

IMPLEMENTATION OF GAMIFICATION IN COMPUTING SUBJECTS: A COMPARISON STUDY

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Abstract

Gamification, which involves the use of game elements in non-game contexts, has been gaining increasing popularity and is being applied in various domains of studies in 'Computing Education'. However, not many studies have been carried out in terms of the application of gamification in technical and non-technical subjects within computing education. Taking this in view, this paper will investigate the impact of gamification on student engagement, motivation and student learning in two introductory computing subjects, which are Programming (technical) and System Analysis (non-technical). A comparison study would be carried out to study the effect of implementation of gamification for these two different types of subjects using various software applications. Some best practices in gamification such as using badges, levels, providing feedback, rewards and team collaboration would be applied. In order to measure the implementation results, online surveys, focus group interviews and observations would be conducted to answer the research question.

Keywords

Gamification, Programming, System Analysis, Student Engagement, Motivation, Computing Subjects, Comparison Study.

1. Introduction

One of the initiatives of education in order to meet the Industrial Revolution 4.0 is empowering education through innovation. In order to meet this call, it is important for universities to embark in using technology and innovative pedagogy in teaching and learning in order to engage students. This is because passive learning styles that are often used in traditional teaching do not prepare students with the required soft skills for their future careers in this 21st century era. Therefore, success in academia means the educator must demonstrate competency in using Learning Management System (LMS) such as Moodle or Blackboard with innovative teaching approaches in order to produce graduates who can use technology for learning, have excellent social intelligences and collaborative skills. One of the teaching and learning techniques that is gaining popularity is gamification which is often being used to increase student motivation and the learning process (Maia & Graeml, 2015). In fact, gamification has recently become a standout amongst the most important trends in technology and is spreading from the kindergarten-primary school level up to the university stages in many disciplines (Deloitte, 2011). It is estimated that by 2020, the education gamification market value would reach \$1.5 billion (Statista, 2017).

Computing is one of the popular majors in Universities and gaining more popularity due to Industrial Revolution 4.0. But sometimes, students find learning computing subjects difficult as the presentation of the material is difficult to comprehend making it less interesting and boring for them. (Khaleel et. al., 2017). Computing subjects can be broadly divided into technical and non-technical subjects. Technical subjects are subjects such as Programming, Data Structure and Algorithm, Computer Graphic, whereas subjects that are non-technical are System Analysis, User Interface Design, Information Systems and E-Business. Taking this into consideration, more systematic research is needed on determining how different type of subjects in computing can benefit from the use of gamification in an educational setting. Also, according to Thornton and Francia (2014), they stated that the application of gamification may not be applicable to all curriculum, which may result in unfavorable consequences (Thornton & Francia 2014).

Taking these two points in view, this research would fill the gap by studying on the differences between the effect of gamification towards technical and non-technical subjects. The technical subject selected for this study is Introduction to Java Programming and for the non-technical subject, it is System Analysis. Programming was selected for study because it is often viewed as hard and has a dropout rates of 20-40 percent as it contains difficult abstract concepts to master (Niiitsoo,2014). Similarly, Lawrence J. & Mazlack's (1980) research shows that introductory programming courses have a relatively high failure and drop-out rates. This is further supported by Byrne & Lyons (2001), who states that programming to be the most difficult and least interesting subject by most first year students in all computing courses. In an attempt to mitigate this problem, the adoption of mastery learning approach is used in the programming course (Andrew et. al., 2017). This approach allows students to be assessed before being allowed to progress to the next unit which follows similar concepts used in gamification.

Based on our literature review, we did not find much studies on gamification in the area of System Analysis. The nearest to it is research done is applying gamification elements in Software Engineering education which is still in the preliminary stages. Microsoft is one of the giant companies that support the use of game mechanics in the learning of Software Engineering (Ross, 2011). Most of the research in Gamification that are related to software engineering are done in the area of software development life cycles and software process improvement initiatives (Herranz, Amescua & Yilmaz, 2014). Currently, there is still not much research being done in the area of System Analysis in specific. Due to the findings of our preliminary studies, Programming Language and System Analysis are both good candidates to study on the implementation of gamification. Furthermore, the nature of these subjects are very much different, one is technical and another one is non-technical. So it is good to do a comparison study on these two subjects on the effects of implementing gamification.

2. Literature review

Gamification was coined by Pelling (2011) and started to gain popularity in the education circle around 2010. One of the most popular definitions is the one provided by Deterding et al. (2011), who defines gamification as “the use of game design elements in non-game contexts. The main goal of gamification is to use the elements in game design in a non-game environment to increase motivation and engagement (Pedreira et. al., 2015). Game design elements that are often used in an educational or learning context are points, levels/stages, badges, leaderboards, prizes/rewards, progress bars, storyline, and feedback.”

Despite the numerous attempts by educators to incorporate gaming for learning in education, these efforts have yielded only mixed results (Van Eck, 2006). Similarly, other evidence reveals that gamification can be a powerful weapon while dealing with poor students' performance, but its implementation is mainly presented on individual cases and its success differs from study to study. (O'Donovan et.al., 2013) .

Gamification is effective to increase the motivation, and support the student especially in their learning process and has proven successful in enhancing their engagement and interest (Dicheva et.al., 2014) . The most positive benefits obtained from employing gamification is that it provides motivation and supports the students especially in the learning process (Maia & Graeml, 2015).

In addition, gamification has positive effects in student achievement and student's attitudes toward the lesson due to its dynamism (Yildirim, 2017). Gamification has also gained promising results in enhancing student engagement and interest in the subject area.

However, some game designs resulted in boring games that do not promote effective learning (Mitgutsch & Alvarado, 2012). Another result of failure reported are that some students may not interact with the gamified learning task due to their unfamiliarity with gamification and its strategies (Ding et al., 2018; Van Roy & Zaman, 2018). So, it is important for educators to carefully design the gamification activities but it may not be an easy task as many factors need to be considered in order for it to be successful. As Bogost (2011) commented, making games that serve some external purpose is not an easy task.

