Bibliometric Analysis of Scientific Trends in Educational Games: A Comprehensive Roadmap and Trend Identification

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Abstract

This study aims to analyze research trends in the field of educational digital games, as indexed in the Web of Science (WOS) database, from 2005 to 2025, using bibliometric analysis. A total of 906 publications were analyzed, with their distribution over the years, author productivity, country contributions, citation impact, keyword networks, and emerging trend themes assessed. The findings indicate that the number of publications in the field has increased significantly, notably since 2016, and that interest in digital learning and game-based instruction has risen rapidly since 2020, primarily due to the COVID-19 pandemic. Spain, China, and Taiwan are among the most productive countries, while the researchers with the most publications include Martí-Parreño J., Hwang G.J., and Hamari J. The keyword occurrence network showed that research on educational digital games mainly focuses on the concepts of "gamification", "motivation", "learning outcomes", and "student engagement". Based on trend analysis, "virtual reality", "self-determination theory", and "student engagement" are the fastest-growing themes in recent years. In contrast, "educational games", "computer games", and "e-learning" are established themes that form the traditional foundation of the field but currently attract less interest. The results indicate that the field of educational digital games is experiencing a theoretical and pedagogical shift driven by technological advances. While early studies focused on hardware and content design, current research emphasizes student experience, motivation, and sustainable learning. These findings suggest that future game-based learning research will be shaped by virtual reality, self-determination theory, and experiential teaching methods.

Keywords: Educational digital games, gamification, motivation, bibliometric analysis, trend analysis

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Introduction

Over the past two decades, rapid advances in digital technologies have led to significant changes in teaching methods, and the game-based learning (GBL) approach has emerged as a key model in education. Educational digital games are defined as innovative learning tools that increase students' motivation, create interactive learning environments, and support cognitive development (Prensky, 2001). Studies reveal that educational digital games have positive effects on students' learning achievement, motivation, problem-solving skills, and higher-level cognitive processes such as critical thinking (Annetta et al., 2014; Hamari et al., 2016; Qian & Clark, 2016). For example, a meta-analysis of 33 studies conducted by Wang et al. (2022) in the context of STEM education found that digital game-based learning had a medium effect size (ES = 0.667, 95% CI [0.520–0.814]) compared to traditional teaching methods. Similarly, a meta-analysis of 86 studies (136 effect sizes) conducted by Gui et al. (2023) showed that digital educational games are moderately to highly effective in STEM learning (g = 0.624), and that game design elements (e.g., conceptual maps, feedback mechanisms, adaptive tasks) play a decisive role in this effectiveness.

Studies conducted at the higher education level also reach similar conclusions. A systematic review by Vlachopoulos & Makri (2017) and colleagues revealed that game- and simulation-based instruction had positive effects on learning outcomes and student satisfaction, but methodological variation was high across studies. Furthermore, research by Al-Khayat et al. (2023) suggests that educational digital games promote high levels of interaction, collaboration, and problem-solving skills in students, and that these effects are particularly strengthened by motivation. These findings clearly demonstrate that educational digital games can be considered an effective tool in learning processes. However, some significant gaps in the literature are evident:

- Most research is based on short-term experimental applications, and long-term effects have not been adequately examined.
- Longitudinal bibliometric analyses demonstrating the development of the field are limited.
- It is rare to evaluate studies from different disciplines within the framework of a holistic trend analysis.
- Inadequate reporting on the design elements of educational games (mechanics, feedback, story structure, etc.) complicates the comparability of studies (Gui et al., 2023).

Therefore, in addition to evaluating the effects of specific applications within the field, it is imperative to explore the evolution of scholarly production trends and thematic orientations in educational digital games over time. The rapid expansion of distance education and digital learning platforms, particularly following the COVID-19 pandemic, underscores the strategic prominence this field has attained in both academic discourse and practical educational policymaking.

Notwithstanding the exponential proliferation of research in educational digital games, indicators such as the distribution of these publications by year, changes in research intensity, and the evolution of trend themes have not been systematically examined. The current gap in the literature highlights the lack of a comprehensive overview of the years in which the field gained momentum, when it stagnated, and what thematic trends it holds for the future. Furthermore, a longitudinal analysis of studies within authoritative databases, such as the Web of Science (WOS), is crucial for understanding the scientific maturation process and the interdisciplinary expansion of educational digital games. Accordingly, the present study seeks to provide a holistic perspective on the field by analyzing the quantitative trends and the evolution of publications on educational digital games in the WOS database between 2005 and 2025.

The primary objective of this study is to examine the annual distribution, research trends, and shifts in trends of academic publications in the field of Educational Digital Games, published between 2005 and 2025, based on the WOS database. This research encompasses the following sub-objectives:

- To reveal the quantitative change in publications on educational digital games between the specified years.
- To determine the periods in which the field exhibited growth or stagnation.

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- To identify emerging and traditional themes through trend analyses.

