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Review

Capturing student interest in software engineering through gamification: a systematic literature review

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Abstract
ICT tools in education are widely used to support the aim of achieving learning outcomes by improving critical areas such as student engagement, participation, and motivation. In this study, we examine literature to explore how game elements are used in capturing students' interest, which the study suggests is fundamental to the teaching and learning of Software Engineering in higher education. Given the potential of alternative ICT tools such as flipped classrooms to increase interest in learning activities, there is a gap in similar literature on capturing interest in gamified environments, which has the potential to improve the achievement of learning outcomes. We applied flow theory to provide a guiding frame for our study. Following a systematic literature review for our data, we analysed 15 papers from the initial 342 articles, which were extracted from IEEE Xplore and Science Direct databases. The main finding in the reviewed papers underscores the positive impact of gamified learning environments on capturing student interest when teaching and learning Software Engineering. While the reviewed papers were not conclusive in identifying the best game elements for capturing students' interest, we found, that game elements such as points and leaderboards were the most common mechanisms used to advance students' interest when studying Software Engineering courses. The findings also suggest that different game elements are used in gamified environments to increase participation and engagement. The paper adds voice to the practical implications of gamification for teaching and learning. Although our study requires empirical evidence to validate our claims, we believe it sets the stage for further discussion. In the future, comparative studies of game elements in similar environments will be beneficial for identifying the ones that are more engaging and assessing their long-term impacts.

Keywords Gamification · Software Engineering · Student interest · Game elements · Engagement · Motivation · Participation

1 Introduction and background of the study

Effective content delivery in Higher Education (HE) remains an active area of interest for both lecturers and students [1]. The study in [2] emphasised how technology is helping higher education move towards new training modes. The continuous evolution of the academic space continues to necessitate new methods of teaching and learning, such as gamification, to ensure optimal learning outcomes. Most studies [3, 4] seem to concentrate on increasing student motivation and engagement through gamification or game-based elements in the teaching and learning of Software Engineering (SE).

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Teaching the SE module presents challenges to educators as they struggle to choose the most appropriate and effective methods for delivering content to the students [5] with some studies [6–8] highlighting the lack of interest in the subject. The study in [9] highlights the importance of technology in fostering motivation and engagement in students learning. Kadar et al. in [7] identify students' attitudes as one of the contributing factors to learning difficulties in subjects like SE. Engaging with a particular subject or activity out of interest can lead to changes in attitude over time. However, "if students are not interested or motivated, it is difficult to keep them engaged in classrooms" [10]. Perhaps, capturing students' interest becomes a vital starting point in the teaching and learning of subjects such as SE, which are perceived by students as dry and boring [10].

ICT modules such as Software Engineering make it difficult for students to grasp the concepts, which leads to poor performance and a high failure rate among students [11]. Combining the lack of interest with the lack of industry professionals who can deliver the practical concepts in a way that links to the theoretical aspect exacerbates the lack of interest in students, ultimately resulting in some negative learning outcomes. Many research studies note that failure rates in computing courses, particularly in introductory programming courses, are higher than their institutions would like [12–15]. Two distinct research projects in 2007 and 2014 concluded that average success rates in introductory programming courses worldwide were in the region of 67%, and a recent replication of the first project found an average pass rate of about 72% [16] in comparison to the rest of the modules in ICT or Computer Science.

SE is a competent subject requiring active involvement by students [17], which should come from increased interest; otherwise, students will miss the essence of what needs to be learned. There is a need to craft teaching and learning styles to trigger the interest that most students lack when taking Software Engineering courses. Claypool and Claypool [8] lament the lack of fun factors as one of the causes leading to low student interest. Practitioners voice the difficulties associated with teaching Software Engineering courses since frequently students lack the desire [18] to practice the material before the lecture.

The challenge remains with the transfer of practical concepts as well as the igniting of innovation required to keep up with the fast-paced, ever-evolving discipline of Software Engineering [19]. While several alternatives to traditional face-to-face [20], such as practical approaches, problem-based learning, flipped classrooms, role-playing and gamification [21] have been proposed and implemented in different cases, it is imperative to identify the purpose of these supplements, which, in our view, is to pique interest in students. Given the potential of alternatives such as flipped classrooms to increase interest [1] in learning activities, there is a gap in similar literature on capturing interest, with the majority focusing on attributes such as participation, motivation, and engagement. Another alternative that is widely used in the learning of SE has been reported to increase participation, motivation, and engagement [22–24] but still, the learning outcomes in the area are impacted. Even though gamification has the potential for teaching and learning, empirical studies have not yet delineated the common elements used to capture students' interest in studying Software Engineering. There is a need for synthesised coherence [25] for a good contribution to knowledge. The present study focuses on identifying common elements or mechanisms used in gamification to capture students' interest. It addresses one key question:

How can gamification assist in capturing students' interest in the teaching and learning of Software Engineering?

