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APPLICATION OF GAMIFICATION IN INTRODUCTION TO PROGRAMMING: A CASE STUDY

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Abstract

Institution of higher educations has struggled to provide engaging method to learn programming although effort has been made by educators but often with limited success. The question is how best to teach introductory to programming for novices students is often not addressed properly. This is because learning programming for college students especially for new learners in programming present many challenges such as subject difficulty, lack of motivation in doing exercises, passiveness in class and diversity of student abilities. Since students often faced a lot of difficulties when learning introductory of programming, gamification has the potential to provide a way to promote students' motivation and engagement while also providing feedback on the students' level of competency of the learned material. Gamification is the process of incorporating game elements into education in an effort to increase student engagement. Thus, there appears to be a good fit between introductory of programming and gamification. Taking these elements into consideration, this paper seeks to apply the concept of gamification to semester 1 students taking Java Programming as the first level of programming subject. Some best practices in gamification

such as competitions, incorporating engaging games elements, scoring using rewards and levels, badges, providing feedback, and providing homework to encourage informal learning are going to be applied. Finally, several popular online applications such as Kahoot, Online Crossword Puzzle and Online Quiz were also designed to see the impact on these gamification tools towards learning of students. The game would be designed to have 3 levels that increase in difficulties with competition as a core element to increase student's engagement. This paper would also seeks to design the user evaluation form that can be used to determine the effects of applying gamification on the student's engagement, motivation level, and understanding of the topic in introductory programming subject. Through the research findings it could provide a platform in formulating alternative ways besides the traditional teaching method for educators in creating educational programming games and applying it to teach novices in introductory programming subjects.

Keywords

Gamification, Student Engagement, Online Applications, Java Programming, Introductory to Programming

1. Introduction

Programming is one of the key areas of computing course, through which a student is required to acquire the competences. However, several problems have been reported in literature related to learning programming. One of the reasons is high failure in programming courses although decade of effort have been put to decrease these rate. Novice students face challenges in learning programming due to lack of motivation, engagement and difficulties in understanding the programming fundamentals especially for first year students. Weaker students also find the computer programs and algorithm too abstract and complex entities that involve concepts were hard to learn and teach (Olosson et. al., 2015). Furthermore, learning programming with traditional methods such as lecture and lab session is often found to be boring and ineffective (Nikula et. al., 2011). This sometimes causes students to cheat, feel helpless and drop out from the course. (Robins et al, 2003, Adorjanet.al., 2013)

Today learners are a new profile who grew up in a digital age and have a different learning style and higher requirement for teaching and learning. It was found that an average student today spend 10,000 hours gaming by the time they reach 21 years old (McGonigal,2015) which is a remarkable amount of time. Educators are faced with new challenges on how to incorporate gaming, which is one of the technique that can promote active learning to meet students who have a variety of learning style. The aim of the paper is

to fill in the gap by identifying how best to incorporate gamification to make students learning more engaging, motivated and increase student understanding. With this, it is hope that it could provide a framework for educators on how to implement gamification to meet the learning style of 21st century learners who are taking Java programming subject.

2. Literature Review

2.1 Gamification

This term refers to the use of game element in a non-game context to increase engagement between human and computers (Deterding, 2012). The game elements are characterised by the use of items such as points, badges and levels. According to (Deterding et.al, 2011) the adoption of gamification did not see widespread before the 2nd half of 2010 although the term was first documented in 2008. It is also found that the early adopters of gamification are mostly from the area of computing and IT schools. Gamification as an academic topic is relatively young as compared to its boom in the area of business, marketing corporate management and wellness initiative. According to Gartner Hype Cycle (Garner, 2013) it was indicated that gamification is at the peak of the Hyper Cycle and is expected to reach the productivity plateau in five to ten years' time.

The majority of the reviewed studies on gamification did yield positive results. Findings studies performed in higher education settings showed that there are significant improvements in subject understanding, diligence, and motivation for students learning through gamification (Barata et al., 2013). It was found the use of gamification as a learning tool is able to meet the gap as it reinforce not only knowledge but also develop soft skills such as problem solving, collaboration and communication. It also able to provide motivation power as gamification encourages engagement which is able to meet with just having the joy of playing and possibilities of winning it. The embedding of gamification in programming course could reduce dropout rate and enhance student participation and have a positive impact on learning. (Azmi et.al, 2015). Muratet et al (2010) found that some platform may even help recruit students in computer science. Given that gamification is known to promote engagement and motivation, the idea to incorporate gamification principles to motivate the students is appealing.

