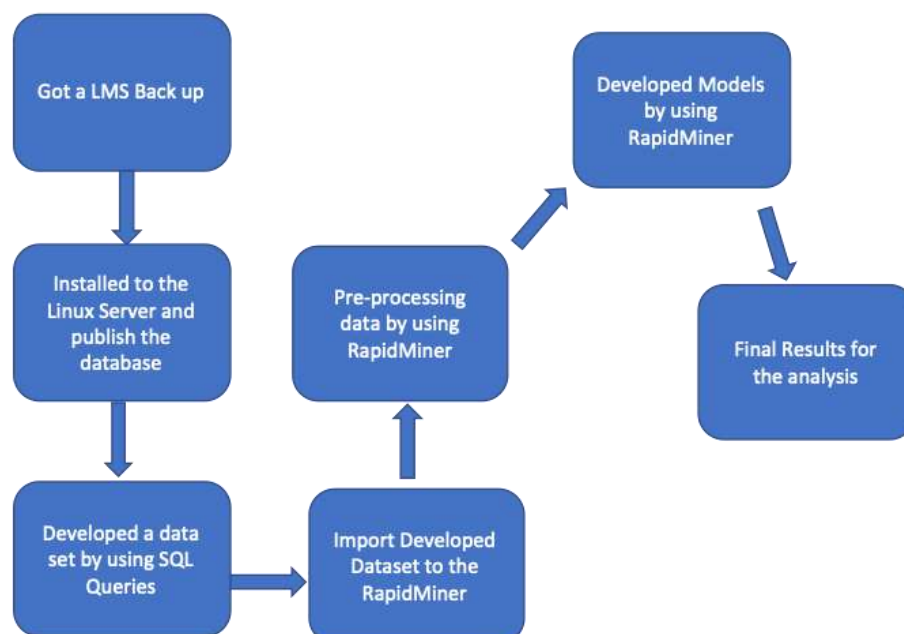


Figure 5.0 - System Design

5.3 Data collection and data pre-processing

5.3.1 Data collection

There were 405 log data tables in the Moodle Learning Management System (LMS). All the log tables have been perused and the following tables have been identified to carry on research of the students' study behaviour and the study patterns of the Learning Management System.

The log tables and the major attribute which was taken for the research and to develop the dataset by writing SQL queries to the published Moodle database is shown in Table 5.0

Data Consider for this research

Activity	Description of the activity view	Relevant log Table
Content Access	resource_viewed	mdl_stats_user_daily
	dashboard viewed	mdl_logstore_standard_log
	course_viewed	mdl_logstore_standard_log
	module_viewed	mdl_logstore_standard_log
	course_category_viewed	mdl_logstore_standard_log
	content_page_viewed	mdl_logstore_standard_log
	attempt_viewed	mdl_logstore_standard_log
	user_profile_viewed	mdl_logstore_standard_log
	report_viewed	mdl_logstore_standard_log
	blog viewed	mdl_logstore_standard_log
	message_viewed	mdl_logstore_standard_log
	notification_viewed	mdl_logstore_standard_log

	question_viewed	mdl_logstore_standard_log
	discussion_viewed	mdl_logstore_standard_log
Engagement	message_sent	mdl_logstore_standard_log
	notification_sent	mdl_logstore_standard_log
	discussion_created	mdl_logstore_standard_log
	message_contact_added	mdl_logstore_standard_log
	user_password_updated	mdl_logstore_standard_log
	forum_discussions	mdl_forum_discussions
	Chat	mdl_chat_messages
Assignment	question_attempt	mdl_question_attempt_steps
	question_answered	mdl_logstore_standard_log
	quiz_attempt	mdl_quiz_attempts
	assignment_submissions	mdl_logstore_standard_log
Errors	email_failed	mdl_logstore_standard_log
	user_login_failed	mdl_logstore_standard_log
	'webservice_login_failed'	mdl_logstore_standard_log
Total Access	total view	mdl_logstore_standard_log

Table 5.0 - The Moodle log tables, used for Data Collection

5.3.2 Pre- Preparation

The RapidMiner support was obtained for the pre- preparation of the data set. The Harvard Business Review publication confirmed that the analytics teams spend 80% of their time preparing data. Once the process outline is set up in the RapidMiner, the following design view appeared, is shown in **Figure 5.1**

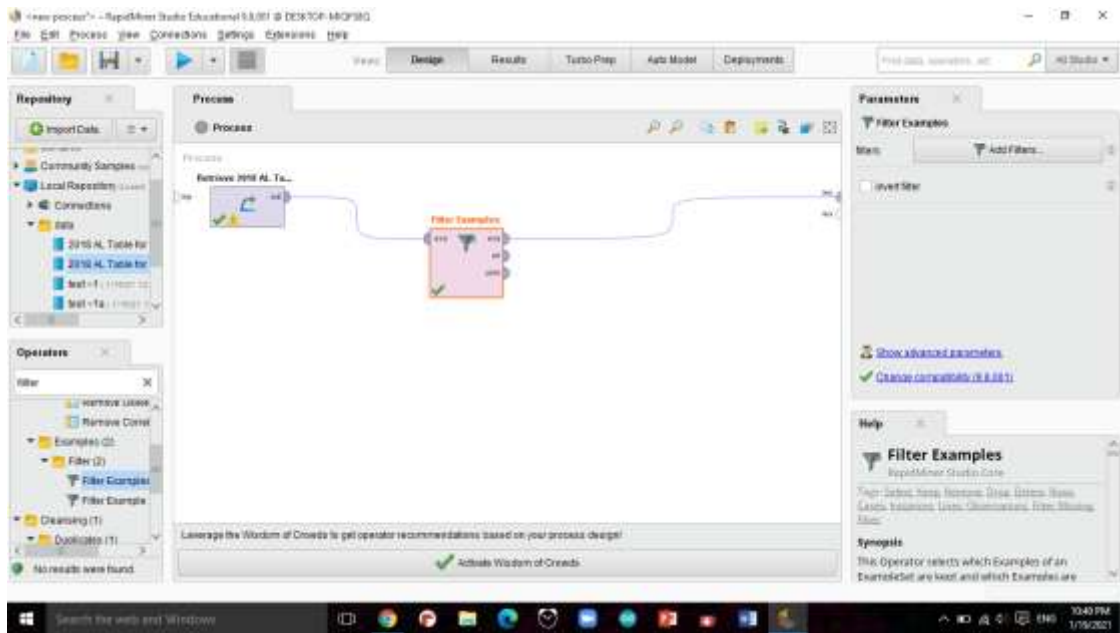


Figure 5.1 - Data cleaning (Pre-Preparation)

5.3.3 Pre-processing

Data pre-processing, a data mining technique, has been deployed for transforming the raw data into an understandable format. The data of the real-world is almost inconsistent, incomplete, and lacking in certain features of behaviours or trends, and it is also likely to contain many errors. This Pre-processing has been affected by several methods viz discretization, building normalisation sampling and correlation determination to solve the problem.

The analysis has developed a dataset by using SQL queries and the created dataset was imported to the sub folders i.e. data folder and process folder of the RapidMiner repository. Once the data set was imported to the RapidMiner it showed all the attributes of the dataset.

Some of the attribute types are not accurate, for example, some of the attribute types should be integer or real whereas it appeared in the data type as polynomial. Initially, these anomalies were corrected. Then the data were stored in the data folder. The RapidMiner calculates and shows the null and missing values based on the attributes. There are two methods to eliminate null values or missing values. The missing value can be removed or deleted from the dataset by using a filter operator. The second method is by replacing missing values operator insert an average value or minimum value or maximum value. In this research the 2nd method has been used to handle the missing values of the attribute. That is by

replacing missing values with inserting average values through operators. Then the data set is not reduced (Figure 5.2).

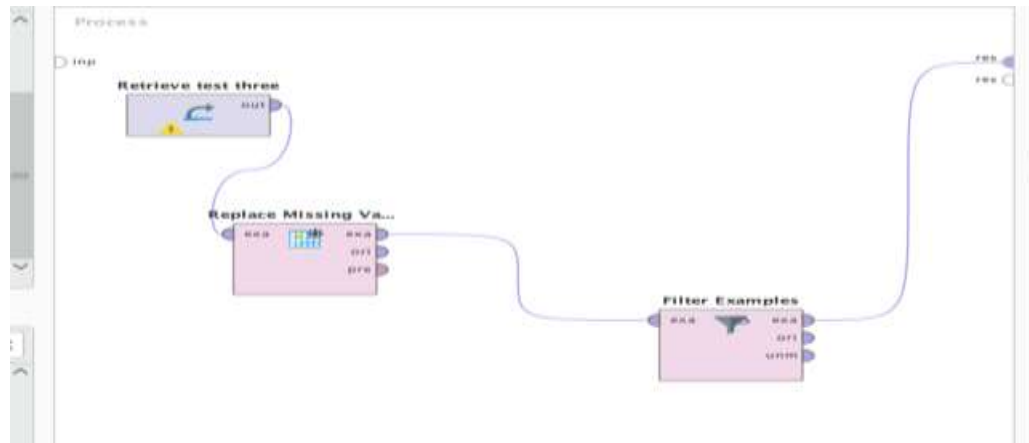


Figure 5.2 - Data cleaning

5.3.4 Eliminate the outliers

The data set retrieved from the repository of the RapidMiner and add delete outlier operator to eliminate the outliers of the data set. There are different types of outlier operators in the RapidMiner data mining engine, such as distance-based outlier detection, density-based outlier detection, local outlier factor and class outlier factor. In this research the distance-based outlier detection operator has been used to identify the outliers of the dataset. In order to filter the outliers, the filter operator has been used, shown in Figure 5.3.

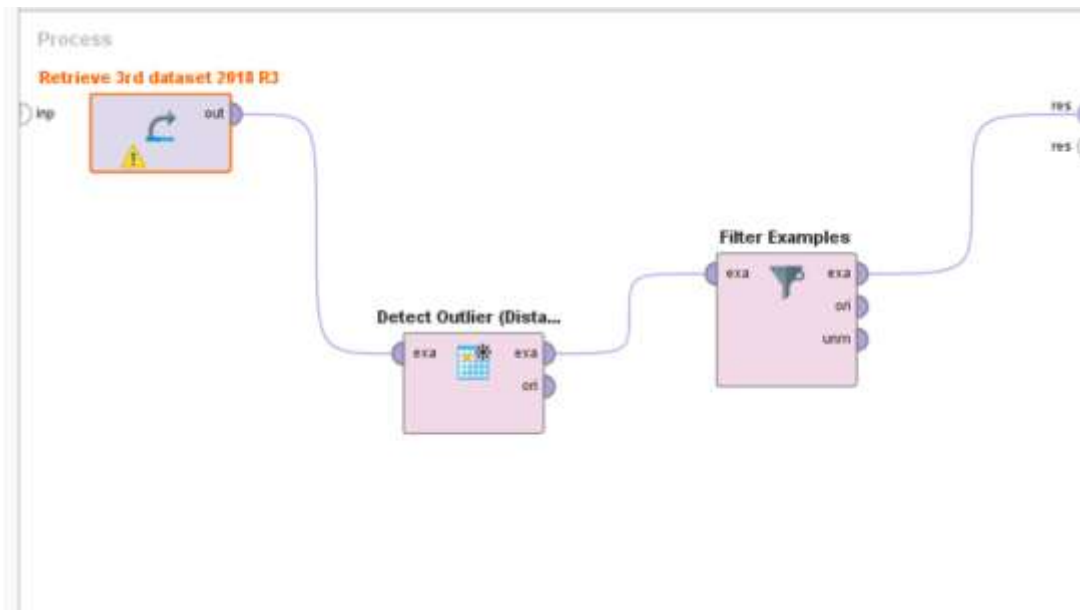


Figure 5.3 - Eliminate outliers values

5.4 User interface model

The main dashboard of the undergraduate Learning Management System (LMS) of the Faculty of Medicine University of Colombo is displayed in Figure 5.4

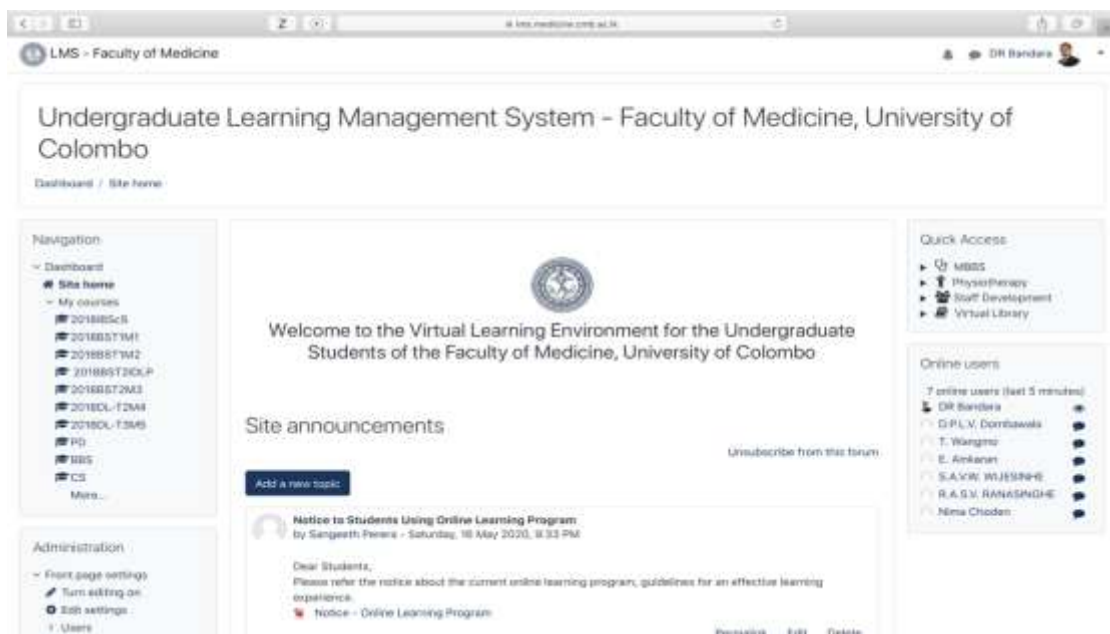


Figure 5.4 - Dashboard of the Learning Management System (LMS)

5.5 Back end Database

Back end database of the Moodle version 3.9 (Learning Management System LMS).The back end data backup collection from the Moodle database of the live Learning Management System (LMS). Thereafter the backup is stored in the different server environment and the said database is published.

5.6 Summary

In this chapter, the design and implementation of the decision support system, i.e. students' study behaviour and students' study patterns of the Learning Management System LMS and how exactly the research is to construct the system in steps were discussed

Data Analysis and Results -*Discussion on Implementation*

6.1 Introduction

The previous chapter considered the design of the proposed solution of the research issue. In this research which aimed to evaluate the students’ study patterns and the student’s behaviour of the Learning Management System, the present chapter will consider as to how the implementation process would work in a detailed manner.

6.2 Overall Implementation of RapidMiner Analytical Engine

In this research, K Mean Clustering algorithm, Correlation Algorithm and Apriori based association rule data mining algorithms have been used for RapidMiner Analytical Engine to examine the students’ behaviour and the students’ study pattern in the Learning Management System (LMS). The Figure 6.0 shows all the views of the attributes in the sample dataset.

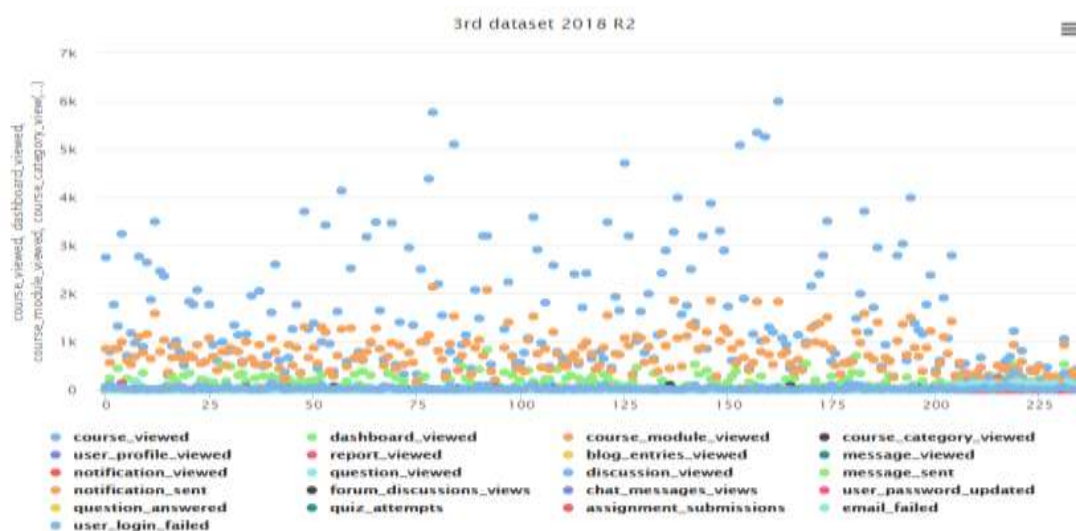


Figure 6.0 – All the views of the attributes in the sample dataset

6.2.1 Clustering algorithm for mining patterns- K Mean Clustering algorithm

In this research K Mean Clustering algorithm is used to mining the data set. The K Mean Clustering algorithm is widely used for data mining. In this algorithm, similar patterns of attributes can be clustered by using a developed dataset. The researcher extracted the dataset from the repository of the RapidMiner analytical engine and added K Mean operator and checked the performance of the Clustering algorithm and added the data to the similarity operator in order to check the similarities of the dataset. Thereafter, the cluster density operator has been added to measure the performance of the model and output from the similarity. Then the output of the data similarities operator has been connected to the cluster density operator and output of the clustering operator was given to the performance operator. Finally, the Clustering algorithm was run to mining the patterns. The Implementation of RapidMiner Analytical Engine for K Mean Clustering algorithm is shown Figure 6.1.

