A Bibliometric Review of Research on Gamification in Education: Reflections for Moving Forward

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Abstract. As the field of education continuously explores innovative teaching methods, gamified education has attracted widespread attention due to its unique mechanisms for stimulating learning motivation and enhancing engagement. This study utilizes bibliometric analysis to systematically evaluate the development of gamified education research from 2004 to 2023. By analyzing 4,373 publications, this research reveals the major trends and academic impacts of gamified education, finding that the United States and China are particularly prominent in research output in this field. The results indicate that gamified education can effectively enhance students' learning motivation and engagement, especially in remote and digital learning environments. Additionally, this study also finds that, despite the increasing research on gamified education, further exploration is needed regarding its long-term effects and specific applications in educational practice.

Keywords: Bibliometric, gamification, education, PRISMA, VOSviewer.

1. Introduction

In the context of the COVID-19 pandemic accelerating the transformation of education, the importance of gamification in education has become increasingly prominent. It has not only facilitated the widespread adoption of remote education and digital tools but has also significantly enhanced students' learning motivation and engagement.

(Bentata, 2020; Lee, 2022). Consequently, the growth in digital technology significantly increased the usage of digital devices in teaching, providing robust technological support for online education (Svoboda, 2020). Gamification teaching strategies, due to their ability to enhance learning motivation and engagement, are being increasingly applied in the education sector. The impact of such strategies on education primarily manifests in enhancing the learning experience and effectiveness through the application of game design thinking to non-game applications, making them more engaging and attractive (Domínguez et al., 2013). Gamification, the application of game design principles to non-game contexts, has gained significant attention in recent years (Hägglund, 2012). The term "gamification" was first coined in 2002, but the concept did not become popular until around 2010 (Mitchell et al., 2020). Integrating gamification elements and mindsets into educational settings can stimulate students' enthusiasm and participation, especially in fostering learning innovation and enhancing educational outcomes (Lu & Ho, 2020). The rise of gamified teaching not only changes educational strategies but also affects students' learning behaviors. Beyond improving learning efficiency and outcomes, gamification also increases student engagement, knowledge mastery, and cultivates interest in subjects (Hamari et al., 2014). As the related literature continues to grow, gamified teaching will continue to attract researchers' attention. Therefore, understanding the knowledge structure in this field is crucial. Although some studies have extensively explored the application of gamification in various scenarios, systematic research on how gamification impacts student behavior and learning outcomes in education is relatively scarce. To address this research gap, this study employs bibliometric analysis methods. Specifically, this research aims to answer the following questions: (1) What is the total number of publications, research disciplines, authors, countries, institutional affiliations, most renowned journals, articles, and authors in gamification (especially in education)? (2) How is knowledge in the field of gamification, particularly in

educational studies, constructed over time? (3) What are the collaboration structures among authors, institutions, and countries?

Through a systematic review of the relevant literature, researchers have explored the effectiveness of gamification in education and its potential impact on learning outcomes. The purpose of this study is to conduct an in-depth investigation of various aspects of gamified education through bibliometric analysis, aiming to reveal the development trends, effectiveness, and potential applications of gamification teaching strategies in different educational settings. The research questions focus on the implementation methods of gamified education, the evaluation of its effects, and its implications for future educational models.

As research on gamification teaching methods deepens, compiling comprehensive literature reviews to summarize key findings in the field and propose directions for future research has become increasingly common (Rosli & Zaki, 2023). The strategies for literature reviews include four main approaches: narrative reviews, systematic reviews, meta-analyses, and bibliometric studies (Badger et al., 2000). Narrative and systematic reviews, which primarily employ qualitative analysis, are widely used due to their methodological accessibility, though these approaches are limited by the depth and reproducibility of data analysis (Finfgeld-Connett, 2014). On the other hand, meta-analyses and bibliometric studies focus on quantitative methods. Meta-analyses synthesize results from multiple studies to assess the magnitude and consistency of research effects, thereby providing a more precise summary of findings (Flather et al., 1997). Bibliometric studies explore the knowledge networks and academic impact within a research area by analyzing publication patterns and citation data. The impact of bibliometric methods is primarily seen in promoting the objectivity of scientific evaluations, revealing the structure and trends of scientific knowledge, and supporting research decision-making and knowledge management (Rosli & Zaki, 2023). These methods not only evaluate scientific outputs but also identify key papers, major researchers, and institutions in the scientific field and their relationships through co-citation and coupling analysis. Additionally, by analyzing the text within cited references, a "quality" dimension can be added to bibliometrics, further enhancing the accuracy and depth of evaluations (Abu-Jbara et al., 2013).

