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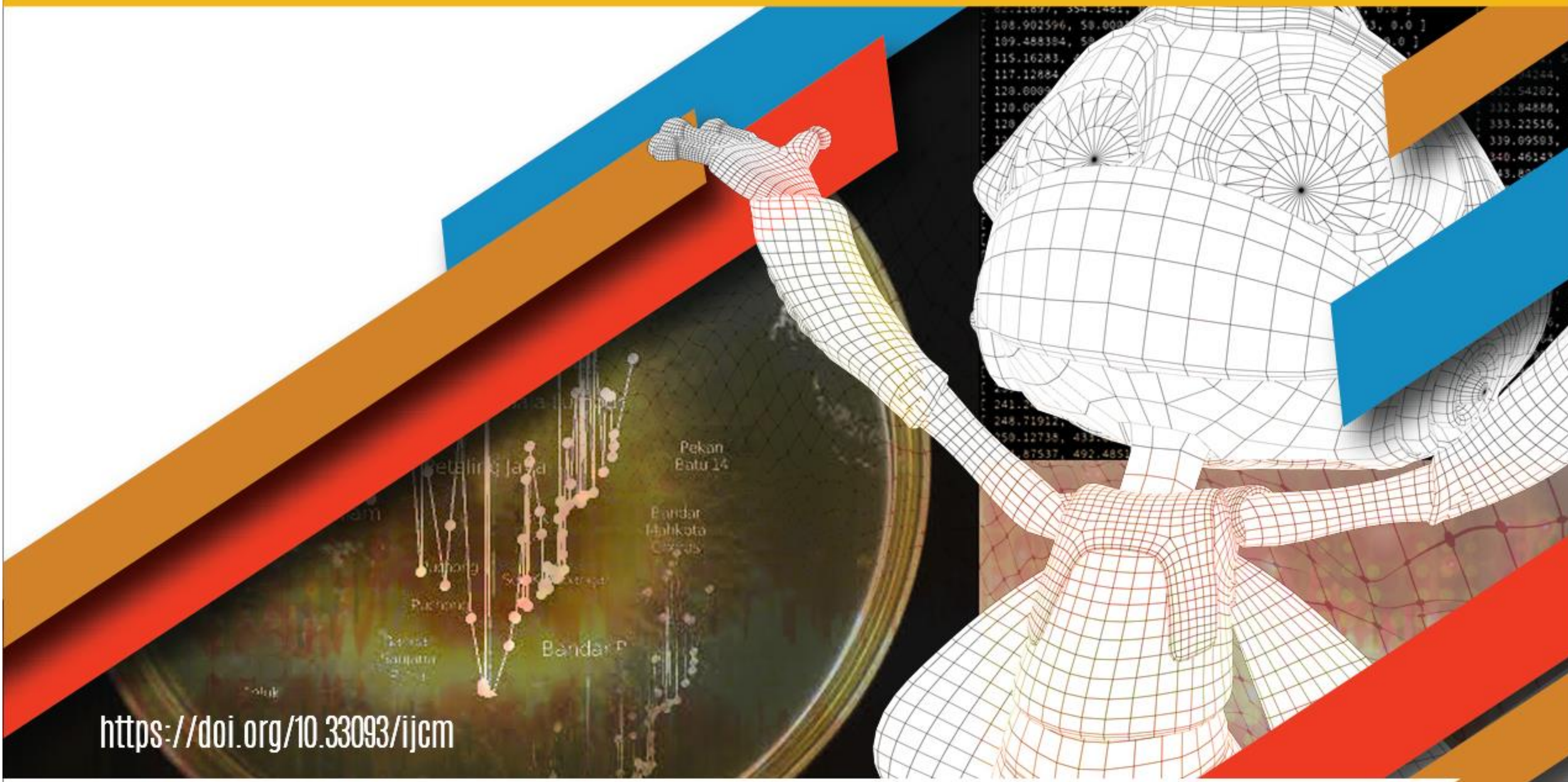

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International Journal of Creative Multimedia

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Aim and Scope

The International Journal of Creative Multimedia (IJCM) is a peer-reviewed open-access journal devoted to publish research papers in all fields of creative multimedia, including Digital Learning, Film & Animation, Media, Arts & Technology and Visual Design & Communication. It aims to provide an international forum for the exchange of ideas and findings from researchers across different cultures, and encourages research on the impact of social, cultural and technological factors on creative multimedia theory and practice. It also seeks to promote the transfer of knowledge between professionals in academia and industry by emphasising research where results are of interest or applicable to creative multimedia practices. We welcome all kinds of papers that connect academic researches with practical and industrial context in the field of creative multimedia. The scope of the IJCM is in the broad areas of Creative Multimedia following the five major thematic streams, includes but not limited to:

- Digital Learning
- Media, Arts & Technology
- Games and Virtual Reality
- Cinema and Film Studies
- Animation and Visual Effects
- Visual Design and Communication

Foreword from Digital Learning Editorial Team

Greetings from the Editors and welcome to the Special Issue on Digital Learning in the 21st century. In this Issue, we present papers from international and local researchers focusing on research papers in areas of education technology, learning analytics, e-learning, engineering, IT, business and management, creative multimedia and many other domains that seek to improve the learning process of the learner with technologies. These papers were presented in the ELITE 2019 International Conference held in Multimedia University, Cyberjaya, Malaysia on October 2, 2019, in conjunction with the 2019 IDE4TE International Exhibition on Oct 1, 2019. Themed, “Empowering Learning, Innovating Teaching Environments”, this event showcased best practices of Malaysian Universities, particularly from the network of Industry Driven Education Alliance (GLU iDE4) comprising of Universiti Teknologi Petronas (UTP), Universiti Multimedia (MMU), Universiti Tenaga Nasional (UNITEN) and Universiti Kuala Lumpur (UniKL), as well as from international presenters from China, India, Bangladesh and Maldives.

The papers presented in this Special Issue centred around 5 sub-themes; 1) Innovative Pedagogies & Instructional Design, 2) New Roles of Teachers, 3) Redesigning Curriculum for Education 4.0, 4) Emerging Technologies In The Classroom, and 5) Designing Learning Spaces for 21st Century Education, and are very timely articles for readers interested in adapting technology in today’s classrooms. We hope that these papers will provide further insight and contributions to the knowledge base in these fields and we hope you enjoy reading them.

Prof. Ts. Dr. Neo Mai, Multimedia University, Malaysia

Professor Dr. Neo Mai is the Director for Academic Development for Excellence in Programmes and Teaching (ADEPT) for Multimedia University, and Professor in the Faculty of Creative Multimedia, and the Institute for Digital Education and Learning (IDEAL). Prof. Mai is the Director of the award-winning MILE Research lab and founding Chairperson form the CAMELOT (Centre for Adaptive Multimedia, Education and Learning cOntent Technologies) Research Centre. Prof. Mai's research interests are in the design of constructivist learning environments, micro-learning, team-based learning and web-based education. She was the recipient of the 2014 Excellent Researcher Award, an AKEPT Certified Trainer for Interactive Lectures (Level 1, 2, 3), an HRDF certified trainer and is certified in Team-Based Learning from the Team-Based Learning Collaborative, USA.

Dr. Gan Chin Lay, Multimedia University, Malaysia

Dr. Gan Chin Lay is a Senior Lecturer affiliated with the Faculty of Business, Multimedia University. Her main research interest is in learning analytics, particularly related to technology-enhanced student-centered learning environments. Her research domains include teaching and learning issues such as student engagement, and educational technology integration frameworks.

Dr. Liew Tze Wei, Multimedia University, Malaysia

Dr. Liew Tze Wei is a Senior Lecturer at the Faculty of Business, Multimedia University, Malaysia. He is leading the Human-Centric Technology Interaction Special Interest Group, in addition to serving as the collaboration & innovation coordinator and research & innovation committee member in the faculty. His research interests and contributions fall within learning sciences, human-computer interaction, and media psychology; with a strong focus on experimental research approach.

