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Research Article

A study on Gamification toward Engineering Students' Engagement in the University Level

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Abstract

Most engineering students may struggle with complicated theories, heavy assignments, lack of motivation and disengagement in the classroom. According to studies, student engagement in the classroom is critical in the learning process. It can increase students' attention and motivate them to practice critical thinking skill. It may also promote positive learning experiences. By this, the learning outcomes in technical understanding and application definitely can be improved. However, how to increase student engagement, particularly for engineering courses in the classroom? Educators are introducing several student-centred teaching methods to replace the traditional direct instruction teaching methods, such as inquiry-based learning, project-based learning, service-based learning and others. This study is to explore the gamification toward the engineering student to increase their engagement in class. A class with 109 students in the second year course of Electrical Engineering Technology (EET) are invited to participate in the study. A gamified learning model with 4 stage games is created in the online platform and participates by the EET students' willingness. This gamified learning model has implemented rank, interactive map and video guide. A survey related to gamification is collected from the EET students who completed the gamified learning model. This survey is mainly to obtain feedback on the gamification experience of the students. The results are generally positive and indicate that gamification can improve engineering student engagement and enjoyment toward the learning process.

Keywords: Gamification, Student's engagement, Engineering courses, Motivation

1. Introduction

Engineering courses usually are emphasising on theoretical concepts and their application. However,

practical work in laboratories is also mandatory in engineering courses [1]. Without full attention and time revision, the students may struggle to have a deep understanding of what they have taught in class.

As this new knowledge is acquired by merely listening to the class, it is hard to digest all the information. One can start listening with much enthusiasm, but it will bore, motivation and engagement may decrease when things go long.

Besides, students nowadays are exposed to overloaded information from the rapid development of new technologies every day. They may cause the students to lose their passion for sitting through the entire period and focus on the professors' lectures. Some students even play mobile games or chatting via social media app secretly in the classroom. This disturbance will cause the learning process in the classroom to become inefficient and low engagement. The traditional education approach, such as giving lectures on a PowerPoint slide, is not enough anymore, particularly to the engineering students at the university level. An active learning environment needs to be created for university students to reduce the technology's distraction.

According to [2], gamers can sit for hours to play a game without losing much attention and energy cause of the fun and excitement within it. The game mechanism is currently applied widely across numerous fields to improve the design of non-game context, helping create outcomes that enhance user engagement [3]. This process is called gamification, where the game mechanism is used in the non-game systems and process [4]. It has proven to bring positive effects in increase the motivation in learning processes [5].

Gamification is defined as the utilisation of game mechanism, frameworks and dynamic forces to promote preferred comportments. It is an elevating technology trend since 2010 and reinforced by recent behavioural studies, which exposed that: the desire to improve, to achieve, to direct our own lives, and to connect with others exists within all of us as a core set of intrinsic motivators [6]. That is why game catching so much attention, in the United States of America alone, the population that plays computer games are around 59% [7]. Therefore, how to motivate someone is the key to successful long-term engagement in the learning process.

In this work, the gamification toward the engineering student to increase their engagement in class is studied. A gamified learning model with four stages of the game is created in the E-leap online learning platform and participates by the EET students' willingness. This gamified learning model has implemented rank, interactive map and video guide. A survey related to gamification is collected from the EET students who completed the gamified learning model. This survey is mainly to obtain feedback on the gamification experience of the students.

The following paper arrangement is background and motivations section that summarised the related papers and provided the motivations behind this project. Next, the methodology section explains the development of the application, and the result section describes the finding after the students participating in the game. Finally, the conclusions section provides the potential future works in gamification for engineering students at the university level.

2. Background and motivation

Several papers were reviewed before the initial development of this study. A brief description of those works is presented in this section. Educators are introducing several student-centred teaching methods to replace the traditional direct instruction teaching methods, such as inquiry-based learning (IBL), project-based learning (PBL), service-based learning (SBL) and others. IBL is a constructivist learning method that requires students to have self-exploration, sit for standardised assessments, and report the progression. Students are welcome to ask any related questions, answer open-ended questions and accumulate their experience [8]. One of the papers proposes that IBL lessons should also be focusing on "Internet Security" [9]. Students are asked to search the information through the internet actively. The quantitative data, including teacher's teaching logs, reflection and student interviews, are collected and analysed. The results are positive and indicate the students enjoyed the IBL approach in learning Computer Studies. The results also show that the student's understanding of the learning unit increased through the IBL approach.