On the contrary, competition in gamification provide a powerful extrinsic motivator but it has been criticized that it reduces intrinsic motivation and so reduce opportunities for optimal learning. Research shown that students who lose in competition perceive themselves as less competent and this dampen their intrinsic motivation.(Vallerand et.al., 1986)

2.2 Related work

The use of gamification for learning is not entirely a new area. Malone in the 1980s done research on how video games can be applied to education as a means to promote student engagement and motivation. There is also generally an increase attempt to exploit the use of gamification to facilitate learning of programming. Some institutions are experimenting with the use of online resources for example Khan Academy which incorporate game elements such as badges and points to make learning more fun and to reward progress. Although this is happening, these resources occasionally struggle to keep learners engaged and it is unclear how much learners actually learn or retain knowledge. (Dainel, 2012)

There are research attempts done to identify how gamification can be applied to programming courses especially as a means to promote student engagement, motivation and improve test score. For instance in a research done by Balraj, K. and Parul, K. (2012), gamified approach was applied to teach the student programming concepts. It was found that that gamification through using of badges encourages students to continue playing thus encourage cognitive engagement.

A study by Ibáñez et al., (2014) to evaluate learning effectiveness and engagement towards teaching C programming language to undergraduate Engineering students shows that students continued working even after earning the maximum amount of grade points to collect all the badges and wanted to still keep learning. The research findings found that that gamification shows positive results on the engagement of students and moderate improvement in learning outcome.

Vihavainen et al. (2014) present another approach whereby this paper reports about 60 pre-interventions and post-interventions and analyses their influence on students' pass rates in introductory to programming courses. Statistically, pass rates after these interventions increased nearly by one third compared to traditional teaching.

3. Research Methodology

The syllabus included 15 face-to-face two-hour lectures, 15 two-hour practical classes, 15 one-hour face-to-face tutorial, and 15 one-hour online tutorial. The lectures covered Java programming concepts ranging from fundamental concepts to object-oriented programming. Practical classes are done in computer laboratory where students were presented with a series of programming tasks that they had to complete individually during the session, with the tutors offering occasional help. Face-to-face and online tutorials are conducted as practice sessions where students are given short questions to be discussed in groups. All course materials were uploaded to the institutional LMS on a weekly basis. The course evaluation

consisted of 7 lab tasks (14%), 3 online quizzes (6%), 3 programming assignments (30%), and a final examination (50%).

The main purpose of this research study is to explore the impact of gamification to students' engagement and motivation in learning Java programming. It also seeks to gauge students understanding on Java programming after implementing gamification. The below are the 2 research questions that this research seeks to answer.

RO1: Does gamification promote students engagement and motivation in learning Java programming for first year students?

RO2: Does students understanding on Java programming improved after the implementation of gamification?

In order to assess the impact of gamification to students' engagement, motivation and understanding a mixed research method which consist of both quantitative and qualitative data is being employed. To collect qualitative data a focus group interview was conducted with 10 randomly selected students who attended the Java Programming class in the first year of the study. The student's age ranged from 19 to 24 years old and are from different groups.

As for quantitative data is collected through an online survey of 9 questions to 22 students with four answer measured on a Likert scale of 1 (Strongly Disagree) to 4 (Strongly Agree).

In addition to that, an independent instructor observation of students' behaviour during the gamification activities was carried out. Specific dimension like interest and attitude was observed to measure students' motivation and engagement.

The table below summarizes the focus of the research methodology conducted for each of the research objectives to obtain the research findings. More information of the online survey questions were discussed in the Finding section of this research paper.

Table 1: Mapping of the Research Methodology against the Research Objectives

Research Objectives \ Research Methodology	Quantitative method	Qualitative method
RO1 (engagement & motivation)	Online survey (Q1, Q2, Q4, Q7)	Focus group interview. (Q1, Q3, Q4) Observation.
RO2 (understanding)	Online survey	Focus group interview. (Q1, Q3, Q4) Observation

	(Q5,Q6)	
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4. Findings

An experiment was conducted on a group of students taking the subject on Fundamental Programming. The students are year 1 students with very little previous knowledge in programming. Normal class was conducted at the beginning with teaching methods involving face-to-face lecture, tutorial, practical, and online learning.

The gamification activities took place in the middle of the semester. A detailed explanation on the gamification activities was given to the students prior to the activities so that they have a full understanding on what they were doing. In addition, instructor's guidance and feedback serve as scaffolding during and after the game based activity. This is in line with the study of Raymond T. and Lesley T. (2015) that claims the importance of instructional support, feedback and debriefing in game-based learning in a pilot study done in Singapore Higher Education.