3. Research Methodology

This research focuses on two main areas:

- (i) To explore the impact of gamification on student engagement, student motivation and student understanding.
- (ii) To compare whether there are any differences between implementation of gamification for technical and non-technical subjects in computing degree courses.

In order to conduct this study, 32 students from Year 1 of the University of Wollongong Degree Programme who are taking the Computing Major, had participated in it. The subjects selected for this study were Programming Fundamentals and System Analysis. Students were divided into 4-5 members in a group and asked to propose a group name in order to participate in this gamification activity. The students remained in the same group throughout the entire gamification activities during the semester.

Two techniques were adopted to obtain data for this research. First, an online survey was conducted and second, a focus group interview was conducted to further understand the student perception towards the implementation of gamification in both the System Analysis and Programming subjects.

The online survey was applied to collect a quantitative perspective of the students' perception. The survey was conducted using Google forms which consisted of both 11 closed-ended questions and 1 open-ended question. All students who were involved in this study, took part in answering the questionnaire at the end of the semester.

The focus group interview was used to provide a qualitative perspective on the students' perception of the gamification elements introduced in the Programming and System Analysis course. For the focus group interview, one member from each group was called to participate in the interview session. In total, 5 questions were asked during this focus group interview.

Finally, an observation of the students' motivation and engagement during the gamification activities was done by observing students' body language and behavior. Some photos were also taken as evidence during the observation. Students were not informed of the observation that took place to ensure that they showed their natural behavior and not perform something that was staged.

4. Design of Implementation

Table 1 summarizes the gamification design plan that was used and implemented in both systems analysis and programming subjects. The detail explanation on each section is given below.

Gamification Elements	<ul style="list-style-type: none"> • Points • Badges • Leaderboards • Levels • Rewards • Feedback • Challenges 	
Software Tools	To help stimulate the Lower Order Thinking (Bloom's Taxonomy – Remember, Understand, Apply)	Online Crossword Puzzle Kahoot Online video
	To help stimulate the Higher Order Thinking (Bloom's Taxonomy – Analyze, Evaluate, Create)	Wiki on Moodle LMS Online Quiz NetBeans Programming IDE (Integrated Development Environment)
Measurement Tools	<ul style="list-style-type: none"> • Survey through questionnaire • Focus group interview • Class Observation 	
Implementation Plan Map	Two separate path running in parallel: <ul style="list-style-type: none"> • Race – Points Collection Activities • Learning – Badge Collection Activities 	

Table 1: Summary of Gamification Design Plan

4.1. Gamification Elements

Gamification elements (or techniques) are building blocks or features that are normally used in games which can be used in a non-game context to create a game-like environment for the purpose to increase motivation and engagement (Barata et. al., 2013).

The following figure shows the percentage of the gamification elements (or techniques) used in previous studies. From the figure, it is clearly shown that some of the elements (or techniques) are more commonly used compared to others. The figure shows that the most common gamification elements used includes points, badges, and leaderboards.

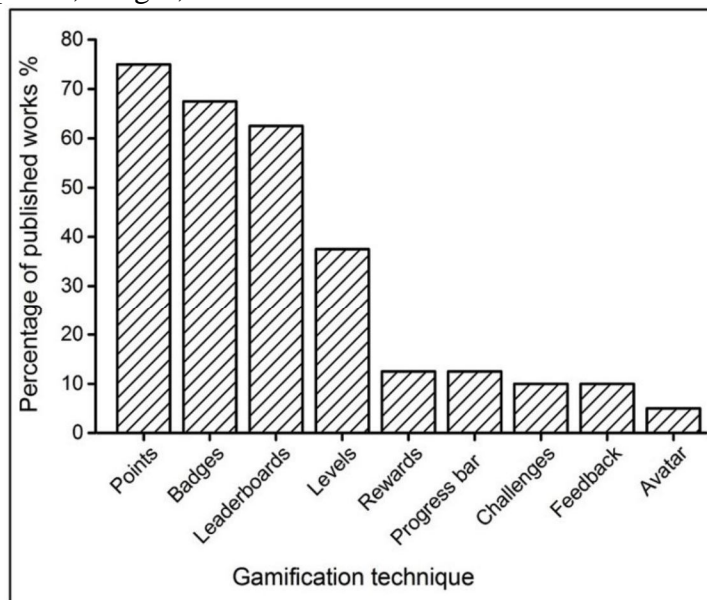


Figure 1: Gamification techniques used in previous studies (Alomari et. al., 2019)

For the purpose of this research, the selected elements (or techniques) are points, badges, leaderboards, levels, rewards, feedback, and challenges. This represents more than 70% of the elements (or techniques) shown in the figure above. Furthermore, the elements (or techniques) that have the highest percentage used in published works were selected to be used in this research. In addition to that, according to Nah et al.(2014), game design elements that are often used in an educational or learning context are experience points, levels/stages, badges, leaderboards, prizes/rewards, progress bars, storyline, and feedback.