The research findings are expected to guide researchers working in the field of educational digital games regarding future research directions and priority areas for research. Furthermore, as digital learning ecosystems become increasingly widespread, such analyses provide policymakers and educational technology developers with essential data for informed decision-making.

Method

This study employed Bibliometric Analysis, a quantitative research approach, to examine the development of academic production and thematic focuses in the field of educational digital games. Bibliometrics allows for the analysis of scholarly communication processes and dynamics based on the quantitative characteristics of published documents. The study aimed to generate findings in two main categories:

1. Performance Analysis: Identifying productivity trends (annual number of publications, most productive authors/institutions/countries) and impact (most cited publications) in the field.

2. Trend and Relationship Analysis: Identifying the conceptual and thematic structure (keyword association) and current research trends (emerging trends/year deviation) in the field.

3. Data Collection.

The dataset was compiled from the WOS Core Collection database, the most reliable and comprehensive primary source of scientific literature, providing data in a format compatible with bibliometric software. The logical search string, designed to cover all the fundamental concepts used in the field and to search only the Title, Abstract, and Keywords (TS) fields, is presented below:

$$\text{(educational game* OR learning game* OR serious game* OR "game-based learning" OR "digital game based learning" OR gamification OR "applied game*")}$$

To enhance the consistency and academic quality of the dataset, the following limitations were applied:

- Timeframe: The study covered the years 2005 to 2025 to provide a holistic picture of developments in the field.

- Document Type: The "Article" and "Review" types were selected to focus only on comprehensive academic studies. Proceedings, book chapters, and editorial materials were excluded from the analysis.

- Language: Only publications in "English" were included to ensure data consistency and standardization.

The applied filters resulted in a final dataset containing a total of 906 publications for analysis. All records obtained from WOS were exported in Plain Text format with the "Full Record and Cited References" option selected, which is mandatory for bibliometric network analyses. The downloaded raw data was prepared for analysis using data cleaning, Python (Pandas), and VOSviewer. In this preparation phase, the Keywords (DE, ID) and Publication Year (PY) tags were specifically filtered to ensure that the data fields required for Bibliographic Matching and Trend Detection analyses were correctly parsed.

Findings

In this section of the study, the studies were analyzed based on their bibliometric characteristics. This analysis answered the research questions and presented relevant evaluations. The findings, based on the questions formulated in line with the primary objectives of the study, are systematically presented under separate subheadings.

Publication Trend by Year

The distribution of publications indexed in the WOS database between 2007 and 2025 in the field of Educational Digital Games is given in Figure 1.:

Figure -1

Publication Trend by Year
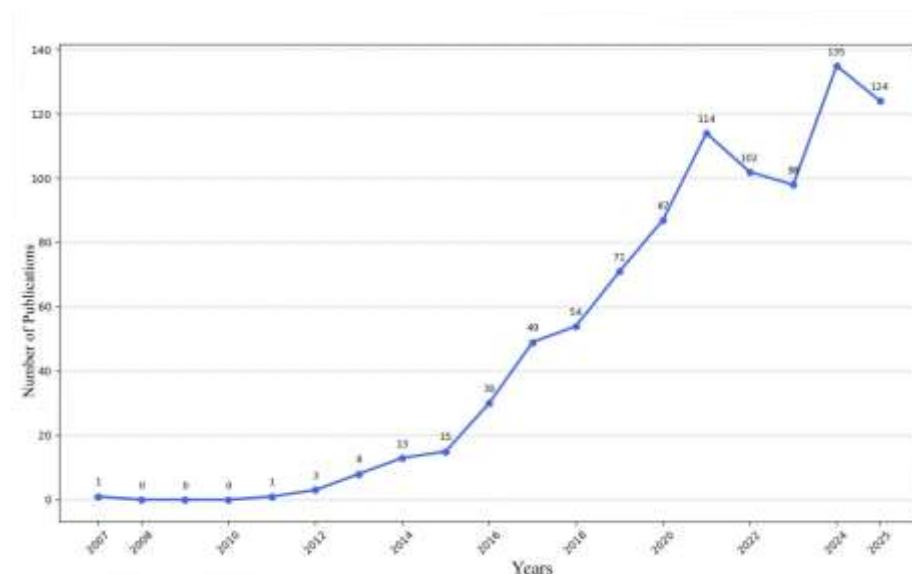
An examination of the graph in Figure 1 reveals a consistent upward trajectory in scholarly output within the field. The number of publications was relatively low between 2007 and 2011, during a period when the topic was beginning to be discussed in the academic field. These years can be considered the discovery and conceptualization phase of educational digital games. A gradual increase in the number of publications began in 2012. A significant acceleration was observed, particularly after 2016. This increase can be attributed to the proliferation of empirical studies on the usability of digital games in education, as well as the widespread adoption of technology-supported learning environments.