The study analysed different studies in gamification to uncover key common elements or mechanisms that these studies use to capture interest in the teaching and learning of Software Engineering.

The rest of the article is structured as follows; Sect. 2 reviews the literature, Sect. 3 discusses the methodology used; Sect. 4 presents the findings, Sect. 5 discusses the findings, and finally, Sect. 6 concludes the paper with recommendations.

2 Theoretical background

This section discusses pertinent literature relevant to the study to provide support for our discussion of what is known and the gaps.

2.1 Defining gamification

Games are considered powerful tools that have the potential to influence human behaviour and achieve positive outcomes in diverse fields, including higher education. Gamification and serious games are two distinct concepts that recognize how the appeal of games can extend beyond entertainment into areas where motivation, learning, behaviour change, and problem-solving are important goals [26]. There are multiple definitions of gamification, this study aligns

itself with the definition that gamification is the use of game-based mechanics, aesthetics, and game thinking in non-gaming contexts [27, 28, 28–30, 30]. The purpose of gamification is to address challenges such as low user interest, lack of motivation, low engagement, and the need to encourage specific behaviours or actions in fields outside of traditional entertainment-based gaming [31]. Gamification can be said to rely on the premise that certain traditional teaching and learning practices are inherently not interesting, and that, because gaming is fun, game-like features can be introduced to make these otherwise 'dull activities' more attractive [8, 32].

2.2 Incentives used to capture students' interests

The study from [31] reveals that gamification increased the interest of students in the class, increased student ambitions for success, and had a positive impact on student motivation. It is understood that achieving such outcomes requires a well-thought-out gamification integration plan. Common components to consider when attempting to integrate gamification are taken from gamification models and frameworks of education and learning namely, mechanics, rewards, dynamics, measurement, aesthetics, measurement, behaviour, and rewards [31] [33, 34]. Elements or mechanics can be defined as distinct game building blocks that characterise a game such as points, badges, levels, challenges, and leaderboards. Reward is incorporated into mechanics and refers to the types of incentives given to 'players' for fulfilling a requirement or task in the 'game' [27]. The term dynamics refers to how progress is measured and how mechanics acting on player inputs and other outputs over time are achieved [33]. Aesthetics refers to the desirable emotional responses evoked in the player, when the player interacts with the game system such as the types of incentives given in a game to 'players' for fulfilling a requirement or task in the 'game' [34]. Maintaining and retaining the interest of 'players' requires a well-balanced design consisting of mechanics, dynamics, aesthetics, measurement, behaviour, and rewards.

2.3 Gamification in higher education

Gamification is becoming a more popular educational innovation that encourages and involves students in their education [9]. Since the introduction of the gamification concept in different sectors of life, there has been a steady increase in teaching and learning within higher education for pedagogical efficiency. Although some studies reported a negative impact [35] on learning outcomes resulting from engagement, the majority reported a positive impact [26, 27, 30, 36]. In [37], escape rooms were shown to have positive effects on student motivation in game-based learning. Gamification helps learners meet their psychological needs. Gamification has also been reported to motivate students in addition to engaging them [36, 38]. Techniques used in gamification, such as leaderboards, badges, and points, motivate high performers while encouraging low performers. Even though there are positive aspects identified, gamification should not replace existing structures but rather complement them, as some weak students might struggle to connect the games to the taught concept. As a result of studying ICT tools for gamified activities, [39] concluded that students' roles are merely limited to receiving game elements for traditional tasks. When implementing gamification in education, it is crucial to ensure that game elements are aligned with the learning objectives and that they enhance understanding rather than creating additional barriers [40]. Implementing digital platforms such as gamification in higher education has the potential to expand education markets by offering courses to new students and locations around the world, as well as to expand educational opportunities through diverse styles and provisions that go beyond traditional programmes [41].