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Using LMS Analytics to Optimise Learning Design from the Activity Theory Perspective

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University of Nottingham Ningbo China, China

Abstract

E-learning technologies are widely adopted in today's university classrooms to supplement teaching approaches. Moodle is the most popular learning management system (LMS) that builds with the features of recording the learners' data and activities. Leveraging learners' data has become a trend in searching for informed guidance and actionable insights to optimise the learning design. Literature shows that the highest levels of participation do not correlate with the best academic results, and the most engaged students are likely the weakest students who try to improve their performance. Therefore, the ability to predict students' achievements plays a vital role in enhancing students' learning experience. In this paper, data extracted from the Analytics feature and Grade feature of Moodle and Echo360 ALP used at the University of Nottingham Ningbo China was organised into a dataset, available as CSV files after four steps of preparation. This dataset contains the information about 659 students, the logs of their interactions, and the summary of site entries over one academic semester. This paper uses RStudio for coding and performing the statistical analysis, aiming at identifying students' interaction patterns. There are three interaction patterns analysed in this paper, for studying the relative frequency distribution, the statistical relationship between students' access frequency and the five key variables, and students' attempts of the weekly quiz. An initial form of the pathway was designed based on the findings, and the component in the Engestrom's activity theory, for optimising the learning design in a university classroom. This pathway has multiple entries (openings) to drive learners into the processes of the entire activity system. In the future, the dataset will be expanded with students' academic performance details for a more sophisticated statistical findings and identifying more interaction patterns, hence enriching the design of the learning pathway.

Keywords Analytics; Dataset; Interaction patterns; Learning management system; University students; Pathway

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Introduction

Despite learning technologies are widely adopted in today's university classrooms to supplement different teaching approaches, many instructors are still unfamiliar with strategies of using learning technologies. For instance, all users automatically leave their digital footprints when interacting with the content on the Moodle, an Open Source learning management system (LMS), and this allows the Analytics feature of the LMS that is capable of recording the users' logs to trace all the online activities of each user. It also allows the instructors or other power users who have the site administrative rights to extract data and gain more actionable insights for leveraging learners' performance or providing research-informed guidance.

Today's university students are expected to juggle multiple tasks in their studies with good academic performance, as well as are responsible for developing their soft skills, employability attributes, entrepreneurship mindsets and industry involvement, for staying competitive in the job markets. It is also observed that the highest levels of participation do not correlate with the best academic results, and the most engaged students are likely the weakest students who try to improve their performance. Therefore, the design of the course syllabus, curriculum, and content delivery plays a vital role in nurturing adaptive learning and engaging in self-learning before and after the contact hours. It is believed that effective learning design can help the university students to devise their learning plan for obtaining the level of achievement that they aim for. The learning design can be optimised as the university's instructors are able to predict students' achievements and outcomes when they are equipped with the mechanism to analyse how students collaborate on tasks, take actions, and use information technologies in the learning context (Sclater, Peasgood & Mullan, 2016). Hence, the LMS Analytics has the potential to transform the instructors to be more instrumental in identifying at-risk students and providing interventions to support the students in their learning environment.

Learning analytics has been widely developed in the USA, United Kingdom, Canada and Australia to measure and optimise the learning process. However, studies found that there is a lack of exchange of ideas, methodologies, and tools in using learning analytics, and the results are still isolated from the community that can collect, measure, analyse, and discover the data about students, instructors and institutions (Lemos dos Santos, Cechinel, Nunes & Ochoa, 2017). In this paper, the author focused on 1) the interaction patterns evolved from the student-LMS interaction, and based on the findings from the LMS analytics, 2) the design of the pathway with Engestrom's activity theory for optimising the learning design in university classrooms.

Activity Theory

Activity theory is a sociotechnical theory which has its origin from the psychological field. It is rooted in Vygotsky's (1920) works that conceptualized learning as a social activity that takes place among individuals. Activity theory was extended and popularised by Engestrom (1987) who organised the components of activity into activity systems and presented in a model that is depicted as a triangle. Activity theory posits that learning emerges from the activity and human mind, and the human mind emerges as a component of interactions with the environment. Hence, human activity is a precursor to learning, and learning is the product of mediating influences through the learning activities (Engestrom, Miettinen & Punamäki, 1999). Therefore, activity theory provides a powerful socio-cultural lens for analysing human activity. Researchers recognise activity theory as an interventionist research approach with the relevant concepts that are based on the interaction between the researchers and the people in analysing work, technology, education, HCI, and system design (Engestrom, 1987; Hasan & Kazlauskas, 2014).

The components of the subject, object, and tools as part of the upper triangle and the base of the triangle consists of components of the community, social rules, and division of labour. These six components are interrelated and centered at the subject and Object (see Figure 1). Specifically, the subject is the individual or group of actors engaged in the activity whereas the object is the product or goal that is sought throughout the processes. The tools consist of the materials, knowledge sources, or technologies used in the processes. The division of labour is the social structure of the system in which it divides the actors into different roles and responsibilities within the system. The social rules describe the way that the actors relate to each other through social interaction, as well as define what the culture allows, what is legitimate, rewarded, or discouraged. The community responds to contextual relationships among the collaborators in the activities for integrating with the external social needs. The goal of the activities may consist of intended and unintended learning, skills and attitudes (Engestrom, 1987; 2000; 2001).

Literature shows that the activity theory provides a set of frameworks for interpreting human activities in a real-world situation and exploring the balance between the goals, roles, norms, materials associated with pedagogic practices. Activity theory was used by Jonassen and Rohrer-Murphy (1999) as the framework to analyse the needs, tasks, and outcomes for designing the constructivist learning environment (CLE), which is a well-known model used for adopting a constructivist approach to promote technology-based learning. Over the years, the components in activity theory are increasingly used in analysing the elements in information systems studies or evaluating the information technologies. These studies place the primary concern with the development of social activities and relationship for explaining the logic behind human activities in a specific context (Iyamu & Shaanika, 2019). Activity theory was also employed as an empirical framework by the technology developers to understand users' information behaviour in ways how they search, gather, and use the information in dynamic environments. It allows the design of the information systems to be more shaped to the information behaviour of this group of users, hence increasing the applicability to technology development (Allen, Karanasios & Slavova, 2011). In instructional design, activity theory is used as the framework in a collaborative student project setting to foster the transactional processes of learning. It emphasises on crafting the division of labour to facilitate learning between novices and experts and formulating rules to reflect real practitioners in a community (Hung & Wong, 2000).

In this paper, the activity theory is used as the framework to design the pathway to optimise the learning design in a university classroom based on the findings from students' interaction patterns on the University of Nottingham Ningbo China's Moodle Online System and Echo 360 Active Learning Platform (shorts as LMS in this paper). In Figure 1, each of the components in Engestrom's activity theory is associated with the students' learning context.

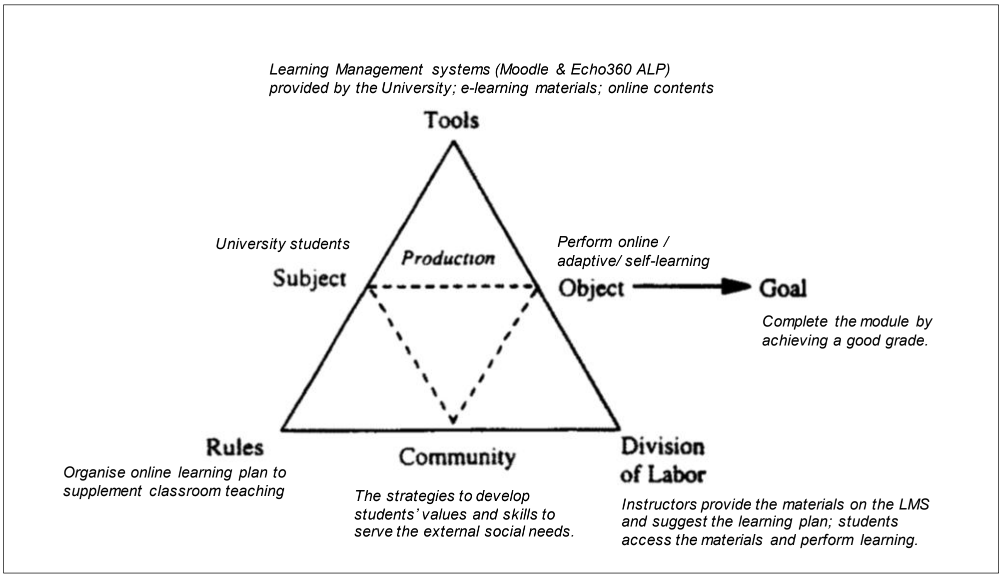


Figure 1 The Triangle of Engestrom's Activity Theory that Consists of Six Components

Methodology

Dataset

In this paper, data is extracted from the Analytics feature of Moodle and the Grade feature of Echo360 ALP used at the University of Nottingham Ningbo China (UNNC) (see Figure 2). This data was organised into a dataset and saved into a CSV file with the first column set as the unique identifiers. This dataset contains the logs of the online activities of 659 students, including their clicks and entries over one academic semester, from Feb 2019 to May 2019, for fifteen teaching weeks. These students were in their first year of the academic programme taking a compulsory module which was designed to enhance their knowledge of technologies and information systems. The learning activities of this module include 11 two-hour lecture, one group project, ten weekly online quizzes, four discussion forums; each for project work, class activities, and exam revision, an online video tutorial for gaining video making ideas and basic skills and four two-hour practical lessons in the computer laboratory. All the learning materials and web links were presented on the LMS in digital versions and downloadable after they were made available to the students, usually one week before conducting the lesson. This study was conducted after gaining ethics approval from the Ethics Committee of the University, where the author is affiliated to at the time of this study.