The number of publications increased to 87 in 2020 and 114 in 2021. This rapid increase demonstrates that distance education, digital learning tools, and game-based learning approaches have gained increased prominence on the educational agenda with the COVID-19 pandemic. The pandemic has led to the evaluation of educational digital games as a crucial tool for interaction, motivation, and accessibility in teaching processes. Although a minor fluctuation in publication volume was observed between 2023 and 2025, the overarching trajectory evinces a persistently elevated level of scholarly engagement. Reaching 135 publications in 2024 demonstrates the maturation of this field and its interaction with other disciplines (e.g., psychology, cognitive science, artificial intelligence, and game design). These findings indicate that the field of Educational Digital Games became a rising research theme after 2007 and entered a phase of scientific maturation and diversification after 2016.

Performance Analysis Results

This section presents detailed quantitative data from the results of the bibliometric performance analysis. The analysis identifies the most productive authors who contribute to the literature (e.g., authors who produce the most publications), the highest impact studies (e.g., the most cited publications), and other key performance indicators (journal, institution, or country-based productivity/impact metrics). The findings related to these indicators are systematically analyzed.

Top 10 Most Published Authors (AU)

Table 1.

Top 10 Authors with the Most Publications

Author	N
Martí-Parreño J	13
Hwang GJ	13
Hamari J	9

Sánchez-Mena A	7
Marconi A	6
Nguyen-Viet B	6
Russell-Bennett R	5
Tlili A	5
Fernández-Manjón B	5
Rosdi F	5

Table 1 lists the top 10 researchers who produced the most publications in the field of Educational Digital Games in the WOS database between 2005 and 2025. According to the data, Martí-Parreño J. and Hwang G.J. are the most productive authors in the field, with 13 publications each. They are followed by Hamari J. (9 publications) and Sánchez-Mena A. (7 publications). These results demonstrate that researchers based in Asia and Europe have established a strong production network in the field of educational digital games. Hwang G.J. leads the field in mobile learning, gamification, and digital learning design with his work based in Taiwan. Similarly, Hamari J. has authored highly cited studies in gamification theory and user motivation through his research in Finland (Hamari et al., 2016).

Martí-Parreño J. and Sánchez-Mena A. have contributed to business education, marketing education, and digital game-based learning in higher education, particularly through their research groups based in Spain. On the other hand, researchers like Marconi A., Nguyen-Viet B., Russell-Bennett R., Tlili A., Fernández-Manjón B., and Rosdi F. reflect the interdisciplinary diversity of the field. This distribution demonstrates that educational digital games are no longer solely focused on educational technology; they are also being studied in diverse fields, including marketing, engineering, psychology, and computer science. Furthermore, this global diversity in author productivity indicates that the field has evolved into an international research network.

Countries with the Most Articles Published

Table 2.

Top 10 Countries with the Most Publications

Country	N
Spain	260
China	131
Taiwan	116
Netherlands	94
Germany	80
Portugal	79
England	75
Italy	71
Canada	68
Brazil	67

Table 2 shows the top 10 countries producing the most publications in the field of Educational Digital Games in the WOS database between 2005 and 2025. According to the data, Spain is the most productive country in the field with 260 publications. It is followed by China (131 publications) and Taiwan (116 publications). Together, these three countries account for approximately 40% of the total production, playing a pivotal role in the global publication ecosystem of the field. Spain's leading position can be attributed to the European Union-supported research projects conducted across the country in recent years (e.g., game-based learning and digital pedagogies under Horizon 2020). Furthermore, the high productivity of Spanish researchers, such as Martí-Parreño J. and Sánchez-Mena A., has strengthened the country's institutional and academic contributions to the field.

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The prominent rankings of China and Taiwan underscore the robust momentum in gamification and digital learning research across the Asia-Pacific region. contributions from Asia-based scholars, including Hwang G.J. and Tlili A., have significantly augmented regional research productivity and propelled the proliferation of studies integrating game-based learning into STEM education. In Europe, countries such as the Netherlands (94), Germany (80), Portugal (79), the United Kingdom (75), and Italy (71) constitute the second cluster of studies on educational digital games. Research conducted in these countries generally focuses on subthemes such as instructional design, learning analytics, pedagogical modeling, and gamification within a cultural context.

Canada (68) and Brazil (67) from North America and South America, respectively, are also on the list, demonstrating the continental diversity of research production in the field of educational digital games. This finding demonstrates that game-based learning research is not limited to a specific geographic region but has evolved into a multi-centered research field on a global scale. Overall, production in the field of educational digital games has taken on a global character, with a strong research network centered in Europe, rising trends in Asia, and contributions from the Americas. This demonstrates that knowledge production in the field relies on international collaboration and that the topic is increasingly gaining traction across diverse cultural contexts.

Top 10 Most Cited Publications

Table 3.