Gamified education has been demonstrated to significantly enhance student engagement and academic performance (Barata et al., 2013; Manzano-León et al., 2021). However, the effects of gamification on intrinsic motivation, satisfaction, and empowerment are still unclear, with some studies indicating potential negative impacts (Hanus & Fox, 2015).

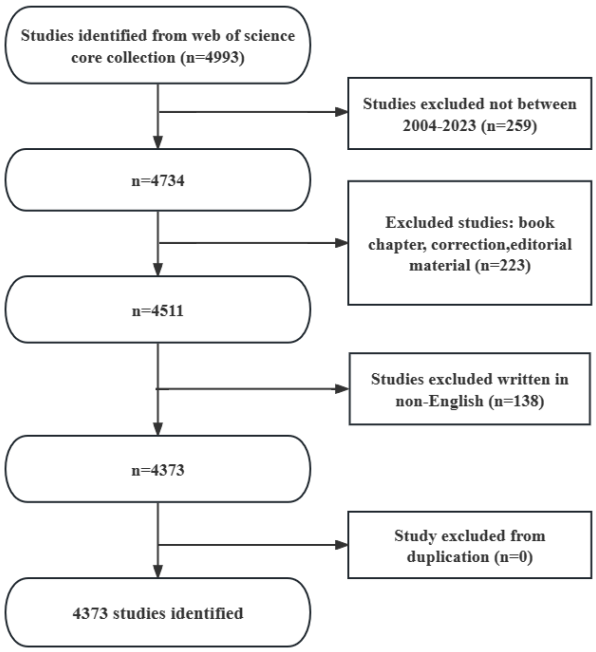

Figure 1. Literature Search Process Flowchart

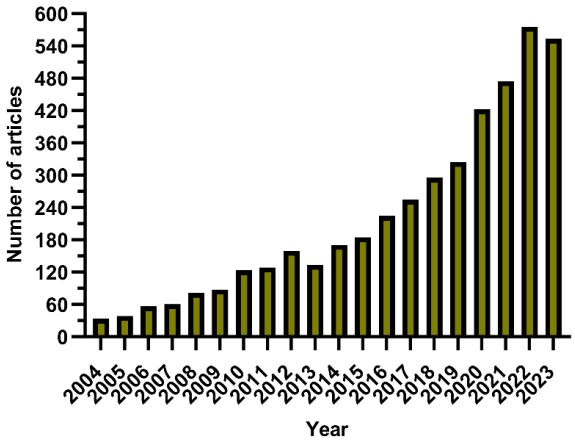

Figure 2. Annual Publication Volume Chart

1.1. Methods

The Web of Science Core Collection (WoSCC) is recognized for its superior accuracy in document type categorization compared to other databases and is considered the best choice for conducting literature analyses. Thus, we selected this database for our search. On January 9, 2024, we conducted a search in WoS for all articles related to the application of gamified education published between January 1, 2004, and December 31, 2023. The search formula was as follows: ((((((TS=(game-based teaching)) OR TS=(game teaching)) OR TS=(gamification teaching)) OR TS=(games teaching)) OR TS=(the game-teaching)) OR TS=(game-oriented teaching)) OR TS=(Gamification of Teaching).

The literature screening for this study was based on the following inclusion criteria: (1) full texts of publications related to gamified education; (2) articles and review manuscripts written in English; (3) articles published between January 1, 2004, and December 31, 2023. The exclusion criteria were: (1) topics unrelated to gamified education; (2) articles that are conference abstracts, news, or briefs. A plaintext version of the papers was exported.

Analysis and graphical representation of annual publications, national publication trends, and proportions were conducted using Graphpad prism v8.0.2. Additionally, CiteSpace (6.2.4R (64-bit) advanced version) and VOSviewer (version 1.6.18) were utilized to analyze the data and visualize scientific knowledge maps.

