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Article

AI-enhanced gamification for collaborative learning

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Abstract: A new innovative way to learn and teach using Gamification is a relatively new educational concept that can bring about a change in the way we learn and teach. Gamification refers to the use of game design elements in non-game contexts in order to increase motivation or engagement. In simpler terms, gamification is the process of incorporating rewards, badges, leaderboards, and points into non-game activities, such as learning, to make it engaging and fun. Gamification is a highly effective method of achieving a wide variety of learning outcomes, as gamification is based on motivational psychology. The paper will explore the effects of playing video games and their cognitive and social impacts, such as increased engagement in learning, reduced anxiety, an increase in self-esteem, collaboration among players, etc. Gamification is anticipated to combine with emerging technologies such as virtual reality and artificial intelligence in the future to achieve a more individualized learning experience. In order to achieve its full potential to increase global equitable access to learning that is more fun and motivating, a student-centered approach needs to become central to the education system, and teachers need to collaborate and work together to achieve this goal. This paper discusses theoretical frameworks, literature review, tools and technologies, methods of implementation, challenges, conclusions, as well as future perspectives related to AI-enhanced gamification to achieve collaborative learning.

Keywords: artificial intelligence in education (AIED); gamified learning environments; collaborative learning platforms; adaptive learning systems; intelligent tutoring systems (ITS); game-based learning analytics; personalized learning through gamification

1. Introduction

Gamification is a pedagogical approach that significantly changes the way we teach and learn. It uses the mechanics of games in educational settings in order to increase students' engagement, stimulate their learning, enhance their social interaction, and foster a deeper understanding of the learned content. Nevertheless, teachers have to be aware of some of the obstacles that gamification presents, including, for example, the risk of children being driven by external incentives and not by the intrinsic joy of playing and learning, issues of equity, and the need for pedagogical training.

Gamification depends on the application of game elements and mechanisms to engage human behavior, and it is considered a learning tool that can be used in the new educational system. Gamification is a strategy that uses a variety of game elements and mechanisms, such as number of lives, levels, points, rewards, etc., to motivate and challenge users and to enhance the interest and fun of learning. This paper aims to investigate the possibility of applying gamification along with collaborative learning algorithms in the proposed educational system.

Collaborative Filtering and Gamification are highly correlated. Thus, educational applications can benefit from the integration of collaborative filtering techniques, as these enable personalized learning materials to be proposed to students, provide relevant feedback, and encourage engagement in educational content, thereby enhancing the learning experience of students.

The motivation of this paper is to clarify and evaluate theoretical frameworks on artificial intelligence (AI), gamification, and education for developing skills. The objective of this paper is to introduce the basic ideas, concepts, and research related to the gamification strategies in the field of education. The literature review of this paper is composed of a wide range of sources. The sources were chosen based on their novelty and significance to the AI-enhanced gamification for achieving collaborative learning in education. This paper analyzes several studies about using artificial intelligence and gamification in learning, including how a recommender system based on AI can be used in education. Important tools and technologies were discussed in this paper. Methods of implementation, the role of AI in achieving adaptability and personalization in education were discussed in this paper. Individual case studies, difficulties, and challenges were mentioned. Finally, future perspectives and conclusion were discussed.

2. Theoretical frameworks on artificial intelligence (AI), gamification, and education for developing skills

Gamification, AI, and education are all very closely related and form individual building blocks for each other in the learning environment of modern classrooms. The pedagogy represents the core element of the three-level model and determines the learning targets, the educational values, and the key competences that the learners have to attain. Relational learning in this context refers to the relationships that are developed between teachers, learners, and learning objects. Relational pedagogical strategies are defined as teacher suggestions in a specific educational context that enhance the learning process of students [1].

Gamification is in the middle layer since it needs to be based on pedagogical reasoning in order to be effective. Gamification can then transform the traditional classroom into a more engaging environment for students and, hence, needs to be built upon solid educational foundations in order to motivate, engage, and improve the problem-solving skills of the students, as well as to improve the social interaction among them and, therefore, to aid in the achievement of learning objectives [2].

In this way, the use of technologies based on Artificial Intelligence (AI) turns the learning process into a more entertaining, more adapted, and more innovative activity.

In this sense, it brings personalization, instant feedback through adaptive learning, as well as through the interactive stories. Therefore, the use of AI works in conjunction with the teacher to create a more dynamic and more relational learning pathway, less authoritarian and less hierarchical. In this way, the classrooms become places where the teacher, the students, and the technology (in this case, AI) interact [1].

So when we dive deep into the three-layer approach for education, we get a method for instruction. Now we have our theory to apply new technologies to the classroom. So here are 3 ways that the AI Gamification will support the teacher in the classroom.

Share examples of strengths and skills you have gained as a teacher from your previous learning and experience. This might include discussing your subject knowledge, lesson planning, teaching, and also your own organizational skills.

2.1. Expressing pedagogical knowledge and possibilities

Before we can implement new learning methods with the aid of artificial intelligence and gamification, we need to create a pedagogical foundation that can ensure that learning is both deep, active, and contextual. There is always a need for pedagogical interaction between technology and learning. Innovative education is not just about introducing new technology, but also requires carefully designed pedagogies to underpin it.