Project-based learning (PBL) is a learning method that the students play an active role in the learning process. In [10], a study that implements PBL activity onto a sample size of 40 students was conducted. Students who equip with reasonably basic knowledge of Mechanical Engineering and Electronics & Telecommunication Engineering discipline were selected. Both discipline students were assigned with different interdisciplinary projects. The comparison on the performance of each activity effect was studied by observing the pre and post-activity performance statistics. In return, this project-based learning can enhance students' self-learning skills, where they can develop skills such as critical thinking, problem-solving, and self-management.

In [11], a free game-based learning platform, Kahoot, was implemented in the Information and Communication Technologies (ICT) course and Legal business environment (LBE) course for teaching. It was used to check the students' understanding and bring out more fun and motivating environment for students to be engaged in class by playing and competing together. Kahoot was used as an examination preparations quiz. The students were given 20 seconds to answer each of the questions in Kahoot that assembled by the lectures. Kahoot ranks the students by their accuracy and the speed of an answer. A sample of 100 students (N=100) for the ICT course and 85 students (N=85) for the LBE course were collected. There were 70% of students for ICT, and 40% of students for LBE filled the survey form after participated in the Kahoot game. Over 95% of students gave grades 4 or 5 in the survey: ICT 96% and in LBE 98%.

Another paper stated that many students do not feel comfortable presenting in front of the public. They will avoid interaction with the lecturers and even avoid answering questions to lecturers in the classroom [12]. As a result, an education learning system with gamification and half-anonymised was created to improve students' interactions. This approach encourages students to engage simultaneously in both off and online communication. The paper in [13] proposed using the gamification approach to enhance students' testing habits and make the learning experience more engaging and enjoyable. A turn-based game called CoverBot was developed to realise the idea by integrating gamification onto the statement coverage teaching. This paper focused on five gamification elements: graphics/animations, sound effects/music, scoring system, combat system, and level progression. The user study was conducted for testing the effectiveness of CoverBot concerning both teaching statement coverage and increasing engagement and enjoyment. It was found that this gamification approach makes the learning materials more engaging. The participant's performance and understanding of statement coverage were enhanced when the engagement and enjoyment rate was high.

Based on the review of related works, there are numerous student-centred teaching methods introduced by educators to replace traditional direct instruction teaching methods. However, which approach is suitable for the courses consisting of complex theories, heavy assignments, and boring class still need to be discovered. This study will focus on the question "how to increase the student engagement, particularly for engineering courses in the classroom?". The gamification learning approach is selected to be implemented in the classroom of engineering course.

3. Methodology

The second-year students for cohort 2018/2019 in the electrical and electronic engineering department are selected in this study. The total of students for the cohort is 107. They are selected because they have experienced one year of study and used to the usual lecture environment at the university. In the second year first semester, they are required to take five core engineering courses and two university courses. Among the core engineering courses are signals and systems, safety and health in engineering, electrical engineering technology, engineering mathematics 3, and analog and digital electronic application. The gamification approach is implemented in electrical engineering technology course because it comprises theoretical concepts, calculations, and design. This course consists of three-course learning outcomes (CLO): CLO 1. analyse the concept of electrostatics, electromagnetism and single-phase electrical installation system in electrical engineering technology, CLO 2. analyse the multiphase system in electrical engineering technology, and CLO 3. apply the concepts of multiphase systems in power alternating current (AC) transformer. This study is focused on CLO 2, where the gamified learning model is developed based on the multiphase system in electrical engineering.

In the gamified model, the elements such as narrative story, rank, interactive map and lesson video are included. The students are advised to watch the lesson video before playing the game. The score and leader board are displayed on the online learning platform called UNIMAS ELEAP. The score in the form of marks is received once completing the game. The leaderboard in each stage of the game is created to boost the engagement of the students. There are five types of rank to be awarded to the students who manage to obtain the cumulative score, as shown in figure 1. The students are informed at the beginning that the participation is based on willingness. The score will not be included in the assessment of the course.

Figure 1. Rank for cumulative score

A. Target Group

A class with 107 students in the second year of the Electrical Engineering Technology (EET) course participates in this study. There are only 105 students who responded to the invitation. Table 1 presented the profile of the respondents in each stage of the game.