2.4 Gamification in software engineering courses

The Software Engineering (SE) discipline is important to society, especially in this era of 4IR. It is therefore crucial for Higher Education Institutions to graduate software engineers who will competently demonstrate all the graduate attributes espoused in the SE curricula. SE can be defined as "the application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software; that is, the application of engineering to software" [42]. One of the major challenges for improving SE practice is to improve interest in the subject, as the majority approach the subject with the background thinking that the subject is difficult. The application of gamification in teaching and learning SE can be promising in capturing students' interest given the various mechanisms highlighted in Sect. 2.2 to achieve positive learning outcomes.

Examples of games that have been implemented in the teaching and learning of software engineering include CodeCombat, Kahoot [43], CheckiO [44]. According to a poll by [43], 44.8% of the students who participated in their study

acknowledged having received better outcomes than anticipated as a result of gamification in the software engineering course. However, these studies did not conclusively agree on the mechanisms that could potentially capture the students' interests.

2.5 Benefits and challenges of gamification in education

Gamification could be of benefit to teaching and learning within HE as it enables students to learn concepts by doing, which in turn improves learning outcomes [45]. In some research studies conducted, gamification was reported to have positive effects on cognitive learning outcomes [46, 47]. For gamification to have positive effects on cognitive learning, it should be well-designed and correctly deployed [48]. Gamification is reported as a motivation for students to engage with content [47, 49, 49–51]. Gamification could be used to transform tasks that could be considered boring into interesting ones [50]. This is because gamification elicits some emotions, such as positive emotional experiences and powerful emotions [51]. It should also be noted that, if applied without caution, competition can demoralise some students, resulting in a loss of interest.

Furthermore, gamification improves the rate of engagement among students in areas such as forums and projects, leading to improved attendance rates, participation rates, pass rates, and the undertaking of difficult assignments [48, 49]. Gamification could provide students who are introverts with a great opportunity to express themselves in a classroom environment and participate in games [51]. In a way, these introverted students who may not participate in a traditional class could participate for free because of gamification. Gamification promotes self-learning as it enables learning to take place even outside the classroom [51]. This enables students to learn on their own time, learn in the process of playing, and learn at their own pace [52].

However, there are also challenges with using gamification in teaching and learning. Game design elements need to be correctly integrated into teaching and learning. It is not easy to decide on the gamification approach to adopt in teaching and learning [53]. Failure to integrate these elements could lead to negative effects such as worsening the students' performance, a lack of motivation, and failure to achieve the expected learning outcomes [54].

Gamification is believed to be useful when dealing with lower-risk assignments such as quizzes and practical activities but does not significantly influence performance on final exams [47]. However, learners can experience emotions such as frustration, wonder, mystery, and amusement, each providing a personal connection to the game or to others playing the game [55]. Demotivating effects negatively impact student performance due to frustrations with not completing stages or levels; not understanding the rules; and not attaining rewards [56].

2.6 Adopted framework

Our study adopted the flow theory proposed by [57] as our lens for understanding the engagement and learning experiences of students in gamified environments. The theory hinges on elements of flow such as clear goals, concentration, immediate feedback, balance between skill and challenge, and autotelic experience [58]. In the context of teaching and learning in a software engineering course, integrating gamification principles aligns closely with the key elements of flow theory, such as clear goals and a sense of purpose. When goals are well-defined, students are more likely to stay engaged and motivated. In our context, one of the important elements is capturing interest. According to [59], flow encourages people to stick with and return to an activity because of the experiential rewards which in the present study could be leaderboards, achievements, interactive simulations, progression, and levels, just to mention a few. In a software engineering course, for example, students can be given a series of coding challenges that gradually increase in complexity, ensuring a balance between their skills and the challenges they face. As this happens, such environments have fewer chances of degenerating into apathy, boredom, and anxiety. While [57] suggested flow theory as a method of comprehending motivation, our thinking is that capturing interest precedes attributes such as motivation and engagement.

2.7 Context of the study

In this study, we look at universities where software engineering is taught. Several offerings of software engineering exist among different institutions, and these range from software engineering as a qualification to software engineering as a module. The researchers in the study confined the focus of the study to universities as they find themselves teaching software engineering in that domain.

