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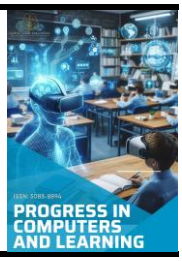

Enhancing Usability in Gamified Computer Programming Courses for Higher Education

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ABSTRACT

Gamification is increasingly recognized as an innovative educational approach that actively engages students in their learning journey. It has the potential to enhance the learning environment by making it more enjoyable and engaging, thereby benefiting education. This research focuses on boosting student intrinsic motivation in a Computer Programming Fundamentals course through gamification. The problem statement addresses the challenge of maintaining student motivation and interest in technical subjects like programming. The study aims to identify effective gamification elements, assess the usability of the gamified system, and evaluate their impact on student intrinsic motivation. A three-phase approach was used in this research: analysis, design and integration, and evaluation. A quantitative methodology, involving surveys, was employed to measure different aspects of usability testing which are usability, educational usability, and user experience. The results indicate high levels of usability across all measured constructs, with mean scores translating to percentages of 89.4% for usability, 89.6% for educational usability, and 89.0% for user experience. The findings highlight the positive impact of gamification on student intrinsic motivation in the Computer Programming Fundamentals course. By effectively incorporating game elements, students demonstrated improved usability, educational usability, and overall user experience in their learning process. This research contributes to the theoretical understanding of educational gamification, offers innovative methods for teaching programming, and promotes self-directed learning.

1. Introduction

1.1 Background

In today's era of rapid advancements in science and technology, the fields of computer science and information technology are gaining significant prominence, with software becoming an integral part of daily life. The excitement surrounding emerging technologies has captured public interest, attracting more individuals to pursue computer-related studies. In Malaysia, higher education standards mandate programming as a prerequisite for computer science and information technology

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degrees. However, despite the soaring global demand for software engineers, the dropout rate among computer science and IT undergraduates remains alarmingly high [1].

Many beginners in computer science and information technology struggle with learning to code. Students often express feeling intimidated by the challenges, viewing programming as a difficult, time-consuming task that demands consistent effort. Research has highlighted various obstacles to learning programming, including the impact of the learning environment in programming courses on students' motivation and performance [2]. Additional challenges include limited conceptual understanding, insufficient hands-on experience, poorly structured lab activities, a lack of enthusiasm, and the need for intellectual effort, logical thinking, cognitive skills, and problem-solving abilities [1]. These difficulties can significantly undermine students' motivation and performance in programming courses [2]. Consequently, a significant number of students choose to withdraw from college.

Learning programming has always been a challenging endeavor, especially for beginners. To address this, one study proposed a semantic approach that integrates a gaming environment to highlight programming structures and abstract concepts, potentially enhancing the learning experience regardless of programming language or syntax [1]. Additionally, several studies suggest that making lessons more engaging and enjoyable can improve students' motivation and participation. Gamification has been identified as a potential solution to this issue [2]. Although online learning has gained significant traction in recent years, particularly during the pandemic, it often fails to sustain student interest and engagement as programming content becomes more complex. For example, while 81% of students enrolled in an online Python course successfully completed the first half during the winter semester of 2018-2019, only 18% finished the entire course [3]. Conversely, studies indicate that incorporating gamification features can significantly boost students' motivation to learn [2].

Gamification involves integrating game elements and strategies into non-game contexts, such as education and business, where entertainment is not the primary objective [2]. The purpose of applying game design principles and mechanics in educational settings is to enhance student engagement and motivation. In addition to gamification, visual presentations, animations, and algorithm simulations are integral in creating a more dynamic, interactive, and engaging learning experience. These elements make concepts more visible and accessible, enhancing understanding of inherently dynamic topics compared to traditional paper-based methods. Therefore, this research aims to develop a web-based gamified platform for programming course content at higher education institutions. The goal is to enhance student engagement, attention, and motivation while learning programming concepts.