Most Cited Articles

Title (TI)	Publication Year (PY)	Number of Citations (TC)
A Meta-Analysis of the Cognitive and Motivational Effects of Serious Games	2013	1044
Challenging games help students learn: An empirical study on engagement, flow and immersion in game-based learning	2016	996
An update to the systematic literature review of empirical evidence of the impacts and outcomes of computer games and serious games	2016	683
Revealing the theoretical basis of gamification: A systematic review and analysis of theory in research on gamification, serious games and game-based learning	2021	481
Gamification of health professions education: a systematic review	2021	303
Gamification in Science Education. A Systematic Review of the Literature	2021	280
Gamification in software engineering - A systematic mapping	2015	248
A systematic review of serious games in medical education: quality of evidence and pedagogical strategy	2018	215
Constructionist Gaming: Understanding the Benefits of Making Games for Learning	2015	207
Designing and integrating purposeful learning in game play: a systematic review	2016	199

Table 3 lists the top ten most cited studies in the field of "Educational Digital Games" in the WOS database between 2005 and 2025. According to the data, the highest-impact article in the field is "A Meta-Analysis of the Cognitive and Motivational Effects of Serious Games" (Wouters et al., 2013), which received 1,044 citations and significantly shaped the theoretical and methodological directions of research in this field. This study provided a comprehensive meta-analysis on the cognitive and motivational outcomes of serious games, thus serving as a foundational reference for many subsequent studies focusing on learning motivation, interaction, and learning success.

"Challenging games help students learn: An empirical study on engagement, flow, and immersion in game-based learning" (Hamari et al., 2016), which ranked second, stands out with 996 citations. This study empirically examined the concepts of flow and engagement in game-based learning, providing empirical support for the effects of educational digital games on the learner experience. In this

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respect, it spearheaded the broad adoption of psychologically grounded measurement frameworks in game-based learning scholarship.

The third-ranked study, "An update to the systematic literature review of empirical evidence of the impacts and outcomes of computer games and serious games," conducted by (Connolly et al., 2016), has received 683 citations. This systematic review evaluated the rapidly growing body of empirical research since 2009, revealing the general trends in the field and comparatively analyzing the effects of games on learning outcomes across various disciplines, including education, health, and engineering.

Among recent studies, the article "Revealing the theoretical basis of gamification" by Seaborn & Fels (2021) stands out with 481 citations. This study systematically classifies the theoretical frameworks used in gamification and serious game research, specifically explaining how psychological models, such as self-determination theory and flow theory, are applied in educational contexts.

Additionally, the 2021 study "Gamification in Science Education: A Systematic Review of the Literature" (Marconi et al., 2021), which has been cited 280 times, examined the effects of gamification in science education and identified a new, thematically focused research trend in this area. Studies focusing on interdisciplinary applications such as medical education (Akl et al., 2018) and software engineering (Pedreira et al., 2015) were also among the top 10. This finding demonstrates that educational digital games are not limited to education faculties or pedagogical research centers; they are also finding application in disciplines such as STEM, health, and engineering.

Overall, the most cited studies were published between 2013 and 2021. This period represents a period of both theoretical and methodological maturation for the field, with an increase in systematic reviews, meta-analyses, and empirical studies. This trend demonstrates the quantitative foundations of game-based learning research and the emergence of an increasingly robust evidence-based literature.

Keyword Co-Occurrence Analysis

Figure -2
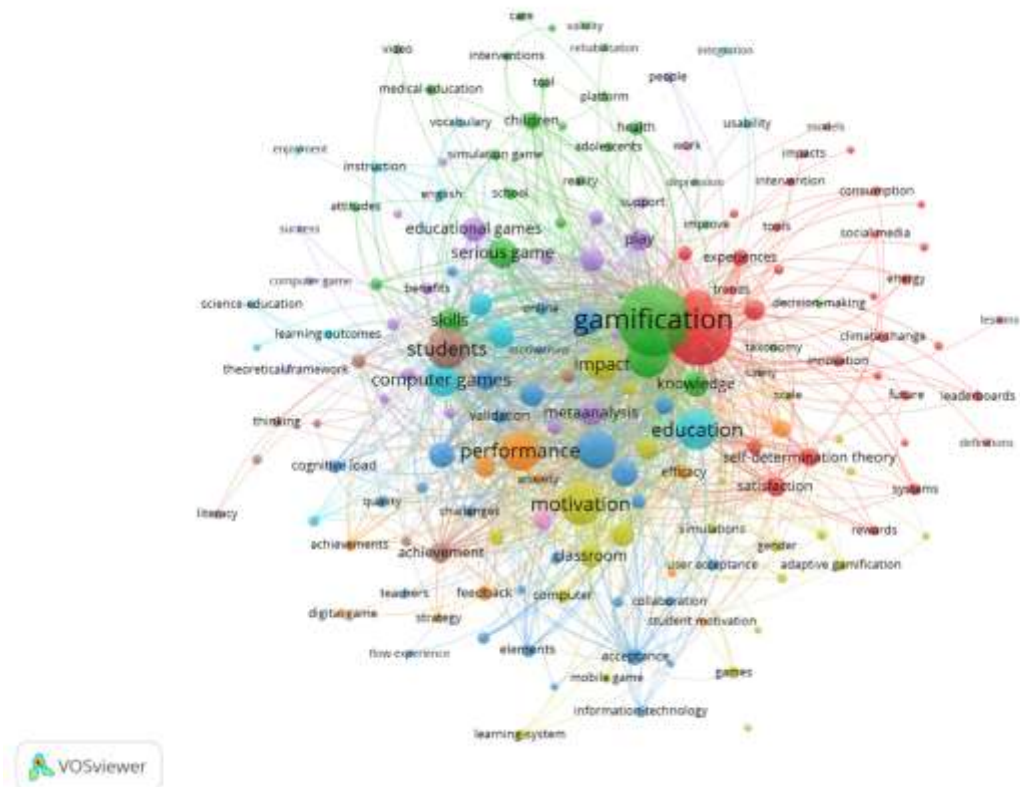
Keyword Co-Occurrence Analysis