Table 1 Inclusion and exclusion criteria

Inclusion	Exclusion
1. Search keywords	1. Unrelatedness to search keywords
2. Relatedness to the phenomenon under investigation	2. Discipline of focus
3. Recency (2012–2022)	3. Recency (> 10 years)
4. Relatedness to the problem statement, research question, and objective	4. Outside the domain of Higher education
5. Academically peer-reviewed articles	5. None peer-peer-reviewed articles
6. Articles written in English	6. Articles in other languages except English

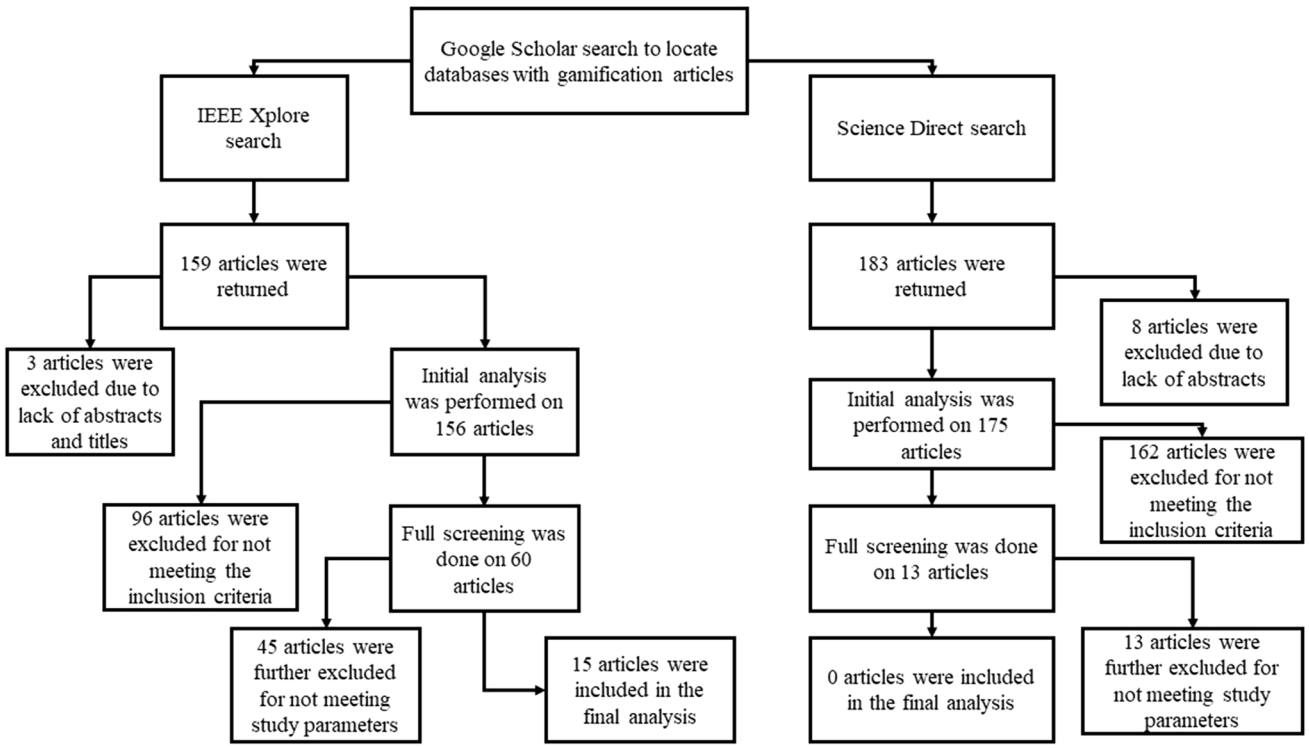

Fig. 1 Diagrammatic representation of the methodology

3 Methods

The researchers followed the principles dictated by, The Preferred Reporting Items for Systematic Reviews and Meta-Analyses, (PRISMA) 2020 statement in obtaining literature for analysis. The PRISMA 2020 statement includes new reporting guidance that reflects advances in methods to identify, select, appraise, and synthesise studies [60]. The rigour, comprehensiveness, and reproducibility provided by PRISMA made it desirable for this type of study. The authors identified and classified the type of research as a systematic review report on the gamification of a software engineering course in Higher education. The research objective, problem statement, and associated research question that the review sought to address were articulated, the search keywords were chosen, and inclusion and exclusion criteria were selected. The inclusion and exclusion criteria are presented in Table 1.