Currently, this dataset is locally hosted by the author on a high-performance workstation. However, as the size of the dataset increased over time throughout the study, the author subscribed for a web-based hosting service to store the datasets on the data centre which is certified with the international standard for information security. There are four steps of preparing this dataset. The first being the selection. It was done by using the Filters feature to select the necessary data and removing the duplicated data. The second being the anonymisation. It was done by representing the private information with the identifiers. The third being the transformation. It was done by formatting the data and converting it into a database schema (see Figure 2). The fourth being the exploration. It was done by writing the Excel formula and programming codes to perform calculations and statistical analysis (see Table 1).

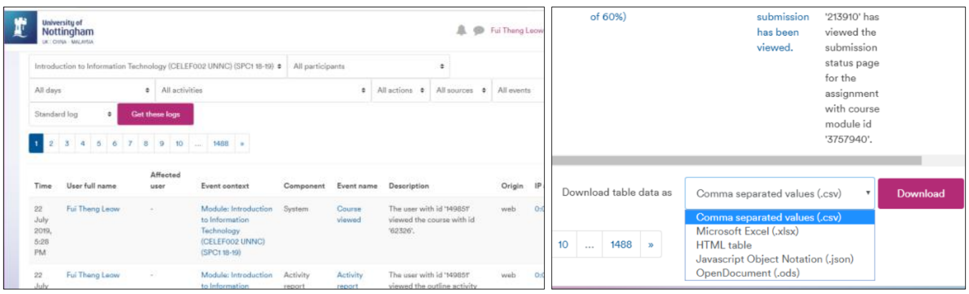


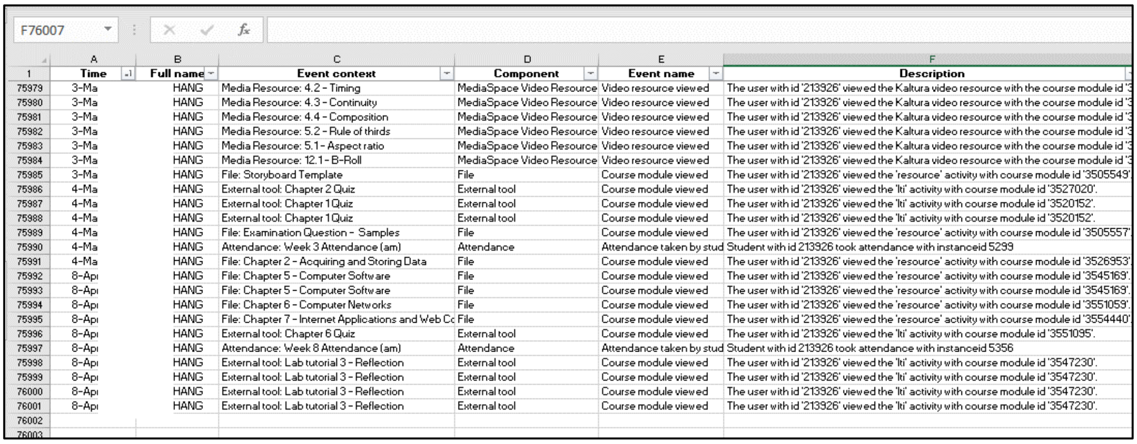
Figure 2 The Analytics and Filter Feature on the Moodle LMS for Downloading Users' Activity Logs

Software Tools

After removing the duplicated and blank data, the collected data consists of 76,000 records (rows) and is organised in a Microsoft Excel spreadsheet data (see Figure 3). Through the data transformation and exploration step, the sorted dataset consists of 659 records (each represents the summary of a student's activity log) and 48 variables (columns). The variables also include the score given to an accumulation of activities, such as a score that ranks the number of login and number of different events combined. Some of the scores or variables are used in this paper to perform the statistical analysis for exploring the interaction patterns of the students in the LMS data (see Figure 4). Some Excel formulas used in generating the variables in the dataset are presented in Table 1 below:

Table 1 The formula used in Microsoft Excel for generating the variables in the dataset

Formula used in Microsoft Excel	**Purpose**
=INDEX(logs!$C$147:$C$218,MODE(MATCH(logs!$C$147:$C$218,logs!$C$147:$C$218,0)))	To search for the most frequently visited page of a student.
=COUNTIF(logs!$D$2:$D$146,J$2)	To calculate the maximum number of times a student watched the online tutorial video.
=SUMPRODUCT(1/COUNTIF(logs!$C$147:$C $218,logs!$C$147:$C$218))	To count for the total number of different events involved by a student.
=COUNTIFS(logs!$A$147:$A$218,">="&AJ$3, logs!$A$147:$A$218,"<="&AJ$4)	To calculate the maximum number of logins of a student within a duration of one week.



F76007

	A	B	C	D	E	F
1	Time	Full name	Event context	Component	Event name	Description
75979	3-Ma	HANG	Media Resource: 4.2 - Timing	MediaSpace Video Resource	Video resource viewed	The user with id '213926' viewed the Kaltura video resource with the course module id '3
75980	3-Ma	HANG	Media Resource: 4.3 - Continuity	MediaSpace Video Resource	Video resource viewed	The user with id '213926' viewed the Kaltura video resource with the course module id '3
75981	3-Ma	HANG	Media Resource: 4.4 - Composition	MediaSpace Video Resource	Video resource viewed	The user with id '213926' viewed the Kaltura video resource with the course module id '3
75982	3-Ma	HANG	Media Resource: 5.2 - Rule of thirds	MediaSpace Video Resource	Video resource viewed	The user with id '213926' viewed the Kaltura video resource with the course module id '3
75983	3-Ma	HANG	Media Resource: 5.1 - Aspect ratio	MediaSpace Video Resource	Video resource viewed	The user with id '213926' viewed the Kaltura video resource with the course module id '3
75984	3-Ma	HANG	Media Resource: 12.1 - B-Roll	MediaSpace Video Resource	Video resource viewed	The user with id '213926' viewed the Kaltura video resource with the course module id '3
75985	3-Ma	HANG	File: Storyboard Template	File	Course module viewed	The user with id '213926' viewed the 'resource' activity with course module id '3505549'
75986	4-Ma	HANG	External tool: Chapter 2 Quiz	External tool	Course module viewed	The user with id '213926' viewed the 'lti' activity with course module id '3527020'.
75987	4-Ma	HANG	External tool: Chapter 1 Quiz	External tool	Course module viewed	The user with id '213926' viewed the 'lti' activity with course module id '3520152'.
75988	4-Ma	HANG	External tool: Chapter 1 Quiz	External tool	Course module viewed	The user with id '213926' viewed the 'lti' activity with course module id '3520152'.
75989	4-Ma	HANG	File: Examination Question - Samples	File	Course module viewed	The user with id '213926' viewed the 'resource' activity with course module id '3505557'
75990	4-Ma	HANG	Attendance: Week 3 Attendance (am)	Attendance	Attendance taken by stud	Student with id 213926 took attendance with instanceid 5299
75991	4-Ma	HANG	File: Chapter 2 - Acquiring and Storing Data	File	Course module viewed	The user with id '213926' viewed the 'resource' activity with course module id '3526953'
75992	8-Apı	HANG	File: Chapter 5 - Computer Software	File	Course module viewed	The user with id '213926' viewed the 'resource' activity with course module id '3545169'.
75993	8-Apı	HANG	File: Chapter 5 - Computer Software	File	Course module viewed	The user with id '213926' viewed the 'resource' activity with course module id '3545169'.
75994	8-Apı	HANG	File: Chapter 6 - Computer Networks	File	Course module viewed	The user with id '213926' viewed the 'resource' activity with course module id '3551059'.
75995	8-Apı	HANG	File: Chapter 7 - Internet Applications and Web Cc	File	Course module viewed	The user with id '213926' viewed the 'resource' activity with course module id '3554440'
75996	8-Apı	HANG	External tool: Chapter 6 Quiz	External tool	Course module viewed	The user with id '213926' viewed the 'lti' activity with course module id '3551095'.
75997	8-Apı	HANG	Attendance: Week 8 Attendance (am)	Attendance	Attendance taken by stud	Student with id 213926 took attendance with instanceid 5356
75998	8-Apı	HANG	External tool: Lab tutorial 3 - Reflection	External tool	Course module viewed	The user with id '213926' viewed the 'lti' activity with course module id '3547230'.
75999	8-Apı	HANG	External tool: Lab tutorial 3 - Reflection	External tool	Course module viewed	The user with id '213926' viewed the 'lti' activity with course module id '3547230'.
76000	8-Apı	HANG	External tool: Lab tutorial 3 - Reflection	External tool	Course module viewed	The user with id '213926' viewed the 'lti' activity with course module id '3547230'.
76001	8-Apı	HANG	External tool: Lab tutorial 3 - Reflection	External tool	Course module viewed	The user with id '213926' viewed the 'lti' activity with course module id '3547230'.
76002						
76003						