4.1 Gamification Elements Used

There is a variety of ways to implement gamification in classrooms. It normally involves using several game elements to make the activities become gamelike. This research chooses to use points, badges, and leaderboards gamification elements.

4.1.1 Points

Points are awarded to students who have completed a particular task. There is no maximum points to reach since in a typical game, players get to accumulate as many points as possible. Students who achieved the higher points will move up the ladder of achievement in the leaderboard.

In this experiment, points are awarded after each level has been completed. The points given are based on the correct answers provided by the students during an activity in a particular level. An example of points collected for a level played is shown below. The table was generated and shown on the subject's Moodle page.

CSIT111 (Selection Structures)					
Final Scores					
Rank	Players	Total Score (points)	Correct Answers	Incorrect Answers	
1	Wakanda	14245	13	2	
2	Lightning	13908	13	2	
3	Bananas 4 life	13443	12	3	
4	Legend	13348	12	2	
5	The Boring Team	12310	11	4	
6	Afterglow	11705	11	3	
7	2 EZ XDxDxd	10702	10	5	
8	Avengers	10587	10	3	
9	Knights	9503	9	5	
10	Milo Panas	8504	9	4	

Figure 1: Points collected at a single level of activity (Mohamed Said, 2018)

4.1.2 Badges

A badge can represent an achievement done by the students in exploring something related to the topics covered in the syllabus taught. Badges are awarded based on completion of an activity. For this experiment, a smiley badge is selected. Different number of badges are awarded for different level of achievement. The students are able to view the total badge that they have collected on a table shown on Moodle. The table is updated after each stage has been completed. The badge collection table is shown below which was also shown on the lecturer's Moodle page for the subject.

Grab those badges!!!! 😊

Wakanda	😊	😊	😊
Lightning	😊	😊	
Legends	😊	😊	😊
Knights	😊	😊	
Avenger's	😊	😊	😊
Afterglow	😊	😊	
The Boring Team	😊	😊	
Too Ez	😊	😊	
Milo Panas	😊	😊	
Bananas 4 Life	😊	😊	

Figure 2: Badge collections (Mohamed Said, 2018)

4.1.3 Leaderboards

A leaderboard will be displayed throughout the duration of the experiment. It will display the points accumulated after each level has been completed. A leaderboard is used to serve as a motivator in this experiment. However, to avoid from demotivating the slow progress students, only the top five points will be displayed on the leaderboard. An example of the leaderboard extracted from the lecturer's Moodle page that was used in this experiment is shown below.

LEADERBOARD

Check out the top 5 groups!!

Rank	Players	Points
1	Wakanda	14245
2	Lightning	13908
3	Bananas 4 life	13443
4	Legend	13348
5	The Boring Team	12310

Figure 3: Leaderboard (Mohamed Said, 2018)

4.2 Software Used

Several software has been selected for this experiment. The following table summarizes the software or web-based applications used.

Table 1: Summary of Software Selected

Software	Description
Kahoot!	A web based game where students race to be the first to answer correctly the questions shown on the screen. Students will use their own smart devices to select their answer. Time limit is set for each question. Points will be displayed at the end of the game.
PuzzleFast	An online crossword puzzle where students race to be the first to solve the puzzle. Clues are given that reflects the subject content and students have to identify the correct word for the clues.
Moodle Online Quiz	An online quiz where more challenging questions are given to the students to solve. Questions given are multiple choice programming questions.

4.3 Course Content and Activities

The gamification activity for this research will be conducted in three weeks. Each week the students are required to complete a race level for point collection and take part in a badge collection activity. The following table shows the summary of all activities involved.

Table 2: *Course Content and Activity Involved*

Week	Course Content	Activity
1	Selection Structures	Badge Collection: Stage 1 (using Moodle Lesson) Points Collection Race: Level 1 (using Kahoot!)
2	Repetition Structures	Badge Collection: Stage 2 (using PuzzleFast) Points Collection Race: Level 2 (using Kahoot!)
3	Classes and Objects	Badge Collection: Stage 3 (using PuzzleFast) Points Collection Race: Level 3 (using Moodle Online Quiz)

4.3.1 Points Collection Activity

The first activity is the race where every group was given certain time duration to complete a task that will be given points when completed. These races are mainly to answer questions related to programming constructs learned earlier. The race involves three levels to be completed, each has an increase in difficulties and challenges. Each level covers a single topic and is different from the other levels.