Figure 2 visualizes the co-occurrence relationships between keywords used in the "Educational Digital Games" field between 2005 and 2025 using the VOSviewer program. More than 50 recurring keywords were included in the analysis. Node size represents the implementation of the keyword as a key, while the interruptions between nodes represent the occurrences between the words. The resulting visualization reveals that thematic focuses in the field are concentrated in five main clusters:

1. Gamification (green cluster): The concept of "gamification," located as the most central and largest node on the map, forms the core axis of educational digital game research. This concept is often highly associated with words such as education, knowledge, impact, performance, motivation, and students. This suggests that over the last decade, the concept of gamification has been addressed alongside variables such as motivation, achievement, and engagement in educational processes (Deterding et al., 2011; Seaborn & Fels, 2021).

2. Motivation and Performance (blue-yellow clusters): The second thematic cluster includes concepts such as motivation, performance, achievement, feedback, and flow experience. This cluster is based on empirical studies developed to explain the effects of educational digital games on learning outcomes. Self-Determination Theory and Flow Theory have formed the theoretical backbone of studies in this area (Hamari et al., 2016; Ryan & Deci, 2000).

3. Motivation and Performance (blue-yellow clusters): The second thematic cluster includes concepts such as motivation, performance, achievement, feedback, and flow experience. This cluster is based on empirical studies developed to explain the effects of educational digital games on learning outcomes. Self-Determination Theory and Flow Theory have formed the theoretical backbone of studies in this area (Hamari et al., 2016; Ryan & Deci, 2000).

4. Theoretical Foundations and User Experience (red cluster): This cluster, which encompasses concepts such as self-determination theory, satisfaction, engagement, innovation, and user acceptance, comprises studies examining the theoretical underpinnings and user

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experience dimensions of gamification applications. This theme was particularly prominent in systematic reviews conducted after 2020.

5. Interdisciplinary Applications (brown cluster): Words such as medical education, simulation, science education, digital literacy, and engineering, located around the map, indicate the application areas of educational digital games in various disciplines (e.g., health, science, engineering). This finding demonstrates that the field is not limited to educational sciences but has acquired an interdisciplinary character.

The keyword co-occurrence map reveals that educational digital game research is shaped around gamification-based learning, motivational processes, and learning outcomes. The rise of the concept of "gamification" to prominence after 2015 indicates that the field's focus has shifted toward integrating game mechanics into learning environments.

