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GAMIFICATION IN ONLINE COLLABORATIVE LEARNING FOR PROGRAMMING COURSES: A LITERATURE REVIEW

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ABSTRACT

The popularity of computer science education triggered a dramatic rise in the number of tertiary institutions offering computer science courses. Nevertheless, many employers complain that graduates do not have the required skills. Lately, the higher education sector has faced a continuous decrease in the number of students choosing to study computer science courses, and some of the reasons for this rejection are related to the difficulties in mastering computer science skills. As core subjects in a computer science major, programming language subjects play an important role in successful tertiary computer science education. The embedding of gamification in programming courses has been identified as a potential technique that could maximize student participation and have a positive impact on learning. This research aims to provide an overview of how the embedding of gamification in online collaborative learning can enhance participation among novice programming students. The main findings from this review include the identification of the important participation elements for programming students in the online collaborative learning environment, a list of game elements embedded in online collaborative learning to facilitate participation among programming students, and suggestions regarding suitable gamification approaches for programming courses.

Keywords: gamification, game elements, programming courses, online collaborative learning, participation.

INTRODUCTION

The popularity of computer science education led to a dramatic increase in the number of tertiary institutions offering computer science courses. Nevertheless, many employers complain that graduates do not have the required skills [1]. Lately, the higher education sector has begun to face a continuous decrease in the number of students choosing to study computer science courses; the reasons for this rejection include the difficulties in mastering the computer science skills [2,3]. As core subjects in a computer science major, programming language subjects play an important role in successful tertiary computer science education [4,5]. In the computer science curriculum, students cannot avoid programming subjects. One of the greatest challenges faced by most students, especially those in the first year program, is coping with programming subjects. Among the critical subjects highlighted and widely discussed by researchers is object-oriented programming [6,7].

The embedding of gamification in programming courses has been identified as a potential technique that could maximize student participation and have a positive impact on learning. Gamification refers to the embedding of game elements in environments including the online collaborative learning (OCL) environment, and is becoming a prevalent topic of interest among researchers. Studies on the implementation of game elements in education have reported that the gamification method enhanced participation among students in the traditional classroom and in online learning. Moving from typical collaborative learning to OCL gives many advantages to both the students and teachers. OCL enables the transformation of knowledge through online learning and can be accessed at any time in different places, both asynchronous and synchronous. The use of games in education can be recognized in the concept of serious game, game-based learning and gamification. However, the use of game elements in education most closely meets the definition of gamification. Gamification can be defined as the use of game elements in a non-game context [8,9,10] including in the educational context with the aim to improve participation among learners.

This paper provides an overview of how the embedding of gamification in OCL can enhance participation among novice programing students. As shown in Figure-1, this research hypothesizes that gamification promotes the participation of computer science students who are studying programming courses, which then leads to the achievement of learning outcomes. Hence, this paper starts with the discussion on RQ1: What are the important elements that ensure active participation among programming students in the OCL environment? The keyword "participation" was used in the search results in order to answer RQ1. RQ2: What are the important game elements to embed in OCL in order to facilitate participation among programming students? RQ2 was answered by determining the gamification approaches applied by researchers in the context of gamification for programming courses. RQ3: What gamification approach is suitable for programming courses? To answer RQ3, the categorization of game elements from the mechanics–dynamics–aesthetics (MDA) framework was applied.

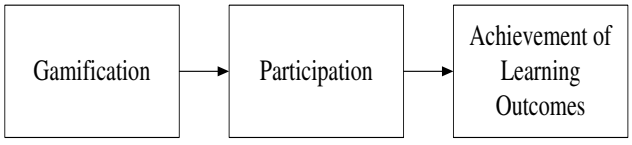

Figure-1. Main hypothesis.

This paper is divided into four parts. The first part deals with the challenges faced by programming students in the context of the computer science curriculum in tertiary education. The second part demonstrates the elements necessary for students to participate and collaborate actively in the OCL environment. The third part lists the game elements that need to be embedded in OCL in order to facilitate participation among programming students. The last part presents three main approaches explored by researchers on gamification in OCL.

METHODOLOGY

Selected journal papers published between 2011 and 2015 were retrieved from several databases. The keywords that have been used as the search terms are game, gamif*, gamification AND programming AND "collaborative learning". After the journal papers were downloaded, they were analyzed according to the research objectives. The review was structured to accomplish the following three research objectives:

OBJ1: To identify the important elements that ensures active participation among programming students in the OCL environment.

OBJ2: To explore the important game elements in OCL that facilitates participation among programming students.

OBJ3: To identify a suitable gamification approach for programming courses.