Gamification and AI have to be incorporated into a pedagogical approach that will change our education system. As mentioned, in new pedagogical approaches, teachers will act as leaders or process designers who are responsible for transforming the education system [3]. Teachers have a high level of professional freedom, which gives them new creative ideas in the education field. The teacher evaluates, puts the content provided by the AI in a pedagogical context, and adjusts it to suit the needs of the students, which is a uniquely human component, and by incorporating it into the technology, the teacher becomes a more successful educator and mediator in the learning-teaching process [4,5].

Teachers should have the freedom to decide how they use technology and for what purpose, bearing in mind their professional skills and qualifications. This relates to the ability to customize, control, or modify digital tools, and to change or adapt the results or data generated by the use of technology such as AI, among other applications. The adaptive features of the technology and the personalization produced by the use of applications for the personalization of content should not negatively affect the diversity of students. Discrimination caused by the algorithmic processes should be avoided. Teachers should have the option to decide whether or not to use technology in the classroom and should be involved in the design of pedagogical policies as well as in the guidelines and rules of the institutions on the use of technology. Teachers should have all the necessary resources in order to be able to perform an innovative and dynamic teaching and learning process with technology.

In this context, teachers have a pedagogical responsibility to construct a learning situation that is relevant, attractive, and significant for their students. This necessarily implies the use of technology and the selection and adaptation of resources so that they meet the diversity, rhythm, and context of each student, so that the knowledge to be

constructed does not become an end in itself, but an instrument to achieve an inclusive, critical, and culturally relevant learning [6].

There is clearly a large overlap between the skills that teachers already possess and the skills required to implement the gamification activities we have identified. We believe that teachers will have to give some serious thought to what they are trading away in order to use technology in their classrooms. Ultimately, teachers are the designers of the learning environment and will need to make the pedagogical decisions that shape the gamification of the learning experience. These will include designing and implementing the gamified learning environment, as well as refining the learning environment in a cycle of design, implementation, and evaluation.

The digital world is changing at lightning speed, and so are the skills required to get a job. Understanding the trends and skills that are sought after by employers is key.

2.2. How AI and gamification can help in developing skills for the modern world

The second relationship between gamification and AI is about the gamification and AI technologies applied in the learning environment in order to create an interactive learning environment where students gain the skills they need for the modern world. Through the application of gamification and AI technologies in the learning environment, the modern learning space could be designed in a way that the students acquire the necessary skills for the modern world, and at the same time, they engage more actively with the educational material, which results in better academic achievement. As mentioned in Bennani et al. [7], Gamification and AI can be used to design the learning space in a way that engages and motivates students to learn, and as a result, they achieve better grades, while they are also helpful for students with special educational needs.

The integration of the flexibility of the AI system with the engagement elements of gamification in the educational context could be a key that unlocks the learning styles of students in a more relevant and student-centered way [6]. Our application helps students to learn a series of skills and competencies that are very important for their academic and professional evolution, such as problem-solving, information management, the use of technology in a more innovative way, being creative, communicating and collaborating, and thinking critically.

Another approach is gamification: by using game design elements in learning materials in order to make the learning and the development of digital skills more entertaining. By turning the teaching and learning process into a game or activity, engaging students physically and mentally through role play, interactive games, or learning simulations, and working cooperatively in groups to resolve real-life problems. An important set of skills for our children for this new digital age. Gamified learning platforms make use of AI so that each student gets an unprecedented, customized, dynamic, and adaptive learning experience. Gamified performance-based activities and problem-based learning activities help children develop important critical thinking skills [8].

2.3. From learning new skills to influencing society, and critical pedagogy

The third relationship is more associated with the critical pedagogy relationship, and it focuses on empowering students to make a change in society. In this view, the main objective of education is to enable learners to think critically and to help them deal with the situations and problems they face in their lives and in society effectively [9].

According to the philosophy of critical pedagogy, students should be able to: see the world in a different way, make informed decisions about the world they live in, and come up with creative solutions to the problems they face in their world. This approach does that. The underlying assumption is that critical thinking and learning skills should be strengthened, and that knowledge should be put to good use, as suggested by the 4th approach to learning according to Paulo Freire and his colleague [10].

These complementary ideas show how critical pedagogy encourages students to question, engage, and co-construct knowledge, which is essential for gamification and AI integration. Game of Thrones and other popular storylines can serve as inspiration for gamified experiences that, when combined with AI, can create robust chances for critical inquiry in a highly gamified setting.

3. Gamification in the field of education

Gamification is the use of specific elements of games in the learning process, which we know well—badges, leaderboards, challenges, rewards, etc. The motivation behind gamification is to increase student motivation in comparison to traditional learning approaches by achieving engagement, motivation, and participation. This term refers to the use of game mechanisms based on psychological elements of games, which are often based on competition, cooperation, and achieving educational goals, and are not related to the simple entertainment of playing for entertainment. Gamification is very relevant to 21st-century learners. In the last decade, gamification has become a common method in schools, colleges, and online learning environments. Contemporary young learners are used to digital learning and assessment environments and therefore tend to prefer gamification in their learning. A history class that incorporates quizzes and a score system is one example. Another is a science course that uses simulations, where students level up as they work through the issues.