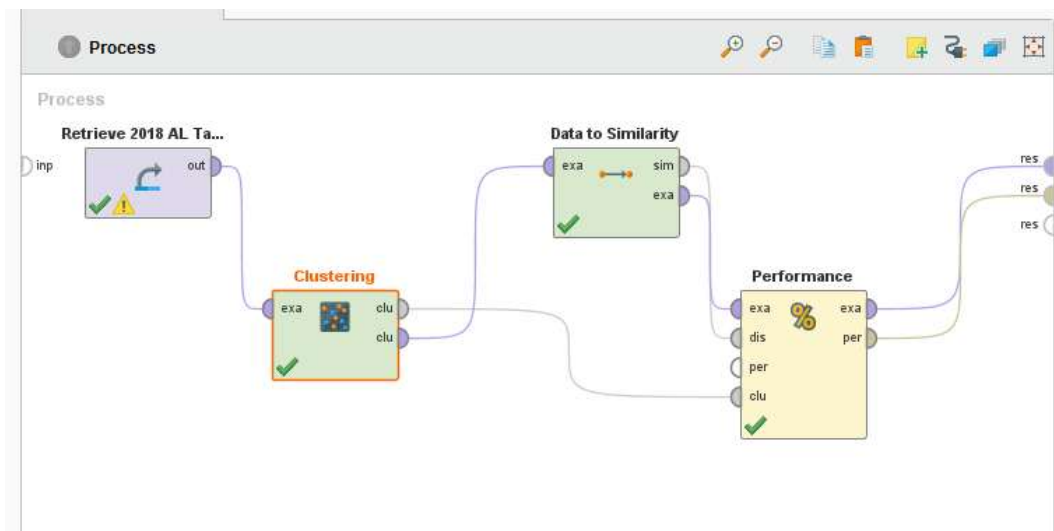


Figure 6.1 - Implementation of RapidMiner Analytical Engine for K Mean Clustering algorithm

6.2.2 Correlation Algorithm for data mining

The correlation algorithm is also used for data mining and to identify the correlation between different attributes. In this algorithm, it is possible to find out the correlation of the attributes by using a developed dataset. It may be a negative correlation, positive correlation with a weak or strong relationship. The researcher extracted the dataset from the repository of the RapidMiner analytical engine and added to the correlation matrix operator. The output of the extract dataset was added to the input of the correlation matrix operator. Finally, for extracting the output of the correlation matrix, the operator was connected to the RapidMiner analytical engine. Then it established the correlation with all the attributes vide Figure 6.2

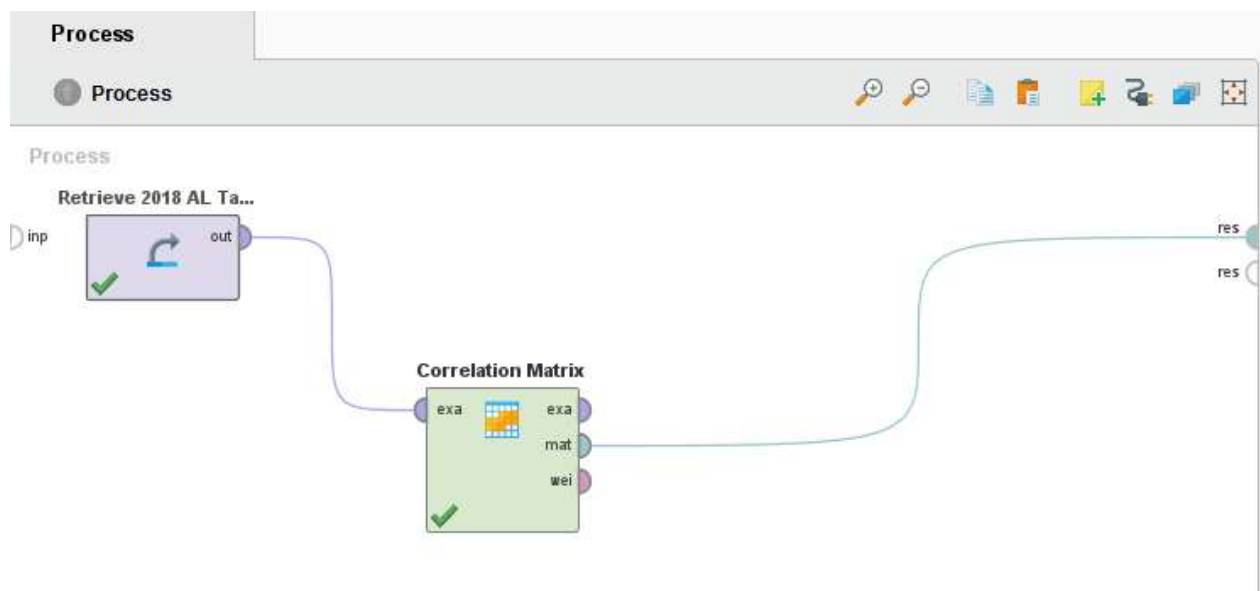


Figure 6.2 Implementation of RapidMiner Analytical Engine for Correlation algorithm

6.2.3 Apriori based association rule mining - Apriori algorithm.

The study also carried out the research on the students' study behaviour and study patterns by using Apriori algorithm. The RapidMiner has been used for data mining. In this algorithm it is possible to find out the association patterns of the attributes and its support and the confidence levels. The researcher imports the dataset from the repository of the RapidMiner

and runs the Apriori algorithm. In order to execute A Priori based association rule mining, Apriori algorithm the FB Growth operator has been added to the design face of the RapidMiner. However, FB growth operator will not work as it needs binomial data. Therefore, discretize operator and normal to binomial operator were added to the design face of the RapidMiner. Then the association rule operator was added to Apriori algorithm vide Figure 6.3.

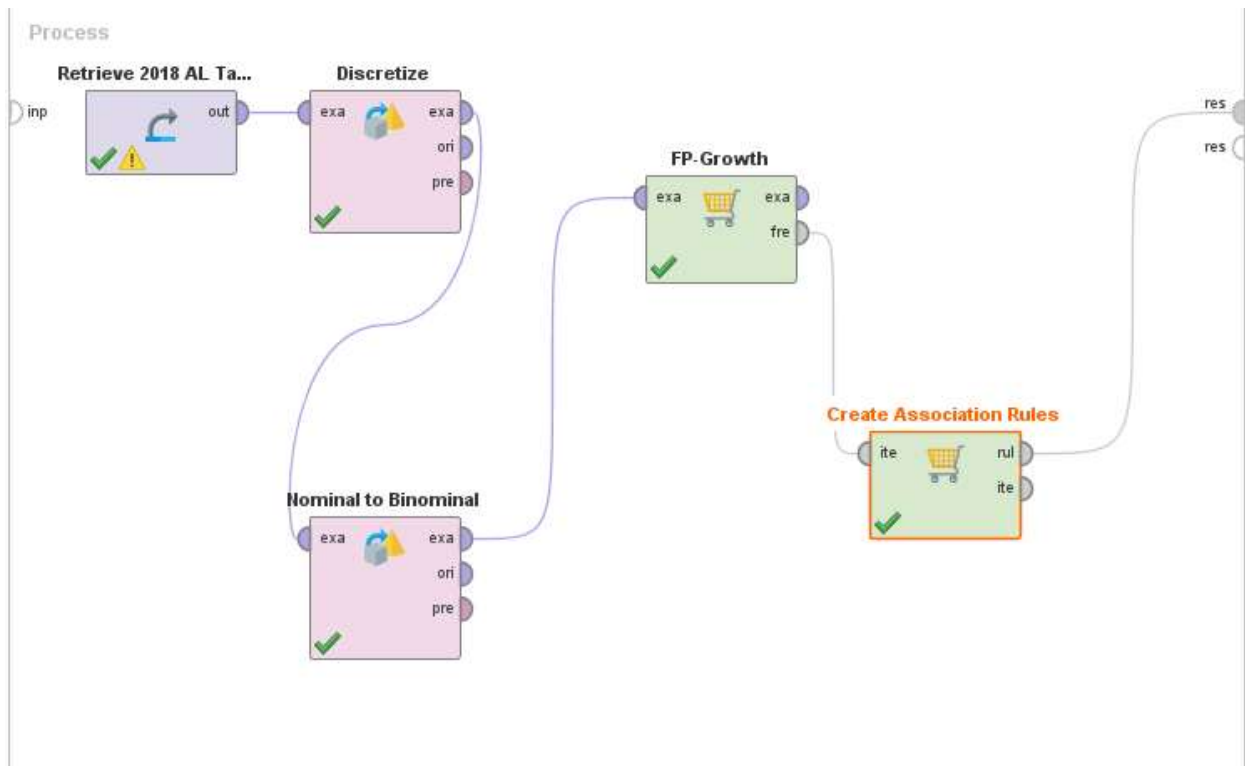


Figure 6.3 - Implementation of RapidMiner Analytical Engine for Apriori based association rule mining - Apriori algorithm

6.3 Summary

In this chapter the overall implementation process of the Decision support system for LMS was discussed. The next chapter explains the evaluation of the proposed solution.

Data Analysis and Results: *Evaluation of new system*

7.1 Introduction

The previous chapter presented the implementation process developed in a detailed manner and this chapter evaluates students' study behaviour and the study pattern of Learning Management System (LMS) and tests the above used strategies within the known parameters to evaluate the accuracy of the findings.

7.2 Evaluation of Data mining and Classification techniques

In this research, the data mining algorithms are used to explore the student's study patterns and the study behaviour of the Learning Management System (LMS) by examining the data set which was developed from the 2018 AL MBBS (Bachelor of Medicine, Bachelor of Surgery) undergraduate batch of the Faculty of Medicine, University of Colombo.

In this research study, K Mean Clustering algorithm, Correlation Algorithm and Apriori based association rule mining algorithm, have been used to examine the students' study behavior and study patterns of the Learning Management System (LMS).

In the study, the K Mean Clustering algorithm is used to mining the data set and this algorithm has the ability to cluster similar patterns of attributes by using the developed dataset. The correlation algorithm is used for data mining and the correlation algorithm can identify the correlation between different attributes. The correlation may be negative or positive correlation with a weak or strong relationship. Apriori Algorithm is also a data mining rule that discovers the probability of the co-occurrence of the items in the data set. Apriori algorithm identified the support, confidence, lift and conviction of the dataset and by using Apriori Algorithm association rules, frequent patterns have been identified.

7.3 Evaluation of the solution

The backup database was taken from the live Moodle Learning Management System and uploaded to the local server and published it. There were 405 number of log tables and all of

the log tables were perused for the selection of required log tables to carry on the research. The SQL queries have been executed to develop the proposed dataset.

The developed dataset was uploaded to the RapidMiner Analytical Engine for Data mining. The Pre- Preparation, Pre-processing and by using delete outlier's operator replaced missing values before implementing the algorithms. The study has used the K Mean Clustering algorithm, Correlation Algorithm and Apriori based association rule mining Algorithm to examine the students' study behaviour and study patterns of the Learning Management System (LMS) from the developed dataset.

7.3.1 K Mean Clustering algorithm for mining patterns

Five clustering patterns were identified as the outcome of the implementation of RapidMiner Analytical Engine for K Mean Clustering algorithm as shown in Graph 7.0, Graph 7.1, and Table 7.1 and Figure 7.0 with the densities of the clusters.

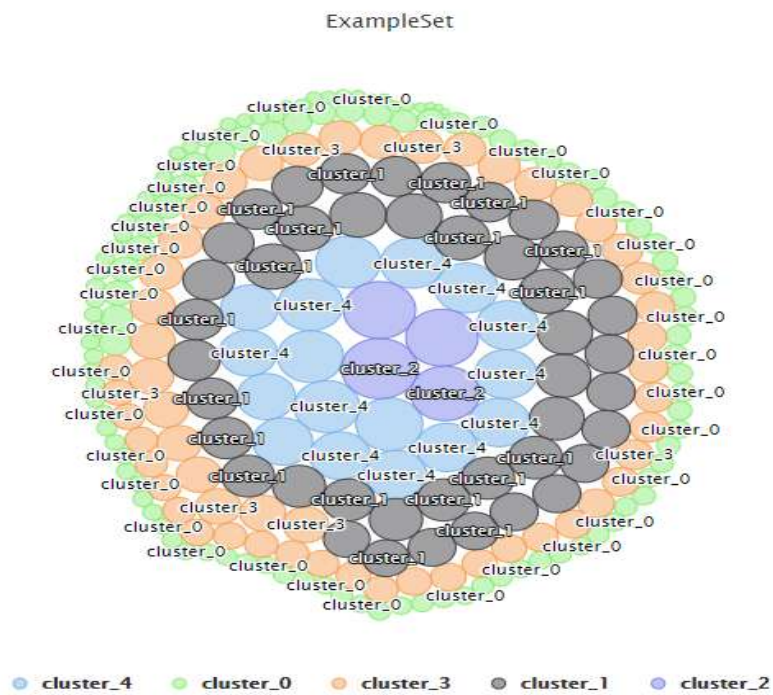
The K Mean Clustering algorithm identified five clusters. The average within the cluster distance was 150280.45 and the cluster average within the cluster distance of the 0, 1, 2, 3, 4 clusters were 193645.20, 102220.60, 10850.32, 136193.22, 47567.26 respectively. The respective cluster densities were 118, 43, 4, 53, 17 , as shown in Table 7.0

The Cluster 0 has 118 number of students views and it is 50% of the sample population but the cluster average views are very low, at 2782. The Cluster 3 has 53 numbers of students' views and it is 23% of the sample population and the cluster average is almost the average of the total sample which is 8985. The Cluster-1 has 43 number of students' views and it is 18% of the total sample population and the cluster average is higher than the total sample average which is 15817. The Cluster-4 have 17 number of students' views and it is 7% of the sample population but their cluster average is reasonably higher than the total sample average of 23101. Finally, the Cluster-2 has only 4 numbers of students' views, and it is 2% of the sample population but this cluster average views are very high at 31319.

Based on the above results it is revealed that the students' Content Access, Engagement and the Assignments (Table 4) distribution among and in between the identified five clusters are not equal.

Cluster	Avg. within cluster distance	Cluster density	%	average views
Cluster 0	193645	118	50%	2782
Cluster 3	136193	53	23%	8985
Cluster 1	102221	43	18%	15817
Cluster 4	47567	17	7%	23101
Cluster 2	10850	4	2%	31319
Total	50280	235	100%	8536

Table 7.0 - K Mean Clustering algorithm for mining patterns, cluster summary



Graph 7.0 - K Mean clustering algorithm and clustering pattern

2 2 3	clu ste r_ 0	3 6	4 3	5 0	8 0	0 0	0 0	5 0	0 0	0 0	0 0	0 0	0 0	1 5	0 0	7 2	0 0	0 0	1 0	0 0	0 0	0 0	0 0	0 0	5 6	6 6	4 4 0	
9 5	clu ste r_ 0	1 2 0	4 1	2 1 3	1 8 8	4 3	2 3	1 2	2	1	0	0	0	0	0	0	0	0	2	0	0	8 9	0	4	0	0	1 8	7 1 7
2 3 1	clu ste r_ 0	1 1 2	3 1	9 7	2 5 0	5 2	0	3	0	0	0	0	0	3 6	0	8 2	0	0	1	0	0	0	0	0	0	5 7	5 8	9 3 9
1 9 1	clu ste r_ 0	1 0 6	4 8	2 9 3	2 6 3	0	2 3 2	0	0	0	0	0	0	7	0	0	0	0	1	0	0	4 1 4	0	1 4	0	0	1 3	1 0 5 1

Table 7.1 - Clustering patterns
(for the full details of this table, please the refer Appendixes -A)

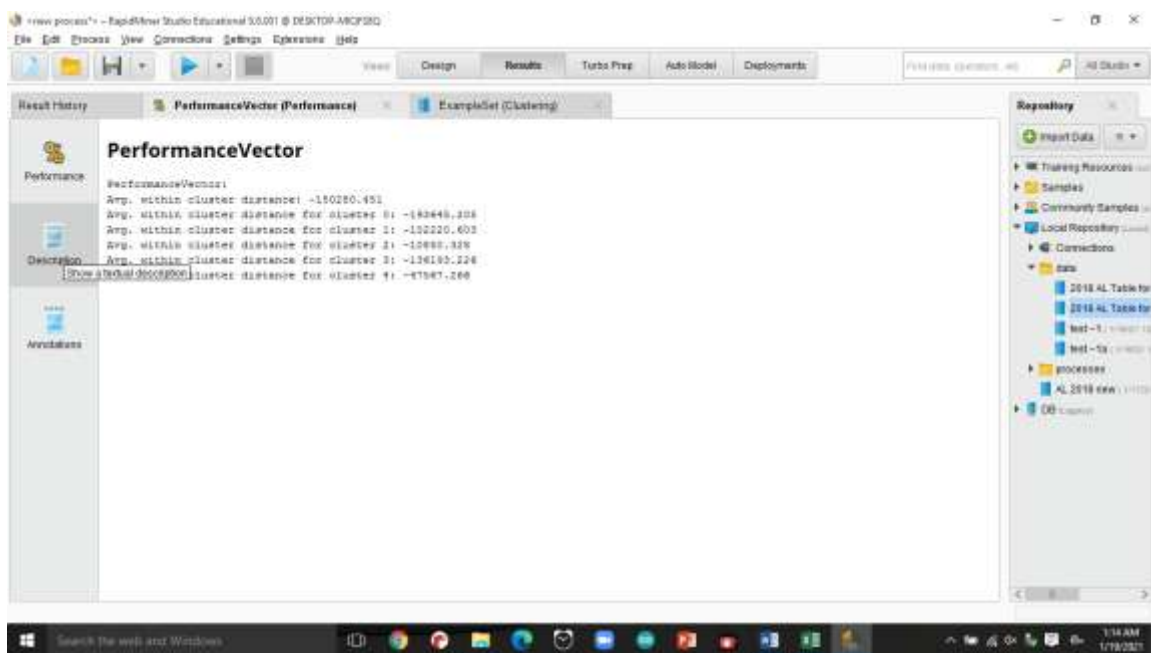


Figure 7.0 Cluster distance patterns and cluster density

Using the K Mean Clustering algorithm, the five clustering patterns were identified as the outcome of the implementation of RapidMiner Analytical Engine. The average within the

cluster distance is 150280.45 and the cluster average within the cluster distance of the 0, 1, 2, 3, 4 clusters are 193645.20, 102220.60, 10850.32, 136193.22, 47567.26 respectively. The respective cluster densities are 118, 43, 4, 53, 17 respectively. The Cluster 0 has 118 number of students' views and it is 50% of the sample, however, the cluster average views are very low, at 2782. The Cluster 3 has 53 numbers of students' views and it is 23% of the sample and the cluster average is almost the average of the total sample which is 8985. The Cluster-1 has 43 number of students' views and it is 18% of the total sample and the cluster average is higher than the total sample average of 15817. The Cluster-4 have 17 numbers of students' views and it is 7% of the sample but their cluster average is reasonably higher than the total sample average of 23101. Finally, the Cluster-2 has only 4 numbers of students' views, and it is 2% of the sample however, this cluster average views are very high at 31319.

Based on the above results, it is revealed that the attributes under the category of Content Access, Engagement, Assignments Error distribution among and in between, the identified five clusters are not equal. This demonstrates that students' study behaviour and the study patterns of the Learning Management System (LMS) are not distributed in an equal manner and students have to satisfy without obtaining full potentials of the LMS.

This research outcome revealed by the Data Mining from the K Mean Clustering algorithm by using RapidMiner Analytical Engine, that the current study patterns and the study behaviours of the online studies are acting as a limitation that keeps the online option at a suboptimal level. Results also revealed that the students do not show a strong study behaviour and favourable study patterns in the use of the Learning Management System (LMS). Further the students' view of the Content Access, Engagement and the Assignments among and in-between the identified five clusters are not found equal.