VOSviewer v.1.6.17, created by Waltman et al. in 2009, is a Java-based free software used to analyze large sets of bibliometric data and display them in a map format. To visualize research outputs in a particular field through the creation of co-citation network maps, Professor Chaomei Chen developed CiteSpace (6.1.6R), which envisions using an experimental framework to study new concepts and evaluate existing technologies. This enables users to better understand knowledge domains, research frontiers, and trends, and to predict future research developments.

1.2. Results

The results indicate that from January 1, 2004, to December 31, 2023, the Web of Science Core Collection (WoSCC) database contained a total of 4,373 documents on gamified education, comprising 4,066 (84.96%) articles and 307 (15.04%) reviews. The literature involved 118 countries and regions, 3,782 institutions, and 12,961 authors.

Since 2004, the number of papers published annually has gradually increased (Figure 2A). This growth can be segmented into three phases: from 2004 to 2009, there was a slow increase (Figure 2B), with fewer than 100 papers published per year, indicating that the field had not yet captured researchers' attention. From 2010 to 2015, the volume of publications gradually increased, suggesting the field was beginning to enter researchers' view. After 2016, the volume of publications rapidly increased, reaching a peak in 2022, indicating that the field had garnered widespread attention post-2016.

1.2.1. National and Institutional Analysis

Research on gamified education has been conducted in 67 countries and regions. Figures 3 and 4 illustrate the annual publication volumes over the past decade for the top 10 countries in this field. The top five countries in terms of publication numbers are the United States, China, Spain, the United Kingdom, and Australia. The United States leads significantly, with its publications accounting for 27.42% of the total volume, far surpassing any other country.

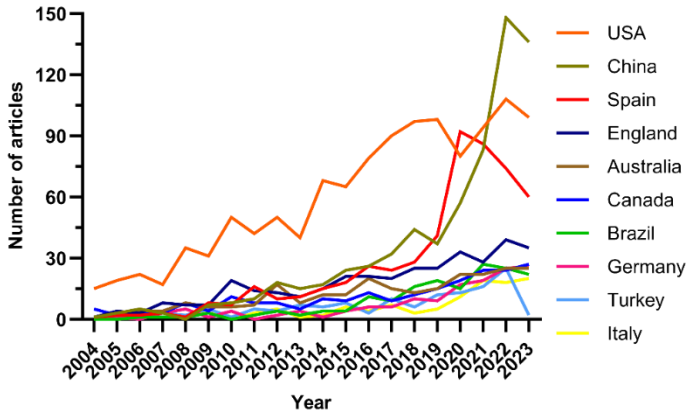

Figure 3. Line Graph of National Publication Volumes

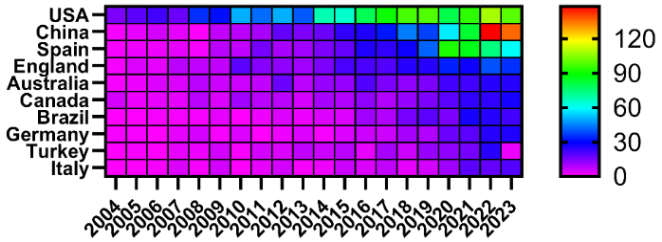

Figure 4. Heat Map of National Publication Volumes

In the top ten countries/regions ranked by the number of published papers, the United States leads with 28,559 citations (Table 1), significantly outperforming all other countries. Its citation-to-publication ratio (23.82) ranks third among all nations, indicating a generally high quality of published research. China, ranking second in terms of publication volume with 674 papers, holds the second spot for citations at 12,536. Its citation-to-publication ratio (18.60) ranks fifth, suggesting a generally lower quality of published research compared to the United States.