The interactive learning activity held the students' interest and motivated them to proceed with their learning in order to achieve the proposed rewards. Research has shown that gamification leads to better learning outcomes due to increased learner engagement. It also helps in reducing learner anxiety and promotes learner cooperation to solve learning tasks, which are all "soft skills" that learners gain through gamification, such as communication, teamwork, and critical thinking. But if not well designed, gamification can lead to the overuse of external rewards, and therefore, the motivation of the learners is not intrinsically motivated. It is therefore important to know which learning objectives should remain in the educational content and how gamification will be integrated in order to achieve them. AI in Modern Education: Artificial Intelligence (AI) is another significant technology in modern education. The term AI refers to software that uses data analysis, machine learning, and natural language processing in

order to create dynamic learning experiences that are more individualized and engaging for students. Modern educational instruction is based on a one-size-fits-all approach that is not appropriate for diverse abilities and learning styles. The use of technology based on the principles of AI enables the computer to monitor learner behavior, performance, and preferences and to present the educational material in an appropriate way based on real-time data. The use of intelligent tutoring systems (ITS) is an example of the application of AI in the context of learning. ITS uses technology to provide instant feedback, suggestions, and support to learners while they are working on content related to a specific concept and linked to the learning objectives. Another example of the AI tools used for learning purposes are the learning platforms which include the creation of a personalized learning dashboard and the carrying out of an adaptive test in order to reach each learner's needs and to increase the learners' engagement with the content, by presenting it at a level that corresponds to each learner's stage of understanding the material before progressing to the next level. Finally, the use of technology based on AI can support the teachers' work by recording learners' progress, grading, and predicting when learners will need teachers' assistance, as shown in **Table 1**. Therefore, the use of AI in gamification learning activities will lead to more engaging and learning experiences, due to the fact that the computer can create an "adaptable learning game", which can increase learner engagement. The computer can "adjust the level of difficulty of the game based on learners' performance", "suggest optimal positions for learners in the leaderboard", and "analyze learners' collaborative learning processes in order to ensure that learners work towards achieving the learning objectives". The use of technology based on principles of AI can also facilitate the creation of learning environments that are more accessible and inclusive for learners with disabilities. This can be done by using "text-to-speech software to support readers with dyslexia" or "speech recognition technology to support hearing-impaired learners". Therefore, the use of AI in education is not only a technological innovation but also leads to more inclusive schools. Nevertheless, there are several concerns that arise from the use of technology based on AI in education, such as data privacy and the presence of bias in the development of the applications that make use of this technology. Teachers should consider these ethical concerns when exploring innovative approaches to teaching and learning, which are based on the use of technology.

Table 1. Conceptual framework of the main elements.

Key components	Elements	Purpose/function	Expected outcomes
Game Mechanics	- Points, Badges, Leaderboards (PBL) - Levels, Quests, Challenges - Rewards & Progress Tracking - Storylines/Narratives	Increase learner motivation and engagement through interactive challenges and rewards.	- Higher student motivation - Active participation - Goal-oriented learning
AI Algorithms	- Adaptive Learning Systems - Learning Analytics - Intelligent Tutoring Systems - Natural Language Processing (chatbots)	Provide personalization, real-time feedback, and data-driven adaptation of learning activities.	- Personalized learning - Better knowledge retention - Improved learner performance

Table 1. *Cont.*

Key components	Elements	Purpose/function	Expected outcomes
Collaboration Tools	- Team-based Challenges - Peer-to-Peer Feedback - Shared Virtual Spaces (forums, chatrooms) - Group Progress Tracking	Promote teamwork, knowledge sharing, and social learning.	- Stronger collaborative skills - Peer learning - Improved problem-solving ability

4. Tools and technologies used (AI tools, gamification platforms)

4.1. Adaptive learning systems

An adaptive learning system is a type of learning system that uses technology, such as AI, to assess the performance of a student and then vary the level of difficulty of the tasks given to the student based on the performance displayed. Examples of some adaptive learning systems are: Knewton Smart Sparrow, which is an adaptive learning system that monitors student performance over time and adjusts the tasks given to the student. The learning path is customized to fit the needs of individual students by identifying weaknesses and providing appropriate learning materials.

4.2. Intelligent tutoring systems (ITS)

An ITS works like a virtual teacher that gives feedback, guidance, and hints for solving problems in learning activities. ITS employs technology from Artificial Intelligence (AI), such as machine learning and natural language processing (NLP), that can enable the system to simulate human communication. The technology used in software provided by Carnegie Learning, such as Aleks and MATHia, enables students to work on numerous exercises and receive instant feedback.

4.3. Learning analytics platforms

Learning analytics platforms use artificial intelligence (AI) to gather insights on learner behavior, skills acquisition, and collaboration. Learning analytics platforms help teachers and learners get a deeper understanding of learning processes. Teachers can use platforms such as “Learning Locker” and “Civitas Learning” to make predictions about learner performance, to identify learners at risk, and to better understand learner behavior in order to create more customized learning experiences.