Figure 3 The Collected Data Consists of 76,000 Records (rows) after Removing the Duplicated Data

2	Start from row?	Ends at row?	No. of Days of login	No. of different events	Most frequently visited page	No. of most visited page	SCORE	MediaSpace Video Resource	File	Forum: Announcements	URL	SCORE
5	2	146	145	57	Quiz: HTML Quiz	28	101	11	68	2	0	70
6	147	218	72	35	Quiz: HTML Quiz	15	53.5	0	21	0	0	21
7	219	342	124	54	Forum: Lecture 1 - Create a Flowchar	14	89	0	45	0	0	45
8	343	441	99	43	Assignments: Final Report (Mark is re	10	71	0	34	0	4	38
9	442	524	83	48	Quiz: HTML Quiz	13	65.5	0	32	0	1	33
10	525	679	155	54	Quiz: HTML Quiz	11	104.5	0	64	0	0	64
11	680	788	109	38	Quiz: HTML Quiz	23	73.5	0	60	0	1	61
12	789	885	97	53	Forum: Project Forum	13	75	0	35	0	1	36
13	886	980	95	40	Quiz: HTML Quiz	10	67.5	0	38	0	0	38
14	981	1020	39	28	ool: Lab tutorial 1 - Reflection and Att	4	33.5	0	15	0	0	15
15	1021	1181	161	65	File: Chapter 1 - Data and Information	12	113	9	83	0	3	86
16	1182	1322	141	51	Quiz: HTML Quiz	21	96	2	47	0	0	47
17	1323	1434	112	55	Quiz: HTML Quiz	17	83.5	3	36	0	1	37
18	1435	1498	64	28	Forum: Project Forum	11	46	1	25	0	0	25
19	1499	1681	183	72	Assignments: Final Report (Mark is re	27	127.5	17	48	0	1	49

2	External tool: Chapter 1 Quiz	External tool: Chapter 2 Quiz	External tool: Chapter 3 Quiz	External tool: Chapter 4 Quiz	External tool: Chapter 5 Quiz	External tool: Chapter 6 Quiz	External tool: Chapter 7 Quiz	External tool: Chapter 8 Quiz	External tool: Chapter 9 Quiz	External tool: Chapter 10 Quiz	Quiz: HTML Quiz	SCORE	External tool: Revision - Online Q&A	Forum: Project Forum	Forum: Class Forum	Forum: Lecture 1 - Create a Flowchart	SCORE	W0 login
5	3	2	2	1	2	1	1	1	1	1	28	43	1	0	0	3	4	0
6	2	1	3	1	1	0	0	0	0	0	15	23	1	0	0	17	18	0
7	3	4	1	3	2	1	2	1	1	2	18	38	1	6	0	14	21	0
8	7	2	1	1	0	0	0	0	0	0	5	16	0	5	0	5	10	0
9	3	2	1	2	1	1	0	0	0	0	13	23	0	1	0	5	6	0
10	8	4	5	5	4	4	3	4	3	3	11	54	0	7	0	10	17	1
11	2	1	0	0	2	1	1	1	2	1	23	34	0	0	0	0	0	0
12	3	4	1	2	1	0	1	1	2	1	8	24	1	13	0	0	14	0
13	3	0	0	2	0	0	0	0	0	0	10	15	8	0	1	4	13	0
14	1	0	0	0	0	1	0	0	0	0	0	2	1	0	0	0	1	0
15	5	6	3	3	1	0	3	1	1	2	10	35	3	1	0	4	8	0
16	9	3	0	1	1	0	1	2	1	0	21	39	0	0	0	0	0	0
17	4	2	3	2	2	3	2	3	3	2	17	43	0	8	0	0	8	0
18	2	0	0	0	1	0	0	0	0	0	7	10	0	11	0	0	11	0
19	5	1	3	3	1	0	2	1	1	1	15	33	2	9	1	14	26	0

Figure 4 The Dataset after the 4-step Process Consists of 659 Records and 48 Variables.

The dataset was arranged into several database tables by using DB Designer.net, an online database schema modelling tool. Each database table houses a set of relevant characteristics. These tables were sorted based on student behaviour and student performance for visualising the structure and relationship of the current data (see Figure 5). It was also done for generating the SQL script to be used in MySQL, which is the next step of storing and managing the datasets (not discussed in this paper).

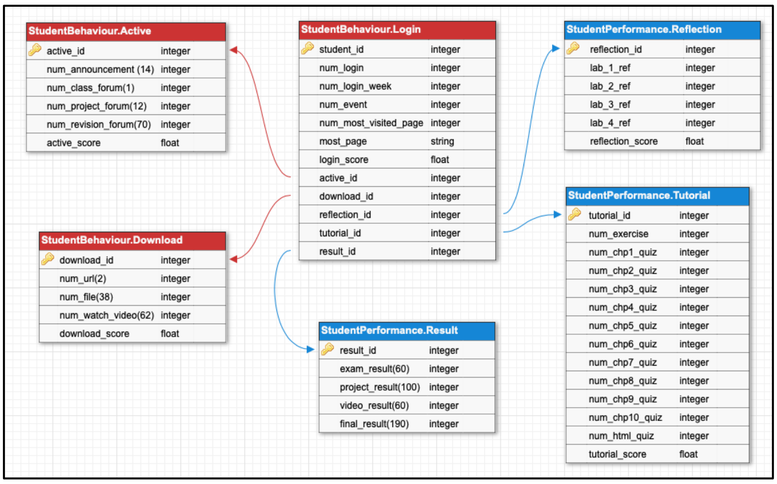


Figure 5 The Database Schema of the Current Dataset Generated by DB Designer

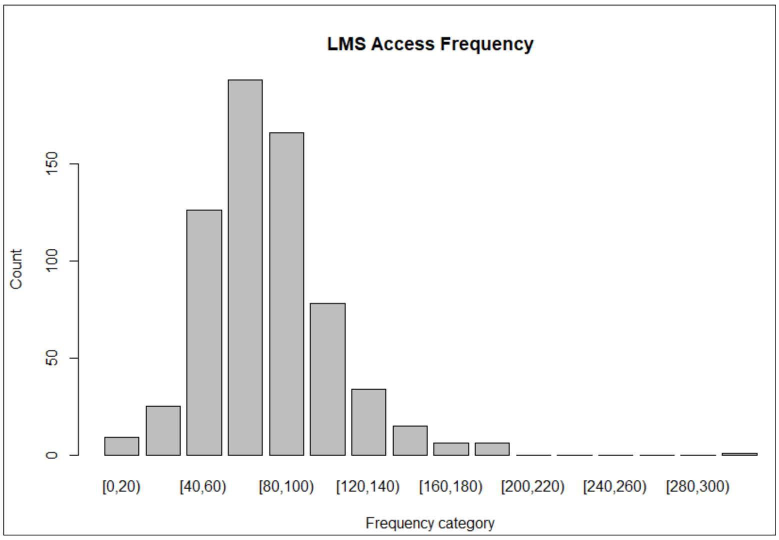
This paper uses RStudio, an integrated development environment (IDE) for coding R, a command-line driven programming language, to transform the data and perform the statistical analysis (RStudio Team, 2015; DataFlair Team, 2018). To identify students' interaction patterns that evolved from the student-LMS interaction. The dataset with 659 records and 48 variables was imported as a CSV file (contains the variable names in the first row) into RStudio by using the command of *dataset1<-read.csv("ALL_logs_no_formula.csv")*. In the Appendix section, Table 2 presents the minimum count, maximum count and mean of the key variables in the dataset. Figure 12 presents the use and process of coding R programming in RStudio.

Results

There are three interaction patterns analysed in this paper and presented in the following sub-sessions.

