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# Gamifying Learning with AI: A Pathway to 21st-Century Skills

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## ABSTRACT

This systematic review examines how gamification and artificial intelligence (AI) can converge to foster essential 21st-century skills like creativity, collaboration, and critical thinking in education. The review followed the main PRISMA statement guidelines, resulting in 175 articles for qualitative content analysis and bibliometric network visualization using VOSviewer. Key findings emerged: 1) Priority skills included creativity, collaboration, communication, and critical thinking. 2) Gamification enhances motivation, engagement, and skill acquisition via game elements. 3) AI personalizes learning experiences, provides feedback, and adapts gamified content. 4) Social interactions in virtual gamified environments promote collaboration. Gamification taps into motivational aspects of games, while AI enables personalized, adaptive learning experiences. Together, they offer innovative strategies for transforming education into an engaging, personalized process for developing vital competencies. This review provides valuable insights for teachers, instructional designers, and policymakers seeking to prepare students for future challenges through leveraging gamification and AI in fostering 21st-century skills.

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21st-century skills; artificial intelligence; collaboration; creativity; critical thinking; gamification

The term gamification was coined by software designer and programmer Nick Pelling and was mainly used in business and social contexts until a few years ago, when it began to gain ground in the field of education. Since its beginnings around 2008 and its consolidation in 2010, several definitions have emerged. Kingsley and Grabner-Hagen (2015) define gamification as the use of game elements in non-game contexts, such as education or work, to increase motivation, engagement, and learning. For his part, M. R. D. F. D. Cruz (2019) describes gamification as a pedagogical strategy that incorporates playful elements into educational activities, whether in analog or digital environments, to improve the learning experience and shape or modify student behavior in the classroom. In this regard, it is worth mentioning the existing relationship between gamification and nudge theory, which lies in their shared goal of influencing behavior. As mentioned by AlMarshedi et al. (2017), gamification often incorporates elements of nudge theory by designing systems that subtly guide users toward desired actions, such as completing tasks, learning new skills, or adopting healthier habits. Thus, both approaches recognize the importance of understanding human psychology and motivation to design interventions that effectively shape behavior without resorting to coercion or mandates.

Similarly, Hussain et al. (2023) define gamification as the application of game mechanics, aesthetics, and perspective to attract and motivate individuals to face specific challenges. It does not necessarily involve electronic devices or video games but can be implemented in any learning or work process in the form of a game.

More than two decades ago, Dempsey et al. (2002) revealed that there were few studies conducted to use computer games for educational purposes. The limited number of such studies forced Dempsey

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and other researchers, such as Gros (2016), to focus their attention on this area. Likewise, in their research, they showed that gamification can increase motivation and engagement in a similar way to how it is achieved in a typical game environment and does not necessarily refer to digital or computer-based games.

In recent years, due to technological advances and more recently because of the COVID-19 pandemic, gamification has been gaining increasing prominence as an educational resource. This importance can be evidenced in Figure 1, which shows the evolution of research production on this topic through publications in journals indexed in Scopus on gamification in general compared to those specifically focused on education. This figure demonstrates a growing and sustained interest from the academic and research community, indicating a consistent trend of relevance in this area.

Since the integration of gamification in the field of education, studies such as those carried out by Kingsley and Grabner-Hagen (2015) and M. R. D. F. D. Cruz (2019) have highlighted the favorable effects of gamification in teaching and learning processes. The former were able to demonstrate that gamification allows the integration of content knowledge, literacy, and 21st-century learning skills in a fun and appealing way, since students, through a game that includes achievement badges, levels, and mastering certain elements, increase their commitment, learn content, and practice literacy skills attractively. Similarly, M. R. D. F. D. Cruz (2019) stated that gamification as a teaching strategy allows for the generation of favorable practices for learning foreign languages in primary and secondary education, and also for developing such 21st-century skills as collaboration and communication, creativity and innovation, critical thinking, and problem-solving.

The inclusion of gamification in the classroom has had significant repercussions on teachers' conceptions of teaching and assessment methods. The teacher is no longer the expert who has the knowledge and transmits it to the students, who typically become recipients of that knowledge and are later evaluated based on their ability to memorize it. In this regard, Oliveira and Cruz (2018) mention that the teacher who implements gamification in the classroom has a role as a facilitator of learning, and the mission is to intentionally involve students in direct experiences to increase knowledge and develop skills, focusing on students' interests and needs. Addressing these new challenges of the teaching role, Ortiz-Colón et al. (2018) affirm that designing gamification in the classroom implies a series of challenges for teachers, related to finding in advance the interests and needs of the students, thinking about interaction dynamics that allow maintaining motivation, and opening the possibility of developing other skills, beyond those foreseen in the curricula of a specific area.

In all the research analyzed, the authors agree that using gamification in the classroom implies keeping the student motivated in what they do, awakening the interest in learning and achieving better results in skill development while having fun; however, making this possible implies a very great

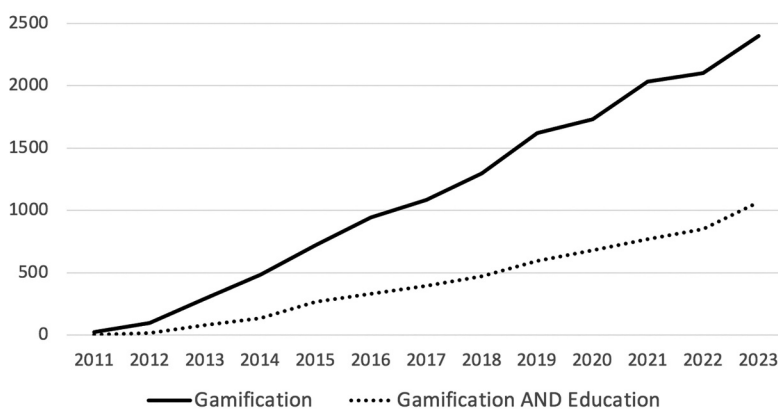


Figure 1. Articles published about gamification as a social sciences topic.