Author Cluster Analysis
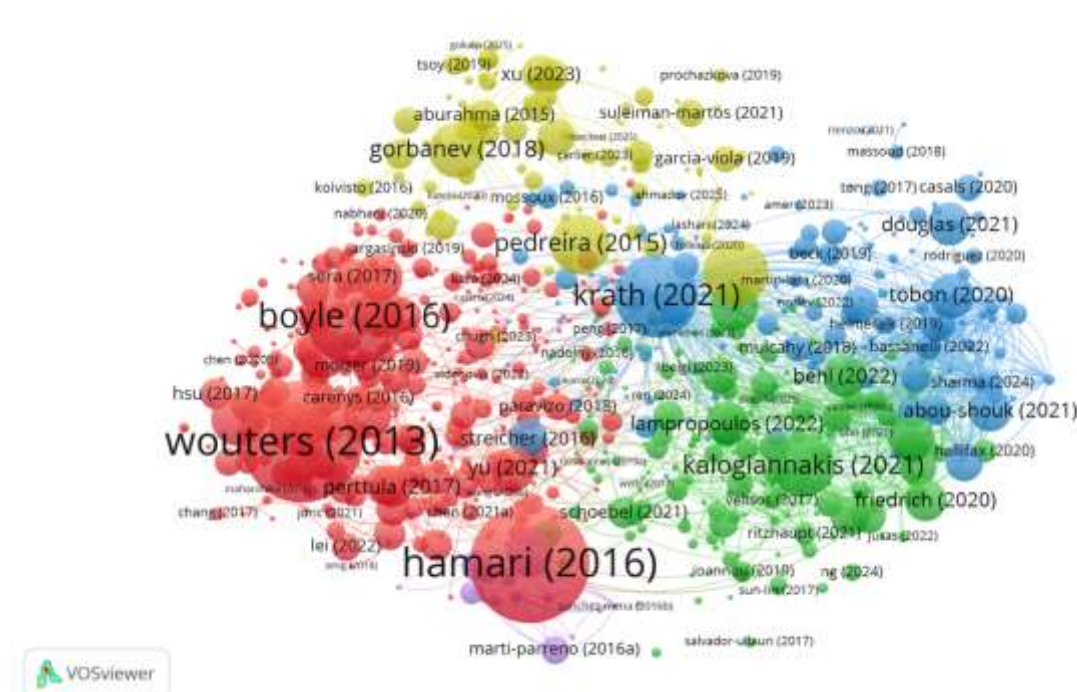
Figure -3

Author Cluster Analysis

Figure 3 presents a cluster map showing co-citation relationships among authors cited in at least five studies in the field of educational digital games. This map, created using VOSviewer, illustrates the primary research groups in the field and the density of relationships between them. The size of the nodes represents the number of citations by the authors, and the colors represent different research clusters. The analysis revealed four main author clusters in the field:

Red Cluster – Early Game-Based Learning Approaches (2010–2017): At the center of this cluster are (Boyle et al., 2016), (Hamari et al., 2016), and (Wouters et al., 2013). This cluster represents the foundational theoretical and empirical work in the field of game-based learning and serious games. A meta-analysis by Wouters et al. (2013) systematically examined the cognitive and motivational effects of educational digital games, providing the first theoretical framework for the field. (Hamari et al., 2016) examined the motivational effects of the concept of gamification in educational environments, guiding research in this field.

Green Cluster – Educational Technologies and Gamification Applications (2018–2023): This cluster includes researchers such as Kalogiannakis et al. (2021), Lampropoulos et al. (2022), Behl et al. (2022), and Abou-Shouk & Soliman (2021). This group's work focuses on the use of gamification,

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particularly in the context of online learning, STEM education, and digital pedagogy. (Kalogiannakis et al., 2021) and the working group provided a current direction for the field by examining the pedagogical effects of digital game-based learning in science education and distance education. This cluster represents the rapid increase in the use of digital game-based teaching applications in the post-2020 period, driven by the COVID-19 pandemic.

Blue Cluster – Systematic Reviews and Literature Mapping Studies (2019–2024): This cluster, which includes researchers such as Krath et al. (2021), Pedreira et al. (2015), and Tobon et al. (2020), focuses on systematic reviews and meta-analyses in the field of educational digital games. The studies in this group aim to explain the conceptual intersections between gamification, serious games, and computer-based learning and to examine trends in the field using bibliometric methods. Krath et al. (2021) holistically evaluated the theoretical foundations and methodological orientations of educational game research.

Yellow Cluster – Interdisciplinary and Applied Approaches (2018–2025): This cluster comprises authors such as Gorbanev (Gorbanev et al., 2018), Xu et al. (2023), and Tsoy et al. (2019), with a primary focus on gamification applications in fields including healthcare, engineering, and management. This group demonstrates the utility of educational digital games not only in educational settings but also in corporate training, health informatics, and professional development.

The author cluster map demonstrates that educational digital games research has evolved from theoretical foundations to practical application over time. Fundamental theories and models were developed between 2013 and 2017, and these theories were tested in various contexts after 2018. Furthermore, the increase in interdisciplinary collaborations after 2020 demonstrates that research communities in the field have evolved into a multi-centered and global structure.

Emerging Research Trends (Trend Analysis)

The keywords with the highest positive deviation (i.e., the youngest) that emerged in the field of educational digital games over the last decade are shown in Table 4. The further the average publication year value has shifted from the field's general average (to the present day), the more prominent that concept is as a current research trend.

Table 3.

Rising Trends

Keyword	Usage Count	Average Year	Deviation (Trend Strength)
virtual reality	13	2023.38	2.09868
self-determination theory	21	2023.05	1.76168
student engagement	11	2023	1.71406
self-determination	11	2022.82	1.53224
experience	13	2022.62	1.32945
science	15	2022.47	1.18073
skills	20	2022.35	1.06406
sustainability	10	2022.3	1.01406
cognitive load	12	2022.25	0.964062
higher-education	15	2022.13	0.847396
game	24	2022.04	0.755729
behavior	13	2022	0.714062
gamification	414	2021.9	0.612613
simulation	27	2021.89	0.602951
intrinsic motivation	42	2021.86	0.571205

The deviation value in the table quantifies the extent to which the mean publication year of a given keyword diverges from the overall mean publication year of the field. This metric numerically signifies the recency or novelty of the associated trend within the research domain. The analysis results reveal

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that research trends focused on experience-based, motivational, and technological innovation have gained strength, particularly in the post-2021 period. The overall average publication year for the field is 2021.29. The concepts with the highest trend strength are:

1. Virtual Reality (Average Year: 2023.38; Deviation: +2.10): The concept of "virtual reality" has been the fastest-rising theme in educational digital games literature in recent years. The use of augmented and virtual reality technologies in gamified learning environments is at the center of research aimed at increasing students' cognitive engagement and experiential learning. This trend represents the technological transformation of game-based learning.