Leaderboard

No	Group Name	Level 1	Level 2	Level 3	Total
1	kmc	15172	3800	1325	20297
3	Ang Moh Kio	14640	3000	1575	19215
2	Hikarium	13358	4000	1550	18908
4	Unicorn	11968	3000	1350	16318
5	ATOM	9392	2800	1233	13425


(Top 5 Achievers in Points Collections)

Different Level implemented


Points awarded



Level 1 Badge: **Gamification Apprentice**
 Task 1: Achieve 8 points - 2 x Level 1 badges, achieve 6-7 points - 1 x Level 1 Badge



Level 2 Badge: **Gamification Journeyman**
 Task 2: Achieve 3 criteria - 2 x Level 2 badges, Achieve 2 criteria - 1 x Level 2 Badge



Level 3 Badge: **Gamification Master Craftsman**
 Task 3: Completed and Uploaded within 10 mins - 2 x Level 3 badges, Completed and Uploaded latest in 20 mins - 1 x Level 3 badges

Figure 3: Badges

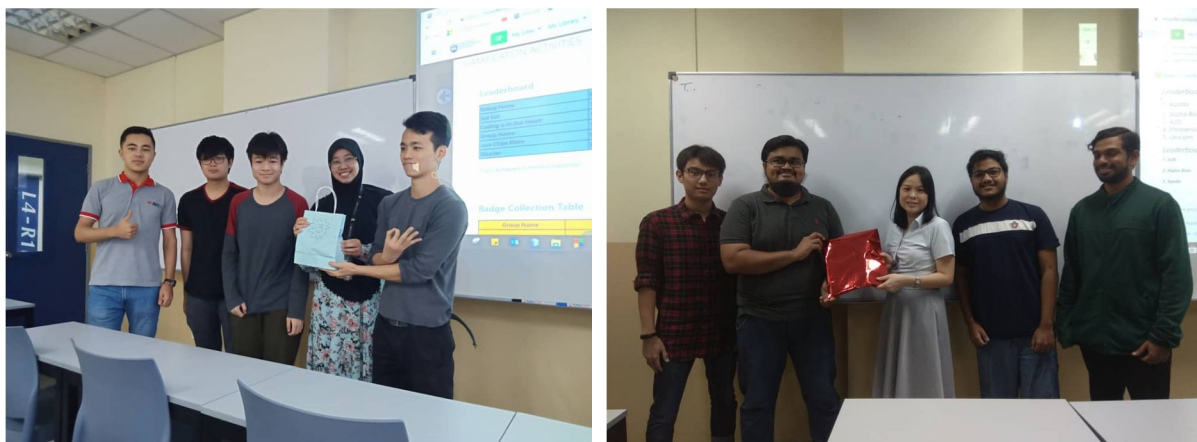


Figure 4: Reward Giving Ceremony

4.1.1. Points

Points refer to the numerical values awarded to evaluate the performance of individuals in game and non-game contexts (Brewer et al., 2013). Points not only provide feedback on an individual's performance but also help to make individuals feel challenged and can be used to rank individuals based on their level (Huang & Ho, 2018). It is also used to help in creating a competitive fun environment where students are motivated to participate in order to get more points and eventually winning the competition (Alomari et. al., 2019).

In this research, points were given to students depending on their placing if they won in a particular race or competition. All students who compete in the race will receive points. However, the faster they finish the race, the more points they will get. The results of the top five winners will be displayed on a leaderboard which will be explained below.

4.1.2. Badges

Badges are tokens in a form of graphical or visual representation of achievement that can be collected after completing an activity in gamification (Seaborn & Fels, 2015). From previous studies, badges are identified as a technique that can be used to reinforce motivation among learners by increasing their sense of competence and self-determination (Suh, Wagner, & Liu, 2018; Van Roy & Zaman, 2018).

In this research, badges were awarded to students who completed a certain task apart from the competition. These tasks are designed to make the students go through a learning process. To complete these tasks, the students will have to do research, revision, or reading of a particular topic. If they complete the tasks successfully within a certain time limit, one or two badges are awarded to them.

4.1.3. Leaderboards

To help create a sense of competition between students, a leaderboard is used to display the top five students after each race or competition. A leaderboard is an electronic board showing the ranking of leaders in a competitive learning environment (Seaborn & Fels, 2015). Using leaderboards can increase the students' performance by enabling them to view the performances of their classmates (Suh et al., 2018) and therefore motivate them to be better than others. The leaderboard is displayed on Moodle LMS and updated after each level has been completed.

4.1.4. Levels

The gamification activities are arranged in different levels. Students will start at the lowest level and move to the higher levels in the sequence that have been pre-arranged. The difficulty of the challenges at each level increases from one level to the next. Some studies have shown that level-based system can improve students' motivation (Alomari, Al-Samarraie and Yousef, 2019). Before starting with the gamification activities, students are informed on the number of levels they will have to go through and that they will be given points after each level is completed.

4.1.5. Rewards

At the end of the gamification activities, rewards are given to the overall top three achievers. The reward used can be of any sort and in this research, hampers made up of chocolates and snacks were given as reward. The reward-based system is reported to be able to give a positive effect on students' motivation and engagement (Ding et al., 2018). Students are informed earlier that at the end of the activities that rewards will be given so that they will look forward to it and work harder.

4.1.6. Feedback

The feedback on the students' achievements are given after they have completed each activity at each level. Combefis et. al.(2016) have analyzed several game-based online programming platforms. Amongst others, they concluded that successful educational game platforms need to be provided appropriate feedback and assessments.

4.1.7. Challenges

The race or competition activities are designed to give increasing challenges to students as they move from one level to another. Studies done by other researches (Rincon-Flores et al., 2018; Van Roy & Zaman, 2018) also show that increasing the level of challenge in gamifying an activity can stimulate students' motivation and performance.

4.2. Software Tools

The software tools selected for this study are divided into two categories:

- Software tools that help to stimulate the 'Lower Order Thinking' as stated in the Bloom's Taxonomy which includes the ability to remember, understand, and apply. The software used are Online Crossword Puzzle, Kahoot, Moodle Lesson, and Online Video.
- Software tools that help to stimulate the 'Higher Order Thinking' as stated in the Bloom's Taxonomy which includes the ability to analyze, evaluate, and create. The software used for this includes Wiki on Moodle LMS, Online Quiz, Online Discussion Forum, and NetBeans Programming IDE.