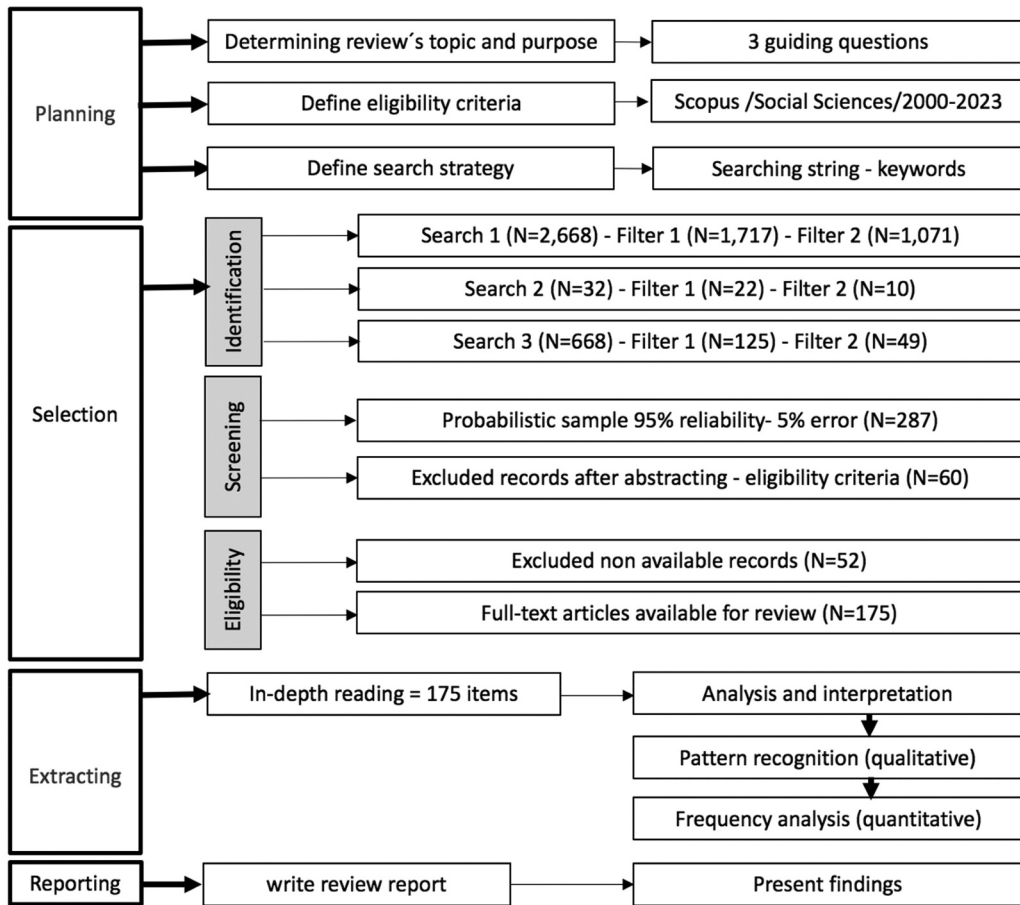


Figure 2. Review method design.

challenge for the teacher. In addition, Krüger Mariano and Chiappe (2021) affirm that if gamification is not implemented well, it can be seen as a distraction and a way of trivializing learning.

This systematic review explores how gamification and artificial intelligence (AI) converge in education to promote the development of 21st-century skills and what aspects should be taken into account for their application and/or design.

## Method

For this systematic literature review, the methodological designs used by Kitchenham et al. (2009) and Okoli (2015) were taken into account, to which the main guidelines of the PRISMA statement (Preferred Reporting Items for Systematic reviews and Meta-Analyses) were integrated. The details of this integration, specifically in the selection phase, are shown schematically in Figure 2.

### Planning the review

As part of this first stage, the researcher's interest is defined as focused on finding relationships between 21st-century skills, gamification, and AI, with the purpose of trying to answer the following three questions: How have 21st-century skills been understood? What 21st-century skills can gamification develop? and What is the role of the teacher and AI in gamified virtual environments?

To answer these questions, some search criteria were established. Initially, it was decided to consult the Scopus database as it contains a large number of published scientific documents with quality and veracity. Next, a string of keywords or search descriptors was defined as “21st-century skills,” “gamification,” and “artificial intelligence.” Finally, to limit the literature review, the following filters were established: Filter 1, documents published between the years 2000 to 2023 and within the thematic area of social sciences, and Filter 2, documents published in article format.

### **Literature selection**

Scopus was chosen as the primary source for this review due to its comprehensive coverage of peer-reviewed literature across disciplines. As one of the largest abstract and citation databases, Scopus offers a wide range of high-quality, multidisciplinary research publications (Airyalat et al., 2019). Moreover, its advanced search features and built-in bibliometric tools, such as citation analysis, h-index calculation, and the ability to export data for use with visualization software like VOSViewer or data analysis applications, allowed for efficient identification and in-depth analysis of relevant articles. Also, Scopus’s broader coverage in technology and education-related fields, coupled with its inclusion of non-English language journals, provided a global perspective that negated the need for additional sources like Web of Science or other open databases.