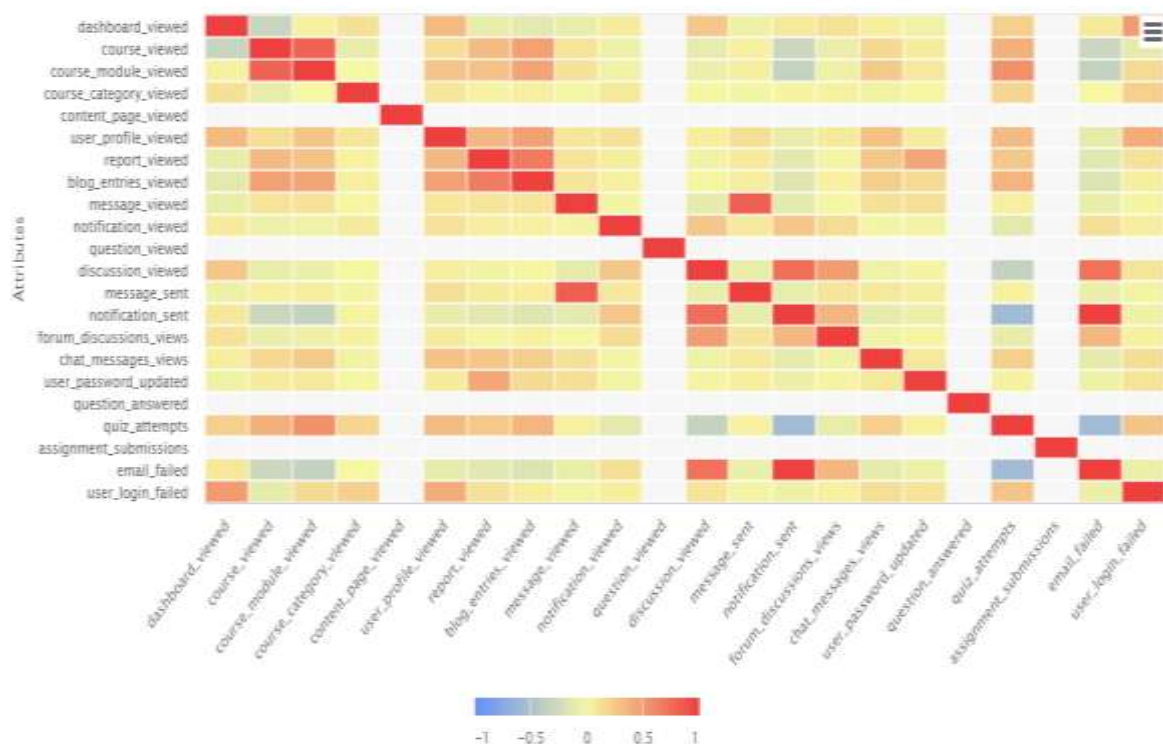
7.3.2 Correlation Algorithm for data mining- Correlation Matrix

The correlation algorithm has also been used in this study for data mining and it identified the correlation between different attributes. The relationship may be a negative, positive correlation with weak or strong character.

In the data mining, by using Correlation Algorithm, following positive correlation, negative correlation and no correlation were identified. Most of the positive correlations are with very

high values which shows a very strong correlation, some attributes show strong negative correlation relationships vide, Graph 7.2 and Table 7.6.

Graph-7.2 shows the correlation of attributes with colour gradient on the heatmap chart, where it is indicated in red-yellow-white-blue. The correlation of the attribute shows in the said colour boxes. The dark red boxes show the strong positive correlated attributes, and it is closer to one or one. The light blue boxes show the strong negative correlated attributes. The yellow indicates the weak correlated attributes, and the white boxes shows attributes which do not have any correlations.



Graph 7.2 - Attribute Correlation pattern

Table 7.2 shows the correlations of the attributes whether it is positive or negative correlation or weak correlations or no correlations. . In Table 7.2, all the attributes have positive correlations. The attributes in between notification, notification sent vs email failed, message viewed s message sent, courseviewed vs course module viewed, discussion viewed vs notification sent and discussion viewed vs email failed indicate a very strong positive correlations with values of 0.986, 0.829, 0.801, 0.742, 0.722 respectively.

Table 7.2, shows a very important correlation in the Engagement and Errors attributes viz. the attributes in row numbers 1,4,5, and 6. All the attributes have very high correlation, which is interesting and very important as this can be very useful for developers to consider

in their next version release. The outcome 4 and 6 will be very important when the academics and students deliver their discussion, notification and reports via LMS.

#	First Attribute	Second Attribute	Correlation
1	notification_sent	email_failed	0.986
2	message_viewed	message_sent	0.829
3	course_viewed	course_module_viewed	0.801
4	discussion_viewed	notification_sent	0.742
5	discussion_viewed	email_failed	0.722
6	report_viewed	blog_entries_viewed	0.671
7	course_module_viewed	quiz_attempts	0.559
8	dashboard_viewed	user_login_failed	0.5
9	discussion_viewed	forum_discussions_views	0.494

Table 7.2 - Correlations algorithm for mining patterns, positive correlated attributes

In Table 7.3, all the attributes have negative correlations. The attributes in between notification_sent Vs quiz_attempts Vs email_failed have very strong negative correlations with values of -0.578, -0.580 respectively and these fall under Access, Engagement and Errors attributes (Table 5.0). The attributes in the row number 7, and 8 show very high correlation, which is interesting and very important, and would be useful for developers to consider for their next version release. This outcome will also be useful to the academics and students when they attempt the quiz via LMS.

#	First Attribute	Second Attribute	Correlation
1	course_viewed	email_failed	-0.305
2	course_viewed	notification_sent	-0.306
3	dashboard_viewed	course_viewed	-0.324
4	course_module_viewed	notification_sent	-0.35
5	discussion_viewed	quiz_attempts	-0.35
6	course_module_viewed	email_failed	-0.351
7	notification_sent	quiz_attempts	-0.578
8	quiz_attempts	email_failed	-0.58

Table 7.3 - Correlations algorithm for mining patterns, negative correlated attributes

Table 7.4, all the attributes have weak positive correlations and weak negative correlations. The result shows that the student's study pattern and the student behavior of the Content Access (Table 5.0) attributes, such as message viewed, discussion viewed, notification viewed, and forum discussion views have very low correlation with other attributes. Engagement (Table 5.0) attributes such as message sent, and notification sent also have very low correlation with other attributes. This demonstrates that students' study behaviour and the study patterns of the Learning Management System (LMS) in Content Access and Engagement are very weak.

#	First Attribute	Second Attribute	Correlation
1	forum_discussions_views	user_password_updated	0.014
2	course_category_viewed	notification_sent	0.012
3	course_category_viewed	user_password_updated	0.007
4	blog_entries_viewed	discussion_viewed	0.007
5	course_category_viewed	discussion_viewed	0.006
6	message_viewed	forum_discussions_views	0.005
7	course_module_viewed	course_category_viewed	0.002
8	course_category_viewed	email_failed	0.001
9	course_category_viewed	message_viewed	-0.006
10	message_viewed	notification_viewed	-0.011
11	course_category_viewed	message_sent	-0.011
12	message_viewed	user_login_failed	-0.013
13	report_viewed	forum_discussions_views	-0.015
14	discussion_viewed	user_password_updated	-0.016

Table 7.4 - Correlations algorithm for mining patterns, weak positive and weak negative correlated attributes

Table 7.5, shows that all the attributes show no correlations; Similarly Content Access (Table 5.0) attributes, such as question viewed, discussion viewed and also Assignment (Table 5.0) attributes, such as assignment submissions and question answered do not have

any correlation with other attributes. This demonstrates that students' study behaviour and the study patterns of the Learning Management System (LMS) in Content Access and Engagement are very weak.

The meaning of this finding is that students do not realise the full potential of the LMS. This pattern and behaviour confirm that students had not attempted or undertaken any questions or examinations via LMS mode. This aspect could be improved by making arrangements to utilize the potential through enhancements of LMS which would give more opportunity to the students. The existing platform attributes of chart, messages, forum discussions and discussion have no correlations with other attributes demonstrating the use of LMS is at a suboptimal level. There is a possibility to integrate into social media like WhatsApp, viber, etc in a very user-friendly manner and effect enhancements to the LMS.

First Attribute	Second Attribute	Correlation
dashboard_viewed	question_viewed	NaN
dashboard_viewed	question_answered	NaN
dashboard_viewed	assignment_submissions	NaN
course_viewed	question_viewed	NaN
course_viewed	question_answered	NaN
course_viewed	assignment_submissions	NaN
course_module_viewed	question_viewed	NaN
course_module_viewed	question_answered	NaN
course_module_viewed	assignment_submissions	NaN
course_category_viewed	question_viewed	NaN
course_category_viewed	question_answered	NaN
course_category_viewed	assignment_submissions	NaN
user_profile_viewed	question_viewed	NaN
user_profile_viewed	question_answered	NaN
user_profile_viewed	assignment_submissions	NaN
report_viewed	question_viewed	NaN
report_viewed	question_answered	NaN
report_viewed	assignment_submissions	NaN
blog_entries_viewed	question_viewed	NaN
blog_entries_viewed	question_answered	NaN
blog_entries_viewed	assignment_submissions	NaN
message_viewed	question_viewed	NaN
message_viewed	question_answered	NaN
message_viewed	assignment_submissions	NaN
notification_viewed	question_viewed	NaN
notification_viewed	question_answered	NaN
notification_viewed	assignment_submissions	NaN
question_viewed	discussion_viewed	NaN
question_viewed	message_sent	NaN
question_viewed	notification_sent	NaN

question_viewed	forum_discussions_views	NaN
question_viewed	chat_messages_views	NaN
question_viewed	user_password_updated	NaN
question_viewed	question_answered	NaN
question_viewed	quiz_attempts	NaN
question_viewed	assignment_submissions	NaN
question_viewed	email_failed	NaN
question_viewed	user_login_failed	NaN
discussion_viewed	question_answered	NaN
discussion_viewed	assignment_submissions	NaN
message_sent	question_answered	NaN
message_sent	assignment_submissions	NaN
notification_sent	question_answered	NaN
notification_sent	assignment_submissions	NaN
forum_discussions_views	question_answered	NaN
forum_discussions_views	assignment_submissions	NaN
chat_messages_views	question_answered	NaN
chat_messages_views	assignment_submissions	NaN
user_password_updated	question_answered	NaN
user_password_updated	assignment_submissions	NaN
question_answered	quiz_attempts	NaN
question_answered	assignment_submissions	NaN
question_answered	email_failed	NaN
question_answered	user_login_failed	NaN
quiz_attempts	assignment_submissions	NaN
assignment_submissions	email_failed	NaN

Table 7.5 - Correlations algorithm for mining patterns, no correlated attributes

The following Table 7.6 shows the attribute Correlations patterns

Attributes	mdl_stats_user_daily	'dashboard_viewed'	'course_viewed'	'course_module_viewed'	'course_category_viewed'	'attempt_viewed'	'user_profile_viewed'	'report_viewed'	'blog_entries_viewed'	'message_viewed'	'notification_viewed'	'question_viewed'	'discussion_viewed'	'message_sent'	'notification_sent'	'discussion_created'	'message_contact_added'
mdl_stats_user_daily	1.00	0.64	0.22	0.48	0.18	0.46	0.37	0.18	0.22	0.02	0.06	NaN	0.22	0.03	0.05	0.07	0.10
'dashboard_viewed'	0.64	1.00	0.32	0.03	0.12	0.23	0.33	0.10	0.13	0.09	0.06	NaN	0.26	0.06	0.08	0.09	0.00
'course_viewed'	0.22	0.32	1.00	0.80	0.10	0.40	0.14	0.32	0.46	0.10	0.06	NaN	0.10	0.04	0.31	0.12	0.06
'course_module_viewed'	0.48	0.03	0.80	1.00	0.00	0.57	0.27	0.28	0.45	0.11	0.05	NaN	0.07	0.04	0.35	0.12	0.11
'course_category_viewed'	0.18	0.12	0.10	0.00	1.00	0.17	0.09	0.02	0.04	0.01	0.07	NaN	0.01	0.01	0.01	0.01	0.01
'attempt_viewed'	0.46	0.23	0.40	0.57	0.17	1.00	0.32	0.26	0.37	0.03	0.12	NaN	0.30	0.02	0.52	0.17	0.05
'user_profile_viewed'	0.37	0.33	0.14	0.27	0.09	0.32	1.00	0.34	0.46	0.09	0.11	NaN	0.05	0.13	0.09	0.03	0.18
'report_viewed'	0.18	0.10	0.32	0.28	0.02	0.26	0.34	1.00	0.67	0.10	0.04	NaN	0.04	0.06	0.14	0.04	0.15
'blog_entries_viewed'	0.22	0.13	0.46	0.45	0.04	0.37	0.46	0.67	1.00	0.10	0.03	NaN	0.01	0.05	0.17	0.01	0.09
'message_viewed'	0.02	0.09	0.10	0.11	0.01	0.03	0.09	0.10	0.10	1.00	0.01	NaN	0.11	0.83	0.13	0.02	0.20
'notification_viewed'	0.06	0.06	0.06	0.05	0.07	0.12	0.11	0.04	0.03	0.01	1.00	NaN	0.26	0.07	0.26	0.10	0.29
'question_viewed'	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	1.00	NaN	NaN	NaN	NaN	NaN
'discussion_viewed'	0.22	0.26	0.10	0.07	0.01	0.30	0.05	0.04	0.01	0.11	0.26	NaN	1.00	0.09	0.74	0.46	0.05

'message_sent'	-0.03	-0.06	0.04	0.04	-0.01	0.02	0.13	0.06	0.05	0.83	0.07	NaN	-0.09	1.00	-0.10	0.05	0.21
'notification_sent'	0.05	0.08	-0.31	-0.35	0.01	-0.52	-0.09	-0.14	-0.17	-0.13	0.26	NaN	0.74	-0.10	1.00	0.38	0.02
'discussion_created'	0.07	0.09	-0.12	-0.12	0.01	-0.17	0.03	-0.04	-0.01	-0.02	0.10	NaN	0.46	0.05	0.38	1.00	0.01
'message_contact_added'	0.10	0.00	0.06	0.11	0.01	0.05	0.18	0.15	0.09	0.20	0.29	NaN	0.05	0.21	0.02	0.01	1.00
'user_password_updated'	-0.01	-0.05	0.06	0.07	0.01	0.03	0.05	0.43	0.15	0.12	-0.03	NaN	-0.02	0.04	-0.07	-0.01	0.09
mdl_forum_discussions	0.12	0.11	-0.08	-0.05	0.02	-0.11	0.07	-0.02	0.03	0.00	0.14	NaN	0.49	0.10	0.35	0.92	0.02
mdl_chat_messages	0.21	0.05	0.17	0.24	-0.04	0.18	0.28	0.26	0.22	0.12	-0.02	NaN	-0.05	0.08	-0.11	-0.05	0.37
mdl_question_attempt_steps	0.47	0.26	0.34	0.52	0.20	0.92	0.32	0.22	0.32	0.03	-0.12	NaN	0.31	0.03	-0.53	-0.14	0.06
'question_answered'	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
mdl_quiz_attempts	0.44	0.22	0.38	0.56	0.18	0.93	0.32	0.25	0.36	0.04	-0.13	NaN	0.35	0.03	0.58	0.17	0.05
'assignment_submissions'	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN
'email_failed'	-0.06	0.07	-0.30	-0.35	0.00	-0.53	-0.11	-0.15	-0.18	-0.09	0.13	NaN	0.72	-0.07	0.99	0.39	-0.02
'user_login_failed'	0.42	0.50	-0.11	0.15	0.21	0.27	0.40	0.11	0.04	-0.01	0.05	NaN	0.09	-0.03	-0.05	-0.02	0.06
mdl_logstore_standard_log	0.18	-0.39	0.96	0.81	-0.11	0.42	0.15	0.38	0.55	0.12	0.05	NaN	-0.12	0.06	0.31	0.12	0.09

Table 7.6 - Correlations algorithm for mining patterns

The outcome of the correlation algorithm revealed whether the correlations of the attributes positive or negative or weak or no correlations.. Some of the attributes have positive correlations viz notifications sent vs email failed, message viewed vs message sent, course viewed course module viewed, discussion viewed vs notification sent and discussion viewed vs email failed, and these are very strong positive correlations with more than 0.7 value. A very high correlation is observed in the category of Engagement and Errors attributes, too, viz notification sent vs quiz attempts, quiz attempts vs email failed. A very strong negative correlations with values of more than -0.6 are found under category attributes of Access, Engagement and Errors attributes. Also, some attributes have weak positive correlations and weak negative correlations. It is further revealed that the student's study pattern and the student behavior of the Content Access attributes such as message viewed, discussion viewed, notification viewed, and forum discussion views, have very low correlation with other attributes. Engagement attributes such as message sent, and notification sent also have very low correlation with other attributes. This demonstrates that students' study behavior and the study patterns of the Learning Management System (LMS) in Content Access and Engagement are very weak.

The outcome of the correlation algorithm revealed that some attributes in the category of Content Access such as question viewed, discussion viewed do not show any correlations. Assignment attributes such as assignment submissions and question answered also show no correlation with other attributes. This demonstrates that students' study behavior and the

study patterns of the Learning Management System (LMS) in Content Access and Engagement are very weak.

The meaning of the above finding is that students of the faculty have not obtained full potential of the LMS. This pattern and behaviour supported the view that the students have not attempted any questions or examinations via LMS mode. This situation reveals the potential yet left that can be utilized and enhanced to give more opportunity to the students. The existing platform attributes of chat, messages, forum discussions and discussion are not correlated with other attributes showing that the LMS delivers at a sub-optimal level. It is evident that LMS can be integrated to social media like WhatsApp, viber, etc. in a very user-friendly manner and that would amount to enhancement of the LMS. These final results and findings are beneficial in early detection of students' study patterns and the behaviour of the students who are experiencing difficulties in studies. Both Academics and the students benefit from these research outcomes.

7.3.3 Apriori based association rule mining - Apriori algorithm

In this research, Apriori based association rule mining, Apriori algorithm, has been used to examine students' study behaviour and study patterns by using RapidMiner analytical Engine. In this algorithm it is possible to find the association patterns and the rules of the attributes and their support and confidence levels.

These association patterns have been examined by data mining of the existing students' study and behaviour patterns by analysing the back end data.

In the Apriori based association rule mining, the support refers to the frequency of occurrence of the rule. The confidence is a conditional probability of the association rule. The Lift is a measure of the performance of the association rule. The Lift of one (1) means there is no association premises-attributes and conclusion-attributes. The Lift of greater than one (1) means premises-attributes and conclusion attributes are more likely to go together. A high conviction value means that the consequent is highly depending on the antecedent. Figure. 7 shows that there are 94 association rules that can be discovered at the minimum confidence level of 0.8 and the minimum support 0.95.

Figure 7.7, shows that there are some similar rules, the rules with the same attributes in premises and conclusion but interchanged, such as rule number 16 and 63 and rule number 33

with 34. In this research outcome, there are uninteresting rules that can be found because of the generalization of relationships, e.g. rule numbers 16 and 33. There are rules that display the relevant information like those shows expected or conforming relationships, e.g. the rules number 34

No	Premises	Conclusion	Support	Confidence	LaPlac e	Gain	P-s	Lift	Conviction
16	message_viewed	message_sent	0.255	0.833	0.961	-0.357	0.124	1.939	3.421
63	message_sent	message_viewed	0.328	0.895	0.972	-0.404	0.181	2.238	5.733
33	course_module_viewed	course_viewed	0.426	0.847	0.949	-0.579	0.173	1.688	3.264
34	course_viewed	course_module_viewed	0.426	0.847	0.949	-0.579	0.173	1.688	3.264

Table 7.7 - Apriori based association rule mining, Apriori algorithm, same attributes in premises and conclusion but interchanged.

Figure 7.8 shows that there are unexpected rules, which shows very interesting relationships such as 93, 94, 92, 89, 87, 85, 83, 81, 82, 80, 79 and 78. All these rules fall under Content Access attributes (Table-5.0). All these rules show higher value of confidence while all the confident values are more than 0.93. All the lift values are more than one with more than 1.85 of Conviction and with more than 0.2 of support value. All these premises attributes and conclusion attributes have higher association which can be very useful for developers of LMS for their next version release as well as for academics when they develop their LMS course modules.