Gamification, described as the use of game mechanics and game thinking to capture attention, spark interest in learning, enhance motivation, promote self-learning, and support problem-solving, has been shown to effectively increase student engagement across various educational contexts [4]. This teaching and learning strategy are particularly valuable in computer programming classes, which many students find challenging, as it helps boost their interest, motivation, and participation while achieving learning outcomes [5,6].

By integrating game elements such as badges, points, levels, leaderboards, and challenges into educational activities, gamification transforms traditional learning environments—both in classrooms and online—into more enjoyable, interactive, and immersive experiences. This approach aims to enhance student engagement and motivation by making the learning process more dynamic and engaging [7]. Gamification fosters a sense of competition, teamwork, and accomplishment, encouraging students to actively engage in their educational journey [8]. It also supports the development of computational thinking through learning programming languages, a vital

multidisciplinary skill in modern education [7]. By transforming learning into an engaging experience, gamification offers immediate feedback and instills a sense of achievement. Features such as leaderboards, awards, challenges, and badges make the process more motivating and enjoyable for students [9].

However, gamifying programming subjects presents unique challenges compared to other disciplines. Due to the technical complexity of programming, more tailored gamification elements are required to align with specific learning objectives. Unlike non-technical subjects where simpler gamification features may suffice, programming education benefits most from integrating elements like coding challenges and problem-solving activities to maximize its effectiveness.

1.2 Literature Review

The term "gamification" was first introduced in the context of digital learning in 2008, but it wasn't until 2010 that it gained widespread recognition [10]. In education, gamification seeks to identify and apply the elements that make games enjoyable and engaging, encouraging learners to persist and stay motivated. Its primary goal is to boost students' motivation to study more thoroughly and effectively, fostering a competitive spirit and a drive to improve their academic performance [11]. Beyond education, gamification has gained traction in various fields, including business and healthcare, drawing significant interest from both the public and private sectors [12]. According to Morschheuser *et al.,* [13] and Shafie and Abdullah [14], gamification incorporates diverse game mechanics and dynamics, such as points, levels, badges or achievements, virtual goods, leaderboards, virtual gifts, and progress bars, as outlined in Table 1. These elements work together to enhance engagement and user experience.

Table 1
Type of Game Elements

Game Mechanics	Game Dynamics
Points	Rewards
Levels	Status
Badges/Achievements	Achievements
Virtual goods	Self-expression
Leaderboards	Competition
Virtual gifts	Altruism
Progress bar	Timers & Pressure

Gamification in education was initially introduced years ago by awarding badges to encourage students to practice more and put in greater effort. This approach has the added benefit of motivating students to take a more active role in their learning, leading to additional positive outcomes [15]. Table 2 highlights the differences between traditional teaching methods and gamification-based approaches.

Students have found that playing games is more enjoyable than relying on traditional calibration methods. According to Shafie and Abdullah [14], evaluating the effectiveness of students' attitudes and interests revealed that gamification, compared to conventional approaches, can positively impact students' perspectives. It makes them more receptive and fosters enjoyable learning experiences. Table 3 outlines the key differences between game-based learning, gamification, and gaming [16].

Table 2
Traditional Method vs. Gamified Approach

Traditional Method	Gamified Approach
Teacher teaches students	Self-learning
Marks to evaluate students	Points to evaluate students
Text (books and board)	Design (more attractive)
Topics to define course contents	Levels (more competition)
Increased complexity	Stages (more complexity)
Test	Master level
Grade	Ranking

Table 3
Difference Between Game, Game-Based Learning, And Gamification Distinctions

Game	Game-based Learning	Gamification
Games are played solely for fun; they may or may not have established guidelines and objectives.	In games, learning objectives are stated.	Depends on doing tasks that have rewards or points.
Both winning and losing are inherent to the game.	The goal is to motivate students to take action and learn.	The goal is to spur students to take some sort of action.
Playing games comes first, with rewards afterward.	In essence, winning the game is gratifying.	Existence is fundamentally voluntary and pleasurable.
In general, games are safe and expensive to design.	Building often costs a lot of money.	In general, gamification is simpler and less expensive.
Scenes and stories are included in the game.	Content is frequently changed to fit the game's narrative.	Typically, game-like topographies rather than content are added to the learning management system (LMS).