This second stage related to the literature selection criteria focused on searching for the articles by applying the aforementioned filters, defining the sample, and making the final selection of articles. To do this, it was established to perform three searches, one for each keyword.

In the first search related to the keyword “21st-century skills,” Scopus returned 2,668 documents; when limited by filter 1, 1,717 documents were identified, and when limited by filter 2, 1,071 documents were identified. In the second search related to the keyword “21st-century skills” AND “gamification,” Scopus returned 32 documents; when limited by filter 1, 22 documents were identified, and when limited by filter 2, 10 documents were identified. In the third search related to the keyword “gamification” AND “artificial intelligence,” Scopus returned 668 documents; when limited by filter 1, 125 documents were identified, and when limited by filter 2, 49 documents were identified.

To define the sample size, the representative sample formula was applied with a 95% confidence level and a 5% margin of error, resulting in a final sample of 287 articles. Then, inclusion and exclusion criteria were applied, based on which 60 articles were excluded. These criteria were:

- Articles that present research results with a significant number of citations
- Articles that address the review topic in the body of the document
- Articles that provide information regarding the review questions.

Additionally, 52 articles that were not available were excluded, resulting in a final set of 175 articles for in-depth reading.

In addition, to safeguard the global publication trend, a certain number of articles to review per year was established, which is shown in [Table 1](#).

### **Information extraction**

At this stage, a systematic and rigorous process was carried out to extract relevant information from the 175 selected articles. Various techniques and approaches were used to ensure a complete and accurate data extraction. The main methods employed are described below:

- **In-depth reading:** A detailed and exhaustive reading of each of the selected articles was carried out, paying special attention to the results, discussion, and conclusions sections. This allowed for the identification and recording of key findings, ideas, and concepts related to the guiding questions of the review.

**Table 1.** Published and selected articles per year.

| Publication year | Published articles | Selected articles |
|------------------|--------------------|-------------------|
| 2000             | 1                  | 1                 |
| 2001             | 0                  | 0                 |
| 2002             | 0                  | 0                 |
| 2003             | 0                  | 0                 |
| 2004             | 0                  | 0                 |
| 2005             | 1                  | 1                 |
| 2006             | 1                  | 1                 |
| 2007             | 1                  | 1                 |
| 2008             | 3                  | 0                 |
| 2009             | 7                  | 1                 |
| 2010             | 15                 | 2                 |
| 2011             | 18                 | 3                 |
| 2012             | 17                 | 3                 |
| 2013             | 42                 | 7                 |
| 2014             | 35                 | 5                 |
| 2015             | 49                 | 7                 |
| 2016             | 54                 | 8                 |
| 2017             | 62                 | 8                 |
| 2018             | 69                 | 9                 |
| 2019             | 97                 | 14                |
| 2020             | 161                | 23                |
| 2021             | 140                | 23                |
| 2022             | 156                | 26                |
| 2023             | 201                | 32                |
| Total            | 1130               | 175               |

- **Categorization and extraction of structured data:** A coding and categorization system was developed to organize and structure the extracted information. This involved identifying and labeling relevant text segments with thematic codes, which facilitated the subsequent analysis and synthesis of the data. Additionally, a standardized documentation matrix was designed to extract key information from each article, such as bibliographic details, methodology, main findings, and conclusions. This ensured a systematic and consistent extraction of data.

### Data analysis

The next stage focused on information extraction, which centered on the analysis and interpretation of data, conducting an in-depth reading of each article to answer the guiding questions of the review and then synthesizing the information with the purpose of disseminating the findings through a descriptive analysis process. Particularly, a qualitative content analysis of the selected articles was performed, identifying and coding key themes, concepts, and findings related to the review questions. This analysis allowed for the identification of recurring patterns, trends, and perspectives in the literature. Additionally, a thematic analysis was carried out to identify and examine the main themes emerging from the data. This involved an iterative process of coding and categorizing the data, which allowed for the identification of central themes and the relationships between them. For this purpose, the VOSviewer software was used, which enabled the construction and visualization of bibliometric networks, especially those related to co-occurrence network analysis for the identification of clusters, trending topics, and most relevant topics among authors.

### Reporting of results

The final stage focused on reporting and disseminating the results and centered on organizing the findings of the review and elaborating the present document to share the results, discussions, and conclusions of the research.

## Results

### *Bibliometric results*

Between 2012 and 2023, there was a consistent increase in published articles addressing gamification and education in relation to 21st-century skills. The review encompassed a wide array of contributing journals ( $n = 160$ ), with only 33 journals publishing more than 10 articles on the subject. Table 2 presents the top 10 contributing journals, along with their academic quality indicators: the SJR (Scimago Journal Ranking) impact factor and CiteScore quartile.

For context, the Journal Citation Reports (JCR) impact factor measures how frequently the average article in a journal has been cited in a given year. This metric is used to assess a journal's relative importance within its field, with higher impact factors generally indicating greater prestige. CiteScore, developed by Scopus, offers an alternative method for evaluating journal impact. It calculates the average number of citations received per document published in a journal over a four-year period. Based on their CiteScore, journals are then ranked into quartiles, with Q1 representing the top 25% of journals in a field. While Table 2 showcases only the top 10 contributing journals, it is important to note that all articles included in this review originate from publications of high scientific quality, as evidenced by these metrics.