In Level 1, Kahoot! is used where each group race to become the first group to select the correct answer for each question shown. This race uses the standard Kahoot! quiz where students are given 15 multiple choice questions related to selection structures. At the end of the game, points are given to the students based on the fastest correct answer given during the race. The top 5 winners are shown on the leaderboard on Moodle. At the end of the level, the top five groups are displayed on a leaderboard shown in Moodle.

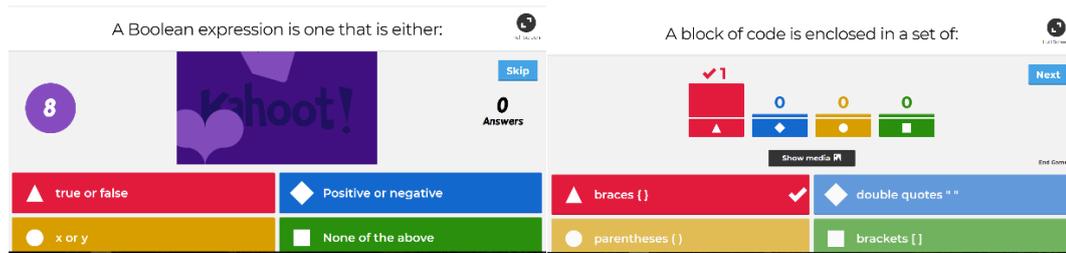


Figure 4: Level 1 Kahoot! (Mohamed Said, 2018)

In Level 2, Kahoot! is still used but using a different kind of quiz called Jumble and covers the repetition topic. In this quiz, the students are given multiple lines of codes that are not in order and they are required to re-arrange the codes so that it can be executable correctly. At the end of the game, points are given to the students based on the fastest correct answer given during the race. The points are then added with the points collection at level 1. The new top 5 winners are then shown on the leaderboard on Moodle.

Finally, in Level 3, the students first get to exchange their badges collected earlier with hints for this level. Every two badges can be exchanged with 1 hint. Each hint is a correct answer from one of the question in the last quiz. The students are only given the answer but not the question it belongs to. The students then are asked to take part in an online quiz on Moodle on the class and object topic. A total of 20 multiple choice questions are given and they are given 60 minutes to answer the quiz. The points collected at this level is added to the earlier points collected and the new top 5 winners are again shown on the leaderboard.