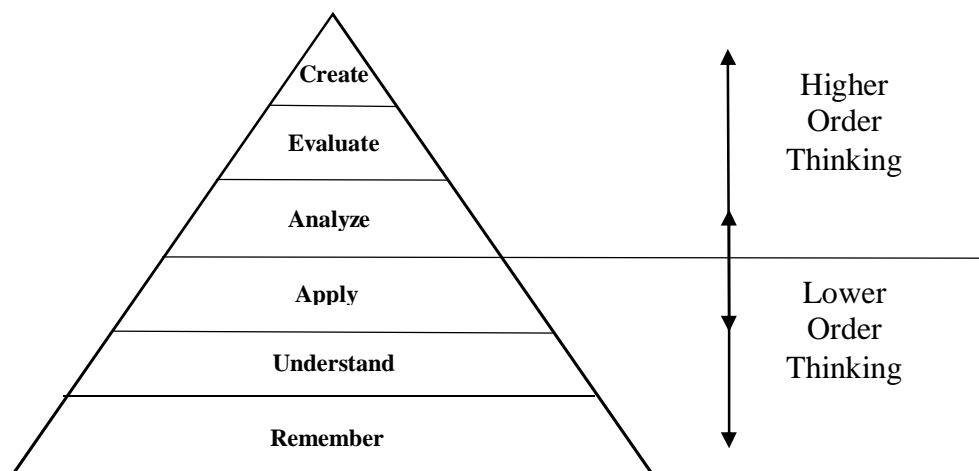


Figure 5: Bloom's Taxonomy

The following table shows the details on how the software tools are used for each subject:

Software Tool	Systems Analysis	Programming
Online Crossword Puzzle	For both subjects, this software tool is used to recall the meaning of certain terms used in the subject.	
Kahoot	For both subjects, this software tool is used to test the understanding of basic knowledge on the subject.	
Moodle Lesson	For both subjects, this software tool is used to present a lesson on a particular topic where students have to go through and answer several short quizzes for reflections.	
Online Video	Students are provided with online videos to view. Questions are given based on the content of the video and students provide reflections on Wiki.	Instead of viewing online videos, students are required to record a video on a given topic and upload the recorded video to a Wiki page on Moodle LMS
Online Discussion Forum	Case studies are given and students are asked to construct questionnaires to elicit information from stakeholders of the case studies. Review of the answers are done in class.	Not used.
Wiki on Moodle LMS	Students provide reflections on the videos they viewed.	Students upload the videos recorded and other students may view the videos for their own learning. Lecturer provides feedback on each videos.
Online Quiz	Both subjects used the Moodle LMS Online Quiz to test the students' understanding using more critical and challenging questions.	
NetBeans Programming IDE	Not used.	Students are given challenging problems to be solved using the IDE.

Table 2: Software Tools Used

4.3. Gamification Implementation Plan Map

The comparison of the gamification implementation between the two subjects will focus on the students' experience. Therefore, the framework used will be the same for both subjects. The overall implementation of gamification for both subjects is divided into two paths with a slight variation. The following diagram shows the flow of the two types of activities when implemented for both subjects. The different activities are shown in red rectangles in the diagram due to the different nature of the subjects.

