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Research paper

The Impact of Using Gamification in Learning Computer Science for Students in University

Risna Oktaviati[1], Adam Amril Jaharadak[1]*

School of Graduates Studies, Management and Science University, Shah Alam, Selangor, Malaysia
**Corresponding author E-mail: adam@msu.edu.my*

Abstract

The utilization of technology can be implemented in education. Gamification is a new technology that used elements such as badges, level, and point of game play that implemented in a non-game context. In this research, the researcher analyzes some of the literature to establish in the extent of gamification to assist student's motivation and engagement among Computer Science related subject. The researcher found that the most common element that implemented in learning Computer Science related subject were badges, point, level, and leaderboards. Implementing gamification elements in learning can be a tool that can motivate and engage the student in learning Computer Science.

Keywords: *Gamification; Computer Science; Education; Badges; Point; Level; Leaderboards.*

1. Introduction

1.1. Gamification

Gamification is a new method that uses the game design or game element to implement in something non-game [1]. In education, gamification described as the effective integration of the game element into an education to enhance understudies' motivation, achievement in studies, and also the attitude in the lesson [2]. Gamification can be implemented in any content including healthcare, marketing or business and learning [3].

1.2. Background Study

In the last decade, implemented gamification in higher education has increased [4]. One of the most popular university majors is Computer Science. There are several subjects offered in Computer Science. Sometimes, students find learning in Computer Science is difficult, the presentation of material was bored [5], and lack of interest and motivation [6].
Nowadays, learning is growing up with technologies, modern and new styles of teaching [7]. The utilization of technology in learning based PC, laptops, or even tablets and smartphone [8] can be implemented to motivating people and support toward various individuals and groups beneficial behavior [9]. The development of gamification that refers to technology and game design can be implemented in activities to increase the motivation [10]. In student's life, games become part that have been shown the effectiveness such as increase the motivation, and support the student especially in learning process [11]. Gamification has positive effect for student achievement and student's attitudes toward the lesson due to its dynamism [2], and gamification has proven successful in enhancing the engagement and interest in contexts [12]. In Computer Science, gamification also can be implemented in any subject in course, such as course of programming [5, 6, 11, 13–16], Cloud Computing [17], Data Structure[18], Basic Computing [19] 3D Computer Graphics [20], Computer Network [21], word processing and databases [22], and artificial intelligence algorithms (Search algorithms) [23].
The utilization of gamification become solutions to overcome the difficulties with the combination of computer games commercially into the classroom [24]. The impact of gamification for students in learning is one of the important topics due it dynamism [2] and has positive effect for the students, especially in learning [25].

2. Organization of the Paper

This paper starts with the section methods about describing how the research conducted the analysis. In the finding, it is about the themes which are identified through the studies that already done by researcher including the common elements in gamification, the impact of gamification in motivation or engaging performance in learning. In the discussion examines, the result is about assessing and evaluating the studies. The conclusion is about highlight the impact of implemented gamification in learning Computer Science related subject.

3. Methodology

The sources were selected from journal research, review paper, and conference proceedings. Development of search string began with the identification of keyword first, then the concept and phrases central to the phenomenon.

Table 1: The summary of descriptive of the studies

No.	References	Source	Method	Target	Course	Demographics
1	[15]	IEEE	Mixed method	22	C-programming language	University Student
2	[6]	IEEE	Quantitative	35	Programming Course	University Student
3	[11]	IEEE	Quantitative	11	Programming Course	University Student
4	[5]	IEEE	Quantitative	30	Computer Science	University Student
5	[16]	Google Scholar	Mixed methods	44	Computer Programming	University Student
6	[26]	IEEE	Not explain	Not explain	Cloud Computing Volunteer	Volunteer Graduate School and University student
7	[17]	Google Scholar	Quantitative	450	Computer Organization and Cloud Computing	University student (Undergraduate and master Student)
8	[18]	IEEE	Quantitative	339	Data Structure and Algorithms	University Student
9	[27]	Google Scholar	Mixed methods	201	Programming and Software engineering	University Student
10	[28]	IEEE	Quantitative	50	Programming	University Student
11	[19]	Science Direct	Quantitative	77	Basic Computing Concept	University Student
12	[20]	Google Scholar	Mixed Method	Not Explain	Computer 3D Animation	University student
13	[21]	IEEE	Qualitative	2 class of Network class (not explain)	Computer Network	University Student
14	[29]	Google Scholar	Mixed Method	44	Computer Science Course	University Student
15	[25]	Science Direct	Mixed Method	80	Communication Course	University Student
16	[30]	Google Scholar	Mixed Method	162	Basic of Programming	University Student
17	[22] 2013	Google Scholar	Mixed method	132	Introduction about computer, Operating System, Network and Communication, word processor, spreadsheets, databases	University Student
18	[23]	IEEE	Quantitative	44	Artificial intelligence algorithms (Search algorithms)	University Student