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Table 1. Table of National Publication Volumes

Rank	Country/region	Article counts	Centrality	Percentage (%)	Citation	Citation per publication
1	USA	1199	0.58	27.42	28559	23.82
2	China	674	0.19	15.41	12536	18.60
3	Spain	526	0.24	12.03	8700	16.54
4	England	349	0.09	7.98	10092	28.92
5	Australia	244	0.12	5.58	5832	23.90
6	Canada	219	0.13	5.01	4569	20.86
7	Brazil	166	0.03	3.80	1626	9.80
8	Germany	144	0.12	3.29	2648	19.39
9	Turkey	129	0.03	2.95	2288	17.74
10	Italy	115	0.09	2.63	1820	15.83

The collaboration network, as shown in Figure 5, indicates close collaboration between the highest producing countries, the United States and China. The United States has strong collaborations with the United Kingdom, Italy, and Spain, while China shows closer collaborations with Germany, Canada, and Turkey. The United States not only has a high volume of publications but also a high

frequency of citations, underscoring its leadership position in the field. In recent years, there has been a rapid increase in publication volumes from countries like China and Spain, which may be associated with collaborations with the United States.

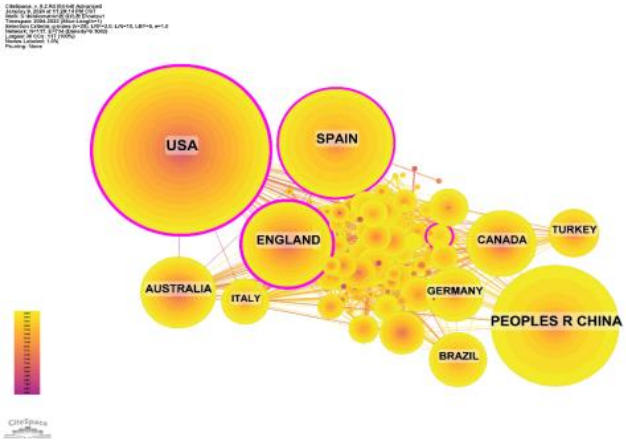


Figure 5. Network Diagram of International Collaborations

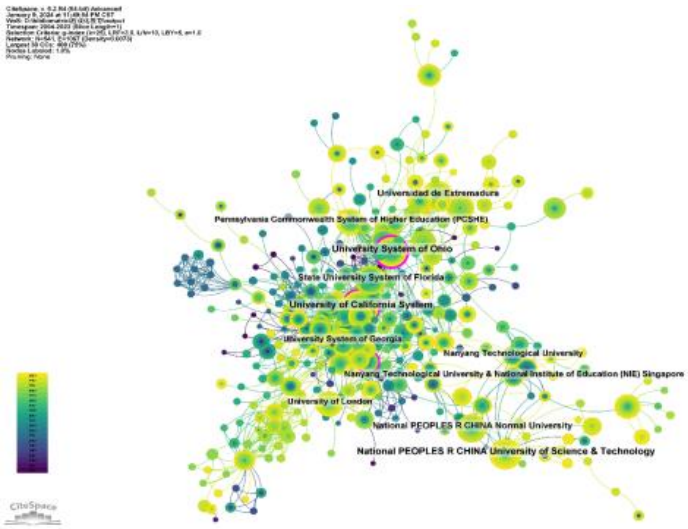


Figure 6. Network of agency

Table 2. Table of Institutional Publication Volumes

Rank	Institution	Country	Number of studies	Total citations	Average citation
1	University of California System	USA	67	1332	19.88
2	University System of Ohio	USA	57	2138	37.51
3	National PEOPLES R CHINA University of Science & Technology	China	57	2283	40.05
4	State University System of Florida	USA	50	1075	21.50
5	Universidad de Extremadura	Spain	48	674	14.04
6	National PEOPLES R CHINA Normal University	China	46	2089	45.41
7	University System of Georgia	USA	38	475	12.50
8	Pennsylvania Commonwealth System of Higher Education (PCSHE)	USA	35	452	12.91
9	Nanyang Technological University & National Institute of Education (NIE) Singapore	Singapore	34	1390	40.88
10	University of London	England	34	627	18.44

A total of 3,782 institutions systematically published articles on gamified education. Among the top ten institutions by publication volume, five are from the United States, two from China, one from Singapore, one from the United Kingdom, and one from Spain (Table 2, Figure 6). The University of California System published the most documents (67 papers with 1,132 citations, averaging 19.88 citations per paper). The University System of Ohio ranks second with 57 papers and 2,138 citations, averaging 37.51 citations per paper, and the National PEOPLES R CHINA University of Science & Technology ranks third with 57 papers and 2,283 citations, averaging 40.05 citations per paper.