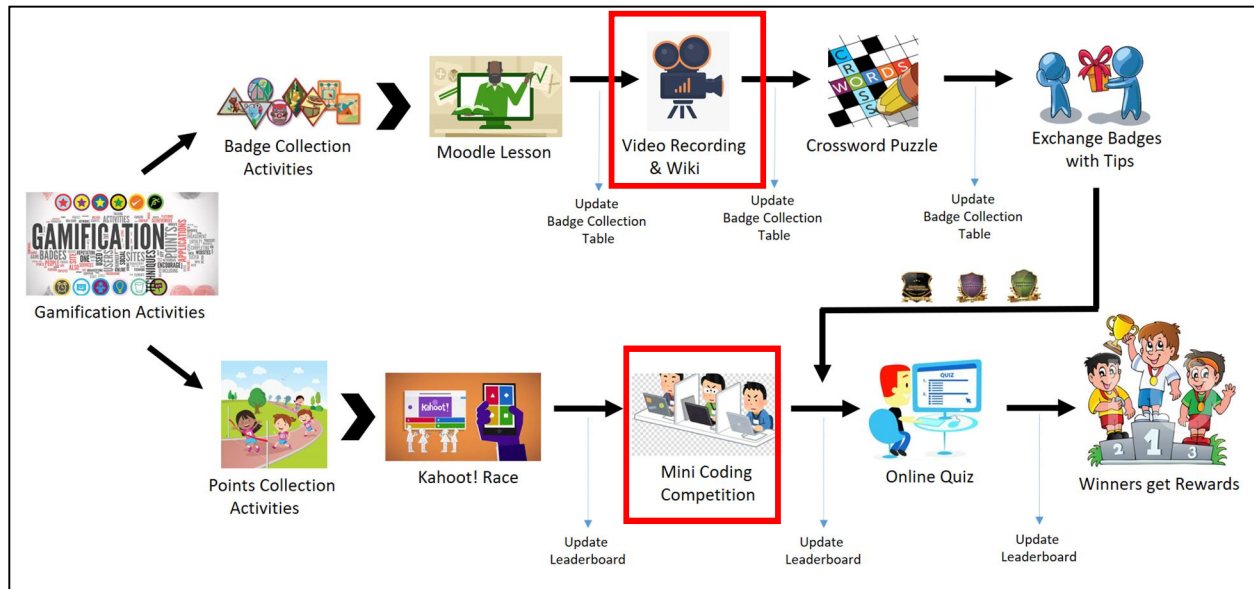


Figure 6: Gamification Activities Plan Map for the Programming Subject

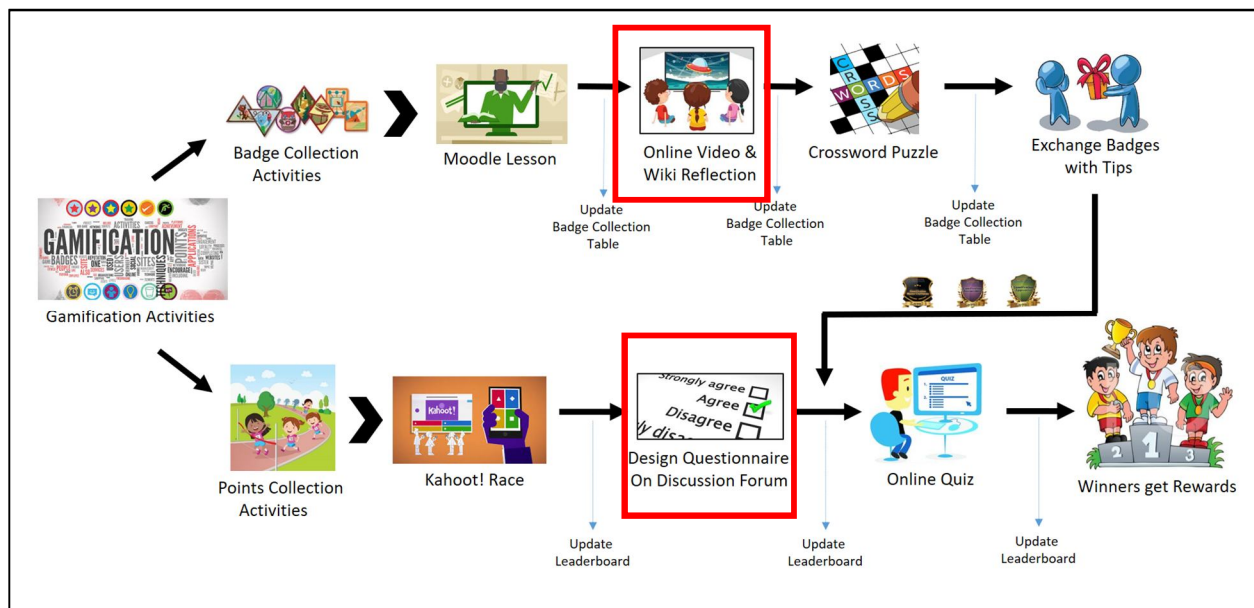


Figure 7: Gamification Activities Plan Map for the System Analysis Subject

The first path is a race or competition where activities are designed to be at three different level of difficulties. At each level, different types of challenges are given and students are required

to complete the lower level before moving to the next higher level. After completing the challenge at a particular level, points are awarded which will be accumulated at the end. After a challenge has been completed, the leaderboard will be updated showing the top five winners for a particular level.

The second path consists of activities for badge collections that are designed to be in three different levels. The activities in this path are designed to allow the students to experience a different learning process by doing research or revision on a certain topic. After completing this activity, they will be awarded with one or two badges depending on certain criteria set for the activity.

5. Findings

5.1. Online Survey using Questionnaire

A total of 32 respondents took part in this questionnaire. The questionnaire used a Likert scale from 1 to 4 with 1 being 'strongly agree' and 4 'strongly disagree'. The students who took part in this questionnaire had taken both the System Analysis and Programming subjects during the same semester. The following were the results.

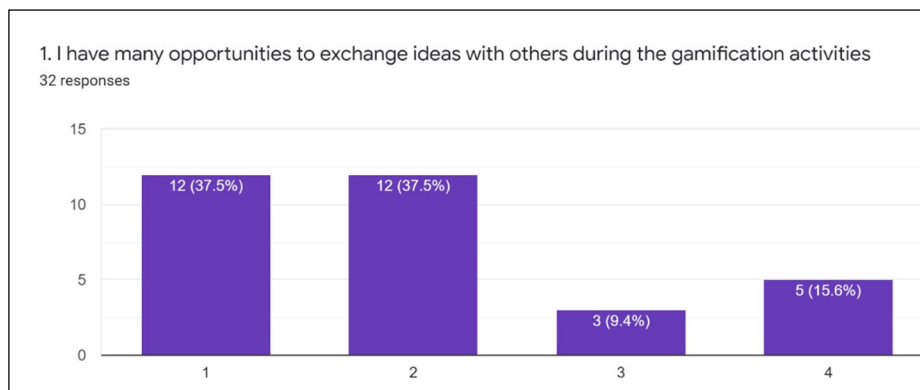


Figure 8: Questionnaire result for Question 1

More than 70% of the respondent agreed that they had many opportunities to exchange ideas with others during the gamification activities.

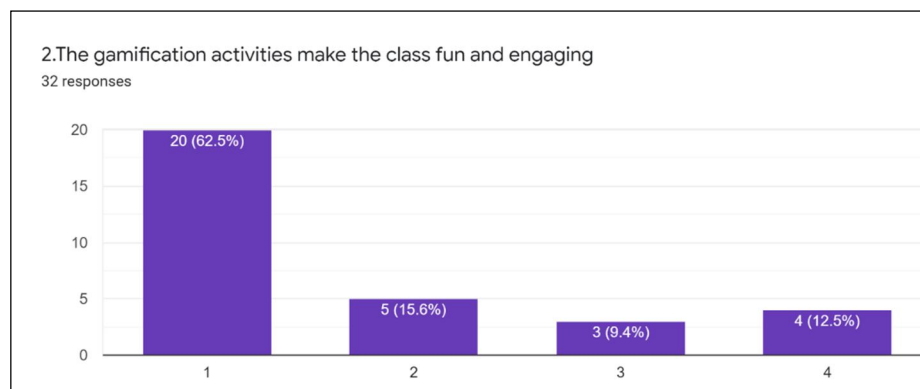


Figure 9: Questionnaire result for Question 2

More than 70% of the respondents also indicated that the gamification activities made the class fun and engaging.