4.4. Virtual assistants and chatbots

Chatbots can also be implemented in collaborative learning environments to respond to students’ frequently asked questions. There are many instances in which students are engaged by IBM’s AI Tutor, and they have also practiced conversational dialogue with Duolingo’s AI bot. They were able to ask and receive feedback for their questions at any time.

4.5. AI for inclusivity

Use speech-to-text and translation tools, or include assistive technologies such as Microsoft Immersive Reader to support students with disabilities in gamified learning

environments. Using the AI and Gamification platforms in the right way, you have to balance between offering individual learning experiences and social fun experiences. In our approach, the gamification platforms keep students engaged by using mechanisms such as points and badges, while the AI technology provides the relevant information to the right student at the right time. The focus of our work right now is to build the gamification models that will then be used in conjunction with the AI technology, with the end goal of making learning fun and relevant to the students.

5. AI-enhanced gamification implementation

To fully exploit the potential of the AI gamification approach in collaborative learning environments, gamified elements, collaborative learning platforms, and AI must be carefully and strictly integrated in order to create a meaningful learning space for students. This must be done taking into account a series of factors that maintain the necessary pedagogical balance between learning and play, including learning objectives, infrastructure, and students' behavior.

5.1. Creating learning goals and game mechanisms

Aligning gamification with the desired learning outcomes is the initial stage of implementation. The knowledge and abilities that students should acquire must be determined by educators and instructional designers, who must then translate them into game mechanics. Quests or challenges, for instance, can be connected to solving problems, while badges or points can be connected to learning important ideas. Although leaderboards and levels may be included to foster healthy competition, they should also be made to encourage teamwork by providing incentives based on performance.

5.2. Applying AI to customization

In order for gamified learning experiences to be relevant to each learner, the use of AI is necessary. Through the use of adaptive learning systems, learner performance data is used to offer the most appropriate learning activities for each learner. In this way, the gamification of learning experiences does not lead to a decrease in motivation caused by activities that are either too simple or too complex. Using the intelligent tutoring systems, for instance, in cases of math problems, the activities can be made either easier or harder, and appropriate suggestions can be given to the learners. The AI can also forecast learner engagement and performance. Using the learning analytics platforms, the gamified learning activities can provide information on how learners collaborate with each other, which skills they have mastered, and which they have not. Thus, the gamification process can be adapted, and the teachers can be informed at the right time.

5.3. Digital tools for cooperation in the game

It is a key element in learning games developed with AI. Collaborative tools will help players to work together on team leaderboards, group quests, or to solve problems together. The AI can help to understand the dynamics of the collaboration of groups

of students, to detect non-cooperative students, and to provide recommendations to the teacher in order to improve the balance of participation in the group. Chatbots and virtual assistants can also be used as conversation starters for debates in the forums or in the chat.

5.4. Technologies and platforms

Choosing the right technology is very important for the project's success. Learning analytics dashboards and adaptive tutoring systems can be implemented on top of gamification platforms like Kahoot, Classcraft, and Quizizz. The AI-driven recommendation systems and gamification plugins can also be implemented on top of the existing platforms like Moodle and Edmodo to facilitate collaboration and, at the same time, meet the diverse needs of learners.

5.5. Handling difficulties

The implementation of gamification technologies based on Artificial Intelligence (AI) in the classroom is a complex task. Teachers need to have the appropriate training for the implementation of these technologies and tools, as well as to have adequate infrastructure to support them. Therefore, they have to take into account ethical aspects such as algorithmic bias, data privacy, and technology dependence. In addition, it is important to avoid explaining the mechanisms that regulate each element so that the final equilibrium that leads to quality learning is the reward and not the intrinsic and extrinsic mechanisms that compose it. Implementing gamification with the help of AI technologies requires the combination of technologies, pedagogies, and collaborations that require a lot of creativity from teachers. They have to think in multiple ways, having to merge collaborative technologies, game design, and learning that extracts the maximum pedagogical potential from the technologies of AI. In this way, the students who are taught in these classrooms will obtain better academic results, but they will also learn more in a greater number of competencies that are necessary for a 21st-century student, such as the management and use of technologies, critical thinking, and collaboration.

6. The function of AI in adaptability and personalization

Artificial intelligence is revolutionizing the way students learn through a more individual and, therefore, perhaps a more effective learning experience. In today's education, the methods of teaching are generally based on mass production – the teacher stands at the front of the classroom and teaches the same material to every single one of the students, without regard to whether or not the students learn in the same way or at the same speed. Factors such as learning styles and different levels of ability are not taken into account, and an AI system is able to "analyze and utilize vast amounts of learner data, such as the learning history, time taken to complete tasks, and interaction patterns, etc., and continuously evaluate learner data, such as learning history, time taken to complete tasks and patterns of interaction. The system is then able to adjust the material instantly based on the evaluation and provide the learner with individualized learning resources based on their knowledge, skills and abilities." An example of an 'intelligent

teaching system' for mathematics is described in this paper. The system "analyzes to find out when the learner is having difficulties with certain math concepts, and will then provide more detailed explanations of the material as well as simpler problems and extra help and hints in order to make the material more easily understandable for the learner. The more advanced learners will receive more difficult problems in order to keep them challenged in their learning." Therefore, the system is self-regulating in order to provide a better match between the learner's skills and the level of difficulty of the material they are required to work with, and it can therefore provide a more individual learning experience and is more likely to motivate learners.