2. Self-Determination Theory (Average Year: 2023.05; Deviation: +1.76): Self-Determination Theory (SDT) has recently become the dominant theoretical framework explaining the psychological basis of motivation in gamification research. In particular, the role of autonomy, competence, and relatedness in increasing students' intrinsic motivation has been frequently examined.

3. Student Engagement (Average Year: 2023.00; Deviation: +1.71): Student engagement stands out as a key outcome variable in measuring the effectiveness of digital game-based learning. Research examines how gamification elements (points, badges, levels, leaderboards, etc.) affect students' cognitive and emotional engagement levels.

These are followed by the concepts of "self-determination," "experience," "science," "skills," and "sustainability." The rise of these concepts demonstrates that the field is not solely focused on game mechanics but has also expanded into a broad pedagogical spectrum, including science education, sustainability awareness, 21st-century skills, and experience-based learning. Previously dominant concepts, such as "gamification," "simulation," and "intrinsic motivation," while still widely used, have now evolved into mature themes. In contrast, concepts like "virtual reality" and "self-determination theory" represent the field's future direction and research potential.

Traditional Foundations (Mature Themes Analysis)

According to the trend analysis results, certain concepts have historically played a leading role in the field's development but have seen a relative decline in research interest in recent years. These concepts represent the "traditional foundations" of the field and reflect early trends in the literature with negative deviation values (mean years aged).

Table 4.

Traditional Foundations (Mature Themes Analysis)

Keyword	Usage Count	Average Year	Deviation (Trend Strength)
educational game	40	2019.05	-2.23594
computer	12	2019.25	-2.03594
educational games	54	2019.69	-1.60075
model	20	2019.8	-1.48594
computer games	52	2019.9	-1.38209
e-learning	10	2020	-1.28594
simulation games	10	2020.1	-1.18594
video games	36	2020.11	-1.17483
video game	11	2020.18	-1.10412
board game	10	2020.4	-0.885937

When Table 4 is examined, the concepts that stand out are the fundamental components of gamification and digital learning, such as "educational game," "computer games," "e-learning," and "video games." These components are as follows:

1. "Educational game" (Average Year: 2019.05; Deviation: -2.23): This concept is one of the oldest and most established research trends in the field. Numerous studies have been conducted on the use of digital games in education since the mid-2000s. Research conducted during this period mostly

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examined the effects on learning outcomes, motivation, and academic achievement, and theoretically grounded the educational potential of games. Today, this concept has given way to broader, experience-based approaches such as "game-based learning" and "gamification."

2. "Computer" and "Computer games" (Average Year: 2019.25 and 2019.9): These concepts point to the technological infrastructure-centered phase of digital game research. In the 2010s, computer games were considered the primary platform for producing educational content; the effectiveness of computer-based games, particularly in STEM and language learning, was examined. However, with the rise of mobile devices, virtual reality, and online platforms, these concepts have become relatively obsolete.

3. "E-learning" and "Simulation games" (Average Year: 2020.0 and 2020.1): These concepts were associated with the digital game-based aspects of distance education. They experienced a brief rise, particularly during the COVID-19 pandemic, but in subsequent years, they were replaced by more interactive, gamified, and blended learning approaches.

4. "Video games" and "Board games" (Average Year: 2020.11 and 2020.40): The term "video game" was frequently used in the early examples of gamification literature. However, today, this term is more commonly used in studies on commercial games or psychological effects. In education-focused publications, the terms "serious games" and "educational games" are being replaced. Similarly, the term "board games," which refers to learning environments supported by physical materials, has recently seen more limited use due to digitalization. These concepts form the historical core of the field, while today's emerging themes (e.g., virtual reality, self-determination theory, student engagement) represent new trends built upon these fundamental concepts.

Conclusion and Discussion

This study comprehensively demonstrates the field's scientific development trajectory, thematic orientations, and emerging research trends by conducting a bibliometric analysis of articles published in the WOS database in the field of Educational Digital Games between 2005 and 2025. The findings demonstrate that educational digital games have progressed from empirical investigations toward theoretical sophistication over the past fifteen years, both in terms of productivity and thematic density, and that thematic diversification has occurred as a result.

The low number of publications in the field between 2007 and 2011 suggests that this period was one of exploration and conceptualization. During this period, the concepts of "game-based learning" and "serious games" were just entering the educational technology literature. Studies conducted during this period were primarily based on conceptual modeling and small-scale pilot applications (e.g., Prensky, 2001; Annetta, 2010).

Subsequent to 2012, advancements in mobile technologies, learning analytics, and gamification applications significantly enhanced the productivity of the field. The era commencing in 2016 denoted the attainment by educational digital games of an "empirical evidence" threshold, evolving from mere innovation into a domain yielding quantifiable pedagogical efficacy. Meta-analyses and systematic reviews conducted during this period (e.g., Wouters et al., 2013; Hamari et al., 2016; Connolly et al., 2016) formed the theoretical backbone of the field.

