**Impact of Personalized Gamification on Students' Cognitive and Social Well-Being in Programming Courses.: A** **literature review**

**Abstract**

Programming courses in computing science are important because they are often the first introduction to computer programming for many students. Many university students find themselves overwhelmed with the amount of information required to learn for an introductory course. The current teacher-lecturer model of learning commonly employed in university lecture halls often results in a lack of motivation and participation in learning. Applying gamification elements to programming courses can positively impact motivation, participation, and overall learning outcomes. The most common gamification features used in gamified learning systems include achievements, badges, points, leaderboards, and daily targets. The most popular implementations of gamification include developing a new content-management system with gamification elements or applying gamification elements to an existing system through a framework. Although most gamification systems use a "one-size-fits-all" methodology, there are some attempts at personalization. This paper compares 30 candidate papers dealing with gamification and personalized gamification. It results in a synthesis of the existing body of knowledge and identifies gaps that need to be completed.

***Keywords:*** Gamification, personalization, education, content-management system, motivation, participation, cognition, social well-being, systematic literature review

1. **Introduction**

Many institutions believe that the largest job growth in STEM will be in computer science-related fields (Venter, 2020). This makes computer programming courses a crucial aspect of education in the STEM fields (Venter, 2020). Researchers have found that computer programming taught in the traditional teacher-lecturer learning format lacks interaction and often results in a considerable decrease in attention (Arif et al., 2019). The knowledge presented in the conventional classroom is abstract in that it is conveyed through text or speech in a "one-size-fits-all" approach and consequently limits the understanding that students gain from their previous programming experience (Arif et al., 2019). Many studies have been conducted to improve student understanding and motivation of computer programming material, of which a fraction discuss personalized gamification. Deterding and colleagues define gamification as "the use of game design elements in non-game contexts" (Deterding et al., 2011).

Studies that utilize personalization techniques tend to group students into strict categories based on their characteristics. This method of personalization is flawed as it sets a constant configuration at the beginning of the study, which does not allow for any mutability as students progress through an online course. A clear advantage of progressive personalization is that students with a good knowledge of the course material will have a personalized experience tailored to their needs, which will inherently differ from the personalized experience of programming beginners. The research area of personalized gamification and cognitive/social impacts on students is scarce. There is a large gap in research on the cognitive and social impact of unpersonalized gamification.

This paper strives to provide a literature review of game-based learning for programming courses, personalized gamification, and the impact of personalization on the cognitive and social well-being of students in programming courses.

1. **Background**

The research area of game-based learning for programming courses has had many studies. The main methodologies include creating an online learning system with gamification elements (Venter, 2020). The most common gamification elements are achievements, points, rewards, badges, and leaderboards (Venter, 2020). The experimental literature reviewed in this paper also reflects this, as shown in Table 1. However, most of these studies do not take the past experiences and existing knowledge of students into consideration. This is one of the biggest gaps in gamification research. Most studies in this area consist of university students completing an introductory programming course within the online learning system throughout a semester (Venter, 2020).

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| --- | --- |
| **Gamification Element** | **Total # of papers** |
| Points | 16 |
| Achievements | 10 |
| Leaderboards | 10 |
| Badges | 9 |
| Reward System | 6 |
| Levels | 5 |
| Feedback | 4 |
| Challenges | 4 |

**Table 1.** Gamification elements are utilized in specific papers.

The research area of personalized gamification for programming courses is minimal compared to non-personalized gamification. The main methodologies include creating an online learning system that personalizes which gamification elements are available by placing students into predetermined groups (Santos et al., 2021). The biggest gap in this area of research is a lack of fluidity or flexibility with personalization; students are statically placed in predetermined groups and do not have the opportunity to change based on generated information (Santos et al., 2021). The main methodologies are similar to those for non-personalized gamification. Additionally, a survey is used to evaluate students’ characteristics to place them within a specific user group (Schatten & Schatten, 2020). Research techniques are identical to non-personalized gamification research (Schatten & Schatten, 2020). Both personalized and non-personalized gamification research show positive effects on students' performance and motivation (Venter, 2020; Santos et al., 2021)

The research area of personalized gamification for cognitive and social well-being in programming courses is also sparse. The current state of knowledge is that non-personalized gamification does not improve cognitive abilities (Sanmugam et al., 2014). Additionally, non-personalized gamification is more effective when it elicits positive and negative emotions (Mullins & Sabherwal, 2018 & 2020). The research techniques generally encompass a stronger psychological stand-point rather than a technological one (Mullins & Sabherwal, 2018 & 2020). There is minimal research on students' cognitive and social well-being in personalized gamification.