Further analysis revealed that institutions tend to collaborate more with entities within their own country. Therefore, we advocate for strengthened cooperation between domestic and international institutions to break down academic barriers and enhance the global exchange of knowledge and innovative practices in gamified education.

1.2.2. National and Institutional Analysis

Tables 3 and 4 list the top 10 journals with the highest output and most citations. "Computers & Education" leads in the field with 208 publications, accounting for 4.76% of the total, followed by "Sustainability" with 136 publications (3.11%), "Education and Information Technologies" with 104 publications (2.38%), and "Journal of Chemical Education" with 101 publications (2.31%). Among the top ten most productive journals, "Computers & Education" has the highest Impact Factor (IF) of 12.0. Seventy percent of the journals are classified in either Q1 or Q2 categories, indicating a high level of academic respect and recognition in their respective fields.

Table 3. Table of Journal Publication Volumes

Rank	Journal	Article counts	Percentage (4373)	IF	Quartile in category
1	computers & education	208	4.76	12.0	Q1
2	sustainability	136	3.11	3.9	Q2
3	education and information technologies	104	2.38	5.5	Q1
4	journal of chemical education	101	2.31	3.0	Q3
5	frontiers in psychology	87	1.99	3.8	Q1
6	physical education and sport pedagogy	85	1.94	3.6	Q1
7	interactive learning environments	75	1.72	5.4	Q1
8	european physical education review	62	1.42	3.4	Q2
9	international journal of engineering education	61	1.39	1.0	Q4
10	computer applications in engineering education	52	1.19	2.9	Q3

Table 4. Table of Journal Co-citations

Rank	Cited Journal	Co-Citation	IF (2020)	Quartile in category
1	COMPUT EDUC	1498	12.0	Q1
2	COMPUT HUM BEHAV	930	9.9	Q1
3	BRIT J EDUC TECHNOL	769	6.6	Q1
4	EDUC TECHNOL SOC	603	4.0	Q1
5	ETR&D-EDUC TECH RES	575	5.0	Q1
6	J COMPUT ASSIST LEAR	532	5.0	Q1
7	REV EDUC RES	521	11.2	Q1
8	J EDUC PSYCHOL	511	4.9	Q1
9	SIMULAT GAMING	464	2.0	Q2
10	PLOS ONE	452	3.7	Q2

The influence of a journal is determined by the frequency with which it is co-cited, indicating its significant impact on the scientific community. According to Figure 8 and Table 4, the journal with the most co-citations is "Computers & Education" (COMPUT EDUC) with 1,498 co-citations, followed by "Computers in Human Behavior" (COMPUT HUM BEHAV) with 930 co-citations, and "British Journal of Educational Technology" (BRIT J EDUC TECHNOL) with 769 co-citations.

Among the top 10 journals with the most co-citations, "Computers & Education" stands out not only for the highest number of co-citations but also for having the highest Impact Factor (IF) of 12.0 among them. All journals within this group of highly co-cited journals are ranked in Q1/Q2 categories, underscoring their quality and importance within the academic community.