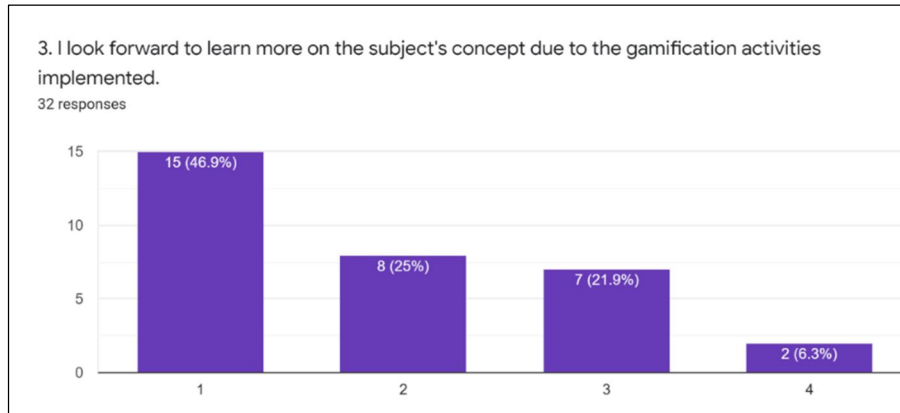


Figure 10: Questionnaire result for Question 3

Question 3 results show that majority of the students are looking forward to learning more on the subject due to the gamification activities implemented.

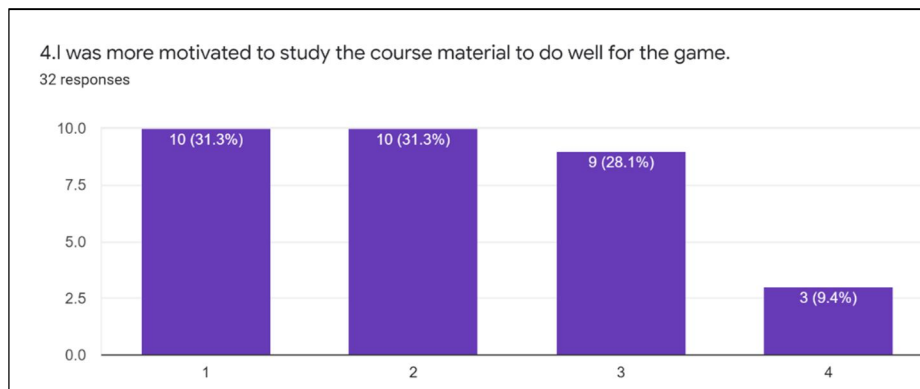


Figure 11: Questionnaire result for Question 4

This result however shows only slightly more than 50% of the respondents felt motivated to study the subject in order to do well for the game.

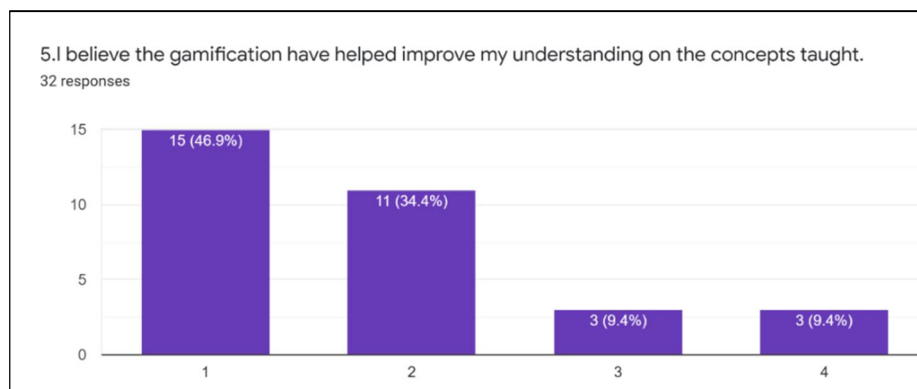


Figure 12: Questionnaire result for Question 5

A significant number of students (more than 80%) believed the gamification had helped them improve their understanding on the concepts taught for both subjects.

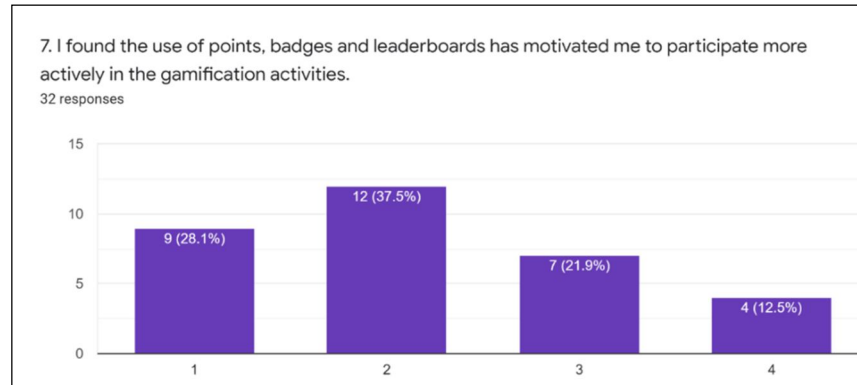


Figure 13: Questionnaire result for Question 7

In terms of using the gamification element that includes points, badges, and leaderboards, a total of 65.6% of the respondents felt that it motivated them to participate more actively in the gamification activities.