The study objective is whether personalized gamification in learning environments affects a student's cognitive and social well-being. Although there is a lot of research on gamification for programming courses, most of these studies use a "one-size-fits-all" approach in which all students are shown the same gamified elements and materials. The research area of personalized gamification is minimal; most approaches create predetermined categories that participants are placed in. This is inadequate because students' learning styles are not concrete and uniform. Additionally, none of the reviewed studies have a personalization system that changes throughout the use of the system. Furthermore, there is not a lot of research on the cognitive and social impacts of personalized gamification for programming courses. This study will seek to fill this gap in existing research.

1. **Method**

The inclusion/exclusion process, as shown in Figure 1, consisted of searching for papers matching the strings: "gamification ", "programming", "social", "cognitive", and "education".

Papers that did not have anything to do with education were excluded from this review, and one reviewer screened each study. The database searched was JSTOR.

Diagram

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**Figure 1.** Inclusion/exclusion process.

Each of the papers reviewed falls under one of the three following categories: gamification for education, personalized gamification, and gamification for cognitive and social well-being. These categories are summarized in Table 2.

|  |  |  |  |
| --- | --- | --- | --- |
| **Type of Approach** | **Advantages** | **Common Gamification Elements** | **Total # of papers** |
| Gamification | The motivation of learners increases. | Points, achievements, badges, leaderboards | 7 |
| Personalized Gamification | Gamification is altered to suit a specific student's needs. | Points, achievements, badges, leaderboards, challenges | 10 |
| Social Gamification | Social elements are applied to gamification, allowing students to collaborate and increasing motivation. | Points, achievements, badges, leaderboards, discussion forums, chats, competitions, challenges | 6 |

**Table 2.** Different types of gamification and their respective advantages.

***3.1 Gamification***

Venter reviewed studies from 2014 until 2019 and found that the most popular gamification elements used were points, achievements, leaderboards, badges, and levels (Venter, 2020). Points are rewarded for completing various tasks, such as a lesson or a coding question. Achievements are granted upon completing a section or a specific action within the gamified environment. Leaderboards show the top students in the class, usually based on points, achievements, badges, or levels. Badges are used as a form of displaying a student's progress and a reward for said progress. Similar to badges, levels also depict the student's progress numerically. Developing a new gamification platform using existing gamification tools was the most popular method for gamification implementation. The studies that Venter reviewed showed gamification of higher-education programming courses positively affected engagement, motivation, and learning.

Schatten and Schatten conducted a comparative study in 2020 of the impact gamification had on Croatian high-school students in a programming course. They sought to answer three questions: (1) "What is the student’s perception of programming before/after using a gamified platform?", (2) "How much did students' programming knowledge increase?" and (3) "Did their motivation to learn programming increase because of gamification?". Schatten and Schatten used an existing gamification platform called "CodeCombat" in four different 8th-grade classrooms, which consisted of students from three different programs: computer technician, economist, and car mechanic. In total, their experiment consisted of 79 participants. Each group completed a self-assessment survey before using CodeCombat and a self-evaluation survey after using CodeCombat. The questions in these surveys consisted of how important the student believes programming knowledge is, if they believe their knowledge improved during a programming lesson and if their motivation to learn to program increased. Schatten and Schatten found that the economist group had an increase in motivation, while the car mechanic group had a decrease in motivation. The computer technician group was indifferent, indicating the effect of having past computer-related experience.