Association's rules under the Content Access (Table 5.0) only the attributes of course viewed, blog entries viewed, discussion viewed, course module viewed, report viewed, user profile viewed demonstrated associations.

No	Premises	Conclusion	Support	Confidence	Lift	Gain	P-s	Lift	Conviction
93	course_viewed, blog_entries_viewed, discussion_viewed	course_module_viewed	0.204	1	1	-0.204	0.102	1.992	Infinity
94	course_viewed, discussion_viewed, report_viewed	course_module_viewed	0.2	1	1	-0.2	0.1	1.992	Infinity
92	course_viewed, discussion_viewed	course_module_viewed	0.268	0.984	0.997	-0.277	0.131	1.96	31.864
89	course_module_viewed, user_profile_viewed, blog_entries_viewed, report_viewed	course_viewed	0.204	0.98	0.996	-0.213	0.1	1.951	24.396
87	course_module_viewed, blog_entries_viewed, report_viewed	course_viewed	0.255	0.968	0.993	-0.272	0.123	1.927	15.434
85	course_module_viewed, course_viewed, user_profile_viewed, report_viewed	blog_entries_viewed	0.204	0.96	0.993	-0.221	0.101	1.979	12.872
83	course_module_viewed, user_profile_viewed, report_viewed	course_viewed	0.213	0.943	0.99	-0.238	0.1	1.879	8.796
81	course_module_viewed, user_profile_viewed, blog_entries_viewed	course_viewed	0.238	0.933	0.986	-0.272	0.11	1.859	7.468
82	course_viewed, user_profile_viewed, blog_entries_viewed	course_module_viewed	0.238	0.933	0.986	-0.272	0.11	1.859	7.468
80	course_module_viewed, report_viewed	course_viewed	0.289	0.932	0.984	-0.332	0.133	1.855	7.269
79	course_viewed, user_profile_viewed, report_viewed	blog_entries_viewed	0.221	0.929	0.986	-0.255	0.106	1.914	7.209
78	blog_entries_viewed, discussion_viewed	course_module_viewed	0.221	0.929	0.986	-0.255	0.102	1.849	6.97

Table 7.8 - Apriori based association rule mining, Apriori algorithm, interesting relationships

The Figure- 7.9 shows unexpected and very interesting relationships in respect of rule numbers 91, 90, 88, 84, and 77. All these rules fall under Content Access and the Assignment attributes (Table 4). All these rules show higher value of confidence i.e more than 0.93 and more than 1.85 lift values; more than 6.85 of Conviction and with more than 0.2 of support value. All these premises-attributes and conclusion-attributes have higher

association which can be very useful for developers to consider for their next version release as well as for academics when they develop their LMS course modules, discussions and quiz.

Associations rules under the Content Access (table 5.0) associations were found only in respect of attributes of course viewed, blog entries viewed, course module viewed, discussion viewed and Assignment attributes (table 5.0) quiz attempts.

No	Premises	Conclusion	Support	Confidence	Laplace	Gain	P-s	Lift	Conviction
91	course_viewed, blog_entries_viewed, quiz_attempts	course_module_viewed	0.217	0.981	0.997	0.0226	0.106	1.953	25.889
90	course_viewed, quiz_attempts, report_viewed	course_module_viewed	0.213	0.980	0.997	0.0221	0.104	1.952	25.391
88	course_viewed, discussion_viewed, quiz_attempts	course_module_viewed	0.200	0.979	0.996	0.0209	0.097	1.950	23.898
84	course_viewed, quiz_attempts	course_module_viewed	0.268	0.955	0.990	0.0294	0.127	1.901	10.953
77	course_module_viewed, blog_entries_viewed, quiz_attempts	course_viewed	0.217	0.927	0.986	0.0251	0.100	1.847	6.846

Table 7.9 - Apriori based association rule mining, Apriori algorithm, interesting relationships

The Figure-7.10 shows unexpectedly very interesting relationships in respect of rules 91, 90, 88, 84, and 77, that fall under Content Access and the Engagement attributes (Table 5.0). All these rules show higher values of confidence more than 0.93 and all the lift values are more than 1.9 with more than 8.7 of Conviction and with more than 0.22 of support value. All these premises attributes and conclusion attributes have higher association which can be very useful for developers to consider for their next version release as well as academics when they develop their LMS course modules, discussion and quiz.

In these associations rules under the Content Access (Table-5.0) associations were found only in respect of the attributes of course viewed, blog entries_viewed, course module viewed, discussion viewed and Assignment attributes (table 5.0) quiz_attempts.

No	Premises	Conclusion	Support	Confidence	Lift	Gain	P-s	Lift	Conviction
86	course_viewed, user_login_failed	course_module_viewed	0.221	0.963	0.993	-0.238	0.106	1.918	13.443
76	message_viewed, email_failed	message_sent	0.217	0.927	0.986	-0.251	0.131	2.534	8.718

Table 7.10 - Apriori based association rule mining, Apriori algorithm, interesting relationships

The Figure- 7.11 unexpectedly shows very interesting relationships in the rule number 68. This rule comes under a combination of Errors, Engagement and Access attributes (Table 5.0). This rule shows higher value of confidence more than 0.91 and a lift value of more than 2.3 with more than 2.7 of Conviction and with more than 0.22 of support value. These premises attributes and conclusion attributes have higher association which can be very useful for developers to consider for their next release as well as the academics when they develop their LMS course modules, and message.

In these associations rules under the Content Access (Table 5.0) associations were found only in respect of the attributes of course_viewed, message_viewed, course_module_viewed, and Error attributes (Table 5.0) user_login_failed and email_failed.

No	Premises	Conclusion	Support	Confidence	Lift	Gain	P-s	Lift	Conviction
68	email_failed, message_sent	message_viewed	0.217	0.911	0.983	-0.260	0.122	2.277	6.720

Table 7.11 - Apriori based association rule mining, Apriori algorithm, interesting relationships

Graph 7.3 demonstrates the simplified version of the attribute association and Graph 7.4 shows the details of the association of the attributes of Apriori based association rule mining, Apriori algorithm.

This association patterns have been obtained by data mining relating to the existing students' study and behaviour patterns by analysing the back end data. Based on the attribute association patterns which shows in table 7.6, Graph 7.3, Graph 7.4, Table 7.12 and Table 7.13 it is possible for the system developers to monitor their development and design architecture as against the real situation and thereby to develop better LMS for future versions. The Graph 7.4 shows the details of association of the Attribute at the minimum confidence level of 0.8 and the minimum support of 0.95.

shows the details of association of the Attribute at the minimum confident level of 0.8 and the minimum support of 0.95.



Graph 7.4 – Rules of associations of the attributes at the minimum confidence level of 0.8 and the minimum support of 0.95.

Table-7.12 shows the Support Confidence Laplace Gain P-s Lift and conviction of the attributes

No	Premison	Conclusion	Support	Confidence	Laplace	Gain	P-S	Lift	Conviction
14	'course_viewed', 'report_viewed'	mdl_logstore_standard_log, 'course_module_viewed'	0.281	0.825	0.956	- 0.40 0	0.14 5	2.06 3	3.429
15	mdl_logstore_standard_log, 'report_viewed'	'course_viewed', 'blog_entries_viewed'	0.285	0.827	0.956	- 0.40 4	0.16 5	2.37 1	3.767
16	mdl_logstore_standard_log, 'course_viewed', 'blog_entries_viewed'	'report_viewed'	0.285	0.838	0.959	- 0.39 6	0.13 9	1.94 9	3.509
17	'course_viewed', 'report_viewed'	mdl_logstore_standard_log, 'blog_entries_viewed'	0.285	0.838	0.959	- 0.39 6	0.15 8	2.23 7	3.849
18	mdl_question_attempt_steps	mdl_quiz_attempts	0.421	0.839	0.946	- 0.58 3	0.19 5	1.86 0	3.409
19	mdl_quiz_attempts	mdl_question_attempt_steps , 'attempt_viewed'	0.379	0.840	0.950	- 0.52 3	0.18 1	1.91 6	3.502
20	mdl_question_attempt_steps , 'course_module_viewed'	'course_viewed'	0.294	0.841	0.959	- 0.40 4	0.11 8	1.67 6	3.140
21	'course_viewed', 'blog_entries_viewed'	'report_viewed'	0.294	0.841	0.959	- 0.40 4	0.14 4	1.95 8	3.597
22	'blog_entries_viewed', 'report_viewed'	'course_viewed'	0.294	0.841	0.959	- 0.40 4	0.11 8	1.67 6	3.140
23	mdl_logstore_standard_log, 'course_viewed'	'course_module_viewed'	0.396	0.845	0.951	- 0.54 0	0.16 1	1.68 4	3.222
24	mdl_logstore_standard_log, 'course_viewed', 'report_viewed'	'course_module_viewed'	0.281	0.846	0.962	- 0.38 3	0.11 4	1.68 5	3.236
25	'course_module_viewed'	'course_viewed'	0.426	0.847	0.949	- 0.57 9	0.17 3	1.68 8	3.264
26	'course_viewed'	'course_module_viewed'	0.426	0.847	0.949	- 0.57 9	0.17 3	1.68 8	3.264
27	mdl_stats_user_daily, 'attempt_viewed'	mdl_quiz_attempts	0.285	0.848	0.962	- 0.38 7	0.13 3	1.88 0	3.614
28	'course_viewed', 'report_viewed'	'course_module_viewed'	0.289	0.850	0.962	- 0.39 1	0.11 8	1.69 3	3.319

Table 7 12 – Support Confidence Laplace Gain P-s Lift and conviction of the attributes

AssociationRules

['report_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.802)
['course_module_viewed', 'attempt_viewed'] --> [mdl_question_attempt_steps, mdl_quiz_attempts] (confidence: 0.802)
[mdl_logstore_standard_log, 'blog_entries_viewed'] --> ['course_module_viewed'] (confidence: 0.807)
[mdl_stats_user_daily, 'attempt_viewed'] --> [mdl_question_attempt_steps, mdl_quiz_attempts] (confidence: 0.810)
['report_viewed'] --> ['blog_entries_viewed'] (confidence: 0.812)
['course_module_viewed', 'attempt_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.815)
[mdl_logstore_standard_log, 'report_viewed'] --> ['course_module_viewed'] (confidence: 0.815)
['course_module_viewed', 'attempt_viewed'] --> [mdl_quiz_attempts] (confidence: 0.815)
['course_module_viewed', 'attempt_viewed'] --> [mdl_logstore_standard_log, 'course_viewed'] (confidence: 0.815)
[mdl_logstore_standard_log, 'report_viewed'] --> ['course_module_viewed', 'course_viewed'] (confidence: 0.815)
['course_viewed', 'blog_entries_viewed'] --> [mdl_logstore_standard_log, 'report_viewed'] (confidence: 0.817)
['blog_entries_viewed', 'report_viewed'] --> [mdl_logstore_standard_log, 'course_viewed'] (confidence: 0.817)
['message_viewed'] --> ['message_sent'] (confidence: 0.819)
['course_viewed', 'report_viewed'] --> [mdl_logstore_standard_log, 'course_module_viewed'] (confidence: 0.825)
[mdl_logstore_standard_log, 'report_viewed'] --> ['course_viewed', 'blog_entries_viewed'] (confidence: 0.827)
[mdl_logstore_standard_log, 'course_viewed', 'blog_entries_viewed'] --> ['report_viewed'] (confidence: 0.838)
['course_viewed', 'report_viewed'] --> [mdl_logstore_standard_log, 'blog_entries_viewed'] (confidence: 0.838)
[mdl_question_attempt_steps] --> [mdl_quiz_attempts] (confidence: 0.839)
[mdl_quiz_attempts] --> [mdl_question_attempt_steps, 'attempt_viewed'] (confidence: 0.840)
[mdl_question_attempt_steps, 'course_module_viewed'] --> ['course_viewed'] (confidence: 0.841)
['course_viewed', 'blog_entries_viewed'] --> ['report_viewed'] (confidence: 0.841)
['blog_entries_viewed', 'report_viewed'] --> ['course_viewed'] (confidence: 0.841)
[mdl_logstore_standard_log, 'course_viewed'] --> ['course_module_viewed'] (confidence: 0.845)
[mdl_logstore_standard_log, 'course_viewed', 'report_viewed'] --> ['course_module_viewed'] (confidence: 0.846)
['course_module_viewed'] --> ['course_viewed'] (confidence: 0.847)
['course_viewed'] --> ['course_module_viewed'] (confidence: 0.847)
[mdl_stats_user_daily, 'attempt_viewed'] --> [mdl_quiz_attempts] (confidence: 0.848)
['course_viewed', 'report_viewed'] --> ['course_module_viewed'] (confidence: 0.850)
['blog_entries_viewed', 'report_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.854)
['course_viewed', 'blog_entries_viewed'] --> [mdl_logstore_standard_log, 'course_module_viewed'] (confidence: 0.854)
[mdl_logstore_standard_log, 'course_viewed', 'report_viewed'] --> ['blog_entries_viewed'] (confidence: 0.859)
['course_viewed', 'report_viewed'] --> ['blog_entries_viewed'] (confidence: 0.863)
[mdl_question_attempt_steps, 'attempt_viewed'] --> [mdl_quiz_attempts] (confidence: 0.864)
[mdl_logstore_standard_log, 'report_viewed'] --> ['blog_entries_viewed'] (confidence: 0.864)
['course_module_viewed', 'attempt_viewed'] --> ['course_viewed'] (confidence: 0.864)
[mdl_stats_user_daily, mdl_quiz_attempts] --> [mdl_question_attempt_steps, 'attempt_viewed'] (confidence: 0.865)
['course_module_viewed', mdl_quiz_attempts] --> [mdl_question_attempt_steps, 'attempt_viewed'] (confidence: 0.867)
[mdl_quiz_attempts] --> ['attempt_viewed'] (confidence: 0.868)
[mdl_question_attempt_steps] --> ['attempt_viewed'] (confidence: 0.873)
[mdl_logstore_standard_log, 'course_viewed', 'blog_entries_viewed'] --> ['course_module_viewed'] (confidence: 0.875)
[mdl_question_attempt_steps, mdl_stats_user_daily] --> [mdl_quiz_attempts] (confidence: 0.877)
[mdl_question_attempt_steps, 'course_module_viewed'] --> [mdl_quiz_attempts] (confidence: 0.878)
['course_viewed', 'blog_entries_viewed'] --> ['course_module_viewed'] (confidence: 0.878)
[mdl_stats_user_daily, 'user_login_failed'] --> ['dashboard_viewed'] (confidence: 0.878)
[mdl_question_attempt_steps, 'course_module_viewed', 'attempt_viewed'] --> [mdl_quiz_attempts] (confidence: 0.878)
['course_viewed', 'attempt_viewed'] --> [mdl_question_attempt_steps] (confidence: 0.880)
['course_module_viewed', mdl_quiz_attempts] --> ['attempt_viewed'] (confidence: 0.880)
['course_viewed', 'attempt_viewed'] --> [mdl_logstore_standard_log, 'course_module_viewed'] (confidence: 0.880)
['attempt_viewed'] --> [mdl_question_attempt_steps] (confidence: 0.880)
[mdl_question_attempt_steps, mdl_stats_user_daily] --> ['attempt_viewed'] (confidence: 0.889)
[mdl_question_attempt_steps, mdl_stats_user_daily, 'attempt_viewed'] --> [mdl_quiz_attempts] (confidence: 0.889)
[mdl_question_attempt_steps, 'course_viewed'] --> [mdl_logstore_standard_log, 'course_module_viewed'] (confidence: 0.890)
['message_sent'] --> ['message_viewed'] (confidence: 0.895)
['course_module_viewed', 'blog_entries_viewed'] --> [mdl_logstore_standard_log, 'course_viewed'] (confidence: 0.897)
[mdl_question_attempt_steps, mdl_quiz_attempts] --> ['attempt_viewed'] (confidence: 0.899)
[mdl_question_attempt_steps, mdl_stats_user_daily, mdl_quiz_attempts] --> ['attempt_viewed'] (confidence: 0.901)
[mdl_question_attempt_steps, 'course_module_viewed'] --> ['attempt_viewed'] (confidence: 0.902)
[mdl_question_attempt_steps, 'course_module_viewed', mdl_quiz_attempts] --> ['attempt_viewed'] (confidence: 0.903)
[mdl_logstore_standard_log, 'attempt_viewed'] --> ['course_module_viewed'] (confidence: 0.904)
['course_module_viewed', 'report_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.904)
[mdl_question_attempt_steps, 'course_viewed'] --> ['attempt_viewed'] (confidence: 0.904)
[mdl_logstore_standard_log, 'attempt_viewed'] --> ['course_module_viewed', 'course_viewed'] (confidence: 0.904)
['course_module_viewed', 'report_viewed'] --> [mdl_logstore_standard_log, 'course_viewed'] (confidence: 0.904)
[mdl_stats_user_daily, mdl_quiz_attempts] --> ['attempt_viewed'] (confidence: 0.905)
[mdl_logstore_standard_log, 'blog_entries_viewed'] --> ['course_viewed'] (confidence: 0.909)
['course_module_viewed', 'blog_entries_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.910)
[mdl_stats_user_daily, 'attempt_viewed'] --> [mdl_question_attempt_steps] (confidence: 0.911)
['course_module_viewed', 'attempt_viewed'] --> [mdl_question_attempt_steps] (confidence: 0.914)