Interaction Pattern 1 – LMS Access Frequency

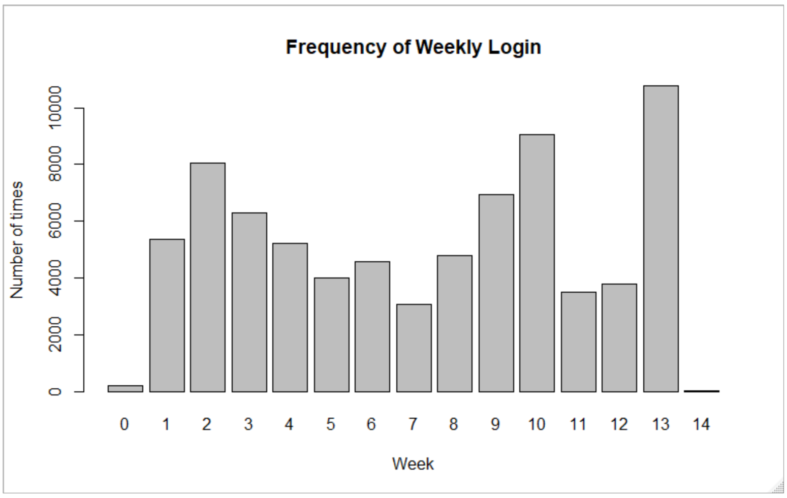
The interaction pattern 1 focuses on studying the relative frequency distribution. It is used to identify how often students accessed the LMS throughout the semester (sampled 15 weeks) based on the frequency proportion with an interval of 20 in each category (see Figure 6). With 1 and 322 being the lowest and the highest record, respectively, it can be noticed that the majority of the students accessed the LMS between 60-80 times throughout the semester. It means, on average, each student accessed the LMS 4 to 5.3 times per week, one time per weekday. It also explains that the majority of the students are on the right track and up to the instructor's expectation of daily access.



[0, 20)	[20, 40)	[40, 60)	[60, 80)	[80, 100)	[100, 120)	[120, 140)	[140, 160)	[160, 180)	[180, 200)	[200, 220)	[220, 240)	[240, 260)	[260, 280)	[280, 300)	[300, 320)
9	25	126	193	166	78	34	15	6	6	0	0	0	0	0	1

Figure 6 The Relative Frequency Distribution of Students Accessing the LMS

Figure 7 shows the frequency of students' weekly login for a total of 15 weeks in an academic semester. For a class of 669 students, only 30% of students accessed the LMS before the class started. There are three peaks found in the weekly login, happened in week 2 with 8049 times, week 10 with 9048 times, and week 13 with 10768 times. On average, each student accessed 12 times per week (more than two times per weekday) in week 2, 13.5 times per week (more than two times per weekday) in week 10, and 16 times per week (more than three times per weekday) in week 13.



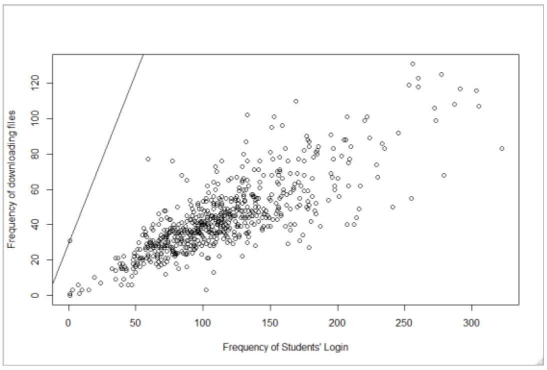
Week 0	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14
201	5355	**8049**	6299	5213	4001	4580	3056	4796	6947	**9048**	3487	3800	**10768**	22
Number of times each student accessed the LMS (average)														
0.3	8	**12**	9.4	7.8	6	6.8	4.6	7.2	10.4	**13.5**	5.2	5.7	**16.1**	0.03

Figure 7 The Frequency of Students Accessing the LMS in Each Week

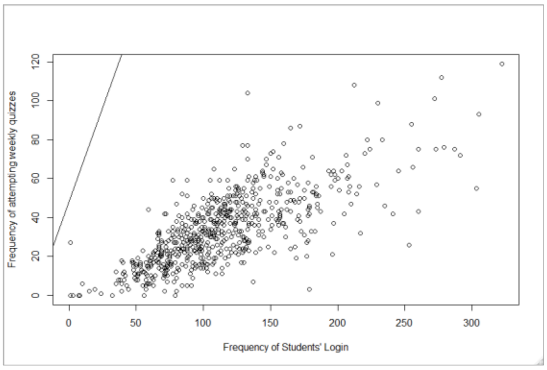
Interaction Pattern 2 – Correlation between Access Frequency and Purposes

The analysis in interaction pattern 2 is categorised into five variables to understand how the statistical relationship between students' access frequency can be used to predict the variables which have been identified in this paper. All the variables are the continuous interval variables, which means the numerical values are used in the analysis. The correlation is used to study the statistical relationship between these variables. In a scatterplot in Figure 8a) shows the correlation value of r=.64, indicating a fairly strong positive relationship between students accessing the LMS and downloading the files. It is followed by another fairly strong positive relationship (r=.55) between students accessing the LMS and attempting the weekly quiz (see Figure 8b). The relationship between students accessing the LMS and interacting with others on the discussion forum is found at moderate positive (r=.44) (see Figure 8c). The positive relationship is very weak between students accessing the LMS and watching online tutorial videos (r=.15) (see Figure 8d). The only weak negative relationship (or very close to no correction) is between students accessing the LMS and reading the notification (r=-.001) (see Figure 8e). Also, all the correlation coefficients show the p-value less than the significant level ($p < 0$). Therefore, it is evidenced that the frequency of student accessing the LMS correlates to the five purposes (variables) at various level. It is also sufficient to reject the null hypothesis of having no linear relationship between the two variables.

The correlation analysis provides the information to rank students' purposes of interacting with the LMS. Firstly, students accessed the LMS for obtaining the learning materials which were usually distributed in downloadable files. Secondly, accessing LMS enabled students to attempt the quizzes, which were added every week. Thirdly, students accessed the LMS to participate in the forum discussion or obtaining updates from the new posts. Fourthly, students accessed the LMS for watching online video tutorials to gain new ideas and skills in project development. On the other hand, it can be noticed that, very slightly, the more students accessed the LMS, the less they read the weekly notifications (to disseminate information about the task and reminder for a particular week), which indicates that they became more aware of their weekly tasks and arrangement, hence less relying on the notifications to learn about their tasks.



(a)



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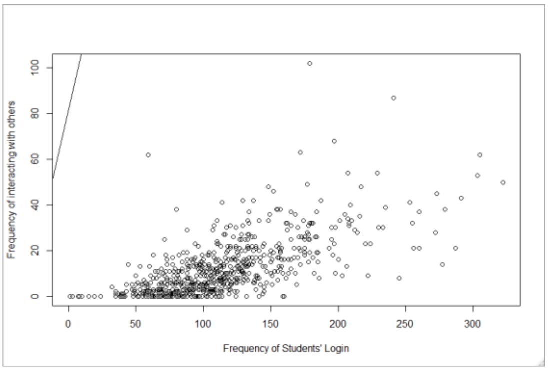
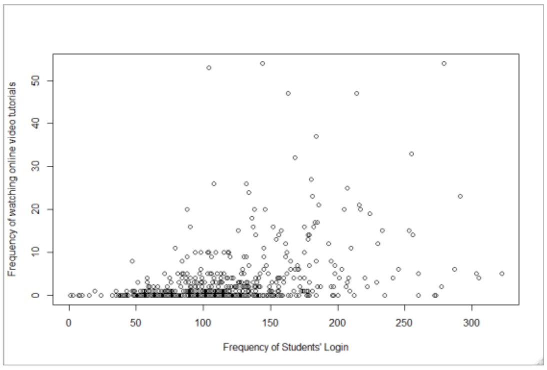
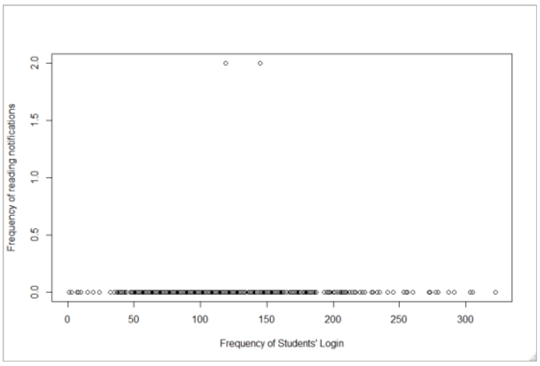


(c)



(d)



(e)

Figure 8 The Scatterplots with Correlations of the Access Frequency and a) The Frequency of Downloading Files (+0.64); (b) The Frequency of Attempting the Weekly Quiz (+0.55); (c) The Frequency of Forum Interaction (+0.44); (d) The Frequency of Watching Online Video Tutorials (+0.15); (e) The Frequency of Reading Notifications (-0.001)

Interaction Pattern 3 – Weekly Quiz Attempt

Based on the records of students attempting the weekly quiz (see Figure 9), the data is widely spread, from 0 to 144 times of attempts throughout the semester. It indicates that the weekly quiz attempt is less consistent across the student population. The peak of students' weekly quiz attempt occurs at 20-30 times. The mean score is 33.89, and the median score is 32. The histogram of students' weekly quiz attempt is skewed right, which is positively distributed and explained that there are students who attempted more than 50 times throughout the semester.