The keyword included such as gamification and learning, gamification in Computer Science, effect gamification in learning, gamification and higher education. These words were refined using databases such as IEEE, Science Direct and Google Scholar. The literature was searched in website after that abstracts and titles were screened manually and cursorily. The paper was included if the studies involved Indonesian and English in written, available in online journals. The selected publication dates ranged from 2010 until 2018.

The aim of the analysis was to identify the similarities, differences and to find the common themes about effect gamification in motivated and engaging the student in learning about Computer Science and Computing. In this literature, a qualitative meta-analysis was conducted. Qualitative meta-analysis is an approach toward the defining or formulation about the complete describing of the subject. Literature was chosen and selected based the relevance about gamification, after selected, the studies was numbered, alphabetized and then read. In each paper was re-read, focus on data, findings, conclusion and implications that related.

4. Results and Analysis

In the result, some studies analyses by the three main sub-theme in gamification such as general element of gamification that often in used, and the impact of gamification in learning Computer Science related subject

4.1. General Element of Gamification

Badges and Leaderboards was the most potential for increase the efficiency in learning setting [29]. In Figure 1, the most common element of gamification that used in learning are badges, leaderboards, point, level.

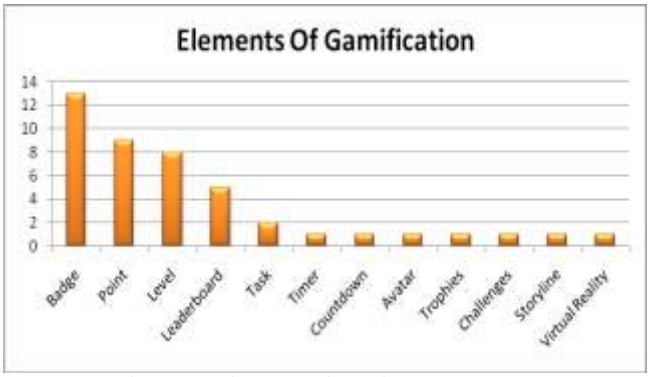

Fig. 1: The frequency of element of gamification in learning computer

There are many game elements can be implement in learning, even only few studies researching the effectiveness such as avatars, tasks, timers, countdown, challenges, and storyline does not mean those game elements cannot be implement to the lesson. Badges is the most common element investigated in gamification for studies in any subject [31] and only few explained the effectiveness of narrative storyline in motivating for student [32]. But, the impact gamification is dependent about the context where the gamification implemented, how user using it [33] and the design in the game also include feedback, freedom to fail, progression and storyline [32]. The element gamification such as narrative that combining task together in learning can create a cohesive whole [20]. The most elements examined by research are leaderboards, badges and reward, point, and level.

Table 2: Examined of summary the common elements in studies

Author	Badges	Leaderboards	Point	Level
[15]	✓	✓	✓	
[6]				✓
[11]	✓			
[5]			✓	✓
[16]			✓	✓
[26]	✓	✓	✓	
[17]	✓		✓	✓
[18]	✓			
[27]			✓	✓
[28]	✓			
[19]	✓	✓		
[20]	✓		✓	
[21]	✓			✓
[29]	✓		✓	✓
[25]	✓	✓		
[30]	✓			
[22]	✓	✓	✓	
[23]				✓

4.1.1. Badges

The result above found that the most common elements used in researcher were badges. There are positive and negative result in studies which use badges. Majority, the finding used badges in learning Computer Science showed the positive impact, which can motivate or engage students in learn about Computer Science. Badges can encourage students to have fun in learning activities and can measure a person's ability [20], students feel appreciated for completing the task and appreciating the additional recognition earned when they get the badges. Some students found that badges can motivate them in learning, the one-third did not find that badges motivate their work while the one-third remaining felt indifferent [30]. Contrary with [25] which finds that badges and leaderboards has negative effect in learning, students tend to score lower and less motivation than the student with non-gamified.