Gamification is a strategy that enhances motivation and engagement by integrating game design elements into non-gaming contexts, such as education. When applied to programming classes, it makes the learning experience more engaging, motivating, and immersive [17]. However, not all students may benefit from this approach, and its effectiveness can vary depending on the situation [18]. Additionally, developing appropriate assessment methods and identifying relevant factors for evaluating the success of gamification are crucial. Since gamification can increase student motivation and engagement, it is important to consider potential challenges. Poorly designed gamification elements may fail to inspire or engage students effectively [19].

This study examines how various gamification components can be used to measure their impact on increasing students' intrinsic motivation [20]. Each type of game discussed includes elements designed to capture students' interest and enhance their drive and academic performance. Table 4 outlines how game components were utilized in previous studies. The most commonly used gamification elements include badges, leaderboards, points, and levels, followed by feedback, progress, challenge, achievement, and story/theme. Given their role in fostering intrinsic motivation, this study recommends incorporating points, leaderboards, rankings, and progress as key elements.

Table 4
Summary of Game Elements in Existing Study

Previous Study	Points	Leaderboards	Badges	Achievements	Levels	Story/themes	Feedback	Rewards	Progress	Challenges
Romero-Rodriguez *et al.,* [22]		/	/							/
Facey-Shaw *et al.,* [23]			/							
Dikcius *et al.,* [24]								/		
Khaleel *et al.,* [11]	/	/	/		/					
Khaleel *et al.,* [25]	/	/			/					
Uz Bilgin & Gul [26]	/	/	/		/	/	/			/
Sanchez *et al.,* [27]							/		/	
Asiksoy & Canbolat [28]	/	/	/		/		/			
Adams & Du Preez [29]	/	/	/		/		/	/		/
Garnett & Button [30]			/							
Orgur *et al.,* [31]		/	/		/					
Coleman [32]			/							
Gündüz & Akkoyunlu [33]	/		/	/	/					
Milenković *et al.,* [34]	/	/	/							
Pakinee & Puritat [35]	/	/			/				/	/
Van Roy & Zaman [36]		/	/							/
Ahmed & Asiksoy [37]	/	/	/		/		/			
Marín *et al.,* [38]	/	/						/		/
Saleem *et al.,* [39]	/	/	/	/						
Donnermann *et al.,* [40]	/		/							
Ozdamli [41]	/		/				/			
Cuervo-Cely *et al.,* [7]		/	/		/		/		/	
Costa [42]	/	/	/	/	/			/	/	/
Hope *et al.,* [43]	/	/	/	/			/			
Heryadi *et al.,* [8]	/	/	/		/			/	/	/
Piteira *et al.,* [44]	/	/	/		/				/	
Smiderle *et al.,* [18]	/		/							
Dichev & Dicheva [45]	/	/	/				/	/		/
Proposed Elements of Study	19	19	23	4	13	1	9	6	6	9

Based on 28 previous research studies presented in Table 4, badges, representing success and recognition, were used in 23 studies (82.1%), making them the most popular gamification element. This demonstrates their widespread appeal as a way to reward students when they achieve specific goals. Leaderboards and points were also frequently used, appearing in 19 studies (67.9%), as these elements help create a competitive environment, motivate students, and provide immediate performance feedback. Levels were used in 13 studies (46.4%) to guide students' progress in a structured way, emphasizing the importance of maintaining engagement through clear objectives and a sense of advancement. Feedback, an essential component for guiding and reinforcing learning, was incorporated in 9 studies (32.1%), highlighting its critical role in the educational process. However, achievement elements were used less frequently, appearing in only 4 studies (14.3%). Story and theme elements were the least used, featured in just 1 study (3.6%), possibly due to the challenge of creating engaging narratives that align with educational content. In summary, the table illustrates various combinations of gamification components that can create an engaging and

motivating learning environment, enhancing student performance. For this study, the focus will be on four (4) key gamification elements: points, leaderboards, levels, and progress, as highlighted in Table 4.