Khaleel et al. (2019) were interested in developing a gamification-based learning website for a programming language course and conducting a study to measure its effectiveness. Their website used gamification elements: points, rewards, badges, levels, competition, altruism, leaderboards, statuses, virtual gifts, and self-expression. They used the ARCS motivation model and experimented with 30 participants. They found that using a gamification-based learning website increased effectiveness and motivation. Although this study used many different gamified elements, the gap in this research is a relatively low number of participants.

Moreno and Pineda (2018) created a learning-management system which included a private chat feature, a forum-based discussion platform and notification. Students receive points based on their performance in exercises and lessons and are shown on a leaderboard. Students were also able to gain various trophies and badges. Each chapter consisted of programming lessons about a certain topic and automatically-graded exercises. After each lesson, students could rate it out of 5 and leave an optional comment. 43 first-year engineering students enrolled in a "computer programming 101" course participated in a quasi-experiment and correlational study. The participants were split into two groups, one of which used the learning-management system in addition to in-person classes, while the other did not. The students with the gamification learning-management system also completed a survey asking their opinions on the course. Most of these responses were positive and indicated enthusiasm. The gamification learning-management system proved effective, as the students in that group had better academic performance and a better perception of the course overall. This research did not analyze the social well-being of students before, during, or after the experiment but made great contributions to the research area of gamification with social features.

Arif et al. (2019) found that programming material taught in a conventional lecturing format could not be effective in student comprehension. They also argue that conventional learning is less interactive and makes students bored quickly. Arif et al. (2019) developed a web application containing basic web development content. In this application, users had achievements, badges, stars, daily targets, and personal levels. The learning environment consisted of game elements such as lives, scores, and energy, intended to show students that they could gather achievements throughout the lesson. They also added a time element, which challenges the student to gain stars based on their time spent solving a problem. The learning environment also had three columns: the lesson material, the code editor, and the output. Arif et al. (2019) studied the effects of high-school students using the web application and experimented with 45 participants. They concluded that more than 87% of students believed the web application was valid and feasible to support the learning process.

Sanmugam and colleagues (2014) investigated the cognitive impact of gamification and the importance of creating a meaningful experience in gamified. They argue that due to gamification being engaging and attractive to users, it is still not proven to be able to influence a user’s cognitive processing capabilities. They further argue that most gamification research fails in developing cognition (for example, observing, undertaking, retaining and solving problems), therefore not accomplishing the main purpose of creating a meaningful learning experience. They have further discovered a correlation where gamified systems with a good storyline and manage to make difficult tasks fun for new learners have a greater impact on a user's achievement.

Pankiewicz (2020) studied students’ behaviour who completed automatically-evaluated programming tasks in a programming class. He found that students often solve assignments and skip parts that the teacher has deemed to be important. His gamified learning system implemented a set of achievements, progression, and scores as gamification features. Pankiewicz (2020) experimented with 493 participants. He found that the number of completely solved modules was significantly higher for students with previous programming experience. It made no difference for students who self-identified as beginners.

Chalco and colleagues (2015) investigated the personalization of gamification in collaborative learning contexts using ontologies. They claimed that scripted collaboration (collaborative learning in which students do not have a choice) could decrease motivation; therefore, they believe that collaborative gamification techniques can tackle this issue. Challco et al. (2015) created an ontology called "OntoGaCLeS" to define personalized conceptual models to gamify an online learning environment based on individual students' characteristics and desires.

Queirós (2019) presented a framework called "Proud," which can be used to apply gamification features in learning environments. Said gamification features are based on the usage data of programming exercises. To use PROud, the developer must manually download the client library and reference it in an IDE. Working in tandem with the client library, a docker container containing the PROud engine must also be installed on a server machine. This container receives query and mutation requests and executes them, returning data to the client. The gamification aspect of this framework lies in the correctness of code solutions submitted by students. Through this approach, Quieros hopes to foster competitive nature between students and leaves creating leaderboards, achievements, and statistics up to the developer.

Kiraly and Balla (2020) developed a learning management system containing online programming language courses. They gamified the courses by adding points, badges, incentives, immediate feedback, and a leaderboard. Kiraly and Balla (2020) experimented with 400 participants. They studied two groups of students: one that completed a Java course without gamification and another who completed a Java course with gamification. Their results showed that the students who completed a Java course with gamification were better at solving coding tasks.