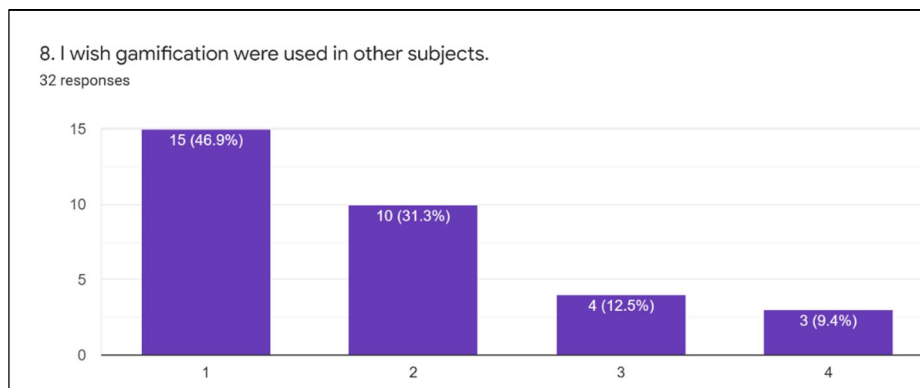


Figure 14: Questionnaire result for Question 8

Majority of the students also wish that gamification was used in other subjects apart from system analysis and programming.

5.2. Focus Group Interview

From the focus group interview, it can be deduced the gamification has a positive effect to student learning for both subjects. Representatives from 9 groups had contributed to the focus group interview and below are the overall summarised feedback that provides the necessary evidence.

- i) Do you think that it is a good idea to use gamification to teach Systems Analysis or Programming subject? Why?

Feedback:

All groups have commented that it is a good practice for both subjects because it allows groups to share ideas with one another. They like the interaction opportunity and the interesting game elements that make the class more interesting.

- ii) Which particular gamification activity helps you most in your learning for both subjects?

Feedback:

For both subjects, most of the students like the Kahoot game and also the Crossword Puzzle. The time limit gives them extra excitement to find the correct answer and make the class more engaging. The students responded that these two software tools are good in testing theoretical concepts in the subjects.

For programming, they also like the experience with Programming IDE in the mini coding competition because it helps them to have more practice writing codes.

- iii) In one word, describe your gamification experience.

Feedback:

Exciting, challenging, fun, interesting, awesome, motivating, positive competition, helpful, and tough.

- iv) Would you like gamification to be implemented for other subjects in INTI?

Feedback:

Yes.

- v) What needs to be improved in the gamification activities for both subjects?

Feedback:

For System Analysis, the students feel that there is not much individual learning because all activities are done in groups. Students also feel that there should be marks awarded for individual effort.

For Programming, the students prefer to have a postmortem session to discuss the mistakes that they have done so that they can improve. They also prefer to have more time to complete each activity.

5.3. Class Observation

From the observation done for both subjects, the students had shown excitement during the activities which was seen through their body language such as laughing, clapping hands and etc. Students had also shown that they had developed soft-skills such as prompt decision making and problem-solving skills. There were a lot of discussions being done which showed high level of engagement even among the students who were normally very passive in class.

Apart from that, during the race or competition activities, the students has also shown eagerness to complete the task so that they could be the first to finish and win that competition. They were seen to be deeply focused and engaged in the activities set for them. There were also slight feeling of disappointment that were shown by those who lost in the competition indicating that they were really looking forward to being the winner.

These observations are seen as positive results from the gamification activities implemented in the classes. Below are photos taken during one of the class observations.



Figure 15: Observation Evidence on Students' Engagement

6. Comparison Analysis

This section analyzes the comparison of the implementation of gamification for both subjects, System Analysis and Programming. These two subjects were chosen because they differ in terms of technicality in computer science studies. System Analysis is known to be less technical and requires a lot of reading and understanding as compared to programming where logical thinking is required to code a program. This research highlights any similarities or differences that can be seen when implementing gamification for these two different subjects.

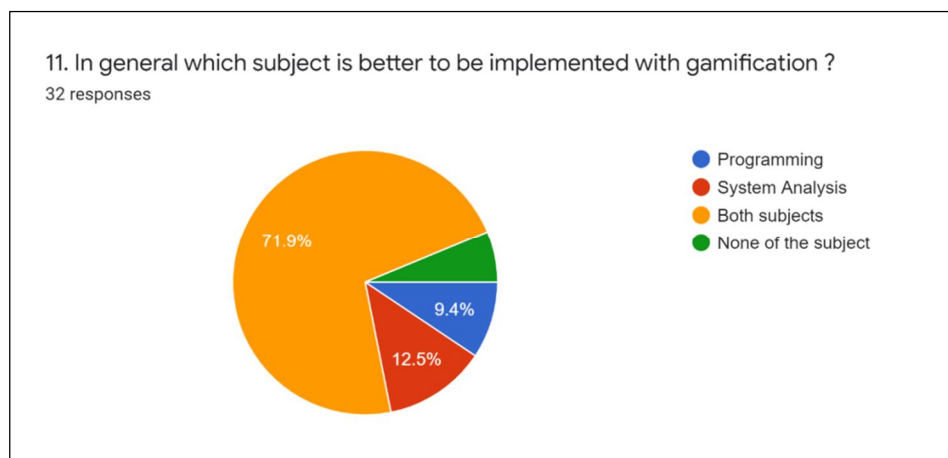


Figure 16: Questionnaire result for Question 11

In general, students' acceptance is the same for both subjects with regard to the implementation of gamification. Majority of the students (71.9%) reflected that they felt gamification can be implemented for both subjects as shown in the graph above. Only a small percentage (12.5% for system analysis and 9.4% for programming) chose one subject as being the better subject for implementation with gamification.

There is a small percentage of 6.2% of the respondent who felts that none of the subjects are better when implemented with gamification. However, this number is too small and does not represent majority of the students. It can therefore be concluded that generally, both subjects regardless of being technical or non-technical are better to be implemented with gamification.