CHALLENGES IN PROGRAMMING SUBJECTS

As a core subject of a computer science major, programming language subjects play a huge role in the successful attainment of tertiary computer science education [4,5]. In the computer science curriculum, students cannot avoid programming subjects. However, most students have difficulties coping with programming subjects, especially during their first year of university. Their passion slowly decreases in the first year due to the difficulties to tackle the programming language subject, which is the necessary subject for first semester syllabus [6,7,11,12]. The frustration begins when the feel of lacking satisfactory skills in developing correct computer program and unfamiliarity with the programming structures [13]. The frustration however leads to low participation, a terrific drop out from the courses and the fears continues in the following programming courses [12].

One of the critical subjects highlighted and widely discussed by researchers is object-oriented programming [6,7]. Object-oriented programming is a method of programming based on a hierarchy of classes and well-defined and cooperating objects [14]. Object-oriented programming was introduced during the 1990s [6,12] when students were introduced to programming languages such as Scheme, COBOL and C in their programming subjects. However, these programming languages became irrelevant as the industry discontinued their use [6]. Object-oriented programming is offered by most universities since it is widely used in education and industry [15].

Much effort has been made to overcome the challenges faced by programming students. Among the solutions, researchers have suggested that programming subjects should be taught with the active involvement of students in the learning process [16]. Recognizing that the learning process is not limited to traditional face-to-face lectures, researchers started to implement online learning as a tool to engage and improve students' satisfaction with object-oriented programming courses [16,17]. In order to enhance learning programming among novice students, researchers have suggested that online support is essential [16,18] especially in the higher education setting where study teams are formed and members spend a lot of time and effort outside the class to study together while providing assistance and feedback to each other [12,17,19].

According to the Khan Academy [20], in order to inspire students to explore programming by themselves, they must be allowed to look at the codes and programs produced by other students. This can indirectly promote collaborative learning among novice programming students. Thus, this paper proposes that OCL is a suitable method to overcome the participation problems in programming subjects since OCL lets students learn together and provide feedback and assistance to each other. However, enhancing the participation among learners is the key factor in enhancing OCL [10]. Next section will explain in details on participation in OCL.

PARTICIPATION IN ONLINE COLLABORATIVE LEARNING

OCL is a situation in which learners learn together with the involvement of information technologies, such as the Internet, as mediating tools [21]. Researchers have defined OCL as a situation where discussion occurs collaboratively among the whole class or within smaller groups in an online classroom [22]. Specifically, OCL adopts the use of technology during the learning process, most of which will occur online. Evidence indicates that online collaboration is the computer-mediated form of the conventional in-class collaborative learning [23].

In the educational context, a large number of studies have been conducted to increase learner outcomes. However, most of the studies have overlooked some important key factors in engaging learners. Enhancing the participation among learners is the key factor in enhancing OCL [10]. This concern is supported by Hrastinski who found that participation should come first in the overall online learning process [10]. In the collaborative learning scenario, researchers highlight participation as an issue that can enhance OCL outcomes [24]. Traditionally, it has been argued that participation is one of the critical attributes of discussion patterns [24] and that participation is the most fundamental requirement of a collaborative group because it is impossible to collaborate without

individual contributions to problem solving. The participation of students relies on three important elements that enable students to actively participate and collaborate, namely, personal encouragement [25,26,27], teamwork [18,26,28], and instructor support [22][28-31]. Empirical research found that participation in a learning community was connected with students' academic success [32].

Although many solutions have been suggested in previous research, the programming language issue is still prevalent among first year students in computer science courses [7]. Personal encouragement among students is identified as an important factor that affects the level of participation in a learning community. Self-efficacy is a critical part of personal encouragement [25]. Students with low self-efficacy are found to participate less in class discussions [33]. Recent evidence concludes that a lack of technology skills will affect students' commitment to online collaboration due to the fear of making technical errors and difficulties in tasks that require the application of technical proficiency [25].

Socialization issues have also been identified as a major problem within the teamwork factor. Students are often given a task or assignment without having the opportunity to get to know each other [34]. One study suggested that non-task interaction such as greeting and friend-making is needed before students proceed to their academic task [35]. Another study that sought to understand OCL in small groups proved that social participation among students is an important indicator of students' active participation in online groups [28].

Research findings show that students perceive their instructor's support to be essential in the collaborative learning environment by encouraging learners, setting clear objectives and goals, offering suitable resources, offering opportunities to view examples, and structuring a well-defined and well-organized instruction [22,28]. Researchers [36,37] have pointed out that participation and interaction in online learning environments cannot ensure collaboration or the achievement at optimal levels of learning, both of which require teacher involvement through feedback or other means [37-40]. The teacher functions as a moderator or facilitator in the online learning environment [41,42], and his/her major role is to encourage and assist effective collaboration between participants and to familiarize them with the objectives and learning outcomes [28].