### *21st-century skills and their strengthening*

The first organizations to refer to 21st-century skills were: the Organization for Economic Cooperation and Development (OECD), the International Initiative for the Assessment and Teaching of 21st-Century Skills (ATCS21), the International Society for Technology in Education (ISTE), and the United Nations Educational, Scientific and Cultural Organization (UNESCO). Although this expression is very common and several researchers use it, finding a definition is not so easy, since most documents describe the skills required to face the challenges of 21st-century society, but do not go into depth on this definition (Krüger Mariano & Chiappe, 2021).

Some research and international institutions talk about 21st-century competencies and others about 21st-century skills. Although this article does not intend to make this distinction, it can be inferred from the readings of some articles that 21st-century skills are those aspects of people considered fundamental to function in the society of the current century (Contreras-Espinosa & Eguia-Gomez, 2022; Milheiro Silva et al., 2021), whether they be capabilities, knowledge, habits, attitudes, or emotions, among others (Kingsley & Grabner-Hagen, 2015).

The development of 21st-century skills is constantly mentioned today as one of the goals of education systems around the world (Voogt & Pareja Roblin, 2023). Some of the 21st-century skills mentioned by the OECD, ATCS21, ISTE, and UNESCO are critical thinking, creativity, communication, and collaboration. However, these are not the only skills mentioned in the literature; in fact, some studies have been recognizing other skills as necessary to face the new and future challenges of 21st-century society, such as problem-solving, information management, appropriation of technologies,

**Table 2.** Top 10 indexed journals with the greatest contribution to the review.

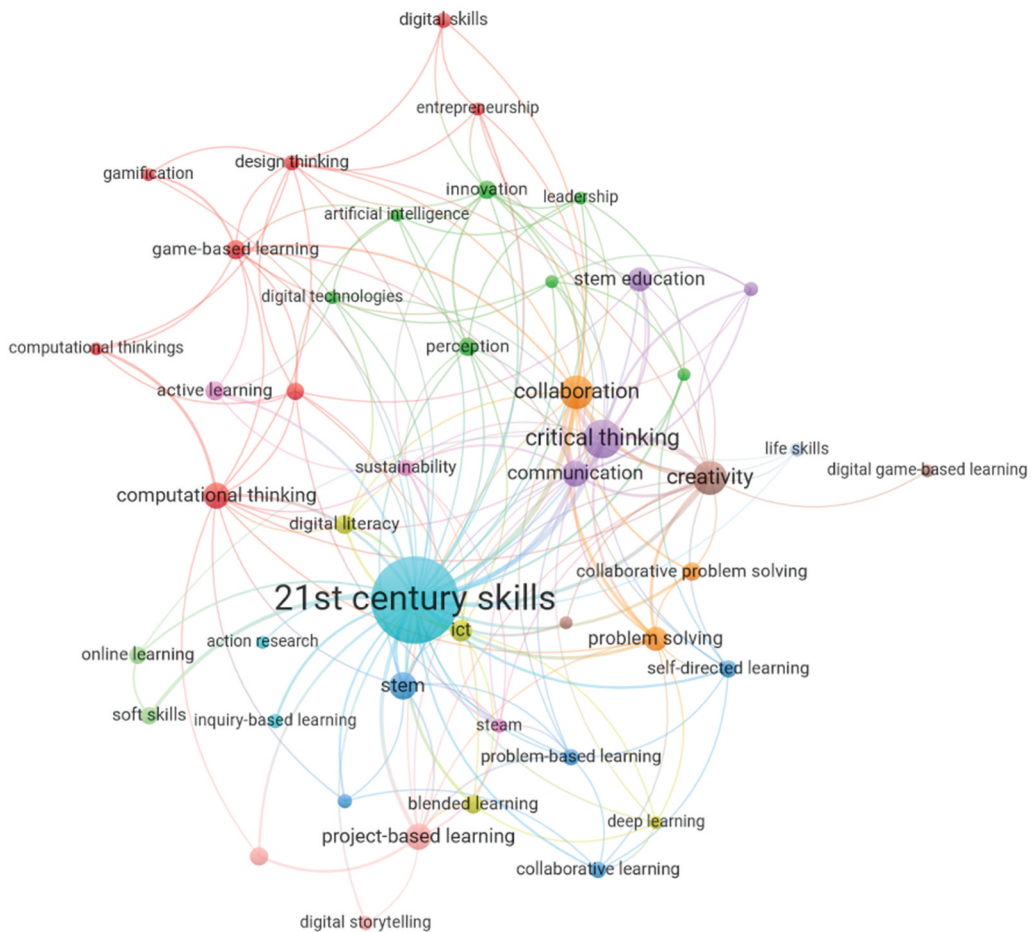
| Journal                                                           | %      | 2023 SJR ImpFactor | CiteScore quartile |
|-------------------------------------------------------------------|--------|--------------------|--------------------|
| <i>Sustainability Switzerland</i>                                 | 12,90% | 0.672              | Q1                 |
| <i>Education and Information Technologies</i>                     | 11,29% | 1.301              | Q1                 |
| <i>Education Sciences</i>                                         | 3,23%  | 0,669              | Q1                 |
| <i>International Journal of Emerging Technologies in Learning</i> | 3,23%  | 0,536              | Q1                 |
| <i>Computer Applications in Engineering Education</i>             | 3,23%  | 0,715              | Q1                 |
| <i>BMC Medical Education</i>                                      | 3,23%  | 0,935              | Q1                 |
| <i>Retos</i>                                                      | 3,23%  | 0,383              | Q1                 |
| <i>Computers and Education</i>                                    | 1,61%  | 3,651              | Q1                 |
| <i>Computers in Human Behavior</i>                                | 1,61%  | 2,641              | Q1                 |
| <i>Applied Sciences Switzerland</i>                               | 1,61%  | 0,508              | Q1                 |