As the demand for the latest technological skills increases, it is essential to develop knowledge and information technology (IT) skills. Students will have the opportunity to explore how technology impacts them both personally and professionally, particularly in the context of organizations. Staying up to date requires extensive reading, research, and the ability to anticipate technological trends. This study focuses on the emerging technological revolution in gamification applied to MOOC content in online distance learning, with the following objectives: i. To identify the essential gamification elements for programming courses in higher education. ii. To develop a game prototype application that incorporates these gamification elements. iii. To evaluate the proposed game prototype for programming courses in higher education through usability testing.

2. Methodology

2.1 Research Flowchart Process

As Figure 1 outlines the research flow for this study, which consists of three phases: (i) Analysis, (ii) Design and Integration, and (iii) Evaluation.

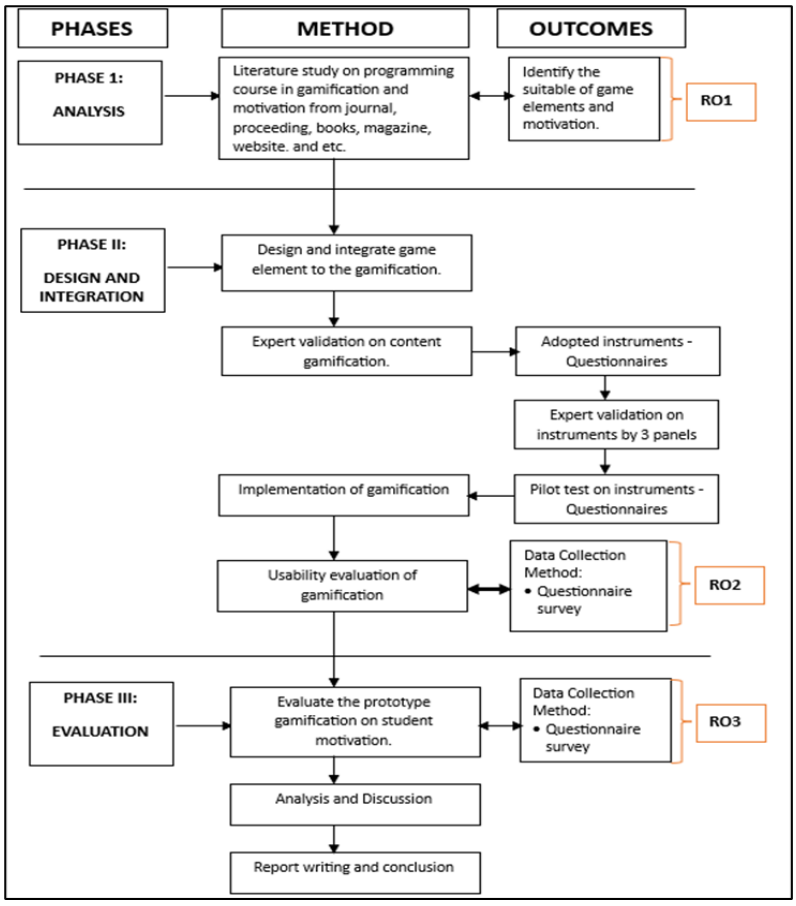

Fig. 1. Research Flowchart Process

Phase I: Analysis involved conducting a literature review to identify potential game elements for gamification. The results from this phase also helped to refine the research problem statement. The

review focused on topics related to computer programming, gamification methods, and student motivation, drawing from studies published between 2018 and 2023.

Phase II: Design and Integration focused on designing and integrating the identified game elements into a gamification tool. This phase also included usability testing and pilot trials of the developed instruments.