Not all students motivated with the same badges [34], some studies reported that gamification elements such as badges was not have any effect and demotivating for the student [30]. Some students continue their work after they got the maximum point was because they wanted to collect all the badges, and they will stop after they collect all of the badges [15].

Badges is a digital emblem or reward, the user will collect the badges after successfully completed a mission or a particular challenge. Badges can be trophies, ribbons, or another symbol. Usually, player get the badges to measure achievement in a specific skill in the game [42]. Badges is the symbol award or reward given to the user that completed the task or any skill, knowledge and achievement displayed by the students to show their skill of their mastery and knowledge [35].

From Table 2 reported 13 of 18 studies that using badges as the element of gamification that implemented in learning about Computer Science such as [11, 15, 17–21, 25, 26, 28–30, 22].

The element of gamification such as badges can be implemented in learning Computer Science to increase the student's motivation or engagement but the most important is an appropriate design, is it too easy or too difficult to collected for the student [28]. There are differences in acquisition patterns in students with the level of knowledge, students with low performance is more motivated to participate while high motivation students are given badges to hone skills [35].

4.1.2. Point

Point used as an indicator, the user can spend points to unlock the next access from the content. Point is accumulation score of task that have been done [42]. Point is the basic element of many games and gamified applications [6]. There are some studies do the research in combination between point and the other element of games.

Some studies examined the impact of points and combination of the element showed the positive impact in learning Computer Science, because the point provided instant feedback that make the student became engage or motivate in learning Computer Science. The teacher can scale the ability using scores collected by the students. For example, students can achieve "A" if the accumulation of points reaches 1800 or they could take higher level by earning 1000 points [20]. This is the way to find instant feedback about their level of knowledge and can also explain the progress they have achieved in the classroom. Some students want to continue their lesson because they want to get more points [15] and they will stop their task because they had earn the maximum point. As shown in the Table 2, there are 9 from 18 studies that examined point as the element of games [5, 15–17, 20, 26, 27, 29, 22].

4.1.3. Level

Levels are the different classes in the program, and an indication if you already reached the milestone. Levels usually often defined as point thresholds, user can directly level up based on their participation, or use levels to indicate status and access to control content on the site. Usually, higher the level means that the more difficulty and complexity task or challenge [42]. Difficulty level refers to the assessment difficulty as a measure of the simplicity of each stage, wherein allow students to solve problems in different domains which can reach by using cognitive efficiency [6].

All of the studies showed that the examined in using level combining with the other element of gamification has positive impact such as motivate and engage the students in learning Computer Science. To be successful in gamification, one of the key is ensuring appropriate scaffolding, progression and sequence in content and do not make the students frustrated but ensure the suitable level for user or students [32].

As shown in Table 2, eight from eighteen studies reported the impact of level in learning [5, 6, 16, 17, 21, 29, 23]. Implementation level usually also combined by points. After the user or student gain some points, then they can continue to the next level or "level up" [17].

4.1.4. Leaderboards

Leaderboards used to track and show desire the action with competition to deliver the valuable behavior. Leaderboards can be a list of the user that playing the game, who get the highest score and who have achieved higher levels. Leaderboards is real-time, user or student can see their place directly. Usually, element of leaderboards used to multiuser game [42].

Leaderboards designed to foster competition for students with the aim of motivating participants [19]. Leaderboards used to showed the ranking , display the best player and how much the collect the reward in the gamified learning activity [15], students can see their positions or how many students have completed and can compare them [19] .

Leaderboards was used in 5 of 18 studies [25, 22]. Some of the result was showed the positive impact. For some students, leaderboards give them motivation [15]. But, there was one studies reported that using element leaderboards was not enjoy the student in learning [25]. For some students, leaderboards can increase their motivation while others dislike the elements of competition such as leaderboards introduced into learning [36]. Student want to continue their task to try get the better position in leaderboards [15].

4.2. The Impact of Gamification in Learning Computer Science

Gamification seems became a new method to enhance students in participate and interact for project in university classroom [28]. Table 3 shown about the impact from the studies. There are most student continued their learning even after they got the maximum

points [15]. From the 18 studies, majority showed the positive impact in using gamification element for learning Computer Science.