Most research in OCL has only focused on studying participation elements separately. Thus, this paper highlights the importance of combining the three participation elements of personal encouragement, teamwork and instructor support in order for students to actively engage with the programming learning process. As shown in Figure-2, this research proposes that the active participation of students in OCL can be successfully implemented by considering the three important elements of personal encouragement, teamwork and instructor support.

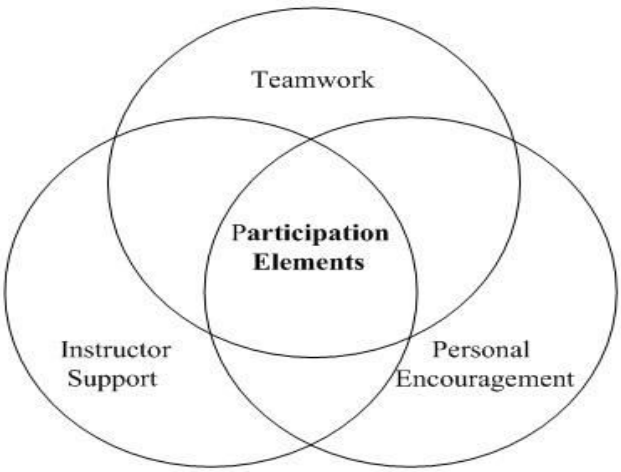

Figure-2. Participation elements in online collaborative learning environment.

GAME ELEMENTS IN GAMIFICATION

Among the many types of game that exist, most researchers agree that the massively multiplayer online role-playing game (MMORPG) is the most addictive game due to its critical design components. The MMORPG type of game contains almost all the components in the MDA framework, with the aim to promote the game experience among players. Many researchers have explored and agreed that the critical design components contribute to the addictiveness of MMORPG [43,58,59].

Several studies have highlighted that the MMORPG contains engaging elements that can successfully integrate players from various places to collaborate. Due to its addictiveness elements, MMORPG able to trigger the emotional response of player and makes the game more appealing. The "collaborative" element is beneficial in programming education to make students collaborate and involve students in the learning process.

In order to understand the game design elements, the MDA framework is used [46]. This framework is a basic framework to understand the game design components. According to the MDA framework, game elements can be divided into three types, namely, mechanics, dynamics and aesthetics. As pointed out by Hunicke [46], the game mechanics describe a particular component of the game that represents data and algorithms. Game dynamics refer to the lifecycle of the mechanics that act to engage a player's input and other's output continuously. Game aesthetics deals with the emotional part of the player in order to keep them engaged with the game.

Research to date has tended to focus on the use of mechanics and dynamics elements rather than the aesthetics part which plays an important role in engaging students. However, developed gamified application has recognized providing fewer aesthetics elements compared to a professional platform have brought [47]. The same problem goes for computer science education where researchers have paid less attention to the aesthetics elements of how gamification works. Aesthetic elements

create a sense of 'fun' and are recognized as playing an important role by dealing with emotional aspects to encourage users to keep engaging with the gamified application. Table-1 lists the game elements identified from the analysis of the literature.

Table-1. Game elements identified in the literature.

Game elements	
Mechanics	Badges[48][49][50][51][52][53][54][55], leaderboard[17][48][49][51][54][55], points[17][47][49][50][51][52][54], levels[17][47][49][51], game board feedback[48], reward[48][54][56], notifications[48], virtual goods[50] progress bar[47][50], paths[47], avatar[47], and teams[56].
Dynamics	Personal dynamics: desire for reward[53] [54], personal promotion[5]. Social dynamics: altruism, status[17][48][49][51][54][55], achievements[55], competition[5][17][48], peer collaboration[17][47][51], confrontation[5], user scores[5][51]. Feedback system[48]
Aesthetics	Challenges[49][56]

GAMIFICATION IN PROGRAMMING COURSES

Previous research on gamification in OCL has explored three main approaches, namely, gamifying learning activity, gamifying assessment activity, and gamifying social activity (Table-2).

Table-1. Categorization of gamification for programming courses.