The researchers ran a search on Google Scholar using the search phrase "Gamification of a Software Engineering classroom" to locate databases with relevant articles, and the relevant results pointed us to IEEE Xplore and Science Direct (See Fig. 1). This initial search and the results obtained guided the researchers in choosing the two (2) databases used in the study. The authors then performed direct searches on the IEEE Xplore and Science Direct databases using refined search strings (i.e., IEEE—"Gamification of software engineering education." and ScienceDirect- "Gamification of "software engineering" education") to find articles that were related to the topic of the study and published between

2012 and 2022. The researchers performed an initial analysis on 156 articles from IEEE Xplore, after which 3 were excluded because of missing abstracts or titles, and 96 were further excluded for not meeting the criteria (not focusing on software engineering education in higher education). After a full article analysis, 45 articles were excluded as they were outside the study parameters. Only 15 remained for the final analysis based on the inclusion criteria, with none from Science Direct.

4 Results

In this section, we present the findings from the remaining 15 articles that were analysed. The findings were tabulated as shown in Table 2. The table summarises the game elements and key findings from each paper.

5 Discussion

The importance of studying gamification in SE courses is critical to identifying positives from such teaching and learning environments as lecturers attempt to improve learning outcomes in subjects perceived to be challenging. Our discussion will answer the following research question:

How can gamification assist in capturing students' interest in the teaching and learning of Software Engineering?

We organise the discussion around three main subheadings, which are fundamental to our findings: benefits and challenges, encouraging intrinsic drive, and student interest and involvement.

6 Student interest and engagement

The main finding in the reviewed papers underscores the positive impact of gamified learning environments on capturing student interest when teaching and learning SE. The data from reviewed papers have shown that game elements such as points and leaderboards help capture the interest of students studying SE courses. The finding mirrored what our literature highlighted [24]. Predictably, the findings suggest that students who are more actively involved in their education will likely have better learning outcomes as a result of this increased student interest. Similar sentiments were also echoed in our literature section [36, 74]. As dictated by the guiding concepts of the theoretical framework, gamification in the learning environment heightens a balance between skill and challenge through a reward system such as points. The idea of getting more points during the game leads to an attempt at the subject with a clear goal. The autotelic experience resulting from game points or leaderboards is a flow state characteristic that reinforces itself, and the learning activity becomes its reward. We also want to mention that literature does not explicitly highlight student interest but rather engagement, which we believe comes after.

7 Fostering intrinsic motivation

As highlighted in the literature, [3, 4] [37] the leading game elements, such as points and leaderboards, foster intrinsic motivation as learners perceive the environment to be enjoyable, distorting the earlier construct of attending the class with the mindset that SE is difficult. Undeniably, SE poses a significant cognitive load, but introducing gamification breaks down the load into more manageable tasks achieved as students attempt to get higher points. The elements of points that are received relate to the immediacy of the feedback with competition in play, which leads to collaborative learning. As shown by the findings of those students who played Kahoot, the majority managed to answer the questions within the allocated time. Suffice to say that the students who score less frequently are likely to be demotivated as they do not feature on the leaderboard. Competition does not automatically translate to better performance among students, as some studies have reported better learning achievements from students in non-competition conditions compared to competition conditions [75].

Table 2 Findings

Paper ID & Citation	GAME(S)	Game design elements	Purpose	Findings
1 [61]	GamiCRS	Points, Badges, and leaderboards	Assist in code readability level	o Leaderboards were more effective than badges in motivating students' participation o The inclusion of challenges and/or explicit collaborations could improve GamiCRS
2 [43]	CodeCombat	a multitude of levels, including mazes, obstacles, avoidance, and combat levels	Assist in teaching students to code	o The study showed that students' interest and motivation to learn SE courses improved considerably after participating in the gaming activities o 44.8% of the students attested that they had accomplished more in the course than they expected to achieve, while 39.5% of the students were satisfied o Alphabet brainstorming helped students synthesize connections between terminology and keywords o 90% of the students who played the Kahoot game answered the questions in the allocated time frame
	Alphabet Brainstorming	a sheet of paper with 30 letters from the Bulgarian alphabet	Assist in synthesizing content	
	Kahoot Game	Interactive Board, Rank ladder Students points	Encourage students to interact with module content	
3 [62]	Gamification embedded in Moodle via a story based	Points, Complete quests, quizzes, and levels, badges	Knowledge transfer using different gamification approaches	o A high level of interest and enjoyment among the students was observed o Most of the students had a positive experience with the module due to the use of media content and a mixture of gamification elements. The results showed that different students were motivated by different elements
4 [63]	Kahoot!	Ranking, Performance statistics, Points, Time restrictions	A comparative study on the application of the Kahoot! face-to-face and remotely	o Acceptance of Kahoot! was 83.3% in face-to-face teaching and 58.8% in remote teaching o An average of 62.81% and 47.56% correct answers for classroom teaching and remote teaching, respectively
5 [64]	SimSE, UbiRE, SimSE SPIAL, Code Defenders, Dojo, Sesam, u-Test, etc	Points, Challenges, Quizzes, Badges, Milestones, Levels, Leaderboards	Investigate the use of games and game elements in teaching SE, from the perspective of educators	o The most commonly used game elements are Points (15), Quizzes (11), Challenges (13), Badges (7), and Levels (7)