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['course_module_viewed', 'blog_entries_viewed'] --> ['course_viewed'] (confidence: 0.923)
[mdl_logstore_standard_log, mdl_question_attempt_steps] --> ['course_module_viewed'] (confidence: 0.929)
[mdl_logstore_standard_log, mdl_question_attempt_steps] --> ['course_module_viewed', 'course_viewed'] (confidence: 0.929)
[mdl_logstore_standard_log, 'course_viewed', 'attempt_viewed'] --> ['course_module_viewed'] (confidence: 0.930)
['course_module_viewed', 'course_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.930)
['course_module_viewed', 'report_viewed'] --> ['course_viewed'] (confidence: 0.932)
[mdl_logstore_standard_log] --> ['course_viewed'] (confidence: 0.932)
['course_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.932)
['course_viewed', 'attempt_viewed'] --> ['course_module_viewed'] (confidence: 0.933)
[mdl_quiz_attempts] --> [mdl_question_attempt_steps] (confidence: 0.934)
[mdl_logstore_standard_log, mdl_question_attempt_steps, 'course_viewed'] --> ['course_module_viewed'] (confidence: 0.942)
[mdl_question_attempt_steps, 'course_module_viewed', 'course_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.942)
['course_module_viewed', 'course_viewed', 'attempt_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.943)
[mdl_logstore_standard_log, 'user_profile_viewed'] --> ['course_viewed'] (confidence: 0.944)
[mdl_question_attempt_steps, 'course_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.945)
[mdl_question_attempt_steps, 'course_viewed'] --> ['course_module_viewed'] (confidence: 0.945)
['course_viewed', 'attempt_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.947)
[mdl_stats_user_daily, 'attempt_viewed', mdl_quiz_attempts] --> [mdl_question_attempt_steps] (confidence: 0.955)
['course_viewed', 'user_profile_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.957)
[mdl_logstore_standard_log, 'blog_entries_viewed', 'report_viewed'] --> ['course_viewed'] (confidence: 0.957)
[mdl_stats_user_daily, mdl_quiz_attempts] --> [mdl_question_attempt_steps] (confidence: 0.959)
['course_module_viewed', mdl_quiz_attempts] --> [mdl_question_attempt_steps] (confidence: 0.960)
[mdl_logstore_standard_log, 'report_viewed'] --> ['course_viewed'] (confidence: 0.963)
['attempt_viewed', mdl_quiz_attempts] --> [mdl_question_attempt_steps] (confidence: 0.967)
['course_module_viewed', 'course_viewed', 'report_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.971)
['course_viewed', 'blog_entries_viewed', 'report_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.971)
['course_module_viewed', 'course_viewed', 'blog_entries_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.972)
[mdl_logstore_standard_log, 'attempt_viewed'] --> ['course_viewed'] (confidence: 0.973)
['course_viewed', 'report_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.975)
['course_viewed', 'blog_entries_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.976)
['course_module_viewed', 'attempt_viewed', mdl_quiz_attempts] --> [mdl_question_attempt_steps] (confidence: 0.985)
[mdl_logstore_standard_log, mdl_question_attempt_steps] --> ['course_viewed'] (confidence: 0.986)
[mdl_logstore_standard_log, 'course_module_viewed', 'blog_entries_viewed'] --> ['course_viewed'] (confidence: 0.986)
... 5 other rules ...

```

Table 7.13 – Association rule mining patterns of the attributes

In the Apriori based association rule mining algorithm, 94 association rules have been discovered at the minimum confidence level of 0.8 and the minimum support of 0.95. In the Apriori based association rule mining algorithm revealed that there are similar rules, the rules with the same attributes in premises and conclusion but interchanged and uninteresting rules can be found because of the generalization of relationships. There are rules that display the relevant information like those shows expected or conforming relationships. Some of the unexpected rules are very interesting relationships such as rules numbers 90, 91, 93, 94, 92, 88, 89, 87, 84, 85, 83, 81, 82, 80, 79, 77, 78 and 68. All the association rules fall under the combined category of Content Access, Assignment, Engagement and Errors attributes. All these rules show higher value of confident more than 0.93 and all the lift values are more than one with more than 1.85 of Conviction and with more than 0.2 of support value which can be very useful for developers to consider for their next release as well as for academics when they develop their LMS course modules.

In the Apriori based association rule mining the attributes under the category of Content Access such as question viewed, the attributes under the category of Engagement such as,

forum discussions and chat the attributes under the category Assignment such as question attempt, question answered, and assignment submissions have not revealed any association. This Association pattern and behaviour supports the finding that the students have used provisions of questions or examinations and any forum discussions and chat via LMS mode. This revealed that this a potential area for the use and enhanced without further investment and to give more opportunity to the students. Similarly, the existing platform attributes of chart, messages, forum discussions and discussion do not have Associations with other attributes demonstrating the fact that LMS is functioning at a suboptimal level.

7.4 Summary

In this chapter the students' study behaviour and students' study pattern of the Learning Management System (LMS) has been evaluated. The research findings, its limitations and directions for further developments in detail will be discussed in the final chapter.

Conclusions, Recommendations and further work

8.1 Introduction

This final chapter concludes the results of the research study and recommendations are being presented based on the research finding. This section of the study encapsulates the overview of the research work. In addition to that, it has been elaborated how research aims, objectives, research questions and hypotheses were achieved during the process of the study. Furthermore, the research contributions have been discussed as per the study. In addition to that, the chapter highlights the limitations of the research and future recommendations.

8.2 Key findings, Conclusion and Recommendations

The research hypothesised that there was a positive relationship between students' strong study behaviour and favourable study patterns, in the use of the Learning Management System (LMS). In order to test the hypothesis, Data Mining techniques were used in respect of the Database of the Undergraduate Learning Management System (LMS) of the Faculty of Medicine, University of Colombo. Various data mining algorithms, such as K Mean Clustering algorithm, Correlation Algorithm and Apriori based association rule mining algorithm have been used to test the research hypothesis. In conclusion, the study has found that there does not exist a positive relationship between students' strong study behaviour and favourable study patterns, in the use of the Learning Management System (LMS), yet a mix of positive, negative and absence of relations. Key findings and recommendations of the study are presented below.

In this research, the attributes under the category of Content Access, such as dashboard viewed, course viewed, course module viewed, course category viewed, content page viewed, attempt viewed, user profile viewed, report viewed, blog viewed, message viewed, notification viewed, question viewed and discussion viewed, have been examined. The attributes under the category of Engagement, such as message sent, notification sent, discussion created, message contact added, user password updated, forum discussions and chat have been examined. The attributes under the category Assignment, such as question attempt, question answered, quiz attempt and assignment submissions have been examined.

The attributes under the category of Errors such as email failed, and user login failed have been examined and also , the attributes under the category of Total Access view have been examined to test the research hypothesis. In this study, by using the RapidMiner Analytical Engine, the techniques of data mining algorithms of (i) K Mean Clustering algorithm, (ii) Correlation Algorithm and (iii) Apriori based association rule mining algorithm have been used to derive the final outcome.

In the K Mean Clustering algorithm, five clustering patterns were identified as the outcome of the implementation of RapidMiner Analytical Engine. The average within the cluster distance is found as 150280.45 and the cluster average within the cluster distance of 0, 1, 2, 3, 4 clusters found were 193645.20, 102220.60, 10850.32, 136193.22, 47567.26 respectively. The respective cluster densities were 118, 43, 4, 53, 17 respectively. The Cluster 0 had 118 number of students-views and it was 50 percent of the sample, however, the cluster average views were very low, which was at 2782. The Cluster 3 had 53 number of students views and it was 23 percent of the sample and the cluster average was almost the average of the total sample which was 8985. The Cluster-1 had 43 number of students' views and it was 18 percent of the total sample and the cluster average was higher than the total sample average which was 15817. The Cluster-4 had 17 numbers of students' views and it was 7 percent of the sample, however, their cluster average was reasonably higher than the total sample average which was 23101. Finally, the Cluster-2 had only 4 numbers of students' views, which was only 2 percent of the sample , however, this cluster average views were very high at 31319.

Based on the above results, the study has revealed that the attributes in respect of identified five clusters under the category of Content Access, Engagement, Assignments and Error, distributions are not equal both among them and in-between. This demonstrates that the students' study behaviour and the study patterns of the Learning Management System (LMS) do not distribute in equal manner and therefore students fail in obtaining the full potentials of the LMS delivery.

By examination of the current study patterns and the study behaviours of the online studies, through the Data Mining from the K Mean Clustering algorithm by using RapidMiner Analytical Engine, it has been found that the LMS is acting as a limitation that keep the online option at a suboptimal level. Based on the above results, it has been found that the students' study patterns and the study behaviours of the attributes under the Content Access,

Engagement and the Assignments among and in-between the identified five clusters are not equal. The research outcome also revealed that the students do not show a strong study behaviour and favourable study patterns in the use of the Learning Management System (LMS).

The outcome of the correlation algorithm reveals whether the correlation among or between attributes is positive or negative or weak or no correlations of any significance. A very strong positive correlations with a high 0.7 value, has been found in respect of attributes (i) between notifications sent vs email failed, (ii) message viewed vs message sent, (iii) course viewed vs course module viewed, (iv) discussion viewed vs notification sent and (v) discussion viewed vs email failed. Also very high correlation has been found under the category of Engagement and Errors attributes. A very strong negative correlation values of more than -0.6 have been found in respect of attributes in-between (i) notification sent vs quiz attempts and (ii) quiz attempts vs email failed under attribute category of Access, Engagement and Errors attributes.

In the meanwhile, weak positive correlations and weak negative correlations have been found in respect of some attributes. It shows that the student's study pattern and the student behaviour with regard to the Content Access attributes such as (i) message viewed, (ii) discussion viewed, (iii) notification viewed, and (iv) forum discussion views have very low correlation with other attributes while Engagement attributes such as (i) message sent, and (ii) notification sent also show very low correlation with other attributes. These findings lead to the conclusion that students' study behaviour and the study patterns of the Learning Management System (LMS) in respect of Content Access and Engagement are very weak.

The outcome of the correlation algorithm also revealed that some Content Access attributes such as question viewed and discussion viewed and some Assignment attributes such as assignment submissions and question answered do not have any correlation with other attributes. This demonstrates that students' study behaviour and the study patterns of the Learning Management System (LMS) in respect of Content Access and Engagement are very weak.

The conclusion that can be arrived at is that there is a wide gap between the actual outcome and the full potentials of the LMS to be achieved. This pattern and behaviour indicates that the students have not attempted questions or examinations via LMS mode. This revealed that

there are unutilized potential areas which can be used or utility can be enhanced without any technical expansion by just giving more opportunities to the students.

The existing platform attributes of chart, messages, forum discussions and discussion have not shown correlations with other attributes demonstrating that the functioning of the LMS is at a suboptimal level. Further it is possible for LMS to be integrated to social media like WhatsApp, viber, etc. in a very user-friendly manner introducing further enhancements to the existing LMS. These final results are beneficial for early detection of students' study patterns and the behaviour of the students' experiencing difficulties in studies. Both Academics and the students would benefit from these research outcomes.

In the Apriori based association rule mining algorithm, 94 association rules have been discovered at the minimum confidence level of 0.8 and the minimum support of 0.95. The Apriori based association rule mining algorithm in the study revealed similar rules, with the same attributes in premises and conclusion, however, due to generalization of relationships, interchanged and uninteresting rules have been found. Some rules display the relevant information as expected or conforming the relationships. Some unexpected rules demonstrate very interesting relationships. e.g. rules number of 90, 91, 93, 94, 92, 88, 89, 87, 84, 85, 83, 81, 82, 80, 79, 77, 78 and 68. All these association rules are related to the attributes that fall under the category of combination of Content Access, Assignment, Engagement and Errors. All these rules show higher confidence values and all the confidence values are more than 0.93 while all the lift values are above 1 (one) with more than 1.85 of Conviction and with more than 0.2 of support value. These results are found to be very useful for developers to consider in their next releases as well as the academics when they develop their LMS course modules.

In the analysis of Apriori based association rule mining, (i) the attributes such as question viewed under the category of Content Access,, (ii) the attributes such as, forum discussions and chat under the category of Engagement and (iii) the attributes such as question attempt, question answered, and assignment submissions under the category Assignment have not revealed any association. This Association pattern and behaviour shows that the students have not attempted any questions or examinations or any forum discussions or chat via LMS mode.

The above results revealed serious gaps in the delivery while showing great potential which is usable or enhanced. Such improvements to LMS would give more opportunity to the students while the use of existing platform attributes of chat, messages, forum discussions and discussion at suboptimal level, would expand the scope of delivery substantially.

The research outcome, in the process of both identifying shortcomings of the existing LMS and making suggestions for improvements based on results, has already been shared with the Faculty IT committee and the Faculty Head of the Department. As a result, the Faculty has implemented a large number of awareness programs among the academic and technical staff and the students for the purpose of the enhancement of the Faculty LMS with the next revised version of the LMS.

It is recommended that more experiments be conducted by using larger datasets in the future, in order to undertake future tests with effectiveness of the proposed model and to increase the general usefulness of this research.

8.3 Limitation

This research though limited to data collected from the medical undergraduates of the Faculty of Medicine, University of Colombo, it is possible to adopt the final outcome of the research to a larger student population who use the Learning Management System. It has been a challenge to carry out the research due to lack of adequate reference material or limited access to required research studies in the Sri Lankan context. The results of the study conducted though seem limited to the University, are nevertheless beneficial to the academic institutions to understand existing trends in e-learning, m-learning types of LMS, facilities provided by them with regard to the Sri Lankan educational system.

8.4 Further Development

This research has been limited to the medical undergraduates of the Faculty of Medicine, University of Colombo and the final outcome of the research has been adopted to the students who use the Learning Management System. The results of the study apparently be beneficial to the academic institutions to comprehend trends existing in e-learning, m-learning types of LMS, facilities provided by them with regard to Sri Lankan context. Further research is recommended with larger data sets in order to further develop the outcome of the present research.

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207	188	419	249	238	82	0	36	0	0	0	2	0	0	0	2	0	0	0	1	0	0	45	0	1	0	0	1	0	858
208	61	46	104	114	2	0	0	2	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	9	0	371
209	264	163	495	534	85	14	16	14	0	0	1	0	0	6	1	1	0	1	2	0	0	30	0	1	0	2	14	0	1684
210	187	123	282	357	12	6	28	0	0	0	0	0	0	1	0	0	0	0	2	0	0	90	0	2	0	0	62	0	1070
211	711	114	815	115	17	0	20	0	0	0	1	0	0	0	0	0	0	0	1	0	0	46	0	1	0	0	10	0	299
212	80	46	65	49	9	0	14	18	0	0	3	0	0	6	7	3	0	2	1	0	0	45	0	1	0	0	31	0	469
213	68	17	87	58	9	0	14	21	0	0	0	0	0	1	0	0	0	0	1	0	0	45	0	1	0	0	21	0	306
214	222	238	510	275	171	0	37	12	0	0	0	0	0	5	0	0	0	0	1	0	0	50	0	1	0	0	7	0	1352
215	35	12	33	19	4	0	18	1	0	0	0	0	0	0	0	0	0	0	1	0	0	46	0	1	0	0	2	0	176
216	71	12	8	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	53
217	191	106	243	184	47	0	39	10	2	0	3	0	0	9	4	0	0	0	1	0	0	47	0	1	0	1	14	0	972
218	0	3	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	12	0	36
219	54	24	62	101	27	0	22	44	4	0	0	0	0	1	1	1	0	1	1	0	0	51	0	2	0	0	14	0	322
220	176	129	253	253	55	1	29	0	1	0	0	0	0	1	0	0	0	0	1	0	0	45	1	1	0	0	42	0	947