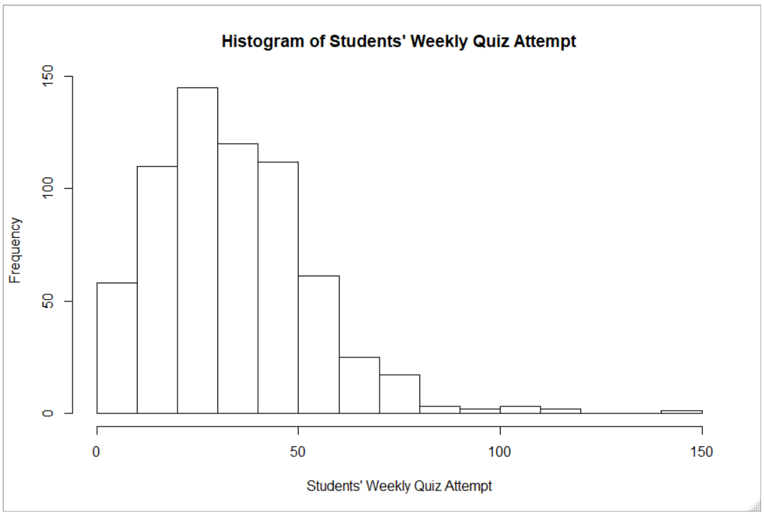
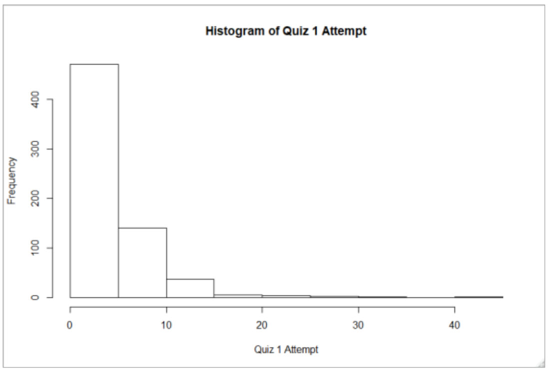
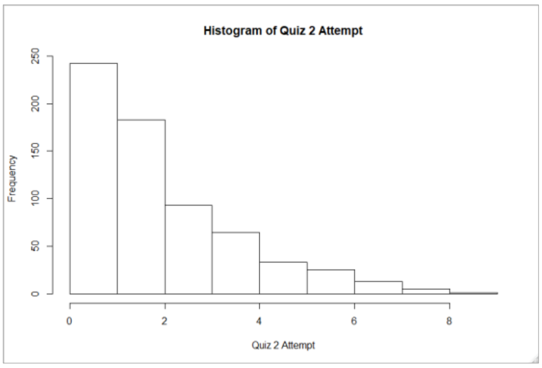


Figure 9 The Histogram of Students Attempting the Weekly Quiz

Figure 10 shows the histograms of the quiz attempt in each week. For the first week, it recorded a mean of 4.58 attempts from a total of 3023 attempts and a peak at the 0-5 attempts per student. For the subsequent weeks, the mean scores decreased from 2.29 (week 2 quiz), 2.13 (week 3 quiz), 2.01 (week 4 quiz), 1.90 (week 5 quiz), 1.96 (week 6 quiz), 1.64 (week 7 quiz), 1.42 (week 8 quiz), 1.33 (week 9 quiz), to 1.19 (week 10 quiz), all with a peak at the 0-1 attempt per student. However, the mean score increased to 13.43, with a peak at 10-15 times per student for the HTML quiz which was posted in week 11. Overall, all histograms are right-skewed, showing the positive distribution, which means there are many students attempted each quiz more than the average times throughout the semester.



(a)



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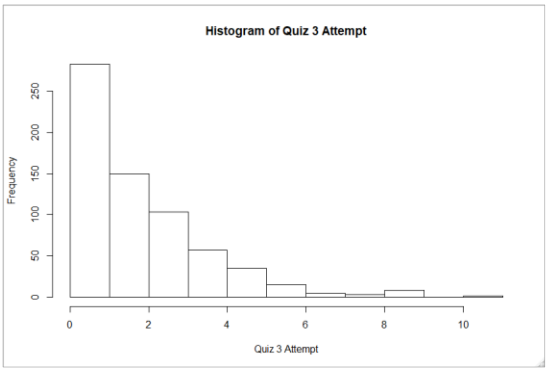

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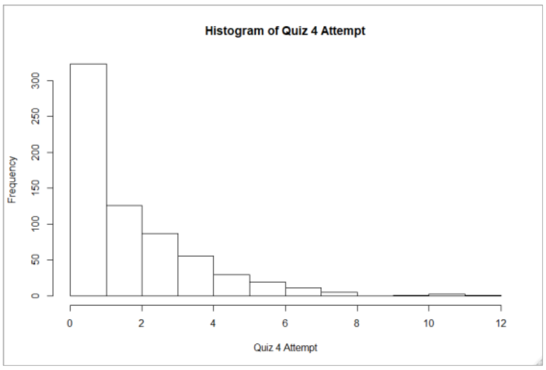

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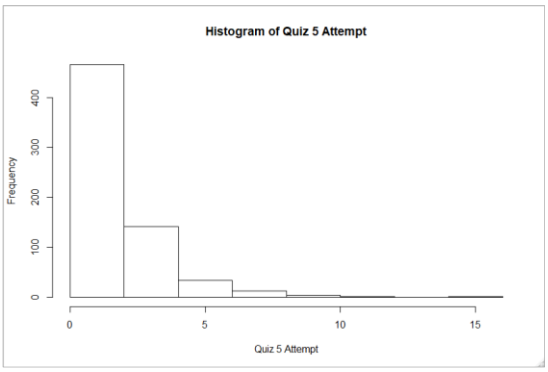

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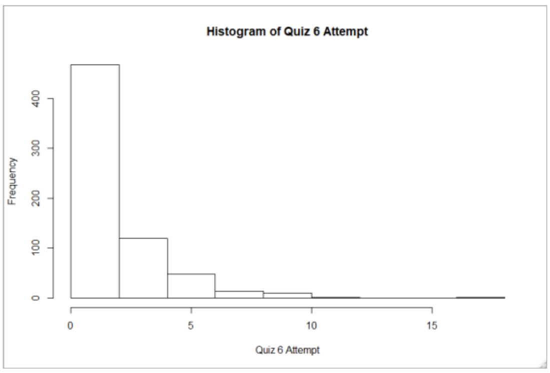

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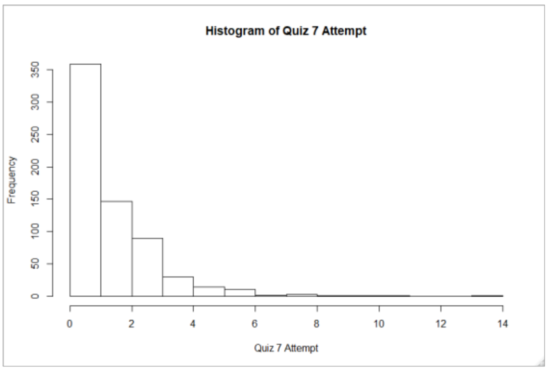

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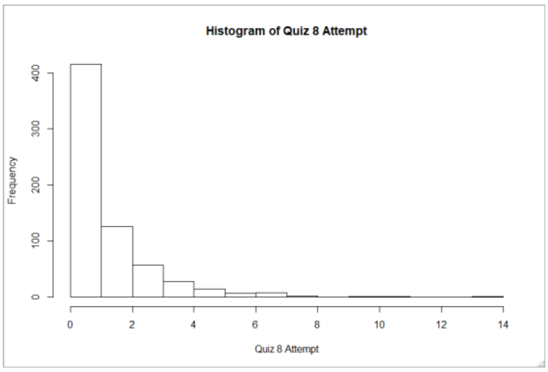