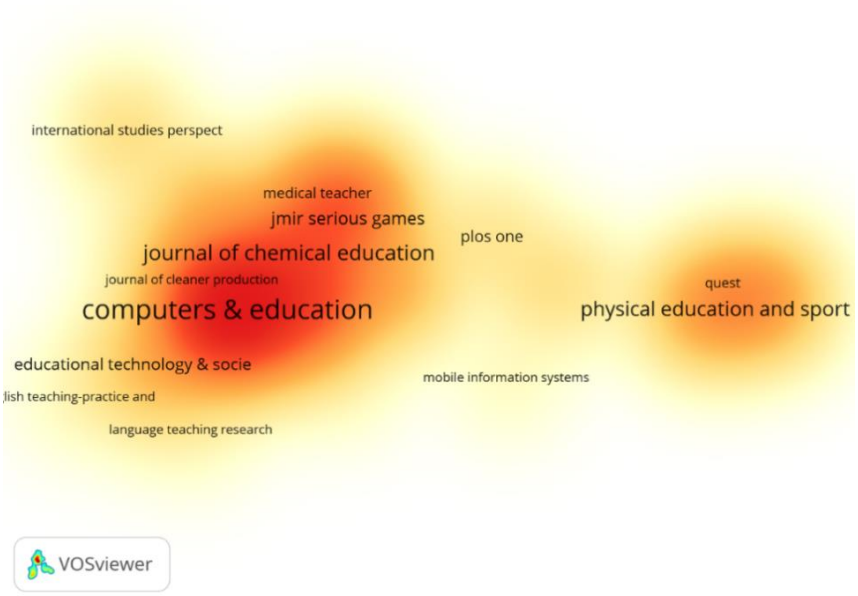


Figure 7. Journal Publication Density Chart

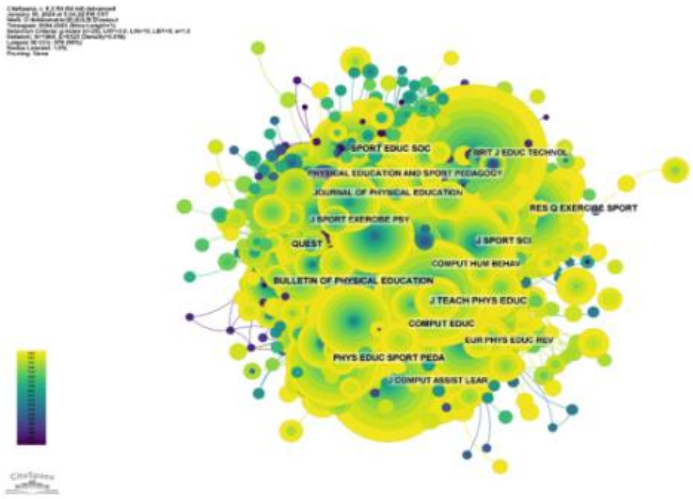


Figure 8. Co-citation Network Map of Journals

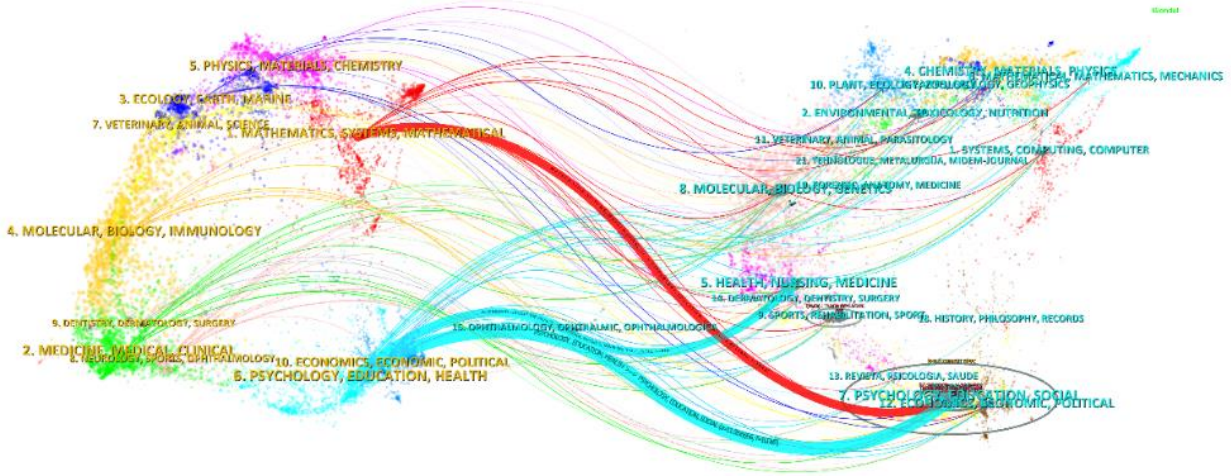


Figure 9. Dual Overlay Map of Journals

The thematic distribution of academic publications is displayed using a dual map overlay (Figure 9). Colored trajectories represent citation links, with journals that cite on the left and journals that are cited on the right. Based on the results shown, two main citation pathways are identified:

Research published in journals from the fields of mathematics/systems/mathematical is predominantly cited by research published in journals from the psychology/education/social fields. This pathway highlights the interdisciplinary influence of mathematical and systematic approaches within the social and educational sciences.

Research published in psychology/education/health journals is primarily cited by research published in psychology/education/social and health/nursing/medicine journals. This demonstrates a significant interconnection between educational and psychological research with health-related studies, indicating the broad impact and applicability of this research across various domains.