221	106	122	139	136	19	0	19	0	1	0	0	0	0	1	0	0	0	0	1	0	0	45	0	1	0	0	16	0	553
222	176	756	223	350	63	0	14	0	0	0	0	0	0	0	2	0	0	0	2	0	0	45	0	1	0	0	41	0	1012
223	147	59	157	167	0	0	30	6	0	0	0	0	0	0	0	0	0	0	1	0	0	52	0	1	0	0	11	0	568
224	143	280	203	123	8	0	16	0	1	0	0	0	0	0	0	0	0	0	1	0	0	46	0	1	0	0	8	0	611
225	17	74	14	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3	0	68

Clustering pattern details is shown in Table 7.1

ID	Cluster	mdl_stas_u ser_dail y	'dash board _view ed'	'cour se_vi ewed'	'cour se_m odule _view ed'	'cour se_c ate gory_vi ewed'	'att em pt_vi ewed'	'use r_pr ofil e_vi ewed'	'rep ort_vi ewed'	'bl og_e ntries _vi ewed'	'm es sa ge _vi ewed'	'not ification _vi ewed'	'q ue sti on _vi ewed'	'dis cuss ion_vi ewed'	'm es sa ge _s ent'	'not ification _se nt'	'di sc uss ion_c rea ted'	'm es sa ge _c on ta ct _a dded'
96	cluster_0	12	21	54	43	0	21	2	0	0	0	0	0	0	0	0	0	0
227	cluster_0	31	19	27	36	1	0	0	0	0	0	0	0	11	0	106	0	0
223	cluster_0	36	43	50	80	0	0	5	0	0	0	0	0	15	0	72	0	0
95	cluster_0	120	41	213	188	43	23	12	2	1	0	0	0	0	0	0	0	0
231	cluster_0	112	31	97	250	52	0	3	0	0	0	0	0	36	0	82	0	0
191	cluster_0	106	48	293	263	0	232	0	0	0	0	0	0	7	0	0	0	0
215	cluster_0	164	50	184	217	34	0	6	0	0	0	0	0	65	0	144	2	0
213	cluster_0	141	73	127	185	0	0	2	0	0	0	0	0	60	0	152	0	0
233	cluster_0	161	81	176	168	1	0	3	0	0	0	0	0	86	0	180	0	0
229	cluster_0	152	105	219	243	0	0	9	0	0	0	0	0	75	0	122	4	0
148	cluster_0	151	167	289	289	7	138	20	0	0	0	0	0	1	0	0	0	0
48	cluster_0	210	184	360	341	0	85	1	0	0	0	0	0	8	0	0	0	0
56	cluster_0	149	87	378	286	71	96	13	4	1	0	0	0	4	0	0	0	0
16	cluster_0	118	127	296	372	12	102	10	0	0	0	0	0	0	4	0	0	0
83	cluster_0	160	216	366	286	0	147	0	0	0	0	0	0	0	0	0	0	0
167	cluster_0	207	250	428	366	2	118	1	0	1	1	1	0	1	0	0	1	0
209	cluster_0	182	147	313	295	6	0	16	2	0	1	0	0	92	0	82	1	0

206	cluster_0	173	142	295	298	0	0	2	0	0	0	0	0	92	0	139	0	0
44	cluster_0	61	129	358	229	9	36	12	0	1	0	0	0	2	0	0	0	0
89	cluster_0	133	138	443	318	2	159	9	1	1	0	0	0	9	0	0	0	0
128	cluster_0	163	164	316	325	5	168	23	0	0	0	0	0	0	0	0	0	0
214	cluster_0	192	89	305	268	3	0	5	0	0	1	1	0	222	0	112	1	0
178	cluster_0	155	143	321	333	15	153	4	10	2	0	0	0	6	2	0	0	0
108	cluster_0	219	215	493	438	3	87	3	3	0	0	0	0	7	0	0	0	0
211	cluster_0	231	86	350	334	5	0	3	0	0	0	0	0	67	0	159	0	0
234	cluster_0	184	104	334	389	0	0	6	7	0	0	0	0	71	0	118	1	0
201	cluster_0	107	125	407	351	0	245	9	0	0	0	0	0	0	0	0	0	0
101	cluster_0	248	207	562	455	1	71	4	1	0	0	0	0	23	0	1	1	0
225	cluster_0	206	140	394	395	4	0	5	0	0	0	0	0	79	0	138	1	0
137	cluster_0	217	114	453	459	94	183	2	0	0	0	0	0	5	0	0	0	0
235	cluster_0	202	208	427	313	4	0	0	0	0	0	0	0	142	0	107	1	0
228	cluster_0	236	265	473	310	0	0	3	0	0	0	0	0	129	0	155	0	0
76	cluster_0	13	139	318	188	0	29	0	4	0	4	0	0	0	7	0	0	0
210	cluster_0	207	169	331	325	10	0	8	0	0	1	0	0	177	1	152	0	0
73	cluster_0	239	179	335	528	0	166	2	0	0	4	0	0	1	5	0	0	0
24	cluster_0	201	221	554	546	2	138	0	0	0	0	0	0	2	0	0	0	0
208	cluster_0	244	279	553	365	0	0	1	0	0	1	1	0	187	0	88	1	0
224	cluster_0	222	179	420	380	8	0	4	0	0	0	0	0	81	0	191	0	0
119	cluster_0	165	144	420	422	0	146	6	0	0	0	0	0	5	0	0	0	0
179	cluster_0	202	208	559	562	8	63	1	1	1	0	0	0	4	0	0	0	0
52	cluster_0	192	211	449	552	1	205	14	0	0	0	0	0	2	0	0	0	0
20	cluster_0	222	300	504	607	13	83	47	0	1	7	0	0	1	11	0	0	0

230	cluster_0	173	126	257	282	0	0	3	0	0	1	0	0	55	1	168	0	0
221	cluster_0	209	197	418	436	19	0	4	0	0	2	1	0	135	1	199	0	0
226	cluster_0	240	218	511	495	14	0	11	0	1	0	0	0	177	0	117	1	0
115	cluster_0	206	251	523	584	3	169	5	0	0	2	0	0	0	1	0	0	0
181	cluster_0	248	364	631	602	4	201	4	0	0	1	0	0	10	0	0	0	0
217	cluster_0	220	229	503	456	0	0	2	0	0	0	0	0	182	0	97	0	0
39	cluster_0	217	284	485	538	8	198	7	0	1	0	0	0	4	0	1	0	0
25	cluster_0	303	206	595	596	0	168	40	0	0	0	1	0	13	0	0	0	0
71	cluster_0	247	261	523	458	12	186	0	0	0	1	0	0	5	0	4	0	0
166	cluster_0	141	172	449	550	73	200	0	0	0	0	0	0	0	0	0	0	0
156	cluster_0	204	166	466	407	5	29	16	4	0	5	0	0	3	4	1	0	1
207	cluster_0	207	310	515	574	4	0	6	1	0	0	0	0	148	0	134	0	0
153	cluster_0	261	378	619	545	0	74	10	1	0	0	0	0	6	0	0	0	0
37	cluster_0	240	243	538	530	0	66	6	0	0	0	0	0	0	0	0	0	0
61	cluster_0	233	319	658	665	14	291	1	0	0	0	0	0	3	0	0	0	0
112	cluster_0	245	235	521	485	18	135	4	0	0	3	0	0	13	8	0	0	0
34	cluster_0	269	339	582	553	2	97	20	0	0	1	0	0	6	1	0	0	0
43	cluster_0	276	254	616	452	21	189	4	3	0	1	0	0	1	1	0	0	0
219	cluster_0	220	321	695	472	0	0	0	0	0	0	0	0	245	0	136	3	0
176	cluster_0	207	288	582	855	2	128	1	0	0	1	0	0	13	1	0	0	0
99	cluster_0	234	303	715	685	1	287	1	0	0	0	0	0	1	0	0	0	0
45	cluster_0	181	229	683	945	0	316	0	0	0	0	2	0	11	0	0	0	0
113	cluster_0	252	308	653	672	0	190	0	0	0	0	0	0	24	0	1	1	0
63	cluster_0	255	382	617	626	4	199	3	0	0	0	0	0	2	0	0	0	0
123	cluster_0	149	113	468	399	21	116	15	1	0	1	0	0	6	1	0	0	0

152	cluster_0	345	287	611	849	13	98	5	2	0	0	0	0	9	0	0	0	0
69	cluster_0	293	345	697	692	27	174	11	0	0	1	0	0	0	1	0	0	0
194	cluster_0	266	257	614	737	16	147	26	3	2	0	0	0	39	1	3	1	1
216	cluster_0	282	289	511	519	26	0	31	10	1	1	250	0	189	5	156	1	4
118	cluster_0	232	261	652	757	1	208	1	1	0	0	0	0	11	0	0	0	0
190	cluster_0	222	310	618	594	3	93	27	1	0	3	0	0	13	1	0	0	0
2	cluster_0	281	243	804	580	100	262	7	0	0	1	0	0	9	0	0	0	0
133	cluster_0	259	350	658	612	0	212	6	2	0	2	0	0	9	1	0	0	0
180	cluster_0	201	223	582	553	12	198	10	6	1	0	0	0	8	0	0	0	0
40	cluster_0	263	90	714	536	23	148	3	8	1	1	1	0	9	0	1	0	0
222	cluster_0	310	264	821	589	29	0	5	0	0	0	0	0	257	0	151	1	0
202	cluster_0	187	184	610	555	1	139	1	0	0	0	0	0	0	0	0	0	0
59	cluster_0	229	189	583	500	1	120	0	0	0	7	0	0	7	3	0	0	0
110	cluster_0	289	424	804	750	0	261	6	0	0	0	0	0	10	0	0	0	0
31	cluster_0	217	492	813	878	0	98	3	3	0	0	0	0	2	0	0	0	0
121	cluster_0	267	334	643	881	13	239	36	7	0	2	0	0	21	3	0	0	0
188	cluster_0	50	10	500	428	30	124	3	0	1	0	0	0	1	0	0	0	0
30	cluster_0	278	187	802	519	74	144	5	11	0	0	0	0	18	0	0	0	0
19	cluster_0	198	88	793	665	13	250	1	1	0	0	0	0	9	0	0	0	0
100	cluster_0	170	94	554	442	12	37	4	5	2	0	0	0	1	0	0	0	0
17	cluster_0	348	295	921	681	3	134	12	7	3	0	0	0	19	0	0	0	0
169	cluster_0	174	60	468	402	0	92	0	3	1	0	0	0	0	0	0	0	0
86	cluster_0	109	22	611	411	41	21	4	2	0	0	0	0	0	0	0	0	0
28	cluster_0	118	70	615	411	0	22	3	2	0	1	0	0	2	1	0	0	0
6	cluster_0	240	240	715	621	0	148	1	0	0	0	1	0	6	0	0	0	0

84	cluster_0	234	206	792	966	1	112	5	3	1	2	0	0	4	2	0	0	0
146	cluster_0	292	407	865	1201	1	227	16	18	2	3	0	0	10	2	0	0	0
53	cluster_0	299	302	1009	1313	24	125	5	0	0	0	0	0	6	0	0	0	0
94	cluster_0	68	26	530	396	5	53	1	3	1	0	0	0	0	0	0	0	0
232	cluster_0	310	537	1066	932	2	0	3	0	0	0	0	0	354	0	97	2	0
144	cluster_0	254	335	832	850	0	114	1	2	0	0	0	0	1	0	0	0	0
29	cluster_0	322	537	997	800	4	208	3	5	0	0	0	0	5	0	0	0	0
10	cluster_0	280	352	908	769	2	240	0	1	0	1	0	0	22	0	0	0	0
87	cluster_0	322	495	937	709	38	148	12	5	0	5	0	0	16	3	0	0	0
220	cluster_0	290	524	1228	935	1	0	1	0	0	0	0	0	377	0	162	0	0
218	cluster_0	177	152	612	426	0	0	6	0	0	0	0	0	117	0	99	0	0
129	cluster_0	289	473	1017	1124	16	261	9	5	1	0	0	0	26	0	4	0	0
143	cluster_0	318	538	1410	1298	6	227	64	0	0	0	0	0	29	0	0	0	0
198	cluster_0	175	184	1165	394	0	138	1	2	0	1	0	0	1	1	0	0	0
170	cluster_0	255	543	999	942	0	129	4	0	0	0	0	0	1	0	0	0	0
103	cluster_0	340	402	1085	1043	23	303	39	11	2	0	0	0	64	0	25	0	4
111	cluster_0	170	89	683	528	4	164	14	0	0	1	1	0	18	30	9	1	0
88	cluster_0	318	255	1141	982	16	266	5	0	0	0	0	0	7	0	0	0	0
68	cluster_0	110	59	632	517	0	91	6	0	0	0	0	0	1	0	0	0	0
165	cluster_0	307	228	939	786	14	157	2	6	1	0	0	0	15	0	0	0	0
65	cluster_0	322	301	976	1004	5	235	11	6	0	1	0	0	43	0	1	1	0
120	cluster_0	160	76	793	503	5	29	0	1	0	1	0	0	4	1	0	0	0
8	cluster_0	170	174	987	704	42	128	0	1	0	0	0	0	31	0	183	1	0
78	cluster_0	317	282	1006	1012	25	162	11	1	1	1	0	0	13	2	0	0	0
106	cluster_0	124	100	976	478	1	104	7	9	2	3	0	0	6	3	0	0	0

102	cluster_0	104	22	768	387	0	156	0	5	2	0	0	0	4	0	7	0	0
50	cluster_3	222	176	1268	668	11	216	25	3	0	0	0	0	25	0	0	0	0
62	cluster_3	167	127	791	725	1	132	12	2	2	4	0	0	2	4	0	0	0
131	cluster_3	34	8	779	573	1	3	5	2	1	0	0	0	1	0	0	0	0
212	cluster_3	205	180	667	476	11	0	24	10	6	0	82	0	255	0	220	0	0
189	cluster_3	217	163	938	668	3	98	4	4	2	0	0	0	1	0	0	0	0
91	cluster_3	331	428	1493	1036	0	213	1	0	0	0	0	0	21	0	0	0	0
33	cluster_3	266	300	1137	788	1	85	17	5	0	0	2	0	1	1	1	0	0
46	cluster_3	138	80	1272	508	8	75	2	0	0	1	0	0	6	1	7	0	0
172	cluster_3	310	203	1340	1005	46	182	11	3	3	1	0	0	20	1	0	0	0
182	cluster_3	369	714	1488	1198	0	267	112	12	2	0	0	0	24	0	1	0	0
159	cluster_3	296	291	1025	799	12	288	3	7	0	0	0	0	28	0	0	0	0
177	cluster_3	59	2	760	511	3	56	9	1	1	0	0	0	1	0	0	0	0
35	cluster_3	308	193	1154	992	71	301	2	2	0	1	0	0	44	0	7	0	0
27	cluster_3	177	170	937	701	3	254	13	0	2	3	0	0	6	3	0	0	0
18	cluster_3	182	189	1028	911	0	86	2	0	0	5	0	0	0	4	0	0	0
134	cluster_3	86	7	1152	388	0	96	2	3	0	0	0	0	0	0	0	0	0
157	cluster_3	216	120	1154	578	9	172	5	0	0	4	1	0	8	4	0	0	0
164	cluster_3	110	49	1084	736	0	65	13	7	3	1	1	0	7	1	2	0	1
204	cluster_3	170	92	1073	759	4	182	3	2	2	2	3	0	4	20	2	0	2
4	cluster_3	339	452	1323	867	5	186	23	3	1	1	0	0	11	4	0	0	0
55	cluster_3	110	3	964	395	0	50	5	1	2	0	0	0	8	0	0	0	0
75	cluster_3	139	1	1337	564	0	14	4	5	2	0	0	0	0	0	1	0	1
21	cluster_3	236	345	1830	733	1	169	8	4	1	0	0	0	9	0	0	0	0
125	cluster_3	244	110	1660	726	0	49	10	10	2	0	0	0	2	0	0	0	0

196	cluster_3	225	127	1384	876	2	283	16	4	1	0	0	0	51	0	13	1	0
32	cluster_3	87	8	1344	840	22	103	2	1	0	0	0	0	0	0	0	0	0
185	cluster_3	202	109	1196	723	25	224	24	11	5	3	1	0	3	2	0	0	0
51	cluster_3	271	195	1391	887	34	166	4	12	3	8	0	0	36	11	0	1	0
162	cluster_3	171	21	1212	530	0	122	39	20	6	0	0	0	8	0	0	0	0
140	cluster_3	145	22	1578	485	1	134	0	4	2	0	0	0	3	0	0	0	0
57	cluster_3	220	89	1642	720	4	106	7	3	0	0	1	0	3	1	0	0	0
197	cluster_3	212	36	1240	686	35	145	14	12	10	1	0	0	2	1	0	0	0
151	cluster_3	249	173	1736	1181	4	83	4	5	2	0	0	0	0	0	0	0	0
97	cluster_3	327	367	1272	882	6	170	19	4	6	0	5	0	29	0	0	0	0
199	cluster_3	118	49	1770	873	1	136	6	8	4	1	0	0	1	0	0	0	0
168	cluster_3	232	36	1139	631	0	147	1	7	0	0	0	0	4	0	0	0	0
161	cluster_3	160	5	1313	730	2	137	9	17	1	0	0	0	5	0	0	0	0
41	cluster_3	314	282	1607	1076	14	199	44	15	3	6	0	0	26	4	0	0	0
7	cluster_3	122	5	1192	536	1	149	0	3	1	0	0	0	1	0	0	0	0
82	cluster_3	154	8	1556	635	0	71	1	5	1	5	5	0	6	4	0	0	0
155	cluster_3	141	8	1893	679	0	117	3	13	3	5	0	0	2	2	0	0	0
22	cluster_3	174	9	1774	678	0	45	10	5	0	6	0	0	6	7	5	0	4
72	cluster_3	122	53	1411	926	3	92	1	5	6	1	0	0	0	0	0	0	0
90	cluster_3	230	75	2086	870	7	259	7	4	1	4	0	0	2	2	0	0	0
12	cluster_3	134	11	1873	650	0	78	2	4	4	2	0	0	2	1	0	0	0
107	cluster_3	296	232	1817	851	1	238	71	33	10	1	3	0	9	1	0	0	0
141	cluster_3	257	106	1747	1117	11	216	2	4	0	1	0	0	13	1	0	0	0
3	cluster_3	197	55	1776	857	1	44	3	0	0	0	0	0	1	1	0	0	0
36	cluster_3	158	7	1963	648	0	50	6	4	1	0	0	0	5	0	0	0	0

183	cluster_3	283	346	2000	983	21	223	60	16	3	2	0	0	45	4	1	1	0
116	cluster_3	253	181	1715	890	0	247	7	3	2	0	0	0	7	0	0	0	0
67	cluster_3	178	6	1647	847	2	156	8	9	4	0	0	0	7	0	0	0	0
132	cluster_3	204	40	2008	901	0	204	8	8	1	1	0	0	5	1	0	0	0
26	cluster_1	163	12	1776	1091	1	146	2	1	0	0	0	0	8	0	0	0	0
114	cluster_1	216	24	2413	745	0	147	6	2	0	0	0	0	7	1	0	0	0
47	cluster_1	263	133	1775	877	2	228	1	3	0	0	0	0	24	0	0	0	0
171	cluster_1	210	66	2168	1277	16	237	2	5	0	0	0	0	11	0	0	0	0
81	cluster_1	93	5	2202	824	0	245	3	2	0	2	0	0	6	2	0	0	0
117	cluster_1	305	184	2429	999	25	224	23	13	5	0	0	0	31	1	0	0	0
42	cluster_1	167	10	2618	797	22	160	12	15	1	0	0	0	1	0	0	0	0
105	cluster_1	174	14	2922	763	0	148	1	1	0	0	0	0	11	0	2	1	0
124	cluster_1	231	142	1930	756	1	258	5	10	4	1	0	0	38	1	0	0	0
92	cluster_1	176	14	3211	706	2	86	18	6	1	5	1	0	6	5	0	0	0
23	cluster_1	127	12	2080	930	2	117	14	32	3	2	1	0	13	2	0	0	0
9	cluster_1	215	96	2778	1110	4	198	1	5	0	0	0	0	21	0	0	0	0
14	cluster_1	244	22	2477	791	3	197	6	0	0	2	0	0	11	1	0	0	0
130	cluster_1	190	35	1640	1091	0	238	6	7	4	2	0	0	14	1	0	0	0
186	cluster_1	180	66	1723	623	0	175	9	7	0	0	0	0	5	0	0	0	0
203	cluster_1	169	9	1928	1106	0	167	9	5	4	0	0	0	18	0	2	1	0
77	cluster_1	289	254	2505	990	16	185	0	4	0	0	0	0	19	0	0	0	0
15	cluster_1	180	17	2370	1036	3	153	18	39	5	6	0	0	13	7	1	0	1
38	cluster_1	181	18	2068	939	1	210	1	32	4	1	1	0	11	1	0	0	0
64	cluster_1	226	54	3176	797	7	120	6	6	3	0	0	0	29	0	0	0	0
135	cluster_1	306	195	2428	1183	11	238	27	4	1	0	0	0	65	0	6	0	5

74	cluster_1	174	23	2966	774	2	127	0	9	4	0	0	0	2	0	0	0	0
60	cluster_1	187	19	2526	1276	0	128	15	1	1	1	0	0	5	1	0	0	0
205	cluster_1	170	15	2794	1435	22	10	5	7	1	17	0	0	1	9	0	0	0
192	cluster_1	187	13	2804	1030	3	174	1	8	4	0	0	0	9	0	0	0	0
136	cluster_1	236	126	2892	921	3	160	12	4	1	3	0	0	11	4	0	0	0
145	cluster_1	184	7	3202	872	0	90	11	1	1	0	0	0	10	0	0	0	0
66	cluster_1	268	23	3487	1278	2	87	9	8	1	0	0	0	14	0	0	0	0
54	cluster_1	185	26	3438	1199	15	222	3	6	0	0	0	0	2	0	0	0	0
70	cluster_1	208	53	3466	988	1	199	3	9	3	1	0	0	13	0	0	0	0
173	cluster_1	156	25	2409	1384	8	164	8	3	0	2	1	0	5	3	0	0	0
127	cluster_1	200	27	3202	926	0	322	9	13	4	0	0	0	41	0	0	0	0
11	cluster_1	187	6	2663	1164	3	91	2	6	7	0	0	0	25	0	0	0	0
174	cluster_1	251	90	2804	965	15	165	8	24	7	0	0	0	25	0	6	1	0
109	cluster_1	257	75	2598	1209	10	278	6	6	6	3	0	0	75	2	10	1	0
98	cluster_1	198	2	2244	1412	1	160	12	3	2	1	0	0	20	0	1	0	0
200	cluster_1	256	38	2397	1232	7	225	9	24	8	1	0	0	32	1	0	0	0
149	cluster_1	210	68	3297	1021	2	325	14	16	0	1	0	0	15	1	0	0	0
13	cluster_1	199	21	3501	1590	2	91	10	4	1	0	0	0	25	0	2	0	1
187	cluster_1	269	87	2957	1399	0	332	11	21	10	0	2	0	49	0	0	0	0
150	cluster_1	213	21	2889	1281	1	137	15	3	1	0	0	0	26	1	0	0	0
142	cluster_1	241	110	2510	1346	6	222	20	17	4	5	3	0	3	6	11	0	9
49	cluster_1	187	67	3710	1307	0	135	2	0	2	2	0	0	5	1	0	0	0
93	cluster_4	419	828	3205	2081	65	622	70	34	11	0	0	0	72	0	0	0	0
138	cluster_4	233	28	3293	1858	9	106	22	10	3	1	0	0	18	2	0	0	0
193	cluster_4	293	41	3033	1377	30	182	10	6	4	1	0	0	6	0	0	0	0

175	cluster_4	230	7	3514	1501	0	155	0	15	5	0	0	0	29	0	0	0	0
139	cluster_4	254	8	4004	1081	4	92	6	5	3	1	0	0	9	0	0	0	0
5	cluster_4	277	16	3242	999	6	191	23	139	13	2	1	0	18	1	1	0	1
1	cluster_4	265	84	2745	865	6	180	19	4	4	4	0	0	15	4	0	0	0
79	cluster_4	201	10	4388	1136	1	180	5	11	1	4	0	0	12	4	0	0	0
126	cluster_4	239	86	4716	1073	8	173	6	9	4	0	0	0	17	0	0	0	0
154	cluster_4	234	48	5092	970	8	130	1	2	0	0	0	0	25	0	0	0	0
58	cluster_4	186	27	4138	1268	0	157	4	2	1	0	0	0	14	0	0	0	0
104	cluster_4	337	174	3589	1522	15	384	104	35	17	3	0	0	100	3	1	1	1
184	cluster_4	256	26	3713	1602	2	349	6	4	2	0	0	0	22	0	0	0	0
85	cluster_4	217	11	5107	1535	13	240	12	3	2	1	0	0	8	1	0	0	0
147	cluster_4	331	231	3869	1859	8	306	8	9	6	0	3	0	61	0	0	0	0
122	cluster_4	313	254	3491	1557	18	502	10	10	6	3	0	0	57	2	10	1	0
160	cluster_4	242	31	5267	1051	4	179	24	19	7	7	0	0	14	6	0	0	0
158	cluster_2	236	14	5349	1828	5	236	33	10	8	2	0	0	19	2	0	0	0
195	cluster_2	304	43	4001	1501	6	215	8	10	5	0	0	0	64	0	0	0	0
163	cluster_2	251	72	5990	1832	3	313	3	0	1	0	0	0	49	0	0	0	0
80	cluster_2	187	10	5771	2152	5	103	1	2	0	2	0	0	6	2	0	0	0

Table 7 12 – Support Confidence Laplace Gain P-s Lift and conviction of the attributes

No	Premison	Conclusion	Support	Confidence	Laplace	Gain	P-S	Lift	Conviction
14	'course_viewed', 'report_viewed'	mdl_logstore_standard_log, 'course_module_viewed'	0.281	0.825	0.956	- 0.400	0.145	2.063	3.429
15	mdl_logstore_standard_log, 'report_viewed'	'course_viewed', 'blog_entries_viewed'	0.285	0.827	0.956	- 0.404	0.165	2.371	3.767
16	mdl_logstore_standard_log, 'course_viewed', 'blog_entries_viewed'	'report_viewed'	0.285	0.838	0.959	- 0.396	0.139	1.949	3.509

17	'course_viewed', 'report_viewed'	mdl_logstore_standard_log, 'blog_entries_viewed'	0.285	0.838	0.959	- 0.39 6	0.15 8	2.23 7	3.849
18	mdl_question_attempt_steps	mdl_quiz_attempts	0.421	0.839	0.946	- 0.58 3	0.19 5	1.86 0	3.409
19	mdl_quiz_attempts	mdl_question_attempt_steps, 'attempt_viewed'	0.379	0.840	0.950	- 0.52 3	0.18 1	1.91 6	3.502
20	mdl_question_attempt_steps, 'course_module_viewed'	'course_viewed'	0.294	0.841	0.959	- 0.40 4	0.11 8	1.67 6	3.140
21	'course_viewed', 'blog_entries_viewed'	'report_viewed'	0.294	0.841	0.959	- 0.40 4	0.14 4	1.95 8	3.597
22	'blog_entries_viewed', 'report_viewed'	'course_viewed'	0.294	0.841	0.959	- 0.40 4	0.11 8	1.67 6	3.140
23	mdl_logstore_standard_log, 'course_viewed'	'course_module_viewed'	0.396	0.845	0.951	- 0.54 0	0.16 1	1.68 4	3.222
24	mdl_logstore_standard_log, 'course_viewed', 'report_viewed'	'course_module_viewed'	0.281	0.846	0.962	- 0.38 3	0.11 4	1.68 5	3.236
25	'course_module_viewed'	'course_viewed'	0.426	0.847	0.949	- 0.57 9	0.17 3	1.68 8	3.264
26	'course_viewed'	'course_module_viewed'	0.426	0.847	0.949	- 0.57 9	0.17 3	1.68 8	3.264
27	mdl_stats_user_daily, 'attempt_viewed'	mdl_quiz_attempts	0.285	0.848	0.962	- 0.38 7	0.13 3	1.88 0	3.614
28	'course_viewed', 'report_viewed'	'course_module_viewed'	0.289	0.850	0.962	- 0.39 1	0.11 8	1.69 3	3.319
29	'blog_entries_viewed', 'report_viewed'	mdl_logstore_standard_log	0.298	0.854	0.962	- 0.40 0	0.12 3	1.70 0	3.402
30	'course_viewed', 'blog_entries_viewed'	mdl_logstore_standard_log, 'course_module_viewed'	0.298	0.854	0.962	- 0.40 0	0.15 8	2.13 4	4.100
31	mdl_logstore_standard_log, 'course_viewed', 'report_viewed'	'blog_entries_viewed'	0.285	0.859	0.965	- 0.37 9	0.12 4	1.77 1	3.651
32	'course_viewed', 'report_viewed'	'blog_entries_viewed'	0.294	0.863	0.965	- 0.38 7	0.12 8	1.77 8	3.745
33	mdl_question_attempt_steps, 'attempt_viewed'	mdl_quiz_attempts	0.379	0.864	0.959	- 0.49 8	0.18 1	1.91 6	4.039
34	mdl_logstore_standard_log, 'report_viewed'	'blog_entries_viewed'	0.298	0.864	0.965	- 0.39 1	0.13 1	1.78 1	3.791
35	'course_module_viewed', 'attempt_viewed'	'course_viewed'	0.298	0.864	0.965	- 0.39 1	0.12 5	1.72 1	3.666
36	mdl_stats_user_daily, mdl_quiz_attempts	mdl_question_attempt_steps, 'attempt_viewed'	0.272	0.865	0.968	- 0.35 7	0.13 4	1.97 3	4.157
37	'course_module_viewed', mdl_quiz_attempts	mdl_question_attempt_steps, 'attempt_viewed'	0.277	0.867	0.968	- 0.36 2	0.13 7	1.97 7	4.213
38	mdl_quiz_attempts	'attempt_viewed'	0.391	0.868	0.959	- 0.51 1	0.16 7	1.74 3	3.802
39	mdl_question_attempt_steps	'attempt_viewed'	0.438	0.873	0.958	- 0.56 6	0.18 8	1.75 3	3.950

40	mdl_logstore_standard_log, 'course_viewed', 'blog_entries_viewed'	'course_module_viewed'	0.298	0.875	0.968	-0.383	0.127	1.743	3.983
41	mdl_question_attempt_steps, mdl_stats_user_daily	mdl_quiz_attempts	0.302	0.877	0.968	-0.387	0.147	1.943	4.446
42	mdl_question_attempt_steps, 'course_module_viewed'	mdl_quiz_attempts	0.306	0.878	0.968	-0.391	0.149	1.947	4.501
43	'course_viewed', 'blog_entries_viewed'	'course_module_viewed'	0.306	0.878	0.968	-0.391	0.131	1.749	4.083
44	mdl_stats_user_daily, 'user_login_failed'	'dashboard_viewed'	0.277	0.878	0.971	-0.353	0.118	1.749	4.094
45	mdl_question_attempt_steps, 'course_module_viewed', 'attempt_viewed'	mdl_quiz_attempts	0.277	0.878	0.971	-0.353	0.135	1.947	4.513
46	'course_viewed', 'attempt_viewed'	mdl_question_attempt_steps	0.281	0.880	0.971	-0.357	0.121	1.753	4.149
47	'course_module_viewed', mdl_quiz_attempts	'attempt_viewed'	0.281	0.880	0.971	-0.357	0.122	1.768	4.184
48	'course_viewed', 'attempt_viewed'	mdl_logstore_standard_log, 'course_module_viewed'	0.281	0.880	0.971	-0.357	0.153	2.200	5.000
49	'attempt_viewed'	mdl_question_attempt_steps	0.438	0.880	0.960	-0.557	0.188	1.753	4.161
50	mdl_question_attempt_steps, mdl_stats_user_daily	'attempt_viewed'	0.306	0.889	0.972	-0.383	0.135	1.785	4.519
51	mdl_question_attempt_steps, mdl_stats_user_daily, 'attempt_viewed'	mdl_quiz_attempts	0.272	0.889	0.974	-0.340	0.134	1.971	4.940