**Table 3.** Benefits of gamification in developing 21st century skills.

| Benefit/Skills                  | # mentions | Percentage |
|---------------------------------|------------|------------|
| Foster innovation               | 66         | 38%        |
| Improved problem-solving skills | 16         | 9%         |
| Better collaboration            | 57         | 33%        |
| Enhanced critical thinking      | 39         | 22%        |
| Improved communication skills   | 98         | 56%        |
| Enhanced motivation             | 82         | 47%        |
| Promote active participation    | 37         | 21%        |
| Strengthen metacognitive skills | 3          | 2%         |
| Enhanced creativity             | 20         | 12%        |
| Increased engagement            | 79         | 45%        |
| Improved digital literacy       | 26         | 15%        |
| Enhanced information management | 22         | 13%        |
| Increased adaptability          | 21         | 12%        |

and capabilities related to innovation and data science. In more detail, Table 3 shows the benefits of 21st-century skills that were identified in the studies reviewed.

Furthermore, using the VOSviewer software and analyzing the articles extracted from Scopus related to the search for “21st-century skills,” other relationships between concepts are shown in Figure 3. When analyzing this visualization map and comparing it with the document review, it

**Figure 3.** Visualization map about 21st-century skills.



became evident that the skills with the highest co-occurrences in research are creativity, collaboration, communication, and critical thinking.

For the time being, this article only addresses creativity within the framework of developing 21st-century skills, which is related to the ability to put imagination, curiosity, reflection, novelty, and originality into parallel functions (Valero Matas, 2019); these are some of the main characteristics that distinguish human beings from other species, since it also contemplates the power of creation. This ability mainly allows human beings to survive and be able to think differently and transform their environment.

Education is plagued with didactics that often overlook the development of creative skills in students. From the different areas of knowledge, teachers must understand the importance of fostering creativity in students (Villacrez Oliva, 2017). From the perspective of 21st-century skills, one of the objectives of current didactic strategies should be contributing to an increase in students' creativity and motivation (Morlà Folch et al., 2018). For Valero Matas (2019), creativity consists of "finding procedures or elements that allow us to perform tasks differently from the usual way to achieve a certain objective" (p. 153). Therefore, a creative person tends to develop and strengthen other skills that allow them to have more self-confidence, as well as cultivate a constant sense of curiosity.

In this vein, teachers are faced with the challenge of thinking about strategies that allow them to strengthen students' creativity in such a way that they acquire the ability to face a great diversity of scenarios with different solution options, notify new ideas, and recognize diverse representations; in addition, it allows them to articulate it with the effective use of information, collaborative work, decision-making, interaction, knowledge production, ethical sensitivity, environmental care, and the use of resources, among other skills that are also part of the purpose of educating for the 21st century (Chaverra-Fernández & Gil-Restrepo, 2017). In this sense, Avila and Puertas (2020) propose that the fundamental task of the teacher is to identify students' abilities and foster a positive attitude in them to acquire the willingness to learn in a meaningful way, thus further developing their skills.

Taking into account the mentioned challenges, it becomes necessary for academia to think about methodologies that allow both teachers and students to use different skills to strengthen them and contribute to excellence and relevance in education (Yordanova & Durakovic, 2020). Therefore, within the framework of active methodologies, this article proposes considering gamification as a way to take on these challenges.

### ***Gamification and the strengthening of 21st-century skills***

Gamification in the field of education is understood as the use of game elements in non-game contexts to improve motivation, engagement, and learning (Parody et al., 2022). In other words, it is about using game techniques and mechanics in situations that are not games themselves, to increase participation and improve the learning experience.

Gamification, as a way of using the key principles or components of games in educational spaces that are not games, is not limited to a particular area; it can be used in any school subject to make learning more attractive and interactive. Although it may be commonly associated with subjects such as mathematics, natural sciences, or foreign languages, due to the number of investigations that take place, its application can be strengthened in subjects such as literature, social sciences, and history. For example, literature teachers can use gamification to encourage students to read more books or write more essays, while social science teachers can use gamification to help students learn about historical events or cultural practices. The key is to identify the learning objectives and design game mechanics that align to create an entertaining and engaging learning experience for students (Kingsley & Grabner-Hagen, 2015).

Scholars on the stages of human development have agreed that children naturally resort to play, thereby strengthening motor, sensory, and cognitive skills and abilities. Considering this, Liberio Ambuisaca (2019), in his study with early education students, states that gamification "is considered as



a didactic and motivational strategy that serves to obtain adequate behaviors in students by promoting attractive environments where participants get involved, obtaining favorable learning results” (p. 394).

Pasmíño Sánchez (2021) affirms that the use of gamification helps in the development of cognitive and metacognitive skills in students, directly influencing their learning, maintaining active participation, and improving their motivation. So gamification, beyond being a tool for recreation and entertainment, is attributed with characteristics that make it an active and effective teaching model in classrooms.