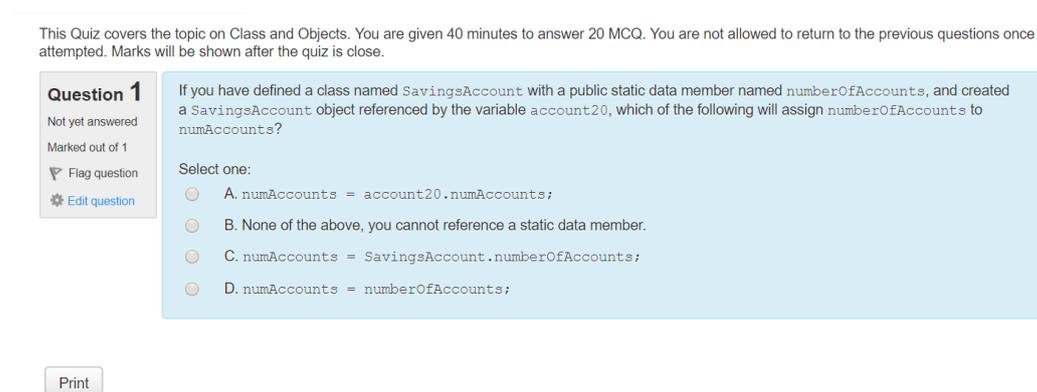


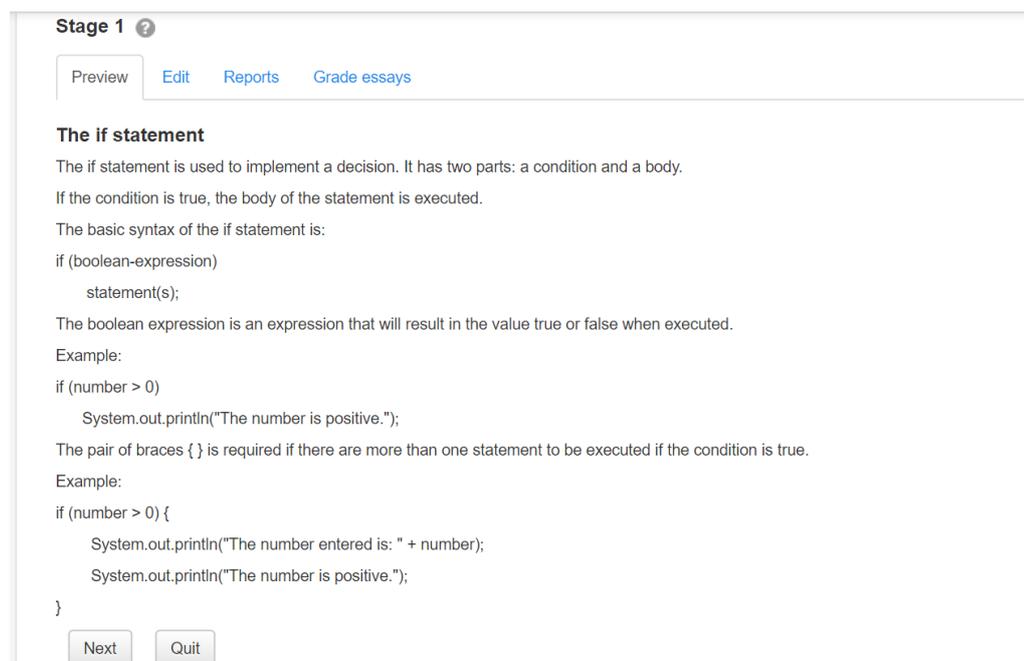
Figure 5:Level 3 Moodle Online Quiz (Mohamed Said, 2018)

4.3.2 Badge Collection Activity

The second activity is a series of activities to allow the students to learn and gain more knowledge in the topics taught by taking part in online lesson, or fun activity such as crossword puzzle. After each of these activities, students are given badges depending on their

effort. The badges collected can later be exchanged with hints that they can use in the last race (the active quiz). There are also three stages in the badge collection activities. Each badge collection activity must be done first before the race for each week.

In Stage 1, students are required to take part in an online Lesson set up on Moodle. The Lesson component requires students to read several pages containing lesson on selection structures. In between the pages there are short quizzes given with only two questions for each quiz. This is repeated until the Lesson ends. At the end of the lesson, the students will be given badges based on the results of the quizzes answered. If all answers are correct, two badges will be given, if not all answers are correct but they get a minimum of five correct answers 1 badge will be given, and if they get less than 5 correct answers no badge will be given.



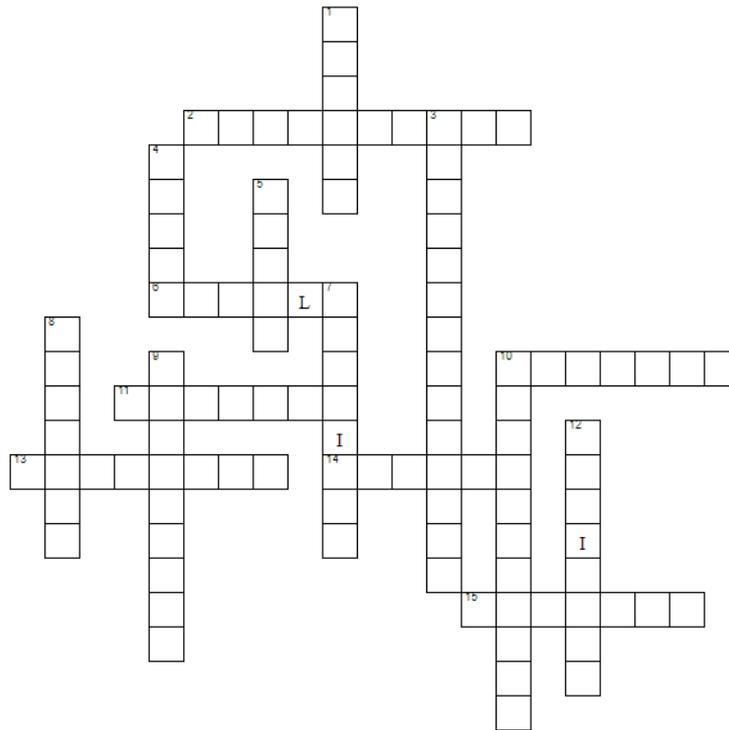
The screenshot shows a Moodle Lesson interface for 'Stage 1'. At the top, there are navigation buttons: 'Preview' (selected), 'Edit', 'Reports', and 'Grade essays'. Below this, the title 'The if statement' is displayed. The main content area contains the following text:

The if statement is used to implement a decision. It has two parts: a condition and a body.
If the condition is true, the body of the statement is executed.
The basic syntax of the if statement is:
if (boolean-expression)
 statement(s);
The boolean expression is an expression that will result in the value true or false when executed.
Example:
if (number > 0)
 System.out.println("The number is positive.");
The pair of braces { } is required if there are more than one statement to be executed if the condition is true.
Example:
if (number > 0) {
 System.out.println("The number entered is: " + number);
 System.out.println("The number is positive.");
}

At the bottom of the content area, there are two buttons: 'Next' and 'Quit'.