Gamification Approaches	Authors
Gamifying Learning Activity	[55][48][49][50][47] [58][5][53]
Gamifying Social Activity	[59][54]
Gamifying Assesment Activity	[51][52]

Gamifying assessment activity is used in evaluating the performance of students. One of the examples is by inserting a leaderboard element in measuring academic performance such as tests and quizzes. Research by Christy and Fox [60] on the impact of the leaderboard showed that leaderboard implementation had a positive impact on the performance of male students compared to female students in a math quiz. The use of a leaderboard on female students resulted in the development of social comparisons with the high-achievers among female students in class [60]. Another example of the use of gamification in assessment is given by Faghihi [61] who studied the gamification techniques used during the training and test phases to help students learn mathematical concepts. The results showed that students who used the gamified system scored above the median compared to students who were taught with a conventional method.

Gamified social activity is designed to promote interaction among students and allow them to provide assistance and feedback to each other. Game dynamics such as status, achievements, competition, co-operation, confrontation, gaining status or high scores can be inserted in order to promote socialization. Knutas [54] developed a gamified online discussion system for an introductory programming course, with the aim of motivating the students to help each other. The system implemented game elements such as rewards, points, leaderboard and achievement badges. The system was found to have a positive impact on the course by promoting student collaboration, decreasing response times and generating course communications 88% more effectively by decreasing email traffic.

Gamifying learning activity can be done by inserting game elements such as a leaderboard, badges, challenges and socialization elements to integrate instructor-personal, instructor–group and personal–group interactions. Gamifying learning activity is concerned with student participation and skill development during the learning process but does not consider the students' achievement. Challco [62] developed the Ontology for Gamifying Collaborative Learning Scenarios in order to solve the engagement problem and enhance motivation in collaborative learning. The ontology gamifies the learning activity through the personalization of game elements in collaborative learning contexts. Each gamified collaborative learning setup is associated with only one player role. Hence, a suitable game mechanic is used to fulfill the psychological motivational needs and to internalize motivation [62]. Code Hunt was developed to help students' master programming from introductory to advanced level subjects [63]. The gamification element was inserted to engage users with the system. The game is available in modern browsers and currently supports C# or Java programs. The game comprises a sequence of worlds and levels which are increasingly challenging. The player has to discover a secret code hiding in each level and write the code. The leaderboard and sounds are used to specifically engage the player. Currently, Code Hunt is used by experienced developers to improve their programming skills and by companies to assess job candidates.

Gamifying the learning activity for programming language subjects is seen as an effective solution to solve programming problems among first year computer science students. The gamified design needs to embed collaborative elements in order to foster collaboration among the students. The collaborative process can be created through establishing OCL. Gamifying the learning activity can be done by considering the participation elements through designing a gamified learning activity

which promotes the development of programming skill, allows interaction between the instructor and students and facilitates social activities in order to promote participation. More aesthetics elements need to be embedded in order to create 'fun' environments in OCL for students to interact and engage with the learning process.

DISCUSSION

There are many efforts in gamifiying OCL for computer science education. Some researchers have suggested that computer science courses should be taught with the active participation of students in order to encourage students to be collaboratively involved in the learning process [16]. Several programming subjects in the computer science curriculum have been gamified by previous researchers to explore alternatives to simplifying the difficulties among students such as introductory programming subjects [52,54], C-programming [9,49], Java programming [5], data structures and algorithms [53], data science [48] and software engineering subjects [44,45].

Most researchers have explored the topic by developing gamified software or designing an application and testing it with real respondents. Various approaches used in the research have embedded gamification, including gamifying programming courses [49,50,52], providing a gamified online collaborative platform for students to interact [16,52,55], creating a cloud-based environment to support teaching materials [48], gamifying an online discussion system to foster discussion among students [54], gamifying learning activities [51,56] and gamifying teaching approaches [5,49].

However, a review of the literature on gamification in OCL especially in regard to computer science education indicates there is still a lack of systematic guidance on the methods and design to implement a proper gamified application [50]. Some of the theories used to explain gamification in education are social learning theory [10] and self-determination theory [64], which are used to explain the effectiveness of extrinsic and intrinsic motivations to increase engagement and performance [64]. Nevertheless, few scientific studies have provided sufficient theory or direction to develop a measuring instrument for gamification research [65].

CONCLUSIONS

Gamifying learning activities for programming language subjects is an effective solution to solve the programming challenges faced by first year computer science students. Previous studies have indicated that OCL is a suitable method for teaching programming subjects. However, previous studies have not implemented participation elements in detail in their research. Thus, this research proposed the combination of participation elements in gamifiying learning activities, with an increased focus on aesthetics elements in order to create a 'fun' environment in OCL and encourage students to interact and engage with the learning process. For the purpose of improving the participation of programming students in OCL, the next phase of this research will be the development of a guideline for gamifying learning activities as this approach is still in its infancy in the area of gamification in programming education.

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