52	mdl_question_attempt_steps, 'course_viewed'	mdl_logstore_standard_log, 'course_module_viewed'	0.277	0.890	0.974	-0.345	0.152	2.226	5.475
53	'message_sent'	'message_viewed'	0.328	0.895	0.972	-0.404	0.181	2.238	5.733
54	'course_module_viewed', 'blog_entries_viewed'	mdl_logstore_standard_log, 'course_viewed'	0.298	0.897	0.974	-0.366	0.143	1.917	5.186
55	mdl_question_attempt_steps, mdl_quiz_attempts	'attempt_viewed'	0.379	0.899	0.970	-0.464	0.169	1.806	4.971
56	mdl_question_attempt_steps, mdl_stats_user_daily, mdl_quiz_attempts	'attempt_viewed'	0.272	0.901	0.977	-0.332	0.122	1.811	5.093
57	mdl_question_attempt_steps, 'course_module_viewed'	'attempt_viewed'	0.315	0.902	0.975	-0.383	0.141	1.813	5.147
58	mdl_question_attempt_steps, 'course_module_viewed', mdl_quiz_attempts	'attempt_viewed'	0.277	0.903	0.977	-0.336	0.124	1.813	5.165
59	mdl_logstore_standard_log, 'attempt_viewed'	'course_module_viewed'	0.281	0.904	0.977	-0.340	0.125	1.801	5.192
60	'course_module_viewed', 'report_viewed'	mdl_logstore_standard_log	0.281	0.904	0.977	-0.340	0.125	1.801	5.192
61	mdl_question_attempt_steps, 'course_viewed'	'attempt_viewed'	0.281	0.904	0.977	-0.340	0.126	1.816	5.236

62	mdl_logstore_standard_log, 'attempt_viewed'	'course_module_viewed', 'course_viewed'	0.281	0.904	0.977	- 0.34 0	0.14 9	2.12 5	5.991
63	'course_module_viewed', 'report_viewed'	mdl_logstore_standard_log, 'course_viewed'	0.281	0.904	0.977	- 0.34 0	0.13 5	1.93 2	5.547
64	mdl_stats_user_daily, mdl_quiz_attempts	'attempt_viewed'	0.285	0.905	0.977	- 0.34 5	0.12 8	1.81 9	5.308
65	mdl_logstore_standard_log, 'blog_entries_viewed'	'course_viewed'	0.340	0.909	0.975	- 0.40 9	0.15 2	1.81 0	5.477
66	'course_module_viewed', 'blog_entries_viewed'	mdl_logstore_standard_log	0.302	0.910	0.978	- 0.36 2	0.13 5	1.81 3	5.548
67	mdl_stats_user_daily, 'attempt_viewed'	mdl_question_attempt_steps	0.306	0.911	0.978	- 0.36 6	0.13 8	1.81 5	5.619
68	'course_module_viewed', 'attempt_viewed'	mdl_question_attempt_steps	0.315	0.914	0.978	- 0.37 4	0.14 2	1.81 9	5.761
69	'course_module_viewed', 'blog_entries_viewed'	'course_viewed'	0.306	0.923	0.981	- 0.35 7	0.14 0	1.83 8	6.472
70	mdl_logstore_standard_log, mdl_question_attempt_steps	'course_module_viewed'	0.277	0.929	0.984	- 0.31 9	0.12 7	1.84 9	6.970
71	mdl_logstore_standard_log, mdl_question_attempt_steps	'course_module_viewed', 'course_viewed'	0.277	0.929	0.984	- 0.31 9	0.15 0	2.18 2	8.043
72	mdl_logstore_standard_log, 'course_viewed', 'attempt_viewed'	'course_module_viewed'	0.281	0.930	0.984	- 0.32 3	0.12 9	1.85 1	7.070
73	'course_module_viewed', 'course_viewed'	mdl_logstore_standard_log	0.396	0.930	0.979	- 0.45 5	0.18 2	1.85 2	7.112
74	'course_module_viewed', 'report_viewed'	'course_viewed'	0.289	0.932	0.984	- 0.33 2	0.13 3	1.85 5	7.269
75	mdl_logstore_standard_log	'course_viewed'	0.468	0.932	0.977	- 0.53 6	0.21 6	1.85 7	7.344
76	'course_viewed'	mdl_logstore_standard_log	0.468	0.932	0.977	- 0.53 6	0.21 6	1.85 7	7.344
77	'course_viewed', 'attempt_viewed'	'course_module_viewed'	0.298	0.933	0.984	- 0.34 0	0.13 8	1.85 9	7.468
78	mdl_quiz_attempts	mdl_question_attempt_steps	0.421	0.934	0.979	- 0.48 1	0.19 5	1.86 0	7.539
79	mdl_logstore_standard_log, mdl_question_attempt_steps, 'course_viewed'	'course_module_viewed'	0.277	0.942	0.987	- 0.31 1	0.12 9	1.87 6	8.588
80	mdl_question_attempt_steps, 'course_module_viewed', 'course_viewed'	mdl_logstore_standard_log	0.277	0.942	0.987	- 0.31 1	0.12 9	1.87 6	8.588
81	'course_module_viewed', 'course_viewed', 'attempt_viewed'	mdl_logstore_standard_log	0.281	0.943	0.987	- 0.31 5	0.13 1	1.87 8	8.713
82	mdl_logstore_standard_log, 'user_profile_viewed'	'course_viewed'	0.285	0.944	0.987	- 0.31 9	0.13 3	1.87 9	8.837
83	mdl_question_attempt_steps, 'course_viewed'	mdl_logstore_standard_log	0.294	0.945	0.987	- 0.32 8	0.13 8	1.88 2	9.086

84	mdl_question_attempt_steps, 'course_viewed'	'course_module_viewed'	0.294	0.945	0.987	- 0.328	0.138	1.882	9.086
85	'course_viewed', 'attempt_viewed'	mdl_logstore_standard_log	0.302	0.947	0.987	- 0.336	0.142	1.885	9.335
86	mdl_stats_user_daily, 'attempt_viewed', mdl_quiz_attempts	mdl_question_attempt_steps	0.272	0.955	0.990	- 0.298	0.129	1.902	11.119
87	'course_viewed', 'user_profile_viewed'	mdl_logstore_standard_log	0.285	0.957	0.990	- 0.311	0.136	1.906	11.617
88	mdl_logstore_standard_log, 'blog_entries_viewed', 'report_viewed'	'course_viewed'	0.285	0.957	0.990	- 0.311	0.136	1.906	11.617
89	mdl_stats_user_daily, mdl_quiz_attempts	mdl_question_attempt_steps	0.302	0.959	0.990	- 0.328	0.144	1.911	12.281
90	'course_module_viewed', mdl_quiz_attempts	mdl_question_attempt_steps	0.306	0.960	0.990	- 0.332	0.146	1.912	12.447
91	mdl_logstore_standard_log, 'report_viewed'	'course_viewed'	0.332	0.963	0.991	- 0.357	0.159	1.918	13.443
92	'attempt_viewed', mdl_quiz_attempts	mdl_question_attempt_steps	0.379	0.967	0.991	- 0.404	0.182	1.927	15.268
93	'course_module_viewed', 'course_viewed', 'report_viewed'	mdl_logstore_standard_log	0.281	0.971	0.993	- 0.298	0.136	1.933	16.928
94	'course_viewed', 'blog_entries_viewed', 'report_viewed'	mdl_logstore_standard_log	0.285	0.971	0.993	- 0.302	0.138	1.934	17.177
95	'course_module_viewed', 'course_viewed', 'blog_entries_viewed'	mdl_logstore_standard_log	0.298	0.972	0.993	- 0.315	0.144	1.936	17.923
96	mdl_logstore_standard_log, 'attempt_viewed'	'course_viewed'	0.302	0.973	0.994	- 0.319	0.146	1.937	18.172
97	'course_viewed', 'report_viewed'	mdl_logstore_standard_log	0.332	0.975	0.994	- 0.349	0.161	1.942	19.915
98	'course_viewed', 'blog_entries_viewed'	mdl_logstore_standard_log	0.340	0.976	0.994	- 0.357	0.165	1.943	20.413
99	'course_module_viewed', 'attempt_viewed', mdl_quiz_attempts	mdl_question_attempt_steps	0.277	0.985	0.997	- 0.285	0.136	1.961	32.860
100	mdl_logstore_standard_log, mdl_question_attempt_steps	'course_viewed'	0.294	0.986	0.997	- 0.302	0.144	1.963	34.851
101	mdl_logstore_standard_log, 'course_module_viewed', 'blog_entries_viewed'	'course_viewed'	0.298	0.986	0.997	- 0.306	0.146	1.963	35.349
102	mdl_logstore_standard_log, 'course_module_viewed'	'course_viewed'	0.396	0.989	0.997	- 0.404	0.195	1.970	46.800
103	mdl_logstore_standard_log, mdl_question_attempt_steps, 'course_module_viewed'	'course_viewed'	0.277	1.000	1.000	- 0.277	0.138	1.992	Infinity
104	mdl_logstore_standard_log, 'course_module_viewed', 'attempt_viewed'	'course_viewed'	0.281	1.000	1.000	- 0.281	0.140	1.992	Infinity

10 5	mdl_logstore_standard_log, 'course_module_viewed', 'report_viewed'	'course_viewed'	0.281	1.000	1.000	- 0.28 1	0.14 0	1.99 2	Infinity
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Table 7.13 – Association rule mining patterns of the attributes AssociationRules

['report_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.802)
['course_module_viewed', 'attempt_viewed'] --> [mdl_question_attempt_steps, mdl_quiz_attempts] (confidence: 0.802)
[mdl_logstore_standard_log, 'blog_entries_viewed'] --> ['course_module_viewed'] (confidence: 0.807)
[mdl_stats_user_daily, 'attempt_viewed'] --> [mdl_question_attempt_steps, mdl_quiz_attempts] (confidence: 0.810)
['report_viewed'] --> ['blog_entries_viewed'] (confidence: 0.812)
['course_module_viewed', 'attempt_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.815)
[mdl_logstore_standard_log, 'report_viewed'] --> ['course_module_viewed'] (confidence: 0.815)
['course_module_viewed', 'attempt_viewed'] --> [mdl_quiz_attempts] (confidence: 0.815)
['course_module_viewed', 'attempt_viewed'] --> [mdl_logstore_standard_log, 'course_viewed'] (confidence: 0.815)
[mdl_logstore_standard_log, 'report_viewed'] --> ['course_module_viewed', 'course_viewed'] (confidence: 0.815)
['course_viewed', 'blog_entries_viewed'] --> [mdl_logstore_standard_log, 'report_viewed'] (confidence: 0.817)
['blog_entries_viewed', 'report_viewed'] --> [mdl_logstore_standard_log, 'course_viewed'] (confidence: 0.817)
['message_viewed'] --> ['message_sent'] (confidence: 0.819)
['course_viewed', 'report_viewed'] --> [mdl_logstore_standard_log, 'course_module_viewed'] (confidence: 0.825)
[mdl_logstore_standard_log, 'report_viewed'] --> ['course_viewed', 'blog_entries_viewed'] (confidence: 0.827)
[mdl_logstore_standard_log, 'course_viewed', 'blog_entries_viewed'] --> ['report_viewed'] (confidence: 0.838)
['course_viewed', 'report_viewed'] --> [mdl_logstore_standard_log, 'blog_entries_viewed'] (confidence: 0.838)
[mdl_question_attempt_steps] --> [mdl_quiz_attempts] (confidence: 0.839)
[mdl_quiz_attempts] --> [mdl_question_attempt_steps, 'attempt_viewed'] (confidence: 0.840)
[mdl_question_attempt_steps, 'course_module_viewed'] --> ['course_viewed'] (confidence: 0.841)
['course_viewed', 'blog_entries_viewed'] --> ['report_viewed'] (confidence: 0.841)
['blog_entries_viewed', 'report_viewed'] --> ['course_viewed'] (confidence: 0.841)
[mdl_logstore_standard_log, 'course_viewed'] --> ['course_module_viewed'] (confidence: 0.845)
[mdl_logstore_standard_log, 'course_viewed', 'report_viewed'] --> ['course_module_viewed'] (confidence: 0.846)
['course_module_viewed'] --> ['course_viewed'] (confidence: 0.847)
['course_viewed'] --> ['course_module_viewed'] (confidence: 0.847)
[mdl_stats_user_daily, 'attempt_viewed'] --> [mdl_quiz_attempts] (confidence: 0.848)
['course_viewed', 'report_viewed'] --> ['course_module_viewed'] (confidence: 0.850)
['blog_entries_viewed', 'report_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.854)
['course_viewed', 'blog_entries_viewed'] --> [mdl_logstore_standard_log, 'course_module_viewed'] (confidence: 0.854)
[mdl_logstore_standard_log, 'course_viewed', 'report_viewed'] --> ['blog_entries_viewed'] (confidence: 0.859)
['course_viewed', 'report_viewed'] --> ['blog_entries_viewed'] (confidence: 0.863)
[mdl_question_attempt_steps, 'attempt_viewed'] --> [mdl_quiz_attempts] (confidence: 0.864)
[mdl_logstore_standard_log, 'report_viewed'] --> ['blog_entries_viewed'] (confidence: 0.864)
['course_module_viewed', 'attempt_viewed'] --> ['course_viewed'] (confidence: 0.864)
[mdl_stats_user_daily, mdl_quiz_attempts] --> [mdl_question_attempt_steps, 'attempt_viewed'] (confidence: 0.865)
['course_module_viewed', mdl_quiz_attempts] --> [mdl_question_attempt_steps, 'attempt_viewed'] (confidence: 0.867)
[mdl_quiz_attempts] --> ['attempt_viewed'] (confidence: 0.868)
[mdl_question_attempt_steps] --> ['attempt_viewed'] (confidence: 0.873)
[mdl_logstore_standard_log, 'course_viewed', 'blog_entries_viewed'] --> ['course_module_viewed'] (confidence: 0.875)
[mdl_question_attempt_steps, mdl_stats_user_daily] --> [mdl_quiz_attempts] (confidence: 0.877)
[mdl_question_attempt_steps, 'course_module_viewed'] --> [mdl_quiz_attempts] (confidence: 0.878)
['course_viewed', 'blog_entries_viewed'] --> ['course_module_viewed'] (confidence: 0.878)
[mdl_stats_user_daily, 'user_login_failed'] --> ['dashboard_viewed'] (confidence: 0.878)
[mdl_question_attempt_steps, 'course_module_viewed', 'attempt_viewed'] --> [mdl_quiz_attempts] (confidence: 0.878)
['course_viewed', 'attempt_viewed'] --> [mdl_question_attempt_steps] (confidence: 0.880)
['course_module_viewed', mdl_quiz_attempts] --> ['attempt_viewed'] (confidence: 0.880)
['course_viewed', 'attempt_viewed'] --> [mdl_logstore_standard_log, 'course_module_viewed'] (confidence: 0.880)
['attempt_viewed'] --> [mdl_question_attempt_steps] (confidence: 0.880)
[mdl_question_attempt_steps, mdl_stats_user_daily] --> ['attempt_viewed'] (confidence: 0.889)
[mdl_question_attempt_steps, mdl_stats_user_daily, 'attempt_viewed'] --> [mdl_quiz_attempts] (confidence: 0.889)
[mdl_question_attempt_steps, 'course_viewed'] --> [mdl_logstore_standard_log, 'course_module_viewed'] (confidence: 0.890)
['message_sent'] --> ['message_viewed'] (confidence: 0.895)
['course_module_viewed', 'blog_entries_viewed'] --> [mdl_logstore_standard_log, 'course_viewed'] (confidence: 0.897)
[mdl_question_attempt_steps, mdl_quiz_attempts] --> ['attempt_viewed'] (confidence: 0.899)
[mdl_question_attempt_steps, mdl_stats_user_daily, mdl_quiz_attempts] --> ['attempt_viewed'] (confidence: 0.901)
[mdl_question_attempt_steps, 'course_module_viewed'] --> ['attempt_viewed'] (confidence: 0.902)
[mdl_question_attempt_steps, 'course_module_viewed', mdl_quiz_attempts] --> ['attempt_viewed'] (confidence: 0.903)
[mdl_logstore_standard_log, 'attempt_viewed'] --> ['course_module_viewed'] (confidence: 0.904)

['course_module_viewed', 'report_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.904)
[mdl_question_attempt_steps, 'course_viewed'] --> ['attempt_viewed'] (confidence: 0.904)
[mdl_logstore_standard_log, 'attempt_viewed'] --> ['course_module_viewed', 'course_viewed'] (confidence: 0.904)
['course_module_viewed', 'report_viewed'] --> [mdl_logstore_standard_log, 'course_viewed'] (confidence: 0.904)
[mdl_stats_user_daily, mdl_quiz_attempts] --> ['attempt_viewed'] (confidence: 0.905)
[mdl_logstore_standard_log, 'blog_entries_viewed'] --> ['course_viewed'] (confidence: 0.909)
['course_module_viewed', 'blog_entries_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.910)
[mdl_stats_user_daily, 'attempt_viewed'] --> [mdl_question_attempt_steps] (confidence: 0.911)
['course_module_viewed', 'attempt_viewed'] --> [mdl_question_attempt_steps] (confidence: 0.914)
['course_module_viewed', 'blog_entries_viewed'] --> ['course_viewed'] (confidence: 0.923)
[mdl_logstore_standard_log, mdl_question_attempt_steps] --> ['course_module_viewed'] (confidence: 0.929)
[mdl_logstore_standard_log, mdl_question_attempt_steps] --> ['course_module_viewed', 'course_viewed'] (confidence: 0.929)
[mdl_logstore_standard_log, 'course_viewed', 'attempt_viewed'] --> ['course_module_viewed'] (confidence: 0.930)
['course_module_viewed', 'course_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.930)
['course_module_viewed', 'report_viewed'] --> ['course_viewed'] (confidence: 0.932)
[mdl_logstore_standard_log] --> ['course_viewed'] (confidence: 0.932)
['course_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.932)
['course_viewed', 'attempt_viewed'] --> ['course_module_viewed'] (confidence: 0.933)
[mdl_quiz_attempts] --> [mdl_question_attempt_steps] (confidence: 0.934)
[mdl_logstore_standard_log, mdl_question_attempt_steps, 'course_viewed'] --> ['course_module_viewed'] (confidence: 0.942)
[mdl_question_attempt_steps, 'course_module_viewed', 'course_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.942)
['course_module_viewed', 'course_viewed', 'attempt_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.943)
[mdl_logstore_standard_log, 'user_profile_viewed'] --> ['course_viewed'] (confidence: 0.944)
[mdl_question_attempt_steps, 'course_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.945)
[mdl_question_attempt_steps, 'course_viewed'] --> ['course_module_viewed'] (confidence: 0.945)
['course_viewed', 'attempt_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.947)
[mdl_stats_user_daily, 'attempt_viewed', mdl_quiz_attempts] --> [mdl_question_attempt_steps] (confidence: 0.955)
['course_viewed', 'user_profile_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.957)
[mdl_logstore_standard_log, 'blog_entries_viewed', 'report_viewed'] --> ['course_viewed'] (confidence: 0.957)
[mdl_stats_user_daily, mdl_quiz_attempts] --> [mdl_question_attempt_steps] (confidence: 0.959)
['course_module_viewed', mdl_quiz_attempts] --> [mdl_question_attempt_steps] (confidence: 0.960)
[mdl_logstore_standard_log, 'report_viewed'] --> ['course_viewed'] (confidence: 0.963)
['attempt_viewed', mdl_quiz_attempts] --> [mdl_question_attempt_steps] (confidence: 0.967)
['course_module_viewed', 'course_viewed', 'report_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.971)
['course_viewed', 'blog_entries_viewed', 'report_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.971)
['course_module_viewed', 'course_viewed', 'blog_entries_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.972)
[mdl_logstore_standard_log, 'attempt_viewed'] --> ['course_viewed'] (confidence: 0.973)
['course_viewed', 'report_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.975)
['course_viewed', 'blog_entries_viewed'] --> [mdl_logstore_standard_log] (confidence: 0.976)
['course_module_viewed', 'attempt_viewed', mdl_quiz_attempts] --> [mdl_question_attempt_steps] (confidence: 0.985)
[mdl_logstore_standard_log, mdl_question_attempt_steps] --> ['course_viewed'] (confidence: 0.986)
[mdl_logstore_standard_log, 'course_module_viewed', 'blog_entries_viewed'] --> ['course_viewed'] (confidence: 0.986)
... 5 other rules ...

Table 7.13 – Association rule mining patterns of the attributs

I

Sample row data

The researcher peruses 405 number of log tables in the Moodle Learning Management System (LMS) some of the data tables noted below.

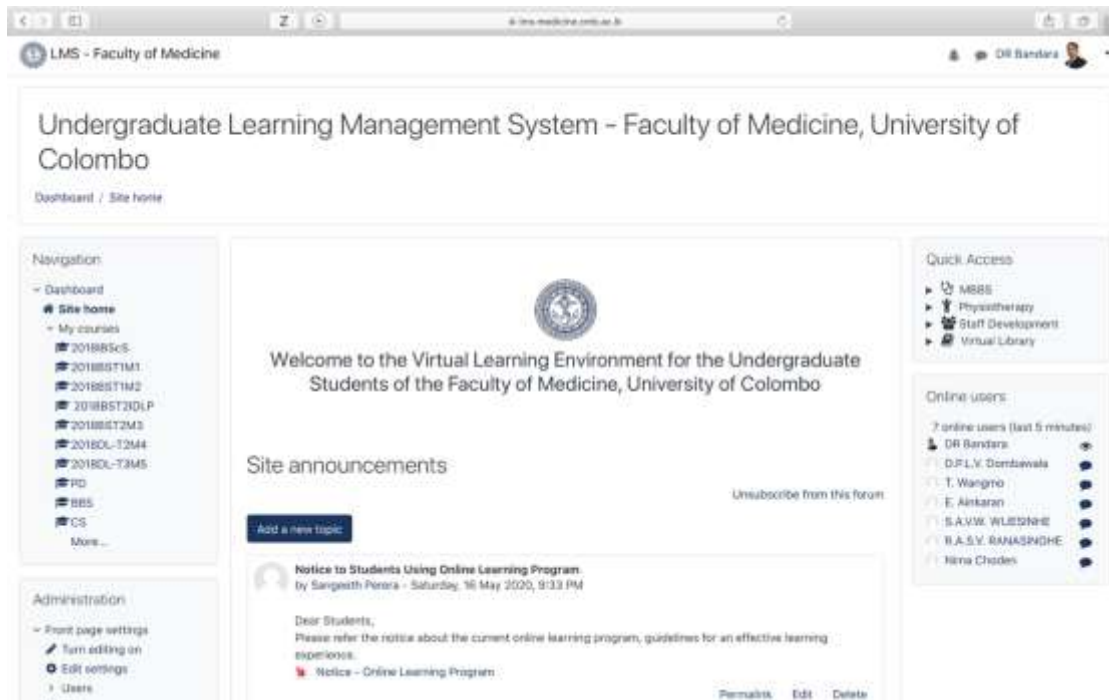
I d	Eventname	componenent	action	target	objecttable	Objectid	userid	edulevel	contentid	contextid	username	courseid	relateduserid	anonymous	Other	timecreated	origin	ip	realuserid			
1	\core\event\user_loggedi	co	logg	user	user	2	r	0	1	0	0	2	0	N	U	0	a:1:{s:8:"username";s:5:"admin";}	155512	w	175.157.	N	U

			s
report_loglive	resumed	course_backup	forum_discusstions
report_stats	reviewed	course_bin_item	forum_posts
tool_usertours	searched	course_category	forum_subscriptions
	sent	course_content	grade_Grades
	shown	course_information	Grade_items
	started	course_module	Groups
	submitted	course_module_completion	Imscp
	unassigned	course_module_instance_list	Lesson
	undated	course_resources_list	Llesson_pages
	uploaded	course_section	message_contacts
	viewed	course_user_report	message_user_actions
		courses	message_users_blocked
		dashboard	Messages
		discussion	Notification
		discusstion_subscription	Null
		edit_page	Page
		email	Question
		enrol_instance	Quiz
		grade_report	quiz_attempts
		group	Resource
		lesson	Role
		message	role_capabilities
		message_contact	Survey
		message_user	tool_recyclebin_category
		motification	tool_recyclebin_course
		post	tool_usertours_steps
		question	tool_usertours_tours
		recent_activity	url
		report	user
		role	user_enrolments
		step	
		submission_status	
		subscription	
		tour	
		user	
		user_enrolment	

			user_list	
			User_login	
			User_password	
			User_profile	
			User_report	
			webservice_function	
			webservice_login	
			webservice_token	

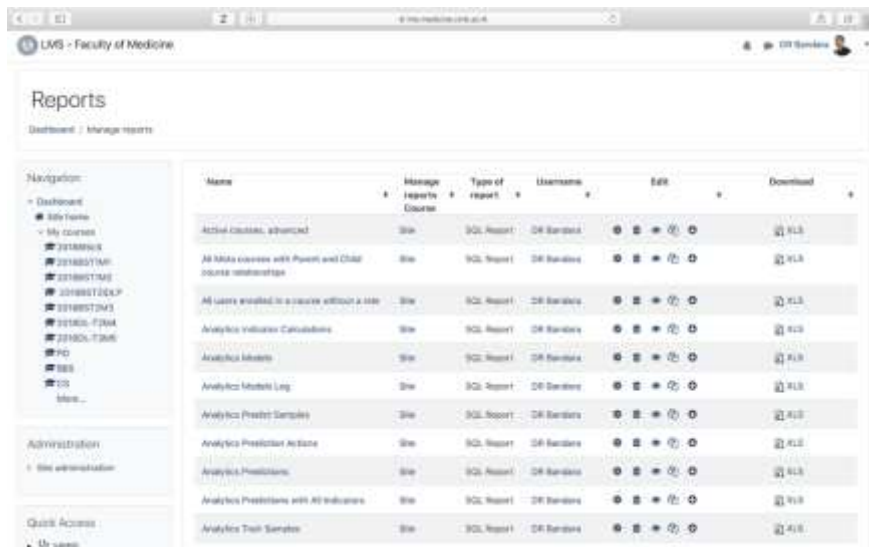
Appendixes – B

Main login dashboard of the undergraduate Learning Management System for the Faculty of Medicine, University of Colombo is mentioned below.

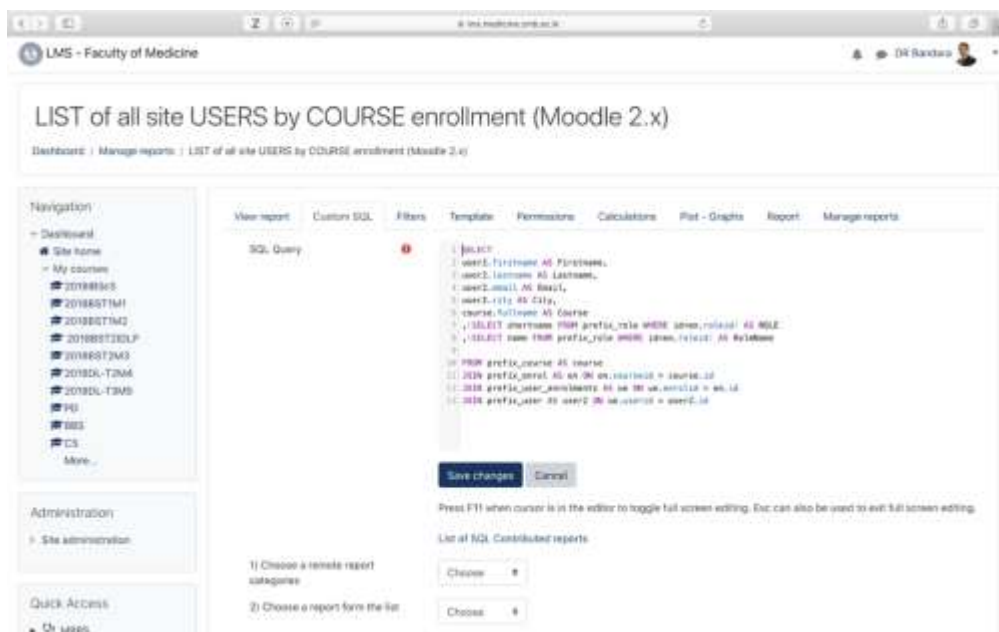


Main login dashboard of the undergraduate Learning Management System

The research created several SQL queries on the live LMS environment to develop required log tables and some of which are mentioned follows.



Main login dashboard of the undergraduate Learning Management System for the Faculty of Medicine, University of Colombo is mentioned follows



Main login dashboard of the undergraduate Learning Management System for the Faculty of Medicine, University of Colombo is mentioned follows

Appendixes – C

The researcher developed a dataset by writing queries using the Structured Query Language (SQL) to the published Moodle database. The executed SQL queries to develop the dataset is shown in Code Snippet 4.0.

The SQL Query executed to prepare research data set