Figure 6: Stage 1 Moodle Lesson (Mohamed Said, 2018)

In stage 2, students are asked to take part in an online crossword puzzle called Puzzle Fast based on the repetition structure topic. The completed puzzle must be uploaded to Moodle to claim their badges. If they manage to upload the completed puzzle within 15 minutes, they will get 2 badges and if they upload the puzzle less than 30 minutes but more than 15 minutes, they will get 1 badge. Stage 3 requires students to also do online crossword puzzle but based on the class and object topic. The badges collected are shown on Moodle.



Down:

1. perform multiple selection and can replace a nested if-else
3. this expression names the loop's control variable and optionally provides its initial value in a for loop
4. this is a pre-test loop structure
5. this ends a case statement
7. used to indicate the end of repetition

Figure 7: Stage 2 Crossword Puzzle (Mohamed Said, 2018)

5. Results of Findings

5.1 Online Survey using Questionnaire

To gather quantitative feedback about the gamified experience, all students are asked to complete 9 questions for an online survey at the end of the semester. Every question has 4 possible answer measured on a Likert scale of 1 (Strongly agree) to 4 (Strongly disagree). Generally the survey shows positive results in terms of improvement in students' motivation, engagement and subject understanding.

5.1.1 Engagement

The responses from question 1 and question 2 shows that nearly 80% of the students find the class fun and engaging as it allows them to exchange ideas with others during the gamification activities. The results are shown in the figures below.

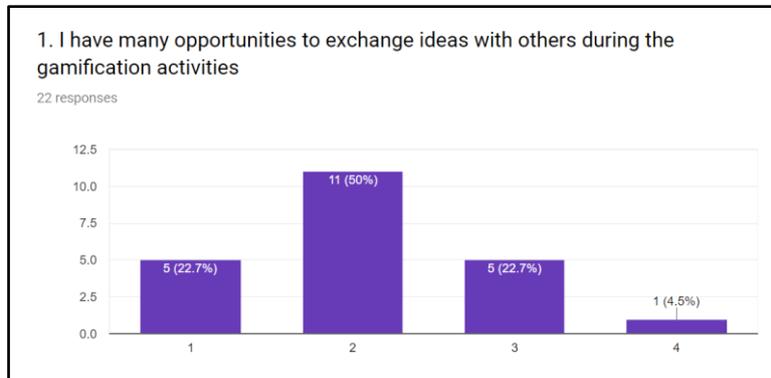


Figure 8: Question 1 Responses

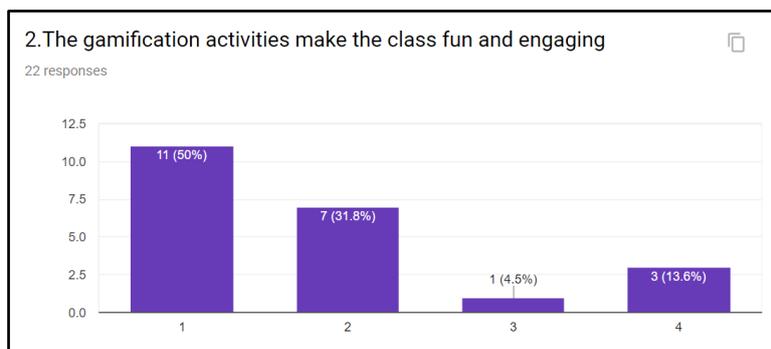


Figure 9: Question 2 Responses

5.1.2 Motivation

The data shows that about 77% of students are motivated by the use of points, badges and leaderboard elements. However, 31.8% disagree that gamification increase the student's motivation to do self-study in order to do well in the gamification activities.

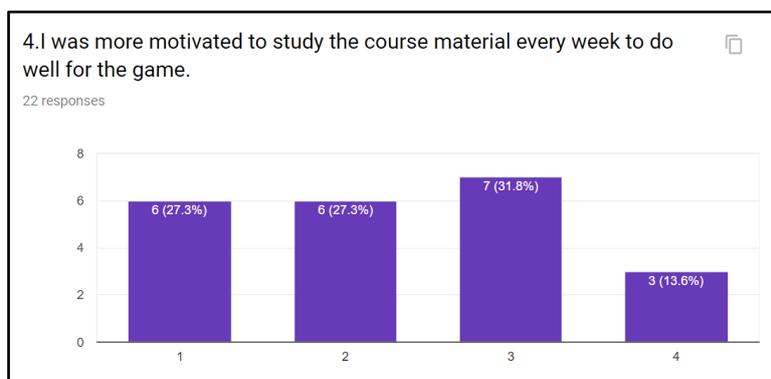


Figure 10: Question 4 Responses



Figure 11: Question 7 Responses

5.1.3 Understanding

Around 78% of the students find that gamification helped improve their understanding on the programming concept taught and it is a valuable use of instructor time. Finally, 63% of students hope that gamification can be used in other subjects.