Phase III: Evaluation involved implementing the proposed gamification and evaluating its impact on student motivation through usability testing questionnaires. This phase aimed to fulfill the research objectives. The questionnaire survey was the primary data collection method, leading to a detailed analysis and discussion that culminated in a final report.

2.2 Respondents Sampling and Research Procedure for the Motivation Evaluation

This section presents the results of the usability evaluation, which assesses the use of gamification by testing it with representative users. The goal of this evaluation is to determine whether the gamification tool is usable and intuitive enough for users to achieve their objectives. For this study, the usability evaluation was conducted using a survey questionnaire consisting of 18 items, divided into four sections. Section A collects demographic information from the respondents, while Section B covers usability aspects with 11 items. Section C focuses on educational usability with 3 items, and Section D addresses user experience with 4 items.

To ensure the reliability of the instrument, a pilot test was conducted with 30 respondents from Kolej Komuniti Bandar Darul Aman (KKBDA), Kolej Komuniti Pandang Terap (KKPT), and Kolej Komuniti Arau (KKA) at three community colleges in the Northern Zone. The results of the pilot test are shown in Table 5. The study involved 81 students enrolled in the Computer Programming Fundamentals course. Participants were selected using the target population technique, where the entire population was chosen as the study sample [46].

The survey was conducted in person across the three community colleges. Researchers coordinated with the course instructors to arrange a suitable time and date for the study. Once the logistics were set, data collection took place in the classroom. Participants were provided with an explanation of the gamification elements to ensure the data collected aligned with the research objectives. After interacting with the gamification, the respondents completed a set of questions. The collected data was then analyzed using SPSS statistical application.

Table 5
Reliability Test (Cronbach Alpha) of the Pilot Test Instrument (n=30) for Usability Evaluation Questionnaire

Construct	Number of Item	Cronbach's Alpha Coefficient Value (α)
Usability	11	.965
Educational Usability	3	.958
User Experience	4	.926

Table 5 presents the results of the pilot test, showing the Cronbach's Alpha Coefficient (α) for each construct of the usability evaluation. The reliability statistic for the Usability construct reveals a high level of reliability, with a Cronbach's Alpha value of 0.965. Similarly, the Educational Usability construct demonstrated a Cronbach's Alpha value of 0.958, indicating high reliability across all three items. The User Experience construct also showed strong reliability, with a Cronbach's Alpha value of 0.926. These results are consistent through classification of statistical, which defines a Cronbach's alpha (α) value above 0.8 as indicating high reliability, a value between 0.7 and 0.8 as moderate and

acceptable reliability, and below 0.6 as weak reliability [47]. Consequently, the findings suggest that the research instrument is highly reliable and acceptable.

3. Results

3.1 Summary Result of the Usability Evaluation

The section discusses data analysis results provide an evaluation of three key aspects: Usability, Educational Usability, and User Experience, based on responses from 81 participants. The mean scores for each aspect are categorized into three levels, as presented in Table 6 [21].

Table 6
Mean Five Likert Scale by Three Levels

Mean Score Range	Level Interpretation
1.00-2.33	Low
2.34-3.67	Medium
3.68-5.00	High

Table 6 outlines the mean values based on a five-point Likert scale, which are divided into three levels. A mean score in the range of 1.00 to 2.33 indicates a low level, a score between 2.34 and 3.67 represents a medium level, and a score from 3.68 to 5.00 indicates a high level. These mean score levels will be used to interpret the overall results of the usability evaluation, as shown in Table 7 and Figure 2.