Katan and Anstead (2020) are working on a gamification platform that teaches introductory programming called "Sleuth". Their platform resembles a traditional "video game" more than the other papers discussed here. In the game, students are chief detective guides. The chief gives them feedback on various automatically-evaluated assignments in the game. Feedback can be provided in the form of a hint or visualization. The evaluated coding assignments in the game are referred to as "code crimes," and the detective must solve these. Once the student solves a coding crime, they receive a badge for that code crime, and the next code crime is unlocked. In their preliminary research consisting of 1500 participants, Katan and Anstead (2020) found that students who used Sleuth received a very high median grade (90.67%), while students who used a module-based testing environment received quite a relatively low grade (66.94%). Their research filled a gap in the literature by creating a gamification platform that resembles a video game.

***3.2 Personalization***

Knutas et al. (2019) investigated the trend of personalization in gamification. They created a machine learning algorithm-based personalized content system that automates a part of the personalization of gamification. The reasoning behind this is that several researchers have come to believe that gamification's effects can be intensified when taking the personal characteristics of users into consideration. They did this by having a certain number of "user types" -- groups of users based on their preemptive characteristics. Knutas et al. (2019) also created a translating system that converts gamification results into machine learning classifiers using a CN2 rule inducer. Their gamification elements included social aspects such as chat and collaboration.

Hassan and colleagues (2021) investigated why e-learning platform users drop out of their courses. They concluded that this lack of motivation comes from their learning experience being provided to them in a "one-size-fits-all" approach despite their ideal learning and gamification environment. They asked, “Why do e-learning platform users drop out of their courses?". They created a framework that determines a user’s learning style and modifies the gamification experience. Their framework included gamification elements such as discussion forums, challenging friends, badges, levels, progress bars, earning multiple badges, and achievement of points. Their experiment consisted of 200 participants, and after testing their new framework, Hassan et al. (2021) discovered that learners’ motivation increased by 25%, and the drop-out ratio was reduced by 26%.

Bennani et al. (2020) have found that online students benefit from a personalized gamification environment regarding engagement, motivation, and cognition. The reasoning behind this is that each student is unique; they have different learning styles, personalities, values, and motivating factors. They created an ontology for adaptive gamification called "AGE-Learn."

Rodrigues et al. (2022) wanted to find out which personalization characteristics are relevant and how to do such tailoring. They built a gamification platform which contained gamification elements such as points, rewards, and achievements. They collected data on how users of gamification learning environments felt about specific game elements. Using this data, they created a conditional decision tree which conducted the personalization of gamified elements. Furthermore, they built a recommendation system that automatically suggests personalized gamification elements based on the conditional decision tree. They experimented with 1018 participants. After cleaning the data and omitting invalid data points, they were left with 361 participants. Their results found that users' preferences differ depending on certain characteristics and physical location.

Gonzalez et al. (2016) looked at enhancing student engagement in learning systems through the personalization of gamification. They wanted to discover why most gamification platforms cannot keep a user engaged in the long term. In their paper, they argue that gamification systems without personalization tend to fail to keep the user involved in the long term. They propose that this can be solved through high personalization. They created an intelligent tutorial system that contains the adaptation/personalization of gamified elements. An example of their personalization system is that only users deemed competitive are shown a leaderboard.
Additionally, they have identified a list of different core elements which should be present in a personalized gamification system: learner-player types, static and dynamic user attributes, activity tracking, observable user behaviour, and behavioural determinants. The personalization process in their proposed system is that all interactions are collected as data, analyzed, and then a model is updated. Using this model, the gamification system selects the gamified elements it believes should be shown to the specific user. Gonzalez et al. did not conduct an experiment, which creates a gap in this research area, specifically in activity tracking, observable user behaviour, and behavioural determinants.

Santos et al. (2021) investigated the relationship between user types and gamification. They conducted a study and grouped users into one of six categories: "achiever,” "disruptor,” "free spirit,” "philanthropist,” "player," and "socializer." Santos et al. investigated the association between these user types and their reviews on different gamification elements. Their results showed that the "socializer" group was positively associated with social, fictional, and personal gamification aspects but negatively associated with performance. The "player" group was associated positively with social, personal, and ecological aspects but negatively with social aspects. The "disruptor" group was positively associated with accomplishment, while the "achiever" group was positively associated with performance and social designs. Finally, the "free spirit" group was negatively associated with social designs. Santos et al. provide recommendations on personalizing gamified systems based on these results.

In their 2021 study, Rodrigues et al. investigated how personalization improves gamification. They describe the personalization of gamification as "overcoming the shortcomings of the one-size-fits-all approach" and further say that there are not a lot of studies on personalized gamification. Those that exist do not provide conclusive results. They created a gamification system with personalization and compared it to a one-size-fits-all gamification system. Their personalizations consisted of selecting game elements suitable to a user’s preferences. Their study showed that using personalization in a gamified learning environment improved students' motivation.

In her 2019 paper, Zaric proposed a model for a personalized gamification e-learning system. Her model placed students into various learning groups categorized based on their common characteristics. Additionally, Zaric (2019) hypothesized that students would observe an increased motivation, enhancement of competitive spirit, and a desire to finish course material when engaged in an adaptive gamified environment.

In their study, Roosta et al. (2016) looked at the personalization of gamified elements in an online learning environment based on learners’ motivation. Their study proposes characterizing various game elements and students' motivation types to create a personalized learning management system. The personalization system adapts the gamified elements shown to students based on their motivation category. Roosta et al. (2016) tested this system in a technical English course at the University of Tehran and found that the participation rate increased.

Knutas et al. (2017) developed a profile-based algorithm for personalization in online collaborative learning environments. They designed the personalization for gamified learning environments based on intrinsic skill atoms and gamification-based user type heuristics. Knutas et al. (2017) also created a personalized gamification software using this profile-based algorithm.

***3.3 Cognitive/social***

Toda et al. (2019) created a guide for gamification with social network-Esque aspects and conducted a qualitative evaluation. Their results showed that gamification could become even more effective when tied to social networks. In their system's social networking aspect, users could create a public or private profile, manage a list of friends, comment on another user's activity or status update, share status regarding course content, and post materials (such as photos or videos). Students also could create groups. Additionally, Toda et al. (2019) had course instructors manually personalize which social networking features are available in which tasks of the learning environment.

Marin et al. (2018) investigated if gamification would improve engineering students' performance in programming courses (programming in C). They conducted a quasi-experiment with two groups of first-year students: one group, which used a non-gamified compiler and the other, which used a gamified platform. Their results showed that students earned better grades when using the gamified platform. They also concluded that gamification is an encouraging way for students to learn C programming.

In their 2020 paper, Mullins and Sabherwal looked at gamification from a cognitive-emotional perspective. They argued that gamification should consider both positive and negative emotions and that emotions and cognitions can interact to affect the outcomes of a gamified system further positively.

In their 2022 paper, Mullins and Sabherwal argue that gamified systems succeed based on how well they can engage users through positive and negative emotions. Further, they say those game design elements, as a whole or individually, can create certain emotions, which can be used to promote desired outcomes. They also discuss a framework of gamification design called Mechanics-Dynamics-Emotions (MDE). Mechanics consist of things such as goals, rules, contexts, and types of interactions which are allowed. Rule mechanics refer to goals, while progression mechanics refer to rewards, points, badges, leaderboards and other similar gamification elements. Dynamics refer to the player's actions, which are out of the developer's or instructor's control. The overall goal of MDE is that "emotions are more important than the rules that make them possible."

Rojas-Lopes et al. (2019) studied engagement in programming courses in higher education through gamification. They discussed the emotional and social aspects of gamification, stating that the emotional aspect can be given when a student is recognized for their accomplishment (through an award, trophy, or achievement) and that the social aspect can be given when students work together to complete a task. Their work concluded that gamification improved engagement with students.

In 2015, Azmi et al. reviewed gamification in online collaborative learning environments. Their review lists some important participation elements that directly benefit the online collaborative learning environment, as well as gamification elements that contribute to increased participation among students. Additionally, Azmi et al. (2015) argued that online collaboration is not only addictive but beneficial to students’ cognitive and emotional states.

In their 2014 case study, Knutas et al. looked at the effect of collaborative communications in a programming course with gamification. They added a gamified online discussion system to an introductory programming course and collected data on the various interactions in the new system. The gamification elements of their system included points, achievements, and a forum. Knutas et al. (2014) experimented with 249 participants. Their results showed that collaborative communication positively benefited students socially.

Ortega et al. (2016) studied the effectiveness of game-like and social approaches in learning by comparing educational games, gamification, and social networking. Their studies showed that all these approaches significantly impact learning, but social gamification had the best results for all types of assessments. Ortega et al. also conducted a different experiment on the social gamification of online learning (Ortega et al., 2017). They presented a social gamification tool with various social aspects. The gamification elements utilized included achievements, points, a virtual shop, and a leaderboard. 374 students participated in their experiment. Their study on an undergraduate course resulted in an overall improvement in academic performance and promotion of social interaction.

1. **Results and Discussion**

The consensus on the current state of the plethora of gamification in education research is that gamification consistently improves motivation and performance, as shown in Figure 2.

Table

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**Figure 2.** Diagram of gamification elements and their outcomes.

Many studies report students' grades increasing and even positive feedback on gamification, with some students going as far as requesting gamification elements in future courses. Additionally, some studies have found that more students complete their online coursework when gamification is applied. Social gamification, such as chat rooms, discussion forums, and leaderboards, have also been shown by studies to improve social well-being among students. Additionally, social gamification has been shown to improve engagement with students and academic performance.

However, not all people are social and not all like trophies or competitions. Students who prefer to work alone may not have a good experience with social gamification elements. This is one of the primary gaps in research and a foundational reason why personalization in gamification is critical. The minimal research on personalized gamification is just as promising as the research on non-personalized gamification. Studies have also shown that multidimensional personalization (personalization based on multiple factors) can improve gamification.

The current state of the cognitive aspect of personalized gamification is not well-researched; neither is non-personalized gamification. Current studies agree that using positive and negative emotions has some impact on the effectiveness of gamification.

1. **Findings, Challenges, and Recommendations**

As discussed above, the current state of gamification research is promising and shows positive effects. However, some studies have shown that gamification was ineffective for people who already knew the material being studied. One study showed that certain groups of people with a common characteristic, such as having a background in trades, do not find gamification to be useful or helpful. Some studies have also shown that gamification was ineffective for students who already knew the material. Many studies do not consider the student’s past experiences and knowledge when evaluating the effect of gamification and personalized gamification.

Additionally, it is generally agreed upon that gamification does not necessarily improve cognitive abilities and that both positive and negative emotions need to be elicited by gamification elements. However, some research also suggests that negative gamification, such as "loss" screens or negative messaging, can decrease student motivation and desire to participate. Similarly, seeing oneself lower on a leaderboard can elicit this same response. Therefore, more research into gamification's personalization and the cognitive and social effects would benefit this research area. There is also a gap in gamification’s “fun” aspect; most gamification systems do not engage the student in the traditional video-game sense. Further research could explore the application of a storyline with characters and quests, much like a realistic and modern video game.

1. **Conclusion, Limitations, and Future Directions**

In conclusion, there is extensive research on the positive effects of gamification in a learning environment, particularly in online introductory programming courses. Despite this, there is little research into personalized gamification and a negligible amount of research into the cognitive and social effects of personalized gamification. There are many limitations in this research field. Personalized gamification fits students into groups initially and does not change over time; students are stuck on a singular configuration throughout the study. Additionally, cognitive and social effects research are lacking and can be hard to measure. Future research into personalized gamification and personalized gamification's effect on the cognitive and social well-being of students would be valuable. Research into "fluid" personalization user groups (user groups whose gamified elements are personalized and dynamic) could improve the effects of gamification even further. Additionally, surveying students on their cognitive and social well-being after a study can benefit the research area. Ultimately, the area of gamification has been explored well, while personalized gamification has the potential for more research.

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