Adaptive Assessment Artificial Intelligence (AI) is part of a wider group of technologies that allow assessment to become adaptive. An assessment, test, or quiz can be adapted to the performance of the learner. So rather than all learners having the same set of questions, an AI can select questions based on the learner's performance. The assessment and feedback process operates in a dynamic feedback loop. Learners complete tasks where they need to improve their skills and, at the same time, strengthen the learning they already possess. Using natural language processing (NLP), an AI-based chatbot can carry on a conversation with each learner to assist with any questions they may have. Every learner needs motivation and engagement in order to learn. AI-powered gamification significantly increases motivation and engagement. Incorporating these features along with adaptive technologies turns learning into an exciting journey for learners.

7. AI-based recommendation system in education

A recommender system is a type of artificial intelligence (AI) technology that uses specific algorithms and techniques to analyze user behavior and preferences to provide relevant or desired recommendations. Many online services use Recommender Systems in their products, such as news apps, music and video streaming platforms, and e-commerce websites. A Recommender System uses the user preferences, such as purchase history, ratings, search history, likes, etc., and then applies specific algorithms to the data to produce relevant and personalized recommendations based on individual user preferences.

Collaborative filtering, content-based filtering, knowledge-based recommendation, and hybrid recommendation are some of the AI technologies used in recommender systems. Machine learning and Deep learning are also being employed to enhance the performance of recommender systems, leading to more accurate and user-specific recommendations. Hence, recommender systems are a type of artificial intelligence that helps users get a personalized experience by recommending items to them that they are likely to be interested in.

Collaborative filtering is one of the techniques for generating recommendations. The way in which collaborative filtering works is based on the assumption that similar users/items have similar tastes, and that the people who like a particular user for the items they have seen are likely to have similar tastes in other items. Thus, by making use of the preferences of all users in a system, collaborative filtering can produce highly relevant recommendations to individual users. There are two forms of collaborative

filtering: user-based vs. item-based collaborative filtering. Collaborative filtering is an efficient way of producing relevant recommendations. Therefore, collaborative filtering is one of the most popular techniques used in recommender systems.

Gamification is all about using collaborative filtering to make the user experience fun and relevant. Using collaborative filtering in gamification also allows the game designers to personalize individual components of the game, like features, missions, or rewards for each user, based on the behavior and preferences derived from other users with similar profiles. Gamification of collaborative filtering, therefore, allows the designers to make the games more dynamic and personalized, which in turn increases the engagement and the overall user experience. Gamification of collaborative filtering helps in personalizing the content of the game to the individual players and thereby increasing the relevance of the content for the players, which in turn leads to engagement in the game and therefore a better user experience.

Collaborative filtering is a technique used in recommendation systems where each user is provided with a set of recommended items based on the preferences of other users with similar behavior and characteristics. Collaborative filtering identifies users behavior and preferences and derives patterns based on users similarities to predict a target user's preferences for items she has not interacted with yet. Collaborative filtering solves the cold-start problem in recommendation systems as well as learns and adapts as new user-item interactions are added. Therefore, the final output of a collaborative filtering system is a highly personalized and dynamic user experience that satisfies a happy user and keeps them engaged on the site for a long time. Collaborative filtering is an extremely effective method of making very accurate and relevant predictions in a recommendation system, as it utilizes the knowledge of all users.

In Gamification and Collaborative Filtering, the user experience [11, 12] in a recommendation system can be improved when gamification and collaborative filtering are implemented. Gamified recommendations can help show users what is valuable to others who have similar interests, and personalize the gamified experience using content suggestions from other users with similar preferences. In the gamified recommendations scenario, the user is gamified the way they interact with the recommended content (for example, by getting points and badges for watching certain content or advancing through a suggested playlist), and the gamified elements themselves are recommended using a collaborative filtering algorithm.

8. Implementation of AI-enhanced gamification in collaborative learning methods

Traditional education methods have failed in terms of student engagement, and teachers are not satisfied with the learning achievements of the students. For example, to investigate the effects of adaptive gamified learning on middle school students' engagement, participation, and social behavior by using AI-based gamification in the educational system, the following suggested method can be implemented, including tools and technologies to be used:

8.1. Suggested tools and technologies

1. Gamification platform: Classcraft. We have been using Classcraft to gamify tasks and activities assigned by the teacher and gain points, level up, and complete quests.
2. AI tools:
    - Intelligent Tutoring System (ITS) for personalized learning tasks.
    - Learning analytics dashboard for monitoring student performance and collaboration.
    - AI-based chatbot to assist students in solving queries in real-time.
3. Collaboration tools: Google Classroom and Padlet for team-based challenges and knowledge-sharing.

8.2. Implementation process

Step 1: Planning and design

- Learning objectives for each lesson are aligned with gamified elements.
- Students are grouped into teams for collaborative quests.
- Tasks are categorized into levels of difficulty to support adaptive learning.