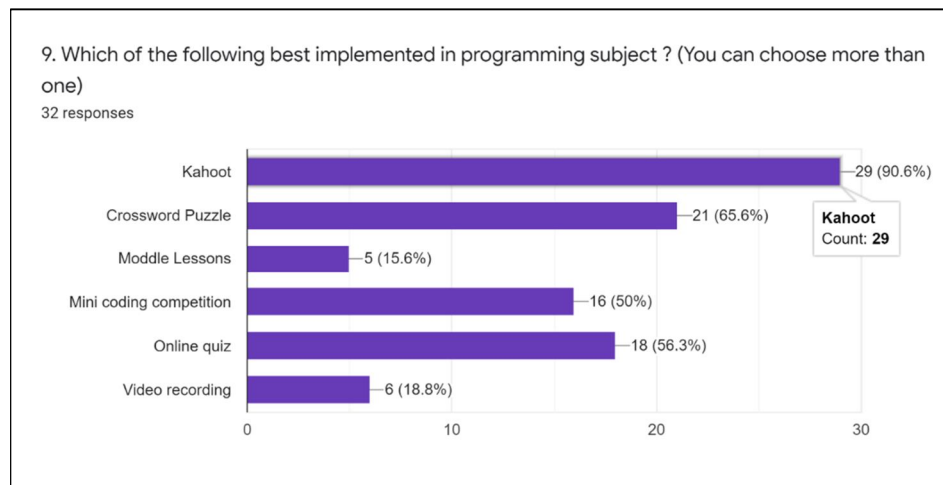


Figure 17: Questionnaire result for Question 9

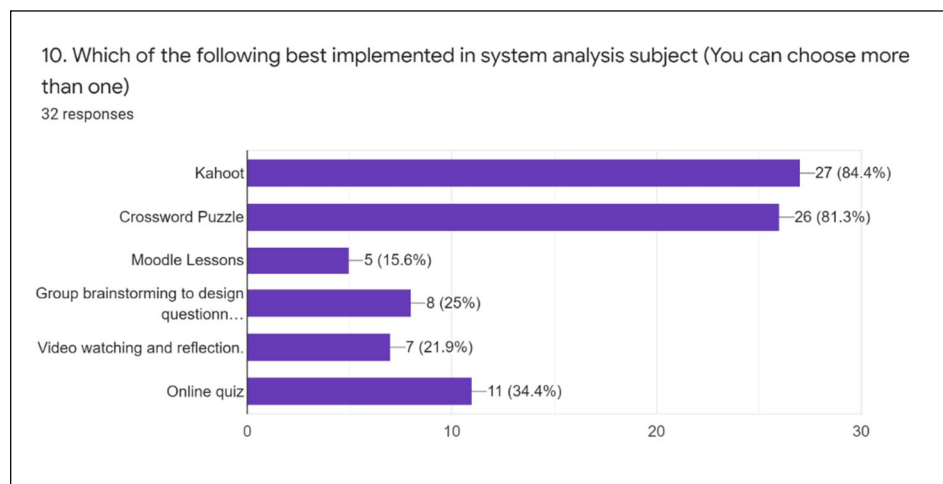


Figure 18: Questionnaire result for Question 10

In terms of the software tools being used, Kahoot and Online Crossword Puzzle are selected by most respondents as the best software used for both subjects. This shows that both software tools are preferred regardless of the nature of the subject being less or more technical. Kahoot and Online Crossword Puzzle are used mainly to test concepts and understanding of basic concepts.

While this is clearly suitable for non-technical subjects, it is also desirable in technical subjects especially in an introduction subject where understanding of the basic concepts is also important.

From the results of the questionnaire, it can also be concluded that for technical subjects (programming in this case) the software tools that are used to provide more challenging tasks and testing on practical knowledge are also widely preferable. The software used for this purpose are the Online Quiz and Programming IDE used in the mini coding competition.

The software tool that is the least preferred in both subjects is Moodle Lesson. This could be due to the reason that it only presents information in a sequential mode and is mainly the information from lecture slides. Therefore, the students may have found it to be less engaging and less interesting as compared with the other software tools.

7. Limitation and Future Work

The present research had some limitations. The focus group interview results could be more accurate if a larger sample size of students were used instead of choosing 1 representative from each group. In addition, a longitude study could be conducted in order to improve the reliability of the results.

This study is basically targeted at new students in Computing Degree, so it would be good to study it for more advanced level students, for example students in their final year, to see whether there are any differences in the results.

It would also be good to investigate if there are any significant differences in the result obtained if the gamification activity is conducted for batches of students who are exposed to gamification activities regularly and thus becomes less of a novelty for them. In order to make the result more reliable, new matrices such as student grades, age, and gender could be used as an element for study.

Further research could also be carried out in order to produce a framework that could be used to support educators in a gamified setting experience tailored specifically for technical and non-technical subjects in computing education. In order to support this research, various elements of gamification such as levels, badges, feedback, competitions, and etc. could be studied in detail to determine which element is responsible for the greatest improvement. This study would be significant, as Burke (2014) claims that incorporating points, badges, and leaderboards to any digital task without carefully designing it, will not foster the desired behavior.

8. Conclusion

In a learning environment, it is important to ensure that students are motivated in learning and become engaged in the learning activities set for them. Gamifying learning activities by using game elements such as points, badges, levels, leaderboards, rewards, feedback, and challenges is one of the technique used to increase motivation and engagement among students. The results of this research shows that using gamification in computing subjects either technical or non-technical has increased the level of motivation among students as well as making them more engaged in the

activities set for them. Selecting the right software tool to be used in the gamification activities is also an important aspect to give a positive impact on motivation, engagement, and student learning.

The research also shows that regardless of the nature of the subject, either technical or non-technical, the impact of gamification is the same. In both areas, gamifying the learning activities increase the level of motivation and engagement among students. In covering theory or concept-based topics in both subjects, the same software tools are preferred which are Kahoot and Online Crossword Puzzle. For technical subject, students also preferred software tools that provided a more practical experience which is the Programming IDE in the mini coding competition.

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