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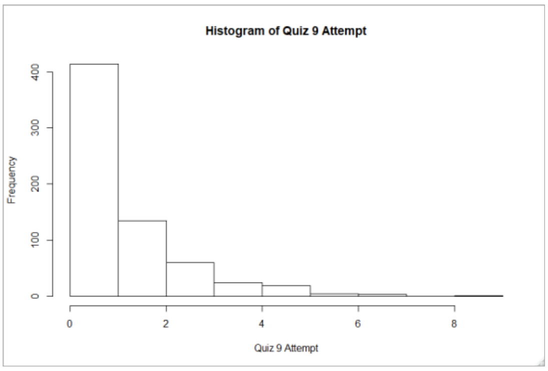
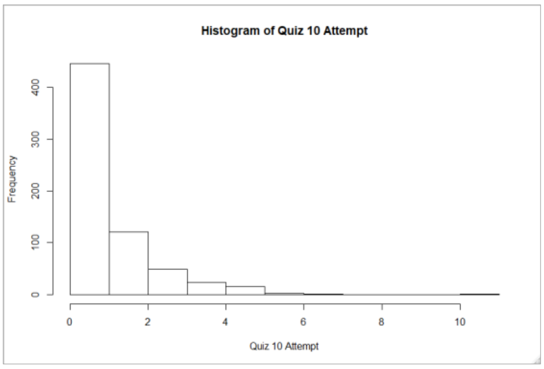
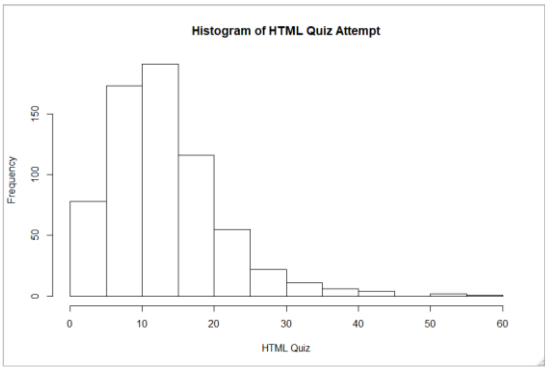


(i)



(j)



(k)

Figure 10 (a-k) The Histogram of Quiz Attempt in Each Week

Discussion and Conclusion

It can be observed that the interaction Pattern 1 shows that the frequency of students accessing the LMS is influenced by the timeline of student assessment. It is also noted that the frequency peaked at every milestone set by the instructor. Specifically, it peaked in week 2 when students checked out their project specification and group members' name, in week 10 when students submitted their project report, and in week 13 when students checked their project mark, as well as engaged in the online quizzes and exam discussion forum in preparing for the final examination which took place at the end of week 13. This result explains that the learning design and the capability of the system feature to support the learning activities are the potential predictors in increasing the frequency of students accessing the LMS. This translates to the usage of the learning technologies in the university classrooms.

The interaction Pattern 2 shows the correlation coefficients between the students accessing the LMS and each of the five purposes, which were emphasised in the learning design of this module. These 5 purposes are downloading the files (learning materials are presented in the downloadable files), watching the online video tutorials (provide additional skills and ideas in supporting their project development), attempting the weekly quizzes (as a form of revision of the lessons), interacting on the discussion forum (ask questions, participate in discussions, or share ideas with the others), and reading the notifications (posted by the instructors as a form of weekly reminders of tasks and deadlines). The main finding from the correlation coefficients shows that students accessed the LMS mainly for downloading the learning materials which were distributed on the weekly or bi-weekly basis. It indicates that the LMS is significantly perceived by students as a means of disseminating learning materials. On the other hand, it means that by providing frequent and consistent content updates on the LMS, it can maintain the frequency of students accessing the LMS. Subsequently, it can potentially increase the frequency of participating in other online activities on the LMS. The second finding of this interaction pattern is that students tend to engage with the activities that require less time to complete, easy to navigate on the LMS and have a sense of urgency. For instance, students attempted the quiz which requires only 10-15 minutes and a few mouse-clicks to complete, and students joined the forum discussion when they were asked to present a flow chart within 24 hours or to ask questions about proposal writing before the submission deadline. The third finding of this interaction pattern is that the technical requirement and predictability can potentially create resistance in using the LMS. It can be noticed that a very weak positive relationship between accessing the LMS and watching the video tutorials despite video is generally known as the richest and most entertaining media in delivering the content. It is believed that students often experienced the unstable connections that are caused by the limited internet bandwidth and the service capability of the third-party video hosting platforms on the LMS, hence it was perceived as time-consuming and less user-friendly to the students. The predictability also plays a role in increasing the viewership of the content on the LMS. The negative relationship from the correlation coefficients explains that as students became more familiar with the routine or repeated tasks, they tend to ignore the content and hence, it is less effective when used as a strategy to increase the students' access and use of the LMS.

For interaction Pattern 3, the data presented in the histograms explained that the interaction pattern of students attempting the weekly quiz. It is noticed that the attempt started to decline from the second quiz, the mean score recorded 50% lower compared to the first week, and attempts continued to fall, but not more than 10% from the previous week, until Quiz 10. It explains that students were attracted to the interactive class quiz when they first encountered it and were interested to try again to obtain a better score. It also shows that students had quickly adapted to the routine of attempting each quiz for 1 to 2 times instead of ignoring it. It is believed that this consistency was contributed by the instructor's practice of administering the weekly online quiz at the end of each lecture. However, the outstanding result of the HTML quiz, 3 times higher than the quiz 1 attempt, can be explained by its approach and content as it was administered in week 11 during a practical lesson in the computer laboratory, and was used to test students' skills in coding an HTML page, which is different from other quizzes that tested students' theoretical knowledge. Therefore, the interaction pattern of students attempting the weekly quiz shows that interactive class activities can potentially receive students' attention in the first place, with their positive attitude in engaging with it. In conclusion, it requires 'surprises' (not repeating the same approach over weeks), challenges (content that allow students to test their knowledge or skill level), and the weekly routine (instructor's teaching plan) in sustaining and increasing the number of quiz attempts, which translate to the usefulness and meaningfulness of the learning activities.

This paper focuses on preparing the dataset and identifying the interaction patterns evolved from the student-LMS interaction. Based on the findings, the author designed the pathway, with the component in the Engestrom's activity theory, for optimising the learning design in the university classrooms. Figure 11 presents the initial design of this pathway. The main idea of this pathway is that it has multiple entries (openings) to drive learners into the processes of the entire activity system. Each of the entries starts from a 'stop', which is like a 'hook' to motivate the learners, and there is a total of 10 stops. In the learning context, each of the stops represents an actionable approach that can be initiated by the instructors or requested by the students for engaging with the components in the activity theory. For instance, when the instructor provides constant updates (*Stop 10*) in the learning process, it triggers the learners (*subject*) to frequently check out (*action*) what is new (*surprise*) and what needs to be done (*task*) in order to fulfil the requirement and get a good result (*goal*). Hence, one of the ways to optimise learning design is to be strategic in releasing or distributing the learning resources on a timely and relevant manner.

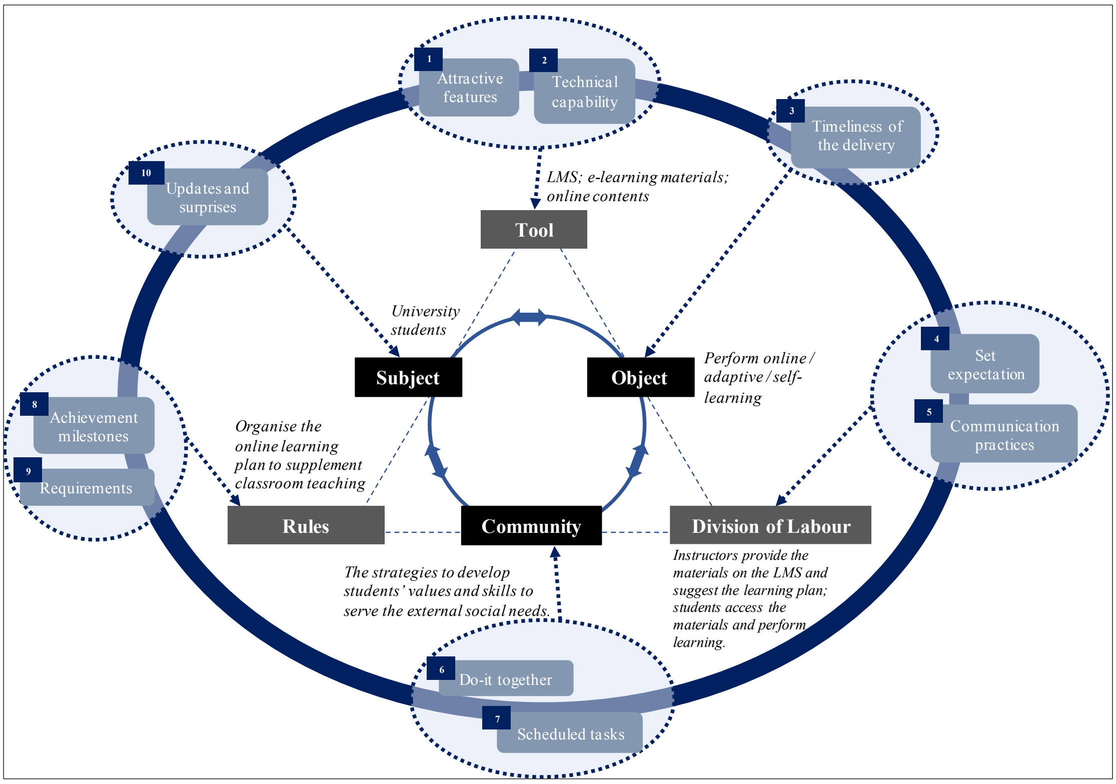


Figure 11 The Pathway with Engestrom's Activity Theory and Ten Stops for Optimising the Learning Design