Step 2: AI integration

- ITS analyzes each student's prior performance and recommends personalized challenges.
- This system uses technology to help students learn and complete assignments on the computer. It tracks time-on-task, accuracy, and types of collaboration for online lessons and activities, and will determine future assignments based on that information.

Step 3: Gamification execution

- Kids earn points and badges for working alone and with others.
- Leaderboards display team performance, encouraging friendly competition.
- Quests and challenges are updated weekly based on AI recommendations.

Step 4: Monitoring and feedback

- Teachers receive weekly analytics reports on student engagement and progress.
- AI chatbots provide instant feedback on task completion.
- Regular peer review sessions encourage reflection and collaborative improvement.

8.3. Expected outcomes

The expected outcomes based on past research [13–15] depend on the schools' facilities, students' capabilities, teachers' skills, and implementation methods, and can vary from one school to another according to the previously mentioned factors. But the expected outcomes in general can be considered as follows:

- There can be an increase in students participating in the Math and Science activities compared to the baseline. Students may be more focused in class, and absences have decreased during gamified activities.
- Increased motivation: Learners will be motivated and engaged through the use

of points, badges, and learning challenges. They may experience enjoyment of learning and have the motivation to progress to the next level.

- Teamwork: Teams may perform better in collaborative tasks, as the AI analysis shows that they distribute their workload evenly and that they interact more with each other.
- They may notice that their scores on quizzes are improving, and that they are able to remember more concepts and ideas, especially those for which the Artificial Intelligence generated Challenge Questions.

9. Individual case studies

In order to improve the way students learn, one of the new trends is based on the application of Artificial Intelligence in the educational process by means of gamification [16]. The intrinsic presence of AI in assistive technologies for games, and therefore in player modeling and non-player characters (NPCs), has led to the AI-assistive technology-games relationship that has a strong connection with the actual video games industry. The Internet of Things (IoT) is applied in a large number of contexts in the field of educational gamification, and it has great scientific potential. Hence, the educational processes are being transformed into game-based virtual learning environments by using IoT technologies and their corresponding hardware and middleware, which allow interaction with the physical world in a learning context.

VR, AR, and MR educational gaming, which allows students to learn through experiential and developmental experiences, has shown greater involvement and interest in learning. With the evolution of the metaverse, educational gaming is expected to undergo many more transformations. As the metaverse provides students with a customized learning environment that is highly interactive and user-friendly, the gamification in education is also expected to undergo a revolutionary shift in the coming years [17].

Duolingo is a gamified app that uses a blend of gamification and AI in its interface. The interface of Duolingo enables learners to very easily engage in the learning content via the use of leaderboards, badges, and points. Finding a balance between content and pedagogy has always been difficult, but Duolingo has managed to engage learners to an extent where they actually aspire to learn another language [18–22]. A meta-analysis carried out by Li et al. [23] found that gamification increased learners' performance in learning activities with a large average effect size of $g = 0.822$.

This study investigates the impact of gamification on foreign language learning. Games make the language learner remember the words and phrases they learn. Researchers in foreign language teaching argue that gamification leads to the creation of motivating games that increase learners' enjoyment, attraction, and motivation towards learning languages. Gamification empowers students with the confidence to learn independently. It gives students greater control and allows them to develop their interactive skills in an online environment. Gamification presents students with a dynamic way of interaction with peers and develops their skills and social capital. The studies in the literature mainly focused on foreign language learning skills such as reading, speaking, writing, listening, collaboration, and foreign language achievement.

Although there are numerous papers that criticize gamification in the context of language learning, this paper discusses some of the problems in the gamification of language learning. It also discusses some of the problems inherent in traditional Grammar-Translation Method (GTM) language teaching and learning activities. Such problems include: Lack of authentic, communicative activities embedded in relevant contexts [19], Low accuracy in translation exercises [20], and many other technical issues that learners may experience, such as connectivity issues and access to mobile devices.

A small number of parents had a few negative comments: they suggested that a gamification tool could act as a class management tool for a teacher with no classroom management skills; expressed concerns over the terms and conditions of the privacy policy and data storage of the app; and thought that graphic violence in the items could be a distraction to learning. One parent even remarked that only students and parents should "be in the know" of the information that the app reveals. An essential tool for giving students the cross-curricular skills they will need in order to be competitive in today's job market. At the university level, this tool can be used to help build social links, work in teams, increase attendance, and motivate students to delve deeper into a subject (such as a research topic).

10. Difficulties and restrictions

Gamified educational apps that enable learners to engage with their learning materials through interactive learning often carry real-time data processing. Hence, latency and real-time issues become a big concern in educational apps. Network latency has a significant impact on gamified educational apps as well. Take cloud gaming, for example. However, it's more relevant in the case of educational Augmented and Virtual Reality (AR/VR) apps, due to the sensitivity of latency in such applications [21,22].