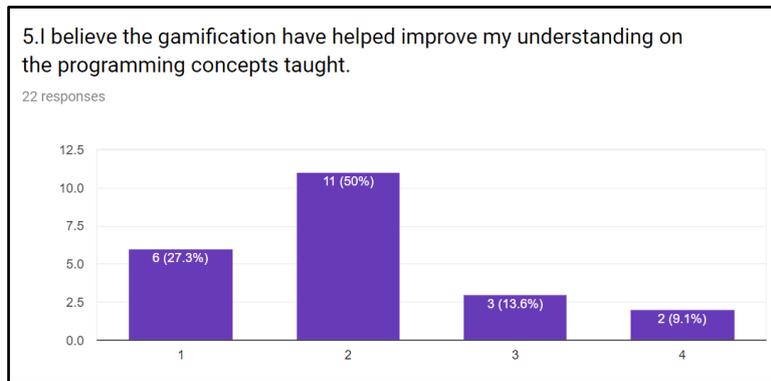


Figure 12: Question 5 Responses

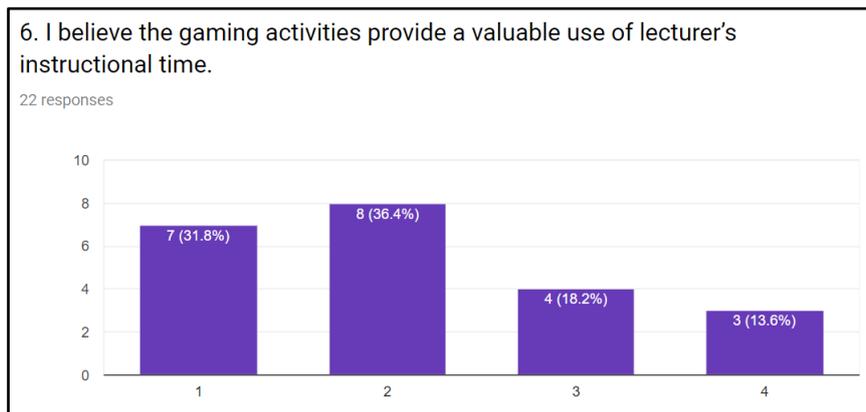


Figure 13: Question 6 Responses

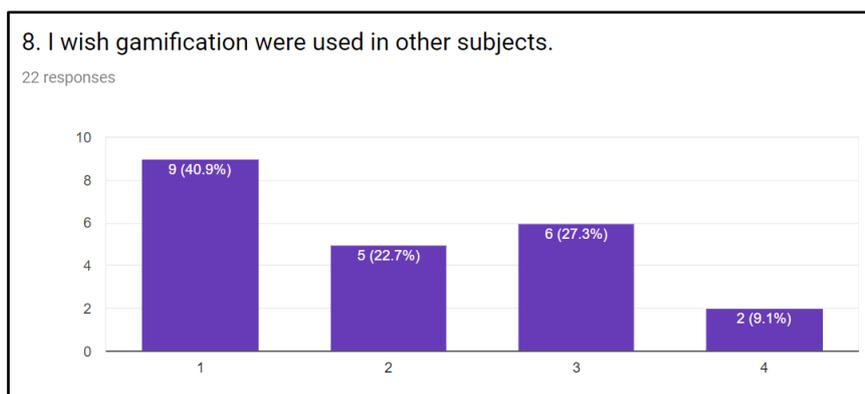


Figure 14: Question 8 Responses

5.2 Focus Group Interview

The focus group interview was done by randomly selecting 10 students from various groups. The interview questions are:

Q1. Do you think it is a good idea to use gamification to teach Java programming? Why?

Q2. What needs to be improved in the gamification activities?

Q3. Which particular gamification activity helps you most in your learning?

Q4. In one word, describe your gamification experience.

The overall reactions from the students' focus group interview showed overall a positive response. Below are several answers given by the students:

Sample answers for Q1:

"Yes it is a good idea as it makes the class more fun, interesting and challenging."