Table I. Number of the participant in gamification activity

Activity	Number of Participants
Game Stage 1	105
Game Stage 2	102
Game Stage 3	98
Game Stage 4	74
Survey	69

B. Game Description

Research has shown that gamification can increase engagement and enhance the learning experience, including the education field [14]. Numerous game elements are applied to the studies, including the best game elements that give the participants the most satisfaction [15]. In this study, the implemented game elements are narrative story, rank, interactive map, and video lesson. A gamified learning model with four-stage of the game is created through UNIMAS ELEAP. The participant will first sign in to the UNIMAS ELEAP account to enter the EET course site. The introduction of the game is displayed at the end of the CLO 2 learning unit. After entering the game model, the narrative story about the game, as shown in figure 2, will appear. The participant needs to read and understand the story to know the role he or she is played in the game. After going through the narrative story, the participant will be redirected to the map, as shown in Figure 3. The participant cannot simply continue to another stage in the interactive map before finishing the stage before one another. This ensures the participant can learn the lesson for each stage before moving to another level of difficulties.

Figure 2. Narrative story

Figure3. Interactive map

C. Stage of game

There are four stages of the game and each with the rules of continuing after finish one from another. There is a video lesson on the topic of each stage of the game. Figure 4 shows the video lesson of stage 2. The participant is advised to watch and understand the video lesson before starting the game to avoid losing the score.

- Stage 1- Kahoot based game where participant needs to have high accuracy and speed in answering the questions related to

the fundamental knowledge of direct current and voltage.

- Stage 2- Video lesson based game and answering the questions related to alternating current and voltage.
- Stage 3- Video lesson based game and answering the questions related to calculation on combination sinusoidal waveforms.
- Stage 4- Video lesson based game and answering the questions related to three-phase electricity.

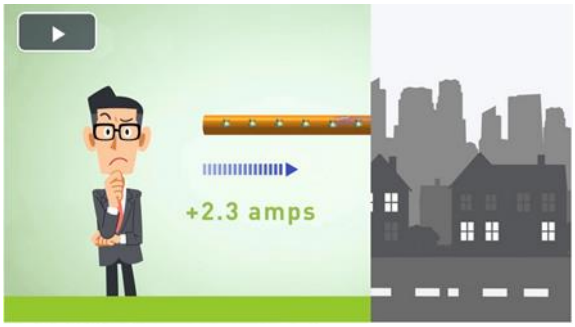

Figure 4. Video lesson for stage 2

D. Data collection and analysis

After the students finish each stage of the game, their progression and score will be fully recorded in the UNIMAS ELEAP. The data collected are the time started, time ended, score, duration and personal information. The collected data will be analysed to investigate the engagement of students in this gamified model learning approach. Furthermore, the participant will need to fill out a survey form, as shown in figure 5, after complete the game. This survey mainly obtains the participant perspective on implementing game mechanism onto the teaching and learning in the engineering course.

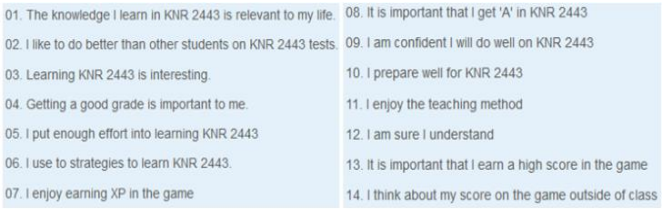

Figure 5. Example of the survey form

4. Result and discussion

A. Game model analysis

The gamified learning model was employed in the invited 107 students from the second year of the Electrical Engineering Technology (EET) course. They are tested with different game levels covering different EET sub-topics, such as alternating current, sinusoidal waveform, and three-phase electricity. Those games required theoretical concepts and practical exercises on the calculation to conquer each stage of the game.

In stage one, the students who were willing to participate in the game were divided into two groups and answered the Kahoot platform's questions simultaneously. The group with the highest score will receive a gift. This is to create an interactive and joyful environment in the classroom and attract them to continue to the second stage of the game.

The results such as time started and duration are taken to finish the game in stages 2, 3, and 4 is analysed to determine the students' engagement and motivation by the gamification approach. The analysis results were presented in figure 6, figure 7, figure 8 and Figure 9. Figure 6 shows the number of participants versus the duration taken to complete the game in the second stage. The participants were given 20 minutes to complete the game. The majority of participants used 15 to 20 minutes to complete the stage 2 game. Only 3% of the participants spent less than 5 minutes to complete the game. So, the engagement of the participants toward the game can be considered high since they fully utilised the time provided in the game to solve the given task.