1.2.3. Authors and Co-cited Authors

Among all authors who have published on gamified education, Table 5 lists the top 10 authors by number of publications. Together, these ten authors have published 158 papers, accounting for 3.61% of all papers in the field. Gwo-Jen Hwang has the most publications, with 34 papers, followed by Stephen Harvey with 23 papers and Isabel Mesquita with 16 papers. Further analysis reveals that among the top ten authors, two are from China, two from Portugal, two from the USA, two from Spain, and the remaining two are from the UK and Australia. CiteSpace visualizes the network among these authors (Figure 10).

Table 5. Table of Author Publications and Co-citations

Rank	Author	Count	Location	Rank	Co-cited author	Citation
1	hwang, gwo-jen	34	China	1	PRENSKY M	247
2	harvey, stephen	23	USA	2	GEE JP	244
3	mesquita, isabel	16	Portugal	3	COHEN J	227
4	pill, shane	14	Australia	4	HWANG GJ	226
5	farias, claudio	13	Portugal	5	DETERDING S	224
6	arias-estero, jose l.	12	USA	6	KIRK D	194
7	davids, keith	12	England	7	MAYER RE	194
8	feu, sebastian	12	Spain	8	VYGOTSKY LS	191
9	hong, jon-chao	11	China	9	HAMARI J	190
10	ibanez, sergio j.	11	Spain	10	CSIKSZENTMIHALYI M	173