"Yes, I can get to understand the programming concept clearer after the answer is displayed and explained by the lecturer".

Sample answers for Q2:

"Please provide longer timing for brainstorming and a variety of questions types (such as MCQ, writing short codes, T/F)"

"More examples should be given before the gamification activities."

"Should allow students to practise how to use the Kahoot software before the gamification activity since it is their first time using it."

Sample answers for Q3:

In conclusion, all students prefer the Kahoot activity as compared to the Crossword puzzle as it is more interesting and have more coding questions. They find the Crossword Puzzle is more appropriate to test theory concept which is better used for theory subjects.

Sample answers for Q4:

Positive words: Competitive, Challenging, Fun, Amazing, Tricky, Great

Negative words: Stress, Pressuring

The students who provided negative comments are those that got low marks for the competition and they find the competitive nature of the game made them more stressful and they cannot think properly because they get panicky easily in this kind of environment. They believe that the winning teams will like it more than the losing teams.

5.3 Observation of Student Behaviour

Class observation was done for the Activity 2 and 3 of gamification. The following behaviour was observed:

- When the lecturer explained the instruction and the answer to the question they actively listened to it. This is especially true when the last question was displayed which was the most difficult question.
- They brainstorm actively with their group members on the possible answer.
- Show excitement especially when the results of the answer was answered.
- Show they enjoyed the activity as some of them was clapping their hands, smiling and laughing.
- Some students asked the lecturer to explain further the answer they did not understand. This show students are engaged and learning from this activity.
- Student utilised decision-making or problem solving skills in responding to all the activity designed.
- Demonstrated body language that was relaxed with appropriate eye contact with their group members and lecturer.
- Class was more noisy that usual as a lot of discussion was being done.

However, there are some glitches faced during the gamification activities. Some of the fonts projected in the screen were too small and students cannot see properly. Due to this some students has to move in front and stand-up to see the words clearly. Students mention

that it would be better if all the lights in the classroom were turn off as this would make the screen image sharper. From this observation, it is clear that it is important to test run the gamification in the actual site before the actual activity so that this issue would not happen.

7. Conclusion

To conclude this paper, learning programming is not easy for students but through gamification it can lessen some of the learning burden of students. The initial study of existing work show that there is a need to a new approach to learning Java programming especially for novice students. It was found through many literature review gamification can increase students motivation and engagement and improve learning if the game is properly designed and implemented. However, the concept of gamification may look simple, a lot of consideration needed to be look in to order to make student learning effective. This is because there is currently no practical guidelines on how to include these elements in a coherent and efficient manner.

The short experiment done for this research has shown that majority students feel more motivated to learn programming after they have taken part in the gamification activities. The activities have also made them become more engaging. This is reflected in the result of the questionnaire and also seen during observation in which the students shown full focus on the activity and excited to take part and answer the questions given. The gamification activities have also helped them to gain better understanding in the topic covered. However, there are a few negative comments from the students mainly regarding the too short time given for them to answer the questions in the game or race conducted. This can be improved in the future by looking into more suitable time duration given so that the students can have enough time to discuss and therefore experience more effective learning when answering the questions.

In terms of the software used, most of the students prefer Kahoot! because it is more interesting and fun. This experiment has used limited number of software since the scope of the experiment is small. Other software can be explored and used in the actual implementation of gamification.

7.1 Research Limitation

We have to acknowledge some limitations in our research. The intervention already showed some promising results but the length of the intervention was only for 3 weeks which was considered short. It would be better if the experiment can be conducted over 2 semesters and with more than one class. Due to the small number of participants, the results findings

may not be so reliable. Hence, study with larger sample size of students must be carried out to get more conclusive and reliable results

7.2 Scope of Future Research

The effect of gamification on different kinds of subject for example theory subjects related to computing area could be as a future work. From this research a study on the differences of implementation of gamification towards theory and programming subject could be studied. A longitudinal study could also be performed to show the impact of gamified courses towards students' outcomes in the long run. It would be good to assess whether gamification only has impact on the performance of the students for the individual course itself or it has a larger impact on their overall performance towards obtaining their degree.

Since students are not exposed to gamification learning activity before it would be interesting to investigate the engagement and motivating factor when gamification is being regularly conducted thus become less of a novelty for students.

The role of educator in motivating students to perform extra activities provided in gamification platform remain a crucial factor to the success of gamification. (Tenorio et al., 2018). Hence it would be interesting if a study could be done in order to identify how best educator can provide motivation for the learners when they are embarking on gamification for their learning.

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