Along the same lines, Zepeda Hurtado et al. (2022) determined that gamification greatly contributes to the development of skills such as collaborative work, written and oral communication, as well as leadership in a technology-mediated context. In other words, gamification in the educational process allows students to develop skills and learn more effectively and enjoyably, as it allows for generating a pleasant and trusting work environment that facilitates the work of teachers (Núñez Linares, 2019).

When analyzing the Scopus articles where the keywords “21st-century skills” and “gamification” were related, a following network map was generated, as shown in Figure 4.

Once the network visualization map generated by VOSviewer was analyzed, three clusters were identified that group the scientific interest of the reviewed articles:

- (1) Educational innovation, where the creation of physical and/or virtual gamified environments is evidenced for the construction of 21st-century skills in students. Some of the research even proposes, within the framework of gamification, using an escape room approach for educational purposes to develop skills in students (M. R. D. F. D. Cruz, 2019; Fotaris & Mastoras, 2022), and suggests using the principles of design thinking for its design.
- (2) Teaching challenge, where the challenge of designing catalyzing digital scenarios or environments for students is mentioned to motivate and involve learning, to effectively evaluate students in collective tasks (Mårell-Olsson, 2021), and to adapt a curriculum into missions with badges, rewards, and experiences that demonstrate a learning process (Kingsley & Grabner-Hagen, 2015).
- (3) Pedagogical balance, with commitment given to the reflection on the implementation and evaluation of scenarios that involve the context of the students, on the use of educational

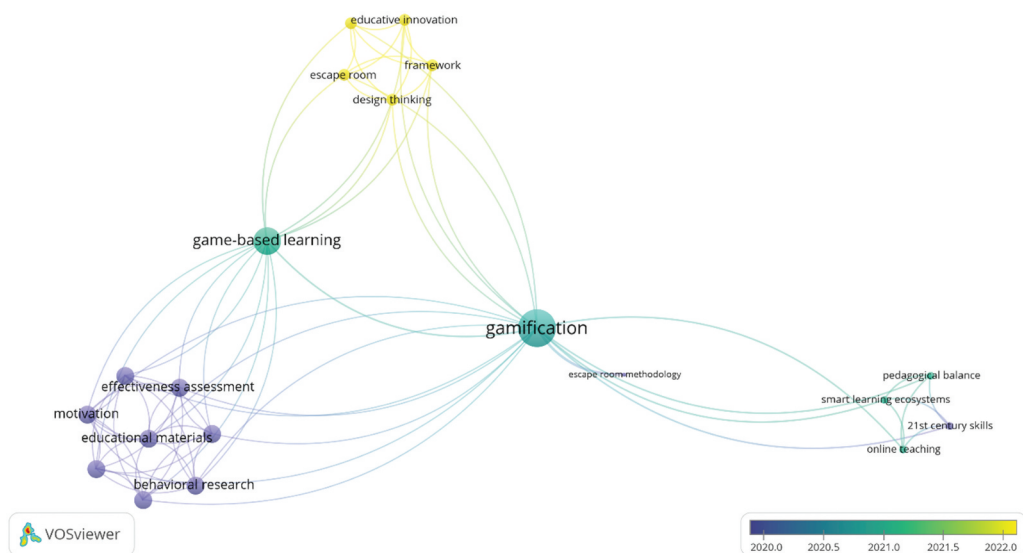


Figure 4. Visualization map about gamification and 21st-century skills.

material adapted to the interest of the students (Gumbi et al., 2024), and on the organization or combination of physical or virtual scenarios, which can include e-learning (online learning), m-learning (mobile learning), b-learning (blended learning), or smart learning (intelligent learning).

### ***The role of the teacher and AI in gamified virtual environments***

Within gamified virtual environments, the role of the teacher necessarily changes in the face of this new reality, since the role of the teacher is changed to facilitator of student learning. The challenge posed by these new learning methodologies demands from the teacher a set of necessary competencies and skills, such as digital competence, content knowledge, cultural awareness, and professional commitment, to face the strong change of scenario in which the new training processes supported by ICT are developed (Fernández-Batanero et al., 2022; Velásquez Arboleda, 2019).

For his part, Salinas (2011) expresses that a virtual gamified model should be centered on student learning and that the role of the teacher, above all, should become a facilitator of learning, where they need to incorporate students' contexts and guide them in the execution of the activities that such scenarios entail, in such a way that they manage to obtain the intended goals. In this way, they overcome the traditional role of transmitter of information and become a creator of learning opportunities.

Therefore, the role of the teacher emerges as a transcendental one in the success of the student's formative experiences; the teacher becomes a tutor capable of designing and moderating virtual environments that motivate students, through the incorporation of tools, to participate within the framework of a learning community, in which knowledge is built (Quiroz, 2010). This is how the 21st-century teacher is characterized as a person who specializes in identifying and selecting those techno-educational opportunities that make the learning and teaching process attractive and motivating. Furthermore, they can critically rethink their pedagogical work to guide their students to reach the skills necessary for inclusion in society, which is in indelible evolution.