Proper use of in-game information, exclusion of students, etc. The algorithms of the gamification platform can, for example, exclude students who are not gamers at heart. Those who do not like to compete or who take more time to learn the material of a level. One of the basic problems of the educational system is the race against time and the fact that teachers are not yet ready for gamification. Finally, a level does not always reflect the knowledge acquired by the student on a subject. Gamification is a teaching strategy used to enhance student engagement and motivation through the use of game design elements in learning activities [23–26]. And by using gamification in the educational system, one risks only feeding the very same psychological dynamics that gamification aims to change, and opening a new way to new forms of addiction. As between intrinsic and extrinsic motivations.

Internet addiction could contribute to the development of ADHD. Social networking often precludes communication with friends and family. Excessive screen time can prevent teenagers from getting the necessary rest to further compromise brain health. Similarly, Alzheimer's has also been linked to excessive screen time in the elderly. Average IQs in first-world countries are reported to peak at around 18 years of age, before beginning to decline.

Researchers have identified yet another side effect of modern technology—the

term for this condition is "AI-Chatbot-induced cognitive atrophy" or ACIA. This condition affects the human brain when it is exposed to excessive interaction with chatbots. Artificial intelligence chatbots are digital applications that reduce the effort and time required for interacting with a computer to perform simple cognitive tasks. Prolonged exposure to these applications can cause dramatic atrophy of human cognitive abilities and is particularly dangerous for young users. Scientists have also recently discovered that students who had to manually complete a list of tasks using large language models (LLMs), search engines or just their brains ended up with the students who had to use their brains the most neural activity in their brains and also ended up with the most written words in the study—whereas the users of the LLMs ended up at the bottom of the comparison [27–31].

11. Challenges

Despite the many benefits of gamification, there is still a lot to explore. Gamification in the educational sector is a huge topic of discussion, due to the potential for students to become over-reliant on external motivators. The gamification mechanics of using badges, points, and leaderboards can initially motivate the user, but if not implemented correctly, they can actually hinder the intrinsic motivation to learn. This means we need to find ways to gamify in a way that achieves the right balance between intrinsic and extrinsic motivators.

Accessibility is still a significant challenge that needs to be addressed. Some countries lack the school infrastructure required to support gamification learning platforms. Our research has shown that the digital divide between schools can hinder the implementation of new learning methods and, therefore, exacerbate the current inequality gap. In cities, gamification is being implemented without any complications, but in rural areas where internet speeds are low and the technology is outdated, the challenges to ensure that students have access to similar learning opportunities are more significant. The cultural context of each community is another factor that should be taken into account. A learning technology that is not culturally adapted may not be of interest to the students, and therefore, it will not be implemented. The importance of culturally adapting the gamification learning platforms' designs. We recommend using traditional games and culturally relevant elements so that all students feel that the gamification platform is relevant to them and therefore more inclusive.

One of the things that teachers consistently say stands in the way of teaching with games is the pedagogical learning curve involved in using gamification technologies to support learning. Teachers often need extensive training in order to learn how to effectively integrate the gamification platforms into their pedagogical approach. Without proper support, gamification can actually become a huge learning hurdle that overpowers the learning of the material, an issue raised in. If teachers were given more training and resources, this barrier would begin to fade away. It will require a lot of work from all parties to understand the challenges gamification presents to our current pedagogical frameworks, and to work together to bring disruptive change to the education systems.

12. Discussion

The purpose of this study was to investigate the effects of gamification on students' engagement and achievement at the elementary level. The study supported the findings of Zainuddin and Perera [32] in which gamification is used in the form of increasing levels of challenges to students playing a gamified learning application, which can enhance students' confidence and help them achieve their learning goals. Loewen et al. [33] also supported gamification by using gamified learning platforms such as Duolingo, which results in higher retention of language learned and applied. This study supports gamification for subjects such as language learning [34].

Subhash and Cudney [35] also found that gamified simulations increased students' understanding of the subject matter as well as improved their critical thinking skills in STEM education. Gamified learning apps are also showing promising results in reducing student procrastination and increasing their inclination towards learning. Some studies also explored the adoption of gamified learning resources by K-12 teachers. In that case, the preparedness and motivation of the teachers played a crucial role in the implementation of gamification in the classroom.

Koç and Kanadlı [36] explored the applications of AI and VR in gamified learning in their study titled "Effect of Interactive Learning Environments on Learning Outcomes in Science Education: A Network Meta-Analysis." Ouyang and Jiao, in their paper titled "Artificial intelligence in education: The three paradigms" [37], also investigated the applications of AI and VR in gamified learning. Arslan et al. in "Opportunities and challenges of using generative AI to personalize educational assessment" [38] elaborated on the role of AI in revolutionizing the education sector through the implementation of intelligent adaptive learning environments to meet the varied learning styles of learners. Murillo-Zamorano et al. [39] examined the effect of gamification on learning in higher education and summarized the main trends and recommendations that must be taken into consideration in order to achieve successful gamification and improve learner engagement and achievement.

The aspects of gamification that need more attention include emotional and social gamification. Lam et al. [40] say that gamification can reduce learning stress by clarifying the objective of the learning and providing timely feedback that enables learners to maintain control over the learning progress. Zainuddin and Perera [32] say that gamification can increase the learner's confidence by achieving a level-up through the gamification elements. Meanwhile, Tam et al. [41] also remind us that over-reliance on extrinsic rewards by using gamification is not always a good thing and that the gamification elements need to be designed so as to encourage the learners' intrinsic motivation towards the learning materials. Kuo and Chuang [42] believe that collaborative gamification can enhance peer learning and communication, hence enhancing the social relationships of the learners.