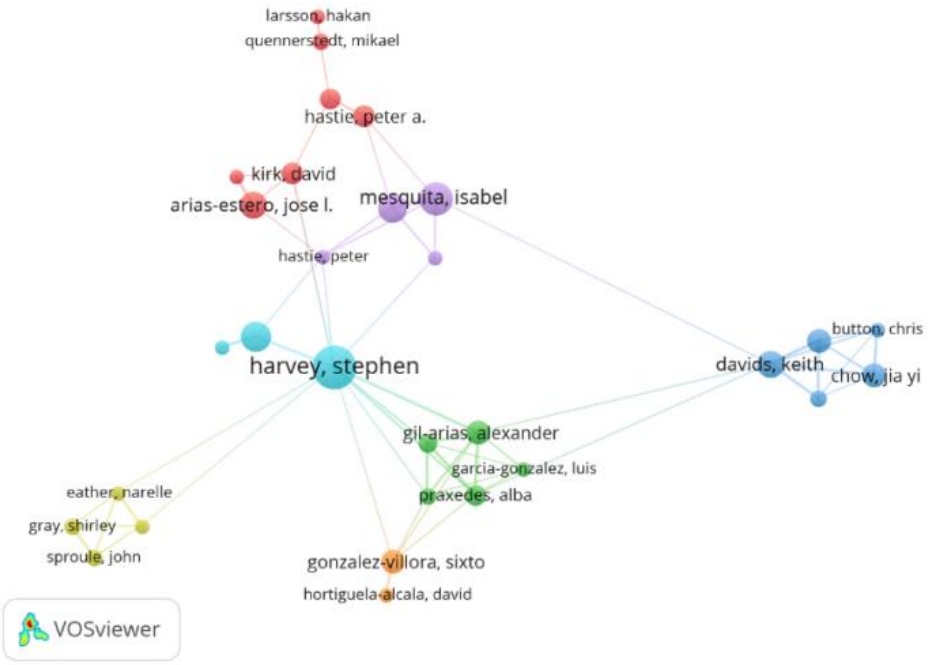


Figure 10. Author Collaboration Network Diagram

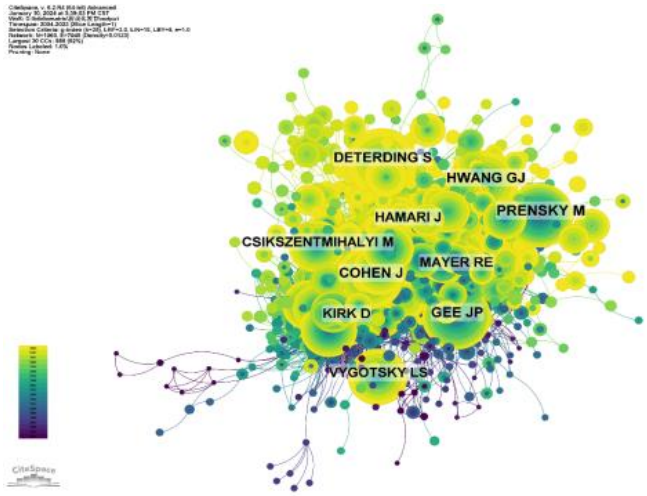


Figure 11. Co-citation Network Diagram of Authors

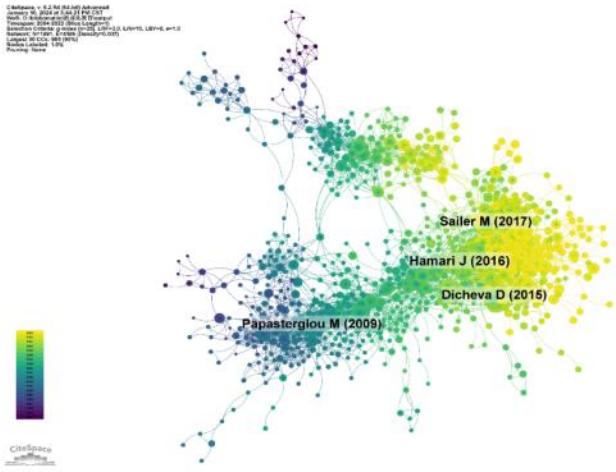


Figure 12. Co-cited Literature Network Diagram

Figure 11 and Table 5 show the top 10 authors who have been co-cited and cited the most times, respectively. A total of 90 authors have been cited over 50 times, indicating that their research holds significant prestige and impact. The largest nodes in the network are associated with the authors who have been co-cited the most, including PRENSKY M (380 citations), GEE JP (314 citations), and COHEN (299 citations). These figures illustrate the central roles these scholars play in the academic community concerning gamified education, highlighting their influential contributions to the field.

Spanning from 2000 to 2023 and utilizing one-year time slices, the co-citation reference network consists of 1,091 nodes and 4,186 links (Figure 12). According to Table 6, which lists the top 10 articles based on co-citation frequency, the most frequently co-cited reference is from the journal "Computers in Human Behavior" (Impact Factor = 9.9), titled "Challenging games help students learn: An empirical study on engagement, flow, and immersion in game-based learning" with Juho Hamari as the first author. In this article, we investigate the effects of flow (operationalized as increasing challenges and skills), engagement, and immersion on learning within a game-based learning environment. The data was collected through surveys of players (173 participants) from two educational games (Quantum Spectre: 134 participants; Spumone: 40 participants). The findings demonstrate a clear positive impact of game participation on learning, although no significant relationship was found between immersive gaming and learning. The challenging nature of games positively influences learning either directly or by enhancing engagement. The skills involved in the game do not directly affect learning but do so by increasing game engagement. Both the challenge and skills in the game positively affect game participation and immersion. The predictive power of game challenge for learning outcomes is particularly notable. For the design of educational games, the results suggest that the challenge level of the games should keep pace with the learners' growing abilities and learning levels to support sustained learning in a game-based environment.

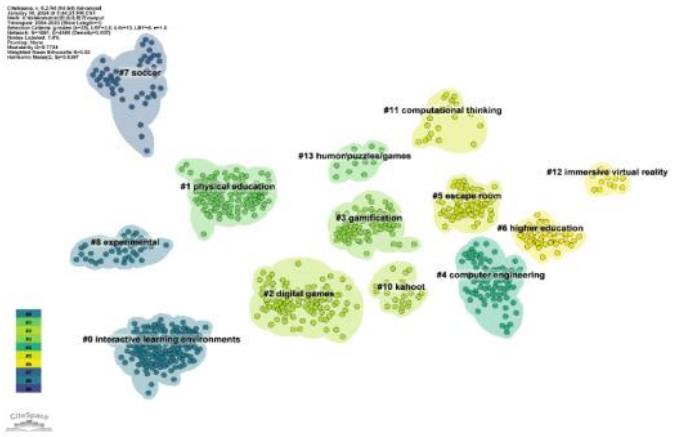


Figure 13. Cluster Diagram of Co-cited Literature