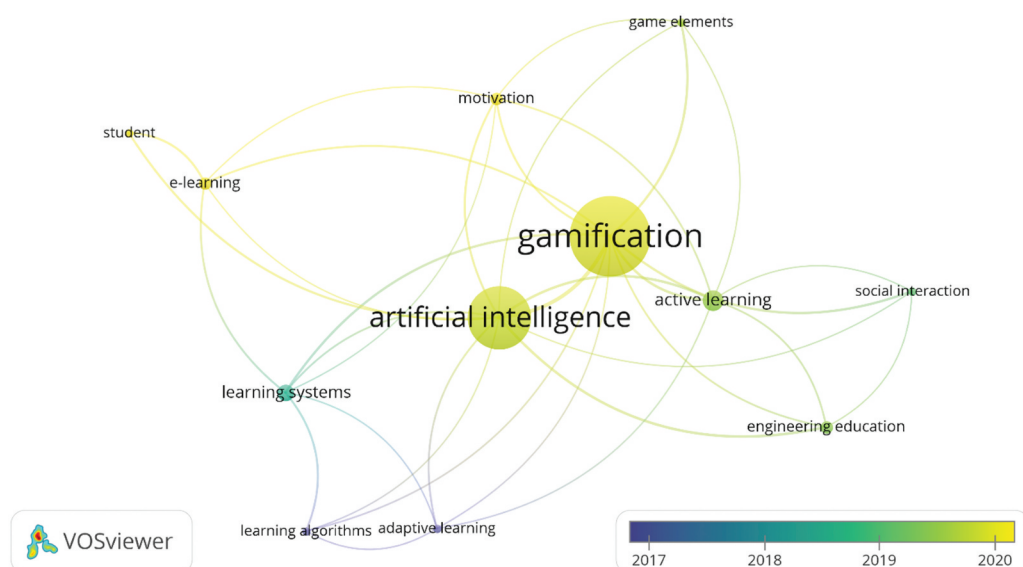
Zhai et al. (2021) define AI as the ability of machines to simulate human intelligence, including perception, reasoning, learning, problem-solving, and decision-making. Additionally, they mention that AI applies technologies, such as machine learning, data mining, natural language processing, and computer vision, to enable machines to perform tasks that would normally require human intelligence.

Likewise, Opešemowo and Adekomaya (2024) state that AI can be an effective learning tool that would alleviate the burdens of both teachers and students, since it could offer effective learning experiences for students, allowing for the digitalization of educational resources, the creation of new gamification developments, and personalized learning experiences.

AI in the education sector has been applied through intelligent tutors that provide personalized learning experiences (Singh et al., 2022), systems that analyze student data and provide feedback (Songer et al., 2020), chatbots or virtual assistants that support student learning (Jeon, 2024), and it has been incorporated into gamification to allow for personalized adaptation of games according to the individual needs and abilities of students (M. Cruz & Orange, 2016).

The opportunities to incorporate AI in the classroom have to do with the ability to provide personalized learning scenarios (Ayuso Del Puerto & Gutiérrez Esteban, 2022; Dichev et al., 2020; Singh et al., 2022), incentivize student participation (Daghestani et al., 2020; Yu et al., 2021), improve motivation in teaching-learning processes (López & Tucker, 2019), support teachers with tools to strengthen expected learning (Zhai et al., 2021), and face challenges related to privacy, surveillance, bias, and discrimination (Akgun & Greenhow, 2022).

However, there is also some resistance among teachers regarding conceptions related to the possibility that AI will replace human teachers in the face-to-face classroom and especially virtual teachers, concerns about the costs of implementing AI in classrooms and especially in rural classrooms without connectivity generating gaps, lack of knowledge about AI tools for education in general, and



**Figure 5.** Visualization map about artificial intelligence and gamification-related network.

the challenge of teacher training on these technological tools for appropriate use in the classroom (Songer et al., 2020; Zhai et al., 2021). In addition, resistance also arises from concern about possible changes to the educational relationship (Grassini, 2023) and to teacher policies and teacher training (Heimans et al., 2023). Some of these relationships are shown in Figure 5, which was elaborated as a visualization map of the network on AI and gamification based on the articles analyzed using VOSviewer.

Upon reviewing the visualization map and analyzing the research studies, the following can be evidenced: although the research mentions that within the framework of implementing gamification and AI in the classroom, active learning is present to improve skills, learning outcomes, and student participation (Clarke et al., 2022; De Santo et al., 2022), and that social interactions and interactions with AI must occur in said implementation (Seiffert & Nothhaft, 2015), there are still few studies that have explored how gamification can be useful for addressing the challenges faced by the incorporation of AI in the classroom (Zhai et al., 2021), and there are few scientific articles where a possible common path or route can be evidenced in the creation and implementation of gamified AI scenarios for education. Even though one of the studies proposed using social networks to approach some AI tools within extracurricular activities (Ng & Chu, 2021), there are still no studies that allow determining socio-affective and/or emotional issues that need to be taken into account when designing and/or using gamification with AI in the classroom. Social interactions from a gamified scenario with AI could lead to negative social appraisals that prevent participation among students.

## Discussion

The integration of gamification and AI in education presents a transformative approach to developing 21st-century skills, which have become increasingly crucial in our rapidly evolving global landscape. This review has explored the intricate relationships between these innovative pedagogical strategies and the cultivation of essential competencies for the modern world. As we delve into the implications of our findings, it becomes evident that while this synergy offers unprecedented opportunities for enhancing learning experiences, it also poses significant challenges that require careful consideration. In the following discussion, we will examine the multifaceted nature of 21st-century skills, the potential of gamification in fostering these abilities, and the complex role of teachers and AI in

shaping gamified virtual environments. By critically analyzing these aspects, we aim to provide a comprehensive understanding of the current state of educational innovation and its implications for the future of learning.

### ***21st-century skills and their strengthening: The AI advantage***

The development of 21st-century skills has undeniably become a global educational priority, with organizations like the OECD, ATCS21, ISTE, and UNESCO emphasizing critical thinking, problem-solving, information management, collaboration, and creativity as essential competencies. In this context, AI offers unprecedented opportunities to enhance the development of these skills (Caro et al., 2023).