The COVID-19 pandemic (2020–2022) marked a critical turning point in this development. With the emergence of digital learning imperatives, educational games emerged as a strategic tool for providing interaction, motivation, and accessibility in online learning. Findings indicate a sharp increase in the number of publications after 2020. This increase reflects the rapid pace of technological adoption in the field and can be interpreted as the adoption of game-based learning as a sustainable pedagogical model.

The presence of names such as Martí-Parreño, Hwang, and Hamari among the most prolific authors demonstrates the global leadership of European and Asian research networks in this field. Hwang's work on mobile learning and gamified instructional designs, in particular, appears to have played a leading role in the proliferation of educational technologies in the Asia-Pacific region. Hamari's empirical models, which explain the relationship between gamification and motivation theories, have strengthened the theoretical foundations of the field.

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It is noteworthy that the most cited articles are meta-analyses and systematic reviews. This demonstrates that educational digital games have become an evidence-based field. For instance, Wouters et al. (2013) integrated evidence on the cognitive and motivational outcomes of serious games, setting the direction for subsequent research. Hamari et al. (2016) pioneered the widespread use of motivational models, with findings confirming the impact of in-game experiences (flow, engagement, feedback) on learning achievement.

These findings demonstrate that game-based learning is not only a pedagogical innovation but also a research axis that has profoundly impacted the fields of cognitive science and motivational psychology. Educational digital games serve as a bridge in the transition from the behaviorist paradigm to constructivist and self-determination approaches.

Keyword occurrence and author cluster analyses revealed that research trends in the field are shaped around five primary thematic axes: gamification and motivation (gamification, motivation, performance), serious games and learning outcomes (serious games, learning outcomes), theoretical foundations and user experience (self-determination theory, flow theory), interdisciplinary applications (medical education, engineering, science education), and technological innovation and virtual reality (virtual reality, simulation). These themes demonstrate the positioning of educational games not merely as teaching tools but as experiential learning ecosystems. In particular, the integration of psychological theories, such as self-determination theory (Ryan & Deci, 2000), into gamification designs has enhanced the pedagogical depth of the field. Games are no longer considered merely "transmitters of knowledge" but rather as dynamic learning environments that foster intrinsic motivational elements such as autonomy, competence, and relatedness.

According to trend analysis, the themes of "virtual reality," "self-determination theory," and "student engagement" have shown high positive deviations in recent years. These concepts clearly indicate future research directions for educational digital games. Virtual reality (VR) has the potential to optimize cognitive load by creating multisensory and interactive learning experiences. In this respect, it opens new research horizons in which game-based learning can be linked not only to behavioral outcomes but also to neuropedagogical effects. Studies focused on self-determination theory explain the psychological foundations of in-game motivation and discuss ways to enhance students' intrinsic motivation sustainably. In this context, a growing consensus has emerged that gamification should be based not only on extrinsic rewards (such as points and badges) but also on intrinsic motivational sources. In contrast, the negative trend deviations of early concepts such as "educational game," "computer games," and "e-learning" suggest that these themes are giving way to more complex and integrated learning models. The field now focuses on the psychological and pedagogical principles of experiential learning designs rather than the technological tools themselves.

The findings of the present study reaffirm the efficacy of bibliometric methods in systematically delineating scientific trends within the domain of educational technologies However, data based on the WOS database has limitations in terms of language, indexing scope, and publication policies. For example, including only English-language articles may exclude local research production. Notwithstanding these constraints, the study has powerfully demonstrated the direction of international knowledge production, thematic clusters, and future research axes in the field of educational digital games.

Generally, the following conclusions are drawn from the findings: Educational digital games have evolved into an interdisciplinary field of science over the last fifteen years. Research orientations are shifting from pedagogical approaches to motivational and experiential designs. The themes of "gamification" and "serious games" have matured, while the themes of "virtual reality" and "self-determination theory" have emerged as emerging trends. Productivity in the field has become global, with the Europe-Asia axis forming the center of the scientific network.

Considering the context of recommendations for future research: Longitudinal studies should examine the persistence and long-term effects of game-based learning. Cross-cultural comparisons should be conducted to evaluate the effects of gamification in different socio-cultural contexts. New technologies such as artificial intelligence, learning analytics, and affective computing should be integrated to personalize game-based learning experiences. The sustainability and ethical dimensions of educational games (e.g., data privacy, fair game mechanics) should be addressed as new research topics.

In conclusion, educational digital games are not merely a teaching method; they are a dynamic field of research at the intersection of technology, psychology, and pedagogy, where learning is being redefined. The evolution of this field appears poised to radically transform the structure of future educational systems and the nature of learning experiences.

Disclosure Statements

Contribution rate statement of the researcher:

The author contributed 100% to this study.

Conflict of interest statement:

The author declares that there is no conflict of interest.

CRediT Authorship Contribution Statement

Serdar Çiftci: Conceptualization, methodology, data collection, data analysis, writing – review & editing.

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