There are a number of barriers that must be addressed. In their paper, Ryan and Deci [43] mention one major barrier to the growth of intrinsic motivation: overdependence on extrinsic motivators. They argue that gamification can lead to a decrease in intrinsic motivation if it is not aligned with learning objectives. Other

studies have identified other barriers, such as access barriers, which proved to be insurmountable in gamification projects in developing countries. So it is essential for educators, policy-makers, and developers to work together to make sure that there are gamified learning platforms that are accessible and pedagogically sound.

In the future, gamification will evolve to incorporate new and innovative technologies, such as the use of AI and VR, in order to produce a more dynamic and personal learning experience. For instance, an AI-driven gamified learning system would always ensure that the work produced by the pupil is always of the relevant difficulty level in order to keep it both challenging and engaging [44]. Moreover, combining gamification and VR will allow for the connection of theoretical concepts in textbooks with real-world applications. Using, for example, a Virtual Reality (VR) tool can enable pupils to experience historical events, participate in experiments that allow for the exploration of the natural world through a fully immersive and safe virtual learning environment [44]. In that way, the future of gamification in education will be based on innovations that include, for instance, the application of blockchain technology, which will help make gamified learning platforms safer.

A global and student-centered gamification strategy must consider the gamification of learning processes, with a research-based approach, strong coordination, and collaboration between the agents that take part in the educational system. If we are able to cope with the drawbacks that this educational innovation implies and we manage to exploit its possibilities, gamification may represent a revolution for education: the learning process could become more entertaining, social, and efficient.

13. Future work

The future of education is looking promising for the use of AI-based gamification. Our study is a starting point to identify possible educational and subject areas where gamification can be applied. Future studies may include additional fields such as language education, STEM labs, and vocational training to identify the most effective ways to implement gamification in different contexts. To confirm the effectiveness of gamification on students' motivation, teamwork skills, and grades, we suggest implementing a longitudinal study that would last for at least two semesters or years to better understand how students learn through gamification. Technological advancements are also opening doors to innovative learning tools that can increase the fun element of learning. This paper also suggests the potential of integrating gamification with modern technologies such as Virtual Reality (VR) and Augmented Reality (AR) to enable the development of learning environments with enhanced engaging features, such as simulation-based learning environments, where students can learn from experimentation, exploration, and teamwork in a safer environment. More advanced forms of AI, such as emotion detection and predictive models, could also be used in conjunction with gamification to learn students' emotional and cognitive states and accordingly personalize and enhance their learning experiences in real time. All in all, AI-based gamification is a student-centered approach that provides meaningful learning experiences through the integration of gamification, personalization, and

AI-based learning adaptation. Thus, through the use of an AI-based gamification model, we can revolutionize learning in classrooms to a more student-centric, more engaging, more adaptable, plug-and-play, and more inclusive learning environment, preparing our students for the demands of the 21st century, provided that research, technology, and the practical application of gamification are closely examined.

14. Conclusion

The future of gamification in Education 4.0 will depend on the adoption of emerging technologies such as artificial intelligence (AI) [45–49] and virtual reality (VR) [50, 51]. The integration of these technologies in gamified learning experiences will allow for more engaging, interactive, and personalized learning for each learner. Combined with culturally sensitive designs, these technologies can help to reduce the learning gap and promote greater inclusivity across diverse contexts, especially in disadvantaged settings.

It will be necessary for a community of teachers, developers, and other stakeholders to work together to achieve the full potential of gamification. In particular, gamification activity will involve the design of fun learning environments that support curriculum learning and teaching, and which meet the needs of all learners. Evaluation and research into pedagogies and learning activities will be required to underpin and guide the development of learning approaches for gamification.

Gamification can help create a more engaging, fair, and motivating learning environment when used as a complement to traditional learning. So gamification can help transform the 21st century education system and make the most of the opportunities and challenges it offers. Learners who participate in a gamified learning environment may show a higher level of engagement when they are exposed to activities generated by an AI-based gamification system. The gamification system can be based on an AI technology, ensuring long-lasting engagement for learners as it continuously assesses learners' abilities and assigns tasks accordingly. Promoting teamwork and communication through collaborative tasks, peer-to-peer review, and discussions on the gamified platform may result in the creation of communal knowledge.

Another advantage of an AI-enhanced gamification is the improvement of student grades and achievements. There are many more concepts that students are able to understand, and they can improve their grades in the evaluations after dealing with their weaknesses and by exploiting their strengths in the learning activities and exercises proposed thanks to the analysis of the learning style, as well as by the gamification functionality, which can enable students to evolve from an extrinsic motivation to an intrinsic one, that is to say they move from an external stimulus to an internal motivation that enables them to achieve the learning objectives in a fun way, through the acquisition of knowledge. To achieve the development of critical thinking skills, and therefore to achieve the goal of acquiring the skill of lifelong learning.

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