Thus, as mentioned by Tapalova and Zhiyenbayeva (2022), AI-powered systems can provide personalized learning experiences that adapt to individual students' needs, thereby more effectively fostering critical thinking and problem-solving skills. For instance, AI algorithms can analyze student performance data to identify areas where critical thinking skills need improvement and generate tailored exercises to address these gaps. Moreover, according to Alrassi et al. (2021), AI can significantly bolster information management skills by simulating complex information ecosystems within learning environments. This allows students to practice gathering, analyzing, and applying data in realistic scenarios, thereby honing their information literacy skills crucial for the digital age.

However, the integration of AI in skill development also raises concerns about potential over-reliance on technology. As Chaverra-Fernández and Gil-Restrepo (2017) note, it's crucial to balance technological assistance with human-guided learning to ensure holistic skill development, including aspects like ethical sensitivity and creativity that may be challenging for AI to fully nurture.

### ***Gamification and the strengthening of 21st-century skills: AI as a game-changer***

Gamification emerges as a promising strategy for developing 21st-century skills, and the addition of AI amplifies its potential significantly. Regarding the above, AI can enhance gamified learning experiences by offering dynamic, personalized adaptations that continually challenge students and promote skill development (Benvenuti et al., 2023).

For instance, AI algorithms can analyze student performance in real-time and adjust game difficulty or introduce new challenges accordingly, ensuring that students are always operating in their zone of proximal development. This personalized approach can significantly enhance motivation and engagement, key factors in successful gamification (Parody et al., 2022). Furthermore, AI can revolutionize the assessment of skills within gamified environments. Machine learning algorithms can analyze complex patterns of student behavior during gameplay, providing insights into skill development that might be difficult for human observers to discern and leading to more accurate and comprehensive assessments of 21st-century skills.

However, the integration of AI in gamification also presents challenges. For example, there is a risk of creating a digital divide, where students with access to advanced AI-enhanced gamified learning have an advantage over those without. Additionally, as Kingsley and Grabner-Hagen (2015) suggest, it's crucial to ensure that game mechanics align with learning objectives, because with AI, this alignment becomes more complex and requires careful design to ensure that AI-driven adaptations consistently support pedagogical goals.

### ***The role of the teacher and AI in gamified virtual environments: A delicate balance***

Regarding the teacher's role, the integration of AI in gamified virtual environments is redefining the whole scenario of teaching practice. As Firat (2023) observes, teachers are evolving from knowledge transmitters to learning facilitators. In this new paradigm, AI can provide teachers with data-driven insights, enabling more targeted and personalized support to students. In this

context, AI can assist teachers in several ways within gamified environments. As examples of the above, it can automate administrative tasks, freeing up time for more meaningful interactions with students. Also, AI can also provide real-time analytics on student performance, helping teachers identify struggling students or areas that need more attention. Moreover, AI can suggest personalized learning paths for each student based on their performance in gamified activities.

However, the implementation of AI in education also raises significant challenges. Issues of data privacy and AI bias need careful consideration (Wang et al., 2024). There's also a need for extensive teacher training to ensure effective use of AI tools. Moreover, there are concerns about AI potentially replacing human teachers, especially in virtual settings (Songer et al., 2020; Zhai et al., 2021).

To address these challenges, we propose:

- (1) Developing comprehensive professional development programs that equip teachers with skills to effectively use AI and gamification
- (2) Establishing robust ethical guidelines for the use of AI in educational settings
- (3) Conducting ongoing research to evaluate the long-term impacts of AI-enhanced gamification on skill development.

As a final insight, it is noteworthy to mention that while the integration of AI in gamified learning environments offers immense potential for developing 21st-century skills, its success depends on thoughtful implementation that balances technological innovation with sound pedagogical principles. As we navigate this new era of education, it's crucial to leverage AI as a tool to enhance, rather than replace the irreplaceable role of human teachers in nurturing well-rounded, skilled individuals prepared for the challenges of the 21st century.

## Conclusions

The findings underscore the significant potential of integrating gamification and AI in education to foster 21st-century skills. These results are of paramount importance as they illuminate the evolving landscape of educational technology and its capacity to address the pressing need for developing critical competencies in learners. The analysis of 21st-century skills, particularly creativity and collaboration, reveals their centrality in preparing students for the challenges of a rapidly changing world. Furthermore, the exploration of gamification's role in skill development and the potential of AI to enhance personalized learning experiences provides valuable insights for teachers and policymakers alike.

As we reflect on the findings, it becomes evident that the convergence of gamification and AI offers a promising avenue for transforming education. However, as widely mentioned in literature, this potential must be tempered with a careful consideration of the challenges involved, including issues of data privacy, AI bias, and the need for extensive teacher training. The discussion's exploration of these challenges aligns with the introduction's call for a balanced approach to educational technology integration.

Looking ahead, the implications of this research are far-reaching. For educational institutions, there is a clear imperative to invest in both technological infrastructure and professional development programs. Curriculum designers are challenged to reimagine course structures that incorporate gamification and AI while maintaining alignment with broader educational goals. Teachers, as highlighted in both the introduction and discussion, must adapt to new roles as facilitators of learning in technologically enhanced environments. Students, in turn, need support in developing the digital literacy and self-directed learning skills necessary to thrive in these new educational paradigms.

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