Figure 7 shows the number of participants versus the duration taken to complete the game's third stage. The participants were given 15 minutes to complete the game. In this game, three questions were provided; one theoretical questions and two calculations. The first two questions were multiple-choice. The participants need to show the working step of the calculation in the last question. Nearly 97% of participants spent nearly 10 minutes completing this game. Besides, nearly 79% of participants scored more than 10 over 20. The participants were genuinely motivated and playing the game seriously.

Figure 8 shows the number of participants versus the duration taken to complete the last stage of the game. The participants were given 20 minutes to complete a question in the last stage. The students need to calculate the line voltage, line current, phase voltage and phase current in a given situation. Nearly 24 of the participants give up in this stage. Also, only 47% of participants spent more than 15 minutes completing the game. The participants that spend less than 5 minutes is increased in stage four of the game, as it can be implied that they have lost some motivation after going through the three stages of the game.

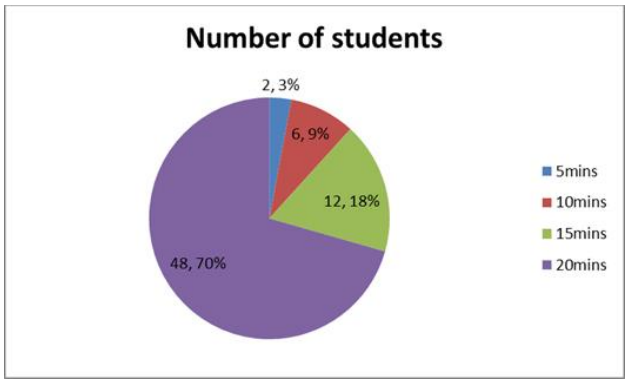

Figure 6. Number of participants versus duration taken to complete the game in stage 2

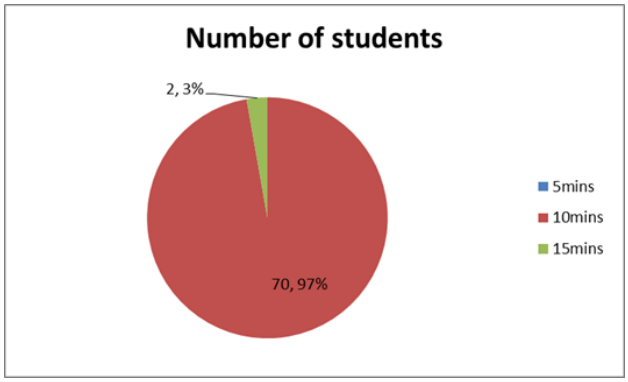

Figure 7. Number of participants versus duration taken to complete the game in stage 3

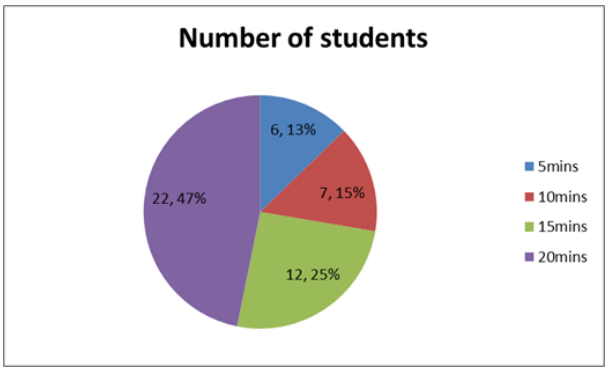

Figure 8. Number of student versus duration taken to complete the game in stage 4

B. Feedback Survey Analysis

There were only 69 students, which is around 65%, who participate in this feedback survey. In the first question of the survey, the participants are given several options to choose from, and they are allowed to choose more than one option. Figure 9 shows the choice of the participants. The three populated options that usually choose by participants are "the knowledge I learned in the Electrical Engineering Technology course is relevant to my life.", " I enjoyed the teaching method with gamification.", and "getting a good grade is important to me." There were around 16 participants who choose "the knowledge I learned in the Electrical Engineering Technology course is relevant to my life." and " I enjoyed the teaching method with gamification" each.

The participants who choose more than one option more prompt to choose "learning the Electrical Engineering Technology course is interesting". Then follow the option of "the knowledge I learned in the Electrical Engineering Technology course and getting a good grade is important to me." There were four participants who choose the option " I enjoyed the teaching gamification method". All these showed that participants enjoyed the gamification teaching approach, thus increasing participants' engagement in the class. The similarity that all participants had is that they feel no important to get a high score.