Table 2 (continued)

Paper ID & Citation	GAME(S)	Game design elements	Purpose	Findings
6 [65]	SW Quantum, SDSim, Groupthink, MOSE-Process, TREG	Pop-up dialogs, conversation dialog, branching stories genre game	Review games teaching requirements engineering (RE) with the student	o Results showed an improvement in students' understanding of the requirements engineering (RE) subject after playing the games o Students were able to control their workflow after the gamification of the course
7 [66]	Introduced badges and leaderboards on the course webpage	Badges and leaderboards	Evaluate the students' perception of game elements	o Students received the badges more positively than leaderboards o Student motivation was more affected by badges than by leaderboards o These elements provide social recognition and rewards for students
8 [21]	N/A	N/A	Investigate the issues and views around the teaching of software engineering	o The majority of respondents found engaging students in software engineering courses to be the biggest challenge o The majority of participants believed innovative teaching techniques like gamification had a beneficial effect on students' learning experiences
9 [67]	N/A	Progression through levels, badges, quizzes for individuals, and quests for teams	Evaluate the learning experience of students using gamification	o Compared to students who did not participate in gamification, research group participants had superior overall test scores and greater attendance rates o Positive outcomes included better topic comprehension, retention, and recall o Also, a shift for the better in the study dynamics and less time spent studying was noted
10 [68]	N/A	leaderboard, points, and quests	A process and a way for standardized documentation were proposed for the creation of gamified learning activities	o The use of gamification design features for the learning of a design pattern was found to be successful and effective, increasing the drive to learn o The students achieved both the desired competency level and the underlying learning outcomes o The application of the combined design aspects of gamification boosted student's motivation to learn

Table 2 (continued)

Paper ID & Citation	GAME(S)	Game design elements	Purpose	Findings
11 [69]	N/A	Points, Levels, Paths, Progress, Challenges, Immediate feedback, Leaderboards	Describes setup for a gamified classroom for the subject of Software Engineering	o The notions of gamification weren't well received by the students. The gamification platform likely had issues in part because it lacked the aesthetic appeal that a professional platform would have provided, even though it had features like a progress bar and finding people who had already mastered a particular level. The ability to earn bonus points and recognition for assisting others was also fully functional but underutilised
12 [70]	N/A	Rewards	Students were rewarded for following software process steps and advancing their "soft skills" through gamification	o The fact that some students put in little effort into the final output or believe their contributions to the final product were not recognized by their grade is one issue the writers have noticed on many student projects
13 [71]	N/A	Points	The authors discuss their experiences instructing a software engineering basic course	Results indicate a high level of satisfaction with both the teaching strategy and the course, with an average rating of 4.01 on a scale from 1 (bad) to 5 (excellent) The course had an overall rating of 78% excellent or very good from respondents, and 80% said the teaching style was excellent or very good Quizzes, essays, and other forms of individual homework received a 4.03 grade
14 [72]	N/A	Levels, Quizzes	Application of a gamification technique in the teaching of programming to students of introductory courses	o Only team 1 out of 4 was successful in completing the test, which is consistent with the outcomes of the entire experimentation period o On the other side, it is evident that the use of the gamification strategy helped the other teams' ability to solve algorithms

Table 2 (continued)

Paper ID & Citation	GAME(S)	Game design elements	Purpose	Findings
15 [73]	Schematic user interface	Points, Badges, Achievements, Leader Boards	The study looked into mechanisms for continuous feedback, both at the process and code levels	Gamification can act as a significant motivator for developers to address software quality issues and enhance knowledge transfer, but it is important to note that considerable work must be placed into balancing the incentive system to ensure a long-term effect