```
select id as user,
(SELECT COUNT(userid) FROM
mdl_stats_user_daily where userid=user ) as
'mdl_stats_user_daily',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%dashboard_viewed') as
'dashboard_viewed',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%course_viewed') as
'course_viewed',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%course_module_viewed') as
'course_module_viewed',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%course_category_viewed') as
'course_category_viewed',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%content_page_viewed') as
'content_page_viewed',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%attempt_viewed') as
'attempt_viewed',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%user_profile_viewed') as
'user_profile_viewed',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%report_viewed') as
'report_viewed',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%blog_entries_viewed') as
'blog_entries_viewed',
```

```

(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%message_viewed') as
'message_viewed',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%notification_viewed') as
'notification_viewed',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%question_viewed') as
'question_viewed',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%discussion_viewed') as
'discussion_viewed',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%message_sent') as 'message_sent',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%notification_sent') as
'notification_sent',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%discussion_created') as
'discussion_created',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%message_contact_added') as
'message_contact_added',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%user_password_updated') as
'user_password_updated',
(SELECT COUNT(userid) FROM
mdl_forum_discussions where userid=user ) as
'mdl_forum_discussions',
(SELECT COUNT(userid) FROM
mdl_chat_messages where userid=user ) as
'mdl_chat_messages',
(SELECT COUNT(userid) FROM
mdl_question_attempt_steps where userid=user ) as
'mdl_question_attempt_steps',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%question_answered') as
'question_answered',

```

```

(SELECT COUNT(userid) FROM
mdl_quiz_attempts where userid=user ) as
'mdl_quiz_attempts',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%assignment_submissions') as
'assignment_submissions',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%email_failed') as 'email_failed',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%user_login_failed') as
'user_login_failed',
(select count(userid) from
mdl_logstore_standard_log where userid=user and
eventname like '%webservice_login_failed') as
'webservice_login_failed',
(SELECT COUNT(userid) FROM
mdl_logstore_standard_log where userid=user ) as
'mdl_logstore_standard_log'
FROM mdl_user ORDER BY `user` ASC

```

Code Snippet 4.0 - The SQL Query executed to prepare research Data set