Figure 10 shows the weightage level for question two to question six from the participants. The weightage level can be divided into five, which are sometimes, rarely, never, often, and always. The purpose of these questions was to better understand participants' ideal on applied gamification onto the teaching. Overall, the number of participants that choose the weightage level for each question has a similar pattern. However, the question "I enjoy earning XP in the game" shows fewer participants choose the weightage of the level of rarely.

Lastly, figure 11 showed the percentage of participants who agree or disagree that the gaming learning method can increase engagement in class. From the graph, around 97% of the participants agree that the gamification approach can increase class engagement, and 3% denied it. Therefore, it can be concluded that implementing gamification into the engineering course can help motivate the students, hence increasing classroom engagement.

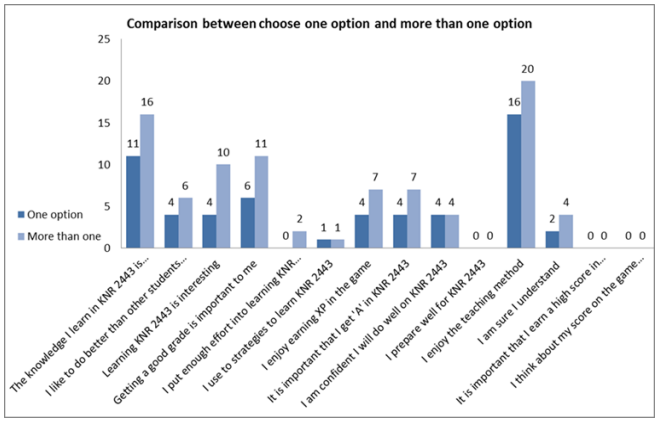

Figure 9. Choice of participants

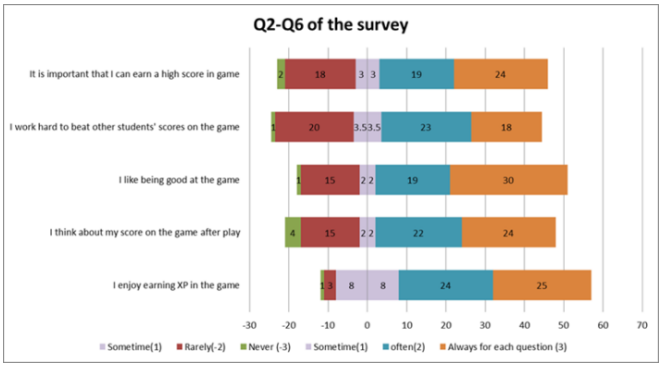

Figure 10. Survey results for question two to question 6

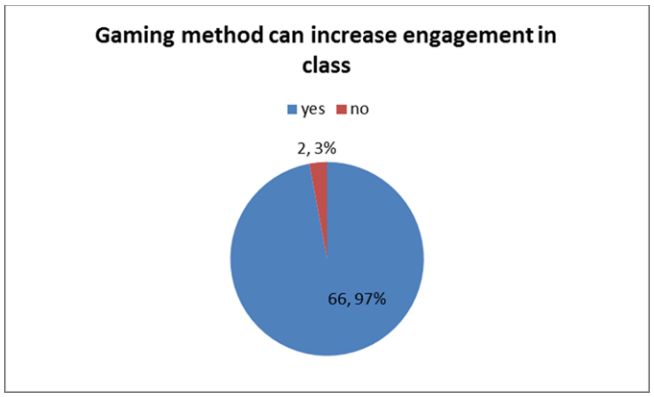

Figure 11. Percentage of participants who agree or disagree that the gaming learning method can increase engagement in class

5. Conclusion

This paper analysed the data collected from each game stage in the online learning platform UNIMAS ELEAP. In addition, the survey related to gamification was collected from the participants who completed the gamified learning model and analysed it. This survey is mainly to obtain feedback on the gamification experience of the students. From the finding, more than 72% of participants enjoy learning by playing the game at each stage. Generally, all the participants spend more than half of the distributed time, which shows that the engagement when implemented gamification can attract students to enjoy the game while learning the lesson from it. Besides, the survey result indicated that integrating game elements in teaching would help increase the engagement in the class. In conclusion, the results are generally positive and indicate that gamification can improve engineering student engagement and enjoyment toward the learning process.

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