Due to the word limit, this paper presented three interaction patterns. For future publication, the author will extend the analysis with more interaction patterns and include the variables of students' final examination result and project performance mark in the dataset. By investigating the variances, regression analysis, and significant level between students' academic performance and online activities on the LMS, more interaction patterns can be identified. That said, it enriches the development of the learning pathway and provides more comprehensive guides to support the instructors in learning and activity design. It is also expected that the findings and the dataset in this study can contribute to the development of the predictive model to unearth students' behaviours and interaction patterns with learning technologies.

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Authors' Bio

Fui-Theng Leow (FT) has more than 12 years of teaching experience in international universities. In addition to teaching, FT involves in various scholarly activities, including guest speaker lectures and student project supervisions. She has experience in the programme coordination, e-learning training, conference organisation, journal editorial board, and student assessment review. She was also trained as the trainer of Blackboard LMS and the learning designer for implementing online learning system. FT has been working on multiple research projects at various scales across different disciplines for more than ten years and published over 20 articles in peer-reviewed journals and international conference proceedings. She also presented in international conferences, conducted workshops on educational technologies, and reviewed research manuscripts.

Appendices

Table 2 The minimum count, maximum count and mean of the key variables in the dataset

Variable	Minimum	Maximum	Mean
No. of Days of login	1	543.0	114.1
No. of different events	0.1648	97.0000	47.1110
Top-5 most frequently visited page			
1. Quiz: HTML Quiz		381	
2. Project Forum		74	
3. Activity Forum		61	
4. File: Chapter 1		34	
5. Chapter 1 Quiz		26	
Video tutorial resource	0.00	54.00	2.88
File download	0.00	164.00	43.67
Announcement	0.00	2.00	0.006
Click on the URL link	0.00	7.00	0.59
Link to Echo360 ALP to access			
- Chapter 1 Quiz	0.00	44.00	4.58
- Chapter 2 Quiz	0.00	9.00	2.29
- Chapter 3 Quiz	0.00	11.00	2.13
- Chapter 4 Quiz	0.00	12.00	2.01
- Chapter 5 Quiz	0.00	16.00	1.90
- Chapter 6 Quiz	0.00	18.00	1.95
- Chapter 7 Quiz	0.00	14.00	1.63
- Chapter 8 Quiz	0.00	14.00	1.42
- Chapter 9 Quiz	0.00	9.00	1.32
- Chapter 10 Quiz	0.00	11.00	1.19
- HTML Quiz	0.00	56.00	13.43
Social interaction on			
- Exam Forum	0.00	42.00	1.34
- Project Forum	0.00	102.00	5.11
- Class Forum	0.00	20.00	0.32
- Activity Forum	0.00	65.00	5.46
Total number of logins in			
- week 0	0.00	9.00	0.30
- week 1	0.00	105.00	8.12
- week 2	0.00	90.00	12.21
- week 3	0.00	43.00	9.55
- week 4	0.00	62.00	7.91
- week 5	0.00	25.00	6.07
- week 6	0.00	42.00	6.95
- week 7	0.00	80.00	4.63
- week 8	0.00	76.00	7.27
- week 9	0.00	65.00	10.54
- week 10	0.00	64.00	13.73
- week 11	0.00	51.00	5.29
- week 12	0.00	47.00	5.76
- week 13	0.00	67.00	16.34

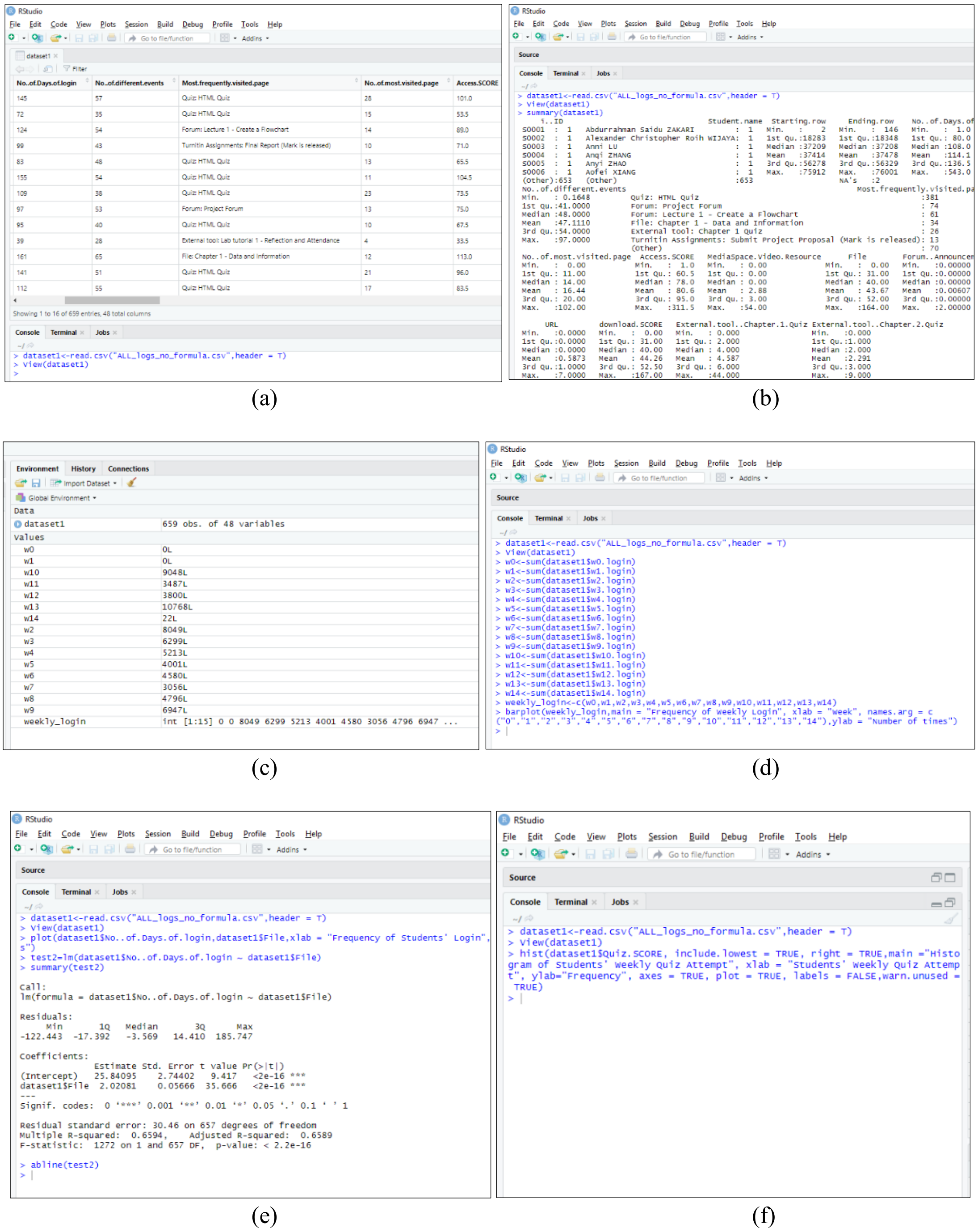

Figure 12 (a) The Display of Dataset in Rstudio in the Source Pane; (b) Coding in the Console Pane; (c) The List of Variables in the Environment Pane; (d) R Codes for Generating the Bar Charts; (e) R Codes for Generating the Scatterplot; (f) R Codes for Generating the Histogram

-END-

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