Table 7
The Overall Result of the Usability Evaluation

	N	Mean	Std. Deviation	Level
Usability	81	4.4763	0.54138	High
Educational Usability	81	4.4815	0.55528	High
User Experience	81	4.4506	0.53970	High

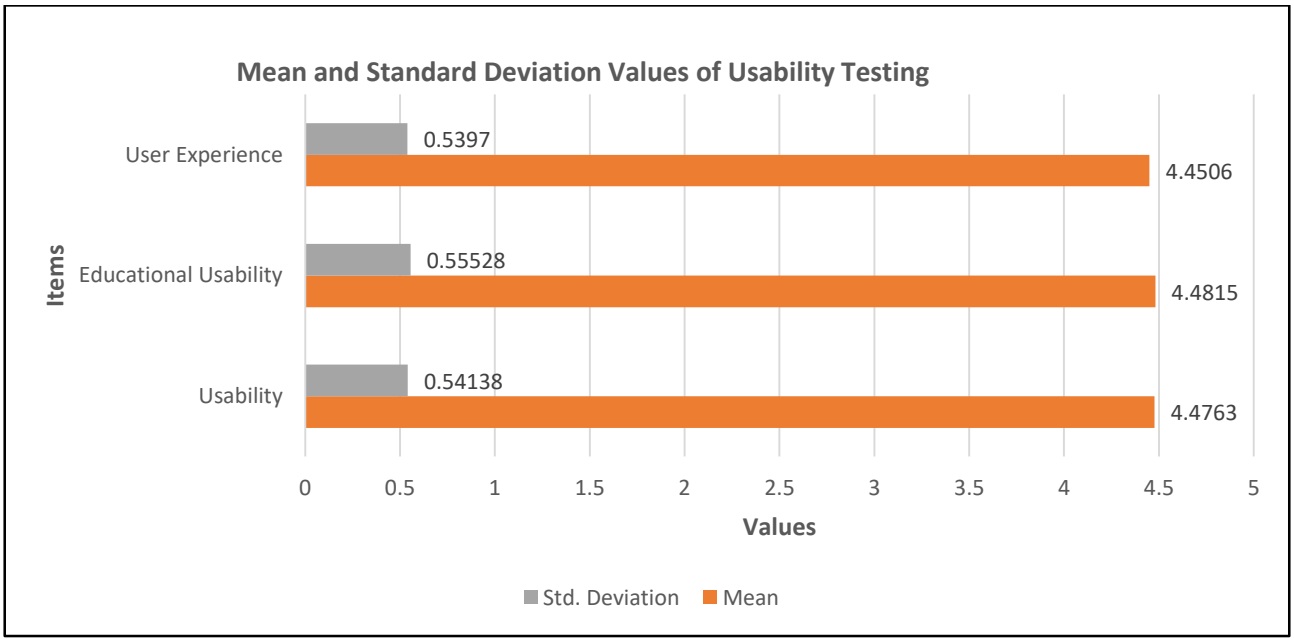

Fig. 2. Mean and Standard Deviation Values of Usability Testing

The results in Table 7 and Figure 2 show summarizes the mean, standard deviation (std), and level of the usability evaluation. Educational usability achieved the highest mean score of 4.4815 (std = 0.55528), indicating a high level. This suggests a strong positive response regarding the educational aspects, though with some variation in respondents' perceptions. Usability followed closely with a mean score of 4.4763 (std = 0.54138), also categorized as high. This indicates that respondents generally found the tool or approach easy and efficient to use, with more consistent agreement among them. Lastly, user experience received a mean score of 4.4506 (std = 0.53970), also reflecting a high level. This suggests overall satisfaction and positive interaction with the tool or approach, with a similar level of consistency in perceptions as seen in usability.

4. Conclusions

In conclusion, all aspects evaluated in terms of usability, educational usability, and user experience which are received high ratings from the respondents, indicating strong overall acceptance. The highest average score was in educational usability, highlighting its effectiveness in meeting learning objectives. This was followed closely by usability and user experience, both of which also received high scores, suggesting that the gamification approach is effective for educational purposes and well-received in terms of general use and user interaction. The standard deviations for all aspects were relatively low, reflecting a general consensus among respondents, but also indicating some room for improvement in aligning user experiences more closely. Overall, the findings show that the gamification approach effectively fostered an engaging and dynamic learning environment, resulting in higher student motivation and enhanced learning outcomes in computer programming education.

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