Table 3: Summary of the impact of gamification in learning Computer Science

Author	Positive	Negative	Mix Positive and Negative
[15]			✓
[6]	✓		
[11]	✓		
[5]	✓		
[16]	✓		
[26]	✓		
[17]	✓		
[18]	✓		
[27]	✓		
[28]	✓		
[19]	✓		
[20]	✓		
[21]	✓		
[29]	✓		
[25]		✓	
[30]			✓
[22]	✓		
[23]	✓		

The implemented of using gamification in learning Computer Science based on the studies above commonly showed the positive impact. Some studies reported the element of gamification could to motivate and engage the student in learning Computer Science [5, 17–19, 21, 26, 27, 16, 20, 28]. In academic, implemented gamification successful to improve the student's knowledge [15], the student's engagement and willingness in learning Computer Science with gamification was increased [28] but some studies reported the negative impact in gamification.

Not all students motivated by implement gamification in learning, some students did not feel any effect in the application of gamification [30]. Some students stopped their task because they already earned the maximum badges or point [15]. Therefore, the most important is planning a proper design in gamification to be success in learning [28] and need to paid attention in the difficulties of the task evaluation [33].

The outcome of gamification has differences in students, which often use technology and students that rarely use it, for example, IT student and Non-IT students. The difference between students IT and non-IT is the attitude of non-IT usually influenced by utility and availability, whereas non-IT students was not [4]. That is because IT student are closer to the technology. The student experience in the game does not affect the level of subjective quality of an application that can determine how easy or difficult it is to use [4], but students who often to play video game were more motivated than the students rarely play video game [37]. However, non-IT students have a clear success in the application of gamification [4].

5. Discussion

Almost all the studies above reported that gamification had positive impact on learning about Computer Science. The most common element used was badges, points, level, and leaderboards. The impact of the element of gamification in learning can increase motivation and engagement between the student and the student enjoyed to do their task [33]. Learning with gamification can be a tool to help students and teacher in learning and make their performance in learning more effective and attractive [11] .

Not all the studies reported positive impact, some studies reported gamification had not any effect in learning [30] and tend to be demotivation [25]. The utilization of game technology could distract the player in academic content, and some players reduce the attempt to learn more about the material [38]. Therefore, it is important to ensure that the application of competition through gamification does not make students careless [30].

Designing of gamification is to encourage the students in learning become fun and enjoy. However, the poor design in gamification sometimes reducing the motivation of students in learning and the lesson become not fun [39, 40].

The impact of gamification is dependent on the context where the gamification implemented and how user using it [33] and the good design in the game also includes feedback, progression, and storyline [32].

Some research successful to motivate and engage the student while the other was not. Emotionally, the effects of gamification in learning are feeling of success and failure, and frustration and anxiety [22]. The most important in gamification to be successful is the design such as the design of reward system, for example badges, is it too easy or too difficult to get for the students [28], a good design in gamification can allow the student's in their experience to all of the emotions [36] and need to paid attention in the difficulties of the task evaluation [33]. To avoid high levels of frustration and anxiety for the students, designing tasks and learning activities at the right level is necessary [22]. The addition of narrative stories can also be an alternative because it has been proven effective to motivate and engage learners [32, 41] .

6. Conclusion

Nowadays, the utilization of technology in learning and become new styles in teaching [7]. Gamification become a tool to help the students in learning, especially learning Computer Science. The research examined gamification especially in Computer Science related subject majority reported gamification had positive impact to the student but the other research reported the negative impact [25].

The most common element in use to the studies was badges, points, level, and leaderboards. Implemented gamification is a new way to increase students in learning and also can improve their motivation and educational effectiveness [27].

Some studies reported the negative impact, however, to get success in gamification must consider some points such as the design [28, 32, 36, 39, 40] the difficultness task at the right level [22], [33], the target [33], and the transparency of reward system and immediate feedback to a user's actions [28].

The element gamification such as a narrative story that combining task together in learning can create a cohesive whole [20]. The narrative story can be implemented into the course, but this needs a lot of effort to create a good narrative that appropriate and motivate the students [41]. The most important is the design of the, for example, badges. Is the badges too easy or too hard to collect for the student because their motivation will drops if reward system is not transparent and there was nothing feedback for user's action [28].

Majority, the result of study above reported positive impact. As shown in the Table 3, 15 from 18 studies reported the positive impact in using gamification in learning Computer Science. There is the different outcome for the course which rarely used computer or technology. The students who rarely use technology usually influenced by utility and availability. Students who often to play video game were more motivated, but student which rarely use technology also had clear success in the application of gamification [4]. Implementing gamification in learning can be a tool that can motivate and engage the student, and make their performance more effective and attractive in learning Computer Science [5]. Then, gamification can be one of the solutions to reduce problems in learning for higher education [4].

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