Our key findings reflected that most papers focused on one game implementing game elements such as points and leaderboards

8 Benefits and challenges

We found out that as the cognitive load of the task increases, the number of achievers decreases. This was highlighted by paper ID 14, in which only one team out of four completed the task. While this might pose unwanted challenges to the other teams, it can be a positive for the future as it highlights the levels of competence necessary for the lecturer to plan future lectures. However, we believe that using game elements such as points in games like Kahoot might not be reflective of students' potential since the ones who get high scores are the ones who quickly respond to the question. Additionally, response time can be affected by the device itself and connectivity. As such, further research is needed to develop robust assessment strategies that align with the gamified teaching approach rather than rely on game elements.

What is unique in the findings is that even though the game elements are not homogenous and even the games used, the rewards all relate to a point system or ranking. Capturing student interest is foundational to other positives such as motivation, and engagement. Through the articles, we have realised that there is a synergistic relationship between student interest, engagement, and motivation, which potentially leads to positive learning outcomes. However, students are engaged and motivated differently since they are unique [76]. It, therefore, requires educators to understand what engages their students more and apply the appropriate approach. For example, not all students can be engaged in a game with points and awards, even the game itself. A surprising finding was that gamified learning environments experienced better attendance, as reflected in paper ID 9. The results also showed us that, despite the importance of game components, a professional website was required for the game. Positive benefits are not realised if a platform lacks the aesthetic appeal anticipated of a professional website, as shown in paper ID 11.

The goal of our study was to review the literature on the topic of using game features to draw in pupils. Our initial assessment of the literature provided information on the ways in which game-based learning environments enhance students' motivation. We extended our inquiry further, and discovered that the majority of the benefits come from piquing students' interests, which became our study's phenomenon of interest. The methodology applied helped to review the different game elements implemented, and we conclusively point out that the game elements may differ, but maintaining a variety of flow elements within gamified environments helps to foster student interest. By harnessing student interest power of gamification through different game elements, educators/lecturers can create more dynamic and effective learning experiences.

9 Conclusion and recommendations

A systematic literature review was conducted to examine the use of gamification in software engineering courses in Higher Education as a method of capturing student interests. The flow theory was applied in this study to provide a guiding frame. The study analysed 15 articles from IEEE Xplore that were relevant to the topic under study. The study revealed the positive impact of gamified learning environments on capturing student interest when teaching and learning Software Engineering. The results also showed how various game components are applied in gamified settings to boost participation and engagement. The article assists those who may want to implement gamification with the practical implications of gamification for teaching and learning. The study concluded that learning can be made more pleasant, inspiring, and efficient by incorporating gamification elements such as points and leaderboards into teaching and learning. While the focus of the paper was on the game elements that foster student interest, we also found other aspects such as intrinsic motivation, and engagement to be positives of gamified environments. We conclude that student interest is the first aspect crucial in gamified environments and other identified positives will follow. The absence of comparative data on game elements that foster students' interest or other positives requires further attention. Nonetheless, all game elements appear to provide the expected benefits though at varying degrees. Educators must use games with different game elements to obtain the maximum benefits of these environments. Students are more likely to become engaged, enthusiastic, and self-directed learners when learning situations are created to promote flow.

As the field continues to evolve, embracing innovative approaches like gamification is critical to preparing students for success in the dynamic world of Software engineering, but understanding the game elements that foster more engagement is also necessary. Future research should focus on comparative studies on game elements in similar environments to identify the ones that are more engaging than others and assess their long-term impact on Software Engineering education.

Our study has two identified limitations, which are as follows:

• Bias in publication- The study only looked at published and peer-reviewed articles. However, there may be additional literature that is not in peer-reviewed databases or is not recorded. Nonetheless, for this study, we believe the methodology was rigorous enough to yield credible results.

• Heterogeneity of Gamification Interventions- The use of gamification varies depending on the situation, such as organisational practice.

Future studies can conduct empirical studies to validate our claims, and we believe it sets the stage for further discussion. In addition, comparative studies of game elements in similar environments will be beneficial for identifying the ones that are more engaging and assessing their long-term impacts.

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Declarations

Competing interests Not applicable.

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