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# LITERATURE REVIEW ON AI-DRIVEN PERSONALIZED LEARNING AND GAMIFICATION IN PROGRAMMING EDUCATION

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## ABSTRACT

*Programming education has become vital in university curricula, providing students with critical thinking and problem-solving skills essential for innovation and adapting to new technologies. However, the abstract nature of programming concepts can lead to a lack of motivation among students, making it challenging to learn effectively. Gamification has emerged as an effective solution to enhance student motivation and engagement, while AI-driven personalized learning techniques offer the potential to further amplify these benefits. This literature review examines related works on AI-driven personalized learning and gamification in programming education. We analyze various techniques and methods introduced in the field, along with performance metrics used to assess their effectiveness. We identify potential future directions and open problems based on our findings, aiming to guide further research and implementation strategies in this area.*

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**KEYWORDS:** AI, Gamification, Personalized Learning, Programming Education.

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## 1. INTRODUCTION

Nowadays, programming learning is crucial in university education. It equips students with critical thinking skills and practical knowledge [31]. These skills are needed to innovate and solve complex problems [4]. Moreover, it helps students adapt to new tools and languages, and hence makes them more flexible and adaptable in their career paths [11, 41]. However, some students may lack motivation and find learning programming excessively tough and challenging, due to its cryptic and abstract concepts [22, 34].

Therefore, students seek innovative approaches and methods to study programming that convert difficult concepts into understandable information and practical tasks, where instructors should incorporate these methods into their teaching to enhance the learning experience and engagement [40]. One of this innovative approach is the serious gamification [7, 9].

It consists of using game tools to motivate students and assist teachers during the programming courses. Recently, the rapid advancement of web technologies and the widespread adoption of devices, e.g., tablets, smartphones, and laptops have significantly facilitated the integration of digital games into the educational framework. As a result, an increasing number of instructors have adopted the gamification approach to boost students' motivation, interest in learning, and academic achievement.

Consequently, gamification has been frequently employed across a diverse range of learning fields, enhancing engagement and retention [14, 51]. For instance, in the realm of artificial intelligence (AI), gamified approaches have proven effective in making complex concepts more accessible to learners [16, 19]. Similarly, in information technology (IT), gamification strategies have been used to motivate students and facilitate hands-on learning experiences [13, 43].

The integration of gamification in science technology engineering and mathematics (STEM) fields has also shown promise in fostering critical thinking and problem-solving skills [21, 24, 42].

In health education, gamification techniques are increasingly utilized to prepare students for real-world challenges in the medical field [12, 37, 47]. Moreover, in subjects such as ecology, and chemistry, gamification has been embraced to create interactive and motivating learning environments [44, 50]. History education has also benefited from these methods, engaging students in immersive learning experiences [27].

Additionally, gamification has been applied in

emerging areas like blockchain technology [49], digital logic [18], and even soft skills development [1]. Furthermore, in the field of cybersecurity, gamification plays a crucial role in preparing students for the complexities of the digital system security [53].

In addition to the gamification approach, the AI and personalized learning have been recently proposed and deployed as promising solutions to further increase the effectiveness of gamification in many learning fields, including programming education [20, 35].

More specifically, this may involve data analysis, AI, and machine learning models in order to understand students' strengths, weaknesses, and learning styles [17, 28, 33]. Based on that, adaptive gaming elements can be designed and deployed to create more immersive and dynamic learning environments.

In this context, Feedback mechanisms has a significant role in the continued evolution of personalized gamified learning experiences [6]. In particular, it can deploy performance metrics, progress monitoring, and real-time feedback on coding exercises so that students can track their progress and adjust their learning strategies accordingly [26].

Overall, the integration of AI, personalized learning with gamification in programming education presents a promising approach to increase student's motivation, making learning more engaging, effective, and accessible for learners of all backgrounds and skill levels [5, 54].

In the literature, various review papers have (partially) addressed this specific topic. These related works have been presented and detailed in Section 2, where the relevant main findings, advantages, and limitations are listed.

As detailed in this section, and to the best of our knowledge having reviewed relevant and seminal literature in the field, a literature review on AI-driven personalized learning and gamification in programming education has not been presented in the literature yet.

### 1.1. Contributions

In light of the presented related works, this paper's contributions can be outlined as follows:

- The related review works in the literature are presented and detailed, where the main findings, the advantages, and the limitations are investigated.
- The gamification elements and techniques that have been used in programming education

have been presented, along with the corresponding evaluation techniques and metrics.

- The AI and personalized techniques and methods are presented and investigated, in order to evaluate its role in boosting the benefits of using gamification in programming learning.
- A comprehensive list of open problems and challenges, as well as future research direction and their potential impacts, within the topic of AI-driven personalized learning and gamification in programming education has been presented.

### 1.2. Paper Organization

The remainder of this paper is organized as follows: First, Section 2 introduces the related works that review (part of) the topic of AI-driven personalized learning and gamification in programming education. Then, the used review method is presented in Section 3.

Section 4 presents and details the relevant research attempts to the considered topic. Then, the corresponding open problems and challenges are listed in Section 5. Accordingly, we present, in Section 6, relevant future directions. Finally, conclusions are drawn in Section 7.

## 2. RELATED WORKS

The aim of this section is to present and discuss the main related works in the literature that review the topic of AI-driven personalized learning and gamification in programming education. To this end, we present in Table 1 different related works, as well as the relevant main findings, advantages, and limitations.

A review on AI-supported tutoring approaches

for learning programming has been presented in [25]. This review has investigated various AI-based methods for learning programming, concluding that the feedback-based approach stands out as the most deployed in the literature. This approach is supported by AI techniques to identify the student's intention. For instance, it analyzes how students tackle problems within the feedback-based learning method.

Although this review presents important insights into AI-based programming learning techniques, it overlooks the potential impact of gamification and personalized learning tools.

The authors in [3] have presented a literature review on gamification in online collaborative learning for programming courses. This work provides an overview of the methods by which gamification embedded in online collaborative learning can improve participation rates among students who are unfamiliar with programming.

The main findings of this literature review include the essential factors that are important for programming students to participate in online collaborative learning, gathering game components that are incorporated into online collaborative learning to motivate students to participate, and suggesting appropriate gamification techniques for programming courses.

In [10], a literature review on student modeling for personalized education has been presented. The aim of this review is to answer three main questions: what to model?, how to model? And why to model?.

To answer these questions, the authors have presented and detailed comparative tables of a 10-year review study in student modeling. This work offers a useful guide for selecting the appropriate techniques to employ in designing a student model for a personalized tutoring system.

Table 1. Related Works (Part 1)

Reference	Year	Gamification	AI	PL	Main Findings	Advantages & Limitations
[25]	2013	×	✓	×	<ul style="list-style-type: none"> <li>• A list of AI-based methods for learning programming.</li> </ul>	<ul style="list-style-type: none"> <li>+ The review presents important insights into AI-based programming learning techniques.</li> <li>- It overlooks the potential impact of gamification and personalized learning tools.</li> </ul>
[3]	2015	✓	×	×	<ul style="list-style-type: none"> <li>• The motivated factors for programming students to participate in online collaborative learning.</li> <li>• The game components that are incorporated into online collaborative learning.</li> <li>• The potential gamification techniques for programming courses.</li> </ul>	<ul style="list-style-type: none"> <li>+ The paper presents valuable details and insights regarding the gamification techniques for programming courses.</li> <li>- The AI and the personalized learning tools have not been considered.</li> </ul>
[10]	2015	×	×	✓	<ul style="list-style-type: none"> <li>• A list of techniques that can be employed in designing a student model for a personalized tutoring system.</li> </ul>	<ul style="list-style-type: none"> <li>+ The review presents and details an important topic concerning the student model for a personalized tutoring system.</li> <li>- The gamification and AI tools have not been considered.</li> </ul>
[39]	2019	✓	×	×	<ul style="list-style-type: none"> <li>• Evaluation techniques to assess the effectiveness of the introduced gamification methods.</li> <li>• The loopholes in the existing literature on gamification for learning fundamental programming.</li> <li>• A list of unresolved issues within this domain.</li> </ul>	<ul style="list-style-type: none"> <li>+ The paper details the loopholes in the existing literature on gamification for learning fundamental programming.</li> <li>- The incorporation of AI and personalized learning tools has been overlooked.</li> </ul>
[32]	2020	✓	×	×	<ul style="list-style-type: none"> <li>• A list of classified gamification applications.</li> <li>• The impact of gamification on motivating the students to be interested in and enjoying learning particular courses or subjects.</li> </ul>	<ul style="list-style-type: none"> <li>+ The paper presents a comprehensive classification of the gamification applications.</li> <li>- The AI and personalized learning tools have not been taken into consideration.</li> </ul>

AI: Artificial Intelligence, PL: Personalized Learning

In [39], a review on gamification for learning fundamental programming has been presented. This review focuses on three main components that have been introduced in the literature to develop an interactive game, named Mechanics, Dynamics, Aesthetics. Furthermore, it has presented a set of

evaluation techniques that can be used to assess the performances and the effectiveness of the considered gamification methods in learning fundamental programming. Literature Review on AI-Driven Personalized Learning and Gamification in Programming Education.

Table 1: Related Works (Part 2).

Reference	Year	Gamification	AI	PL	Main Findings	Advantages & Limitations
[30]	2020	✓	×	×	<ul style="list-style-type: none"> <li>• Difficulties that students face when learning programming.</li> <li>• The used features, technology, and game elements in the implementation of gamification applications.</li> <li>• The gamification's effects on programming learning.</li> </ul>	<ul style="list-style-type: none"> <li>+ The review elaborates on the challenges students encounter while learning programming.</li> <li>- The AI and the personalized learning tools have not been considered.</li> </ul>
[23]	2022	✓	×	×	<ul style="list-style-type: none"> <li>• The main addressed gamification elements in programming education.</li> <li>• The points-based method is the most deployed game element in the literature.</li> </ul>	<ul style="list-style-type: none"> <li>+ Provides detailed insights into gamification strategies for programming education.</li> <li>- Does not consider AI-driven or personalized learning approaches.</li> </ul>
[52]	2022	✓	×	×	<ul style="list-style-type: none"> <li>• The effectiveness of gamification techniques and applications in programming learning, regarding the students' academic achievement, cognitive load, motivation, and thinking skills.</li> </ul>	<ul style="list-style-type: none"> <li>+ The paper details various gamification techniques for programming courses, along with the relevant evaluation techniques.</li> <li>- The use of AI and personalized learning tools has been disregarded.</li> </ul>
[45]	2023	✓	×	×	<ul style="list-style-type: none"> <li>• The key problems that gamification intended to solve.</li> <li>• The main used gamification elements.</li> </ul>	<ul style="list-style-type: none"> <li>+ The paper outlines the main issues that gamification aims to solve.</li> <li>- The AI and the personalized learning tools have not been considered.</li> </ul>
[20]	2023	✓	✓	✓	<ul style="list-style-type: none"> <li>• Personalized gamification is an efficient approach to enhancing the motivation, engagement and learning outcomes of programming courses' students.</li> </ul>	<ul style="list-style-type: none"> <li>+ This work is considering all the elements of the addressed topic, i.e., gamification, AI, and personalized learning.</li> <li>- It is more of a systematic review than a literature review that details the related technical contributions to this topic.</li> </ul>
[35]	2024	×	✓	×	<ul style="list-style-type: none"> <li>• Teachers play a crucial role in guiding students to effectively use AI tools in their studies.</li> </ul>	<ul style="list-style-type: none"> <li>+ Investigating the role of teachers in AI-based programming education.</li> <li>- The gamification and the personalized learning tools have not been considered.</li> </ul>

AI: Artificial Intelligence, PL: Personalized Learning

Based on that, the authors have identified the loopholes in the existing literature on gamification

for learning fundamental programming. Accordingly, they have listed several unresolved issues within this domain, as well as some recommendations for potential future contributions.

In the same context, the authors in [32] have presented another literature review, where gamification has proven to be one of the creative approaches that is able to enhance student's motivation and learning engagement. This review has classified the introduced gamification applications and has provided valuable insights and perspectives on gamification for programming language learning. In particular, the majority of gamification applications have been designed for general programming language, where Gamification is an extremely successful method to get students interested in and enjoying learning particular courses or subjects.

In [30], the authors have presented a detailed literature review on the implementation of gamification in programming learning. First, they have listed the main challenges faced by students when studying programming. Subsequently, they have detailed the technical implementation of gamification, including the required features, the relevant technology, and the used game elements. Then, the impacts of gamification on programming learning have been discussed.

A systematic literature review on gamification in computer programming education have been presented in [23]. In this review, the authors have investigated different related works and have identified the main addressed gamification elements in computer programming learning. According to this review, the points-based method is the most deployed game element in the literature.

In [52], drawing from a meta-analysis of 21 empirical studies published within the past decade, the authors have examined the effectiveness of gamification in programming learning. To this end, the authors have investigated the impacts of various related sides to gamification on students' academic achievement, cognitive load, motivation, and thinking skills. The main considered sides are the types of game, gamification applications, pedagogical agents, programming types, and schooling levels.

**The results of this investigation present many important insights:**

- Gamification has significant impact on students' motivation, with academic achievement ranking next, while having the least influence on students' cognitive load.

- For the types of game, the reasoning strategy

game proves most effective in enhancing academic achievement, whereas the puzzle game is particularly effective in boosting motivation.

- Regarding the gamification application, games used as competitive mechanisms have the most significant impact on students' thinking skills and motivation. Conversely, when games are integrated as instructional tools or student assignments, their effects are primarily reflected in academic achievement.

Another literature review has been presented in [45], where the authors have presented and investigated experimental works that gamified teaching programming language in higher education to boost students' engagement and motivation.

In this work the authors analyzed papers from 2018-2022 the conducted investigation was based on three main questions;

- i) What issues is gamification designed to address? ii) How were the study results evaluated? iii) What types of gamification mechanics were implemented?

Accordingly, this literature review has identified the key points that gamification intended to improve, e.g., teaching methods, psychological and social effects, and study methods. In addition, the review has detailed the main used gamification elements, i.e., Points, Badges and Leaderboard (PBL).

Different from the previous literature review, the authors in [20] have presented a systematic literature review on personalization, cognition, and gamification-based programming language learning. The main findings of this review confirm the efficiency of personalized gamification in enhancing the motivation, engagement, and learning outcomes of programming courses' students.

It is worth mentioning that this work presents a systematic review more than a literature review, where 81 studies were analyzed and investigated. In particular, it has been shown that the effectiveness of personalized gamification can vary depending on several factors. These include the type of used gamification elements, the individual characteristics of the learners involved, and the degree of personalization.

In [38], a review on AI tool usage in programming course has been presented. This study investigates the use of AI in university-level teaching, particularly emphasizing its application in programming learning. This investigation highlights the crucial role of teachers to guide the students in order to effectively use AI tools in their studies. As presented and detailed in this section, a consistent review on AI-driven personalized learning and gamification in

programming education has not been presented in the literature yet.

In light of this, this paper provides a detailed literature review on this topic, using a 10 steps literature review method that is presented and detailed in the following section.

### 3. REVIEW METHOD

As presented in Fig. 1, the used literature review method consists of 10 steps:

Step 1 - Define the Main Topic: The first step consists of identifying the main topic of the paper, which revolves around four main axes: AI, personalized learning, gamification, and programming education.

Step 2 - Conduct a Comprehensive Literature Search: It involves collecting a broad range of relevant sources using keywords related to AI, personalized learning, gamification, and programming education.

Step 3 - Select and Evaluate Sources: In this step, only credible and reliable sources based on publication quality and research rigor have been considered.

Step 4 - Organize The Literature: The selected

sources/ works have been organized in this step, chronologically, thematically, and methodologically.

Step 5 - Read and Analyze: For each related work, the corresponding details, advantages and limitations have been investigated in this step.

Step 6 - Develop logical Structure: In this step, a coherent outline for the review has been fixed, including the related works, the relevant research attempts, the corresponding open problems and challenges, as well as relevant future directions.

Step 7 - Write Clearly and Critically: This step consists of presenting the relevant details and analysis in a clear, precise, and engaging manner, providing critical insights rather than just summaries.

Step 8 - Provide synthesis and Perspective: It aims at offering a comprehensive view, by integrating findings from various sources, highlighting trends and future research directions.

Step 9 - Revise and Refine: This step consists of revisions, ensuring clarity, coherence, and alignment with the main topic and objectives.

Step 10 - Seek Feedback: Finally, comments/suggestions from peers and experts have been considered to enhance the quality of the review

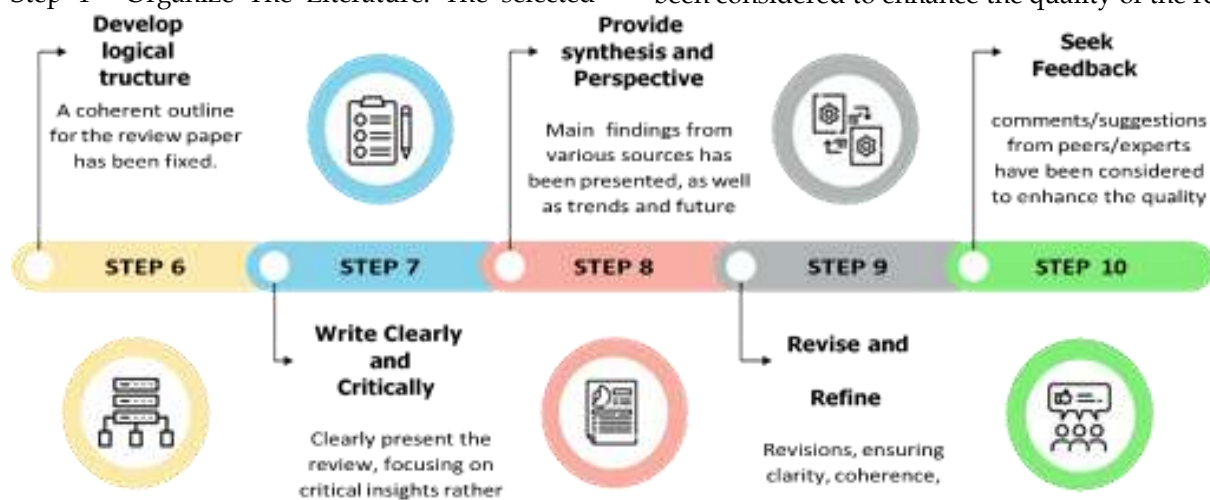


Figure 1: The considered Method of Literature review on AI-driven Personalized learning and gamification in Programming Education.

### 4. RELATED RESEARCH ATTEMPTS

To the best of our knowledge, few research attempts have specifically addressed the topic of AI-driven personalized learning and gamification in programming education. In this section, we detail and investigate these related works, where we present in Table 3, the corresponding approach, technique, advantages, and limitations, as well as the evaluation metrics to assess the performances of the proposed solutions.

In [48], the authors have presented collaboration

and fuzzy-modeled personalization for mobile game-based learning in higher education. In this work, the authors have investigated how game-based mobile learning can be used in higher education. To this end, they have designed and implemented Quiz Time! an intelligent mobile game-based learning app designed to assess and enhance learners' understanding of the C Sharp programming language. **The introduced Quiz time consists of 4 parts:**

1. A knowledge assessment module designed to test learners' understanding.

2. A vectorial-based recommendation module, collaboration in group playing, aimed at suggesting personalized

**Table 2: Summary of related works to the topic of AI-driven personalized learning and gamification in Programming education (Part 1).**

Refs.	Year	Approach	Technique/Method	Advantages & limitations	Evaluation Metrics			
					M1	M2	M3	M4
[48]	2020	Recommender System	A vectorial-based recommendation module and fuzzy logic	+ The use of recommender system and fuzzy logic offer efficient application of personalized gamification. + The application was tested in a university for one semester by students and computer science experts using statistical hypothesis testing. - The student modeling aspect is not addressed. - The introduced application does not incorporate thinking skills and cognitive load metrics for evaluation.	✓			✓
[36]	2021	Hexad Survey	Categorize programming courses' students into different types/models based on their motivations and preferences in gaming and gamified systems. Accordingly, personalizing the gamification experience for each category.	+ This work is considering the students model approach to personalize the gamification experience. - The Hexad survey is not an effective approach for automatically personalizing gamification. - Relying solely on the motivation metric is insufficient for evaluating the introduced gamification technique.	✓			
[6]	2021	Recommender System	A Polyglot Application	+ An interactive and flexible application that supports both students personalized learning and smart teacher evaluation. + The Personalized learning approach is considering different student learning styles with a range of feedback options, e.g., hints, direct feedback, frequent back and forth interaction, or taking their time and making some mistakes before asking for help. - This work is not considering a clear student modeling approach. - The introduced application is focusing on the student motivation metric only.	✓			
M1: Motivation, M2: Thinking Skills, M3: Cognitive Load, M4: Academic Achievement, MF: Matrix Factorization, SVD: Singular Value Decomposition, NMF: Negative Matrix Factorization.								

**Table 2: Summary of related works to the topic of AI-driven personalized learning and gamification in programming education (Part 2).**

					Evaluation Metrics			
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Refs.	Year	Approach	Technique/Method	Advantages & limitations	M1	M2	M3	M4
[2]	2022	Recommender System and Motivation Survey Questionnaire	A motivated survey questionnaire data was used to design the introduced recommender system.	+ Promising results have been observed in the students' performance and motivation to study programming, while using the introduced recommender system. - Student modeling is not taken into consideration.	✓	✓		
[15]	2024	Collaborative Filtering	MF through SVD and NMF algorithms are used to provide recommendations for lessons and problem-solving solutions.	+ The accuracy of the used recommender system. - The students modeling is not considering in this work. - Thinking skills and cognitive load metrics are not considered in the evaluation of the proposed gamification-based solution.	✓			✓
[8]	2024	Recommender System and AI Planner	PolyGloT Application	+ The use of AI planner enhances the advantages of the introduced recommender system. - The student modeling is not being considered in this work.	✓	✓		
M1: Motivation, M2: Thinking Skills, M3: Cognitive Load, M4: Academic Achievement, MF: Matrix Factorization, SVD: Singular Value Decomposition, NMF: Negative Matrix Factorization								

(3) A dynamic advice generator employing fuzzy logic to tailor assistance according to learners' profiles and Misconceptions.

(4) A cognitive learner modeler that supports the previously mentioned modules.

The introduced application was employed within a higher education institution for an academic semester, undergoing evaluation by students and computer science experts using statistical hypothesis testing.

As for the evaluation results, computer science experts confirmed the application's pedagogical adequacy, while students emphasized its positive impact on learning and its practical utility.

Another approach has been used in [36] to personalize gamification in an introductory programming course. The approach consists of conducting Hexad survey to classify a set of students into different categories, in order to adapt the gamification elements to each category.

This survey is based on Hexad model, originally introduced by Marczewski in [29] to classify the users into six types. In this work, the classification is based on a survey of 24 questions to measure user preference for different elements in a gamification environment. By analysing the responses to these questions, the users were classified to the following six hexad user types outlined by Tondello et al. [46]:

(1) Achiever: Driven by the target of competence, this type of user endeavors to prove themselves by

finishing tasks.

(2) Disruptor: This user aims to disrupt the system, motivated by a desire to instigate change.

(3) Free Spirit: Driven by a desire for independence, they seek the freedom to express themselves without external constraints.

(4) Player: motivated by external rewards, this user will make extra efforts to obtain these rewards.

(5) Philanthropist: This user is driven by a sense of purpose, where he is willing to give without expecting any reward.

(6) Socialiser: Motivated by the need for social connections, this user aims to build relationships with others.

By considering this Hexad survey-base approach of classifying the students, this work was organized around the following two research questions:

- Do programming students' responses to the Hexad survey provide significant data for classifying Hexad user types?

- How accurate the Hexad classifications in identifying the students' explicit preferences for game elements?

After addressing these research questions, investigating and analyzing the data of Hexad survey, the authors have concluded that the Hexad survey is not an effective approach for automatically personalizing gamification.

In [6], an example of gamified software in the field of programming has been presented, where the

authors have introduced Polyglot app that consists of four main aspects:

(1) **Learning Paths:** By using interactive dashboard and notebooks, this application enhances the learning experience that fosters student engagement and teacher effectiveness. In particular, the Polyglot Console helps the teachers to create custom assignments, for each student, using a solution prototype, defining exercise-specific metrics, custom feedback, and scoring criteria. During evaluation, student submissions are compared against the teacher's prototype, ensuring clear alignment with learning objectives.

(2) **Learning Exercises:** Personalized notebooks with gamification can be used to enhance student engagement in Software Engineering assignments. Using Visual Studio Code's interface, students can interactively complete exercises by submitting their solution in a code cells, receiving automated feedback and scores. The integration with .NET Interactive kernels allows detailed execution insights like variable values and compilation warnings, enabling incremental learning and real-time progress tracking.

(3) **Exercises Evaluation and Feedback:** The teacher prototype in this application simplifies the evaluation of student submissions using JSON file comparisons between the teacher prototype and the submission. Moreover, this application supports teachers in customizing solution requirements to varying levels of detail, considering different student learning styles with a range of feedback options, including hints, direct feedback, frequent back and forth interaction, or taking their time and making some mistakes before asking for help.

(4) **Motivational Elements:** Polyglot integrates a Gamification Engine component that allows teachers to define rewards such as points, coins, and medals based on specific conditions like meeting optional requirements.

It tracks student progress, exercise submissions, and updates statuses accordingly, facilitating a personalized learning path. The engine evaluates submissions against teacher-defined criteria, providing tailored feedback to help students understand and correct mistakes, thus promoting continuous improvement and engagement.

A personalized gamified recommender system has been presented in [2]. It consists of providing students with personalized recommendations to address their weaknesses and increase their motivation in programming learning. In addition, a learning motivation questionnaire was used to investigate and assess the students' motivation in

learning programming before and after the deployment of the considered recommender system. The results has shown that the personalized gamified recommender system has a significant positive impact on the students' performance and motivation toward learning computer programming.

In [15], a GAMified Mobile Learning Framework (GAMOLEAF) has been introduced. It consists of a learning and assessing mobile application for Java programming language. This application is based on two main approaches, i.e., gamification and personalized learning. For the gamification, it includes many elements, such as levels, scores, badges, leaderboard, and feedback. The second approach involves two modules:

1. A Lessons Recommendation Module (LRecM): provide learners customized lessons based on ratings they have explicitly provided.
2. A problem-solving Solutions Recommender Module (PSSORecM): This module guides learners to use alternative solutions, based on their behaviours.

Both modules employed collaborative filtering, utilizing Matrix Factorization (MF) through Singular Value Decomposition (SVD) and Negative Matrix Factorization (NMF) algorithms, respectively.

Based on that, an experiment was carried out to assess the learning achievement and motivation of 90 students, when the personalised gamification is deployed to learn java programming language.

Another contribution has been presented in [8], where the authors has introduced a personalized and gamified e-tutoring system for learning modelling and programming skills. This learning system is based on PolyGloT application that organizes learning paths, using different activities, including lessons, coding exercises, and quizzes. These pathways can integrate game narratives to sustain student motivation.

In light of the aforementioned related works to the topic of AI-driven personalized learning and gamification in programming education, we present in the following sections, the relevant open problems and challenges, as well as future research direction and their potential impacts.

## 5.1. OPEN PROBLEMS AND CHALLENGES

In this Section, we identify several open problems and challenges related to the topic of AI-driven personalized learning and gamification in programming education.

### 5.2. Personalization Accuracy and Adaptability

The different learning methods and preferences of

individual students are sometimes hard for current AI systems to recognize and adapt to. For example, a student who thrives with visual aids might struggle with text-heavy materials, while another may excel with interactive simulations. It is necessary to develop AI systems that can dependably infer and modify learning routes in response to real-time feedback and changing student needs. This means an AI should adjust its approach instantly if it detects that a student is having difficulty understanding a concept, perhaps switching from written explanations to video tutorials or interactive exercises.

### **5.3. Algorithmic Bias and Fairness**

AI-driven systems may unintentionally reinforce prejudices in evaluation, feedback, or content recommendation, which could compromise the impartiality and inclusiveness of educational opportunities. For instance, an AI system might favor students from certain educational background or with specific learning styles while providing less support to others. It is necessary to develop algorithms that lessen bias and ensure that all students, regardless of their backgrounds or personal characteristics, have equal opportunity to programming education. This involves refining algorithms to avoid perpetuating existing disparities and incorporating diverse datasets and continuous evaluation processes to promote fairness and equity in educational outcomes.

### **5.4. Data Privacy and Security**

Large-scale learner data collection and analysis for customized recommendations presents serious issues with data privacy, security lapses, and regulatory compliance. Maintaining the efficacy of personalized learning algorithms while implementing strong data privacy techniques and safe storage solutions present a big challenge. This involves not only employing advanced encryption and secure access controls but also ensuring transparent data handling practices and regular audits to safeguard against potential vulnerabilities.

### **5.5. Scalability and Resource Constraints**

Scalability in situations with limited resources is restricted by the significant computing and infrastructure requirements of AI-driven personalized learning. For example, a school or a university with outdated hardware might struggle to run complex AI models that demand high processing power and memory, leading to slower performance or inadequate support. Developing efficient

algorithms and lightweight AI models that are compatible with a range of learning platforms—especially those with constrained CPU power—is challenging. This requires designing models that balance performance with resource consumption, such as creating streamlined versions of algorithms that can deliver effective personalization without overwhelming limited computational resources.

### **5.6. Integration with Pedagogical Practices**

Maintaining coherence and consistency with programming educational goals is challenging when integrating gamification and AI-driven individualized learning into current pedagogical frameworks and curricular standards. For example, incorporating AI tools that provide personalized feedback may disrupt traditional teaching methods and complicate lesson planning if they do not align with existing curriculum objectives. It can be hard to provide instructors with the rules and structures they need to successfully use AI technology while ensuring it enhances and supplements more conventional programming teaching techniques. This necessitates the development of clear guidelines and training for educators, alongside tools that seamlessly integrate AI innovations with established pedagogical practices, so that the benefits of personalized learning and gamification complement rather than conflict with traditional instructional approaches.

## **6. FUTURE DIRECTIONS AND POTENTIAL IMPACTS**

Possible suggestions and potential impacts that will be a contributing factor for future researchers are presented in this section.

**An Innovative and Precise student Model for Personalizing the Gamification**

As a future research direction, developing an innovative and precise student model for personalizing the gamification of programming education promises to revolutionize the learning experience. This approach would involve creating dynamic, data-driven models that adapt to individual students' skills, learning styles, and progress. By integrating advanced analytics and AI, this model should tailor educational games to address specific weaknesses and enhance strengths, ensuring that each student receives a customized and engaging learning path. The result would be a more effective and motivating educational environment, where gamification not only makes learning programming more enjoyable but also maximizes each student's potential by providing challenges that

are both appropriate and stimulating. This research could pave the way for a more responsive and adaptive educational framework, ultimately fostering a deeper and more personalized mastery of programming skills.

### **6.1. Advanced AI Techniques**

Examining cutting-edge artificial intelligence methods including natural language processing, deep learning, and reinforcement learning to improve the efficiency and flexibility of personalized learning technologies. Enhanced natural language interactions, real-time feedback systems, and adaptive learning pathways in programming education could all have positive effects. For instance, using deep learning algorithms to tailor coding exercises to a student's skill level could significantly boost their comprehension and engagement, while real-time feedback from AI tutors could rapidly address misconceptions and reinforce concepts.

### **6.2. Mixed Reality and Immersive Learning**

In order to create engaging and immersive learning environments, virtual reality (VR), augmented reality (AR), and mixed reality (MR) technologies can be deployed, enhancing spatial thinking skills and collaborative problem-solving in programming education. For example, VR can simulate complex programming environments, allowing students to interact with and manipulate virtual code structures and debugging tools as if they were physically present in a digital workspace. Similarly, AR can overlay code snippets and debugging information onto real-world objects, helping students visualize how their code affects different aspects of a program and providing instant feedback on their programming tasks in an interactive manner.

### **6.3. Ethical Guidelines and Regulation**

Ethical guidelines and regulations for AI-driven personalized learning and gamification in programming education prioritize student data privacy, fairness in AI algorithms, and transparency in system operations. For instance, ensuring informed consent requires that students and parents are fully aware of how their data will be used and stored, such as through clear consent forms and data protection policies. Additionally, fairness in AI algorithms means that programming learning platforms must be investigated to prevent biases that could affect student evaluations or learning opportunities.

Promoting responsible use of gamification involves creating engaging educational games that do not exploit student data or lead to excessive screen time. Training educators to effectively integrate AI tools is essential, equipping them with knowledge on maintaining ethical standards while utilizing these technologies to enhance the learning experience. These measures aim to foster a supportive educational environment that leverages technology responsibly for optimal student outcomes in programming education.

### **6.4. Longitudinal Studies and Learning Analytics**

To evaluate the long-term effects of AI-driven personalized learning and gamification on student retention, skill development, and career preparedness, longitudinal research and learning analytics should be used. The generation of empirical data to support the development of AI algorithms, teaching techniques, and educational regulations is of high importance.

### **6.5. Collaborative and Social Learning Platforms**

Developing gamification AI-powered collaborative learning environments can significantly enhance programming education by facilitating student interaction, providing mentorship, and promoting the exchange of knowledge. For example, a collaborative platform could enable students to work together on coding projects, receive real-time feedback from mentors, and share insights and resources with their peers. The primary goal is to foster a supportive and engaging learning atmosphere, encourage collaborative problem-solving strategies, and improve access to personalized programming materials and expertise. By creating such environments, we not only enrich the educational experience but also empower students to thrive in a collaborative and resourceful learning community.

## **7. CONCLUSION**

In this literature review, we delve into the integration of AI-driven personalized learning and gamification within programming education. The corresponding approaches, methodologies, performance evaluation techniques and metrics have been detailed. By synthesizing the related works in the literature, we have identified significant findings that highlight the effectiveness of AI, gamification and personalized tools in enhancing students' motivation and engagements.

Moreover, we have listed and detailed areas requiring further exploration and we have outlined potential future directions for research, as well as

unresolved challenges that warrant attention in this evolving field.

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## REFERENCES

- Alessandro Pagano Agostino Marengo and Kamal Ahmed Soomro. 2023. Serious games to assess university students' soft skills: investigating the effectiveness of a gamified assessment prototype. *Interactive Learning Environments* (2023), 1 - 17.
- Andrew Chih-Wei Huang Chun-Hsiung Tseng, Hao-Chiang Koong Lin and Jia-Rou Lin. 2023. Personalized Programming Education: Using Machine Learning to Boost Learning Performance based on Students Personality Traits. *Cogent Education* 10, 2 (2023).
- Antonio Bucchiarone, Antonio Cicchetti, Simone Bassanelli, and Annapaola Marconi. 2021. How to merge gamification efforts for programming and modelling: a tool implementation perspective. In *2021 ACM/IEEE International Conference on Model Driven Engineering Languages and Systems Companion (MODELS-C)*. 721 - 726.
- Ahmed Hanif, Muaz Albaghdadi, Seifeddine Bouallegue, Aymen Omri, Bekir Sait Ciftler, Abdullatif Shikfa, Shibban Khan, and Salem Al-Naemi. 2025. Inferring Learner Styles via Clustering of Uneven MOOC Behavioral Data. In *Proceedings of the 17th International Conference on Education Technology and Computers (ICETC 2025)*. IEEE. To appear.
- Antonio Bucchiarone, Tommaso Martorella, Davide Frageri, and Diego Colombo. 2024. PolyGloT: A Personalized and Gamified eTutoring System for Learning Modelling and Programming Skills. *Science of Computer Programming* 231 (2024), 103003.
- Antonio Bucchiarone, Tommaso Martorella, Davide Frageri, and Diego Colombo. 2024. PolyGloT: A Personalized and Gamified eTutoring System for Learning Modelling and Programming Skills. *Science of Computer Programming* 231 (2024).
- Andrzej Marczewski. 2015. *User Types* (1st ed.). CreateSpace Independent Publishing Platform.
- Anne-Kathrin Peters, Rafael Capilla, Vlad Constantin Coroamă, Rogardt Heldal, Patricia Lago, Ola Leifler, Ana Moreira, João Paulo Fernandes, Birgit Penzenstadler, Jari Porras, and Colin C. Venters. 2024. Sustainability in Computing Education: A Systematic Literature Review. *ACM Trans.*
- Arun Raman and Viraj Kumar. 2022. Programming Pedagogy and Assessment in the Era of AI/ML: A Position Paper. In *Proceedings of the 15th Annual ACM India Compute Conference (Jaipur, India) (COMPUTE '22)*. Association for Computing Machinery, 29-34.
- Aymen Omri, Seifeddine Bouallegue, Ayoub Feki, Robert Ford, Bekir Sait Ciftler, Abdullatif Shikfa, Shibban Khan, and Salem Al-Naemi. 2025. Early Student Performance Prediction in Personalized Programming Education. In *Proceedings of the 17th International Conference on Education Technology and Computers (ICETC 2025)*. IEEE.
- Allan Amaral Tori, Romero Tori, and Fátima de Lourdes dos Santos Nunes. 2022. Serious Game Design in Health Education: A Systematic Review.
- Brett A. Becker, Paul Denny, James Finnie-Ansley, Andrew Luxton-Reilly, James Prather, and Eddie Antonio Santos. 2023. Programming Is Hard - Or at Least It Used to Be: Educational Opportunities and Challenges of AI Code Generation. In *Proceedings of the 54th ACM Technical Symposium on Computer Science Education V. 1 (Toronto ON, Canada) (SIGCSE 2023)*. Association for Computing Machinery, 500-506.
- Carlos Lázaro Carrascosa, Irene Palomero Ylardia, Maximiliano Paredes-Velasco, and María del Carmen Navarro García-Suelto. 2024. Game-Based Learning With Augmented Reality for History Education. *IEEE Revista Iberoamericana de Tecnologías del Aprendizaje* 19 (2024), 14 - 23.
- Chen Zhong, J. B. Joo Baek Kim, and Hong Liu. 2024. The Art of Inclusive Gamification in Cybersecurity Training. *IEEE Security Privacy* 22, 5 (2024), 40-51.
- Dwi Maryono, Budiyo Sajidan, and Muhammad Akhyar. 2020. Implementation of Gamification in Programming Learning: Literature Review.
- Danijel Kucak and Martina Kucak. 2022. Gamification in Computer Programming Education - Systematic

- Literature Review. In 2022 45th Jubilee International Convention on Information, Communication and Electronic Technology. IEEE, 517 – 520.
- Evanfiya Logacheva, Arto Hellas, James Prather, Sami Sarsa, and Juho Leinonen. 2024. Evaluating Contextually Personalized Programming Exercises Created with Generative AI. In Proceedings of the 2024 ACM Conference on International Computing Education Research - Volume 1 (Melbourne, VIC, Australia) (ICER '24). Association for Computing Machinery, 95–113.
- Gilda Manfredi, Ugo Erra, and Gabriele Gilio. 2023. A Mixed Reality Approach for Innovative Pair Programming Education with a Conversational AI Virtual Avatar. In Proceedings of the 27th International Conference on Evaluation and Assessment in Software Engineering (Oulu, Finland) (EASE '23). Association for Computing Machinery, 450–454.
- International Journal Of Information and Education Technology 12 (2020), 1448 – 1457. Issue 12.
- Marcos Vera Morales, Galo Cedeño García, Veris Saldarriaga Lucas, and Leonardo León-Castro. 2023. Gamification in the Teaching of Ecology for University Students. In 2023 IEEE 3rd International Conference on Advanced Learning Technologies on Education Research (ICALTER). 1 – 4.
- Nilüfer Zeybek and Elif Saygi. 2024. Gamification in Education: Why, Where, When, and How? – A Systematic Review. *Games and Culture* 19, 2 (2024), 237 – 264.
- Nazari, N., Shabbir, M. S., Sevbitov, A. V., Sadeghi, M., & Griffiths, M. D. (2023). Psychometric evaluation of the Russian version of the Gaming Disorder Scale for Adolescents. *Current Psychology*, 42(16), 13754-13768. Received June 2024; revised 2024; accepted 2024.
- Fernando Da Silva Pontes, Luis Carlos Costa Fonseca, and Sofiane Labidi. 2024. Enhancing Student Engagement in Distance Learning with Gamified Educational Application. In 2024 IEEE International Conference on Advanced Learning Technologies (ICALT). 60 – 61.
- Juan Carlos Cuevas-Martínez, Antonio Jesus Yuste-Delgado, Jose Manuel Perez-Lorenzo, and Alicia Triviño-Cabrera. 2019. Jump to the Next Level: A Four-Year Gamification Experiment in Information Technology Engineering. *IEEE Access* 7 (2019), 125 – 134.
- David Rojas, Brent Cowan, Bill Kapralos, and Adam Dubrowski. 2014. Gamification and health professions education. In 2014 IEEE Games Media Entertainment. 1 – 2.
- Konstantina Chrysafiadi and Maria Virvou. 2015. Student Modeling for Personalized Education: A Review of the Literature. Springer International Publishing, Cham, 1 – 24.
- Kashif Ishaq and Atif Alvi. 2023. Personalization, Cognition, and Gamification-based Programming Language Learning: A State-of-the-Art Systematic Literature Review. (2023).
- Laila Al-Malki and Maram Meccawy. 2022. Investigating Students' Performance and Motivation in Computer Programming through a Gamified Recommender System. *Computers in the Schools* 39, 2 (2022), 137 – 162.
- Nadezhda I. Gallini, Igor Yu. Grishin, Marianna A. Latysheva, Alexander A. Denisenko, and Maksim N. Popov. 2023. Scientific Gamification of Students in the Study of Artificial Intelligence Technology. In 2023 Seminar on Information Computing and Processing (ICP). 68 – 71.
- Raúl Lara-Cabrera, Fernando Ortega, Edgar Talavera, and Daniel López-Fernández. 2023. Using 3-D Printed Badges to Improve Student Performance and Reduce Dropout Rates in STEM Higher Education. *IEEE Transactions on Education* 66, 6 (2023), 612 – 621.
- Siti Azreena Mubin, Matthew Wee Ann Poh, and Azrul Hazri Jantan. 2020. Gamification In Programming Language Learning: A Review And Pathway. *International Journal Of Advanced Research In Engineering And Technology* 11 (2020). Issue 12. *Comput. Educ.* 24, 1, Article 13 (Feb. 2024), 53 pages.
- Shahdatunnaim Azmi, Noorminshah A. Iahad, and Norasnita Ahmad. 2015. Gamification in Online Collaborative Learning for Programming Courses: A Literature Review. *ARPN journal of engineering and applied sciences* 10 (2015), 18087 – 18094.
- Seifeddine Bouallegue, Aymen Omri, Ayoub Feki, Robert Ford, Bekir Sait Ciftler, Abdullatif Shikfa, Shiban Khan, and Salem Al-Naemi. [n. d.]. Student Classification in Higher Education: Literature Review of Models, Approaches, and Challenges. *Scientific Culture* ([n. d.]).
- Samia Drissi, Aida Chefrour, Karima Boussaha, and Hamed Zarzour. 2024. Exploring the Effects of Personalized Recommendations on Student's Motivation and Learning Achievement in Gamified Mobile Learning Framework. *Journal of Education and Information Technologies* (2024), 1 – 38.
- Rodrigo Pessoa Medeiros, Geber Lisboa Ramalho, and Taciana Pontual Falcão. 2019. A Systematic Literature Review on Teaching and Learning Introductory Programming in Higher Education. *IEEE Transactions*

- on Education 62, 2 (2019), 77 – 90.
- Oscar Colteli, Ximo Grandi, Ricardo Tosca, Pedro Latorre, José Salvador Sánchez, Luís Vicente Lizán, Francisco Ros-Bernal, and Conrado Martínez- Cadenas. 2014. Designing serious games for learning support in medicine studies: A specific method to elicit and formalize requirements. In 2014 IEEE Frontiers in Education Conference (FIE) Proceedings. 1–4.
- Ryan Hare, Ying Tang, and Sarah Ferguson. 2024. An Intelligent Serious Game for Digital Logic Education to Enhance Student Learning. *IEEE Transactions on Education* 67, 3 (2024), 387 – 394.
- Ryan Hare, Ying Tang, and Chengzhang Zhu. 2023. Combining Gamification and Intelligent Tutoring Systems for Engineering Education. In 2023 IEEE Frontiers in Education Conference (FIE). 1 – 5.
- 2023 11th International Conference on Information and Education Technology (ICIET). 167 – 171.
- IC Kim. 2013. Utilizing Computer Games for Effective AI Education. *Korean Society For Computer Game* 26, 3 (2013), 109 – 118.
- Toshiki Katanosaka, M. Fahim Ferdous Khan, and Ken Sakamura. 2023. A Physics Learning System Using Gamification for High-School Students. In
- Leonardo Silva, António Mendes, Anabela Gomes, and Gabriel Fortes. 2024. What Learning Strategies are Used by Programming Students? A Qualitative Study Grounded on the Self-regulation of Learning Theory. *ACM Trans. Comput. Educ.* 24, 1, Article 9 (Feb. 2024), 26 pages.
- Mitchell Rogers, Wendy Yao, Andrew Luxton-Reilly, Juho Leinonen, Danielle Lottridge, and Paul Denny. 2021. Exploring Personalization of Gamification in an Introductory Programming Course. In *Proceedings of the 52nd ACM Technical Symposium on Computer Science Education*. Association for Computing Machinery, 1121–1127.
- Mika Saari, Petri Rantanen, Mikko Nurminen, Terhi Kilamo, Kari Systä, and Pekka Abrahamsson. 2024. Survey of AI Tool Usage in Programming Course: Early Observations. In *Agile Processes in Software Engineering and Extreme Programming – Workshops*. Springer Nature Switzerland, 182–191.
- Mahwish Shahid, Afifa Wajid, Kamran Ul Haq, Imran Saleem, and Abdul Haseeb Shujja. 2019. A Review of Gamification for Learning Programming Fundamental. In 2019 International Conference on Innovative Computing (ICIC). IEEE, 1 – 8.
- Nguyen-Thanh Le, Sven Strickroth, Sebastian Gross, and Niels Pinkwart. 2013. A Review of AI-Supported Tutoring Approaches for Learning Programming. In *Advanced Computational Methods for Knowledge Engineering*. Springer International Publishing, 267 – 279.
- Nicol Del Carmen Solano Gonzales, Karla Cecilia Reyes-Burgos, Hector Zelada-Valdivieso, and Huilder Juanito Mera-Montenegro. 2023. Gamification and programming: enhancing mathematics learning in students. In 2023 IEEE 3rd International Conference on Advanced Learning Technologies on Education Research (ICALTER). 1 – 4.
- Mariya Stupina and Victoria Paniotova. 2024. The Use of Gamification Technology in Student Team Projects in IT. In 2024 4th International Conference on Technology Enhanced Learning in Higher Education (TELE). 131 – 134.
- Angélica Lizeth Sánchez-López, Oziel Rodrigo Camacho-Ornelas, Luis Marcelo Lozano-Sánchez, Maria Fernanda Rivas-Gastelum, Alejandro Parra-Córdova, and Yocanxóchitl Perfecto Avalos. 2023. Enhancing Chemistry Laboratory Teaching through Gamification: The IQ-Mobile Race. In 2023 IEEE International Conference on Teaching, Assessment and Learning for Engineering (TALE). 1 – 4.
- Lazzat Tolegen and Akerke Alseitova. 2023. What Forces Us To Gamify The Programming In Higher Education: A Literature Review. In 2023 17th International Conference on Electronics Computer and Computation (ICECCO). IEEE, 1–4.
- Gustavo F. Tondello, Rina R. Wehbe, Lisa Diamond, Marc Busch, Andrzej Marczewski, and Lennart E. Nacke. 2016. The Gamification User Types Hexad Scale. In *Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play (CHI PLAY '16)*. Association for Computing Machinery, 229–243.
- IEEE Transactions on Learning Technologies* 15, 6 (2022), 827 – 846.
- Christos Troussas, Akrivi Krouska, and Cleo Sgouropoulou. 2020. Collaboration and Fuzzy-Modeled Personalization for Mobile Game-based Learning in Higher Education. *Computers & Education* 144 (2020).
- Wenyao Shen, Zehui Zhan, Chen Li, Han Chen, and Ranhao Shen. 2022. Constructing Behavioral Representation of Computational Thinking based on Event Graph: A New Approach for Learning Analytics. In *Proceedings of the 6th International Conference on Education and Multimedia*

- Technology (Guangzhou, China). Association for Computing Machinery, 45–52.
- Zehui Zhan, Luyao He, Yao Tong, Xinya Liang, Shihao Guo, and Xixin Lan. 2022. The Effectiveness of Gamification in Programming Education: Evidence from a Meta-Analysis. *Computers and Education: Artificial Intelligence* 3 (2022).
- Yu-Kai Chou. 2015. *Actionable Gamification: Beyond Points, Badges, and Leaderboards*. Octalysis Group, California, USA.
- Yung Po Tsang, Carman Ka Man Lee, Chun Ho Wu, and Yanlin Li. 2024. Gamified Blockchain Education in Experiential Learning: An Analysis of Students Cognitive Well Being. *IEEE Transactions on Education* 67, 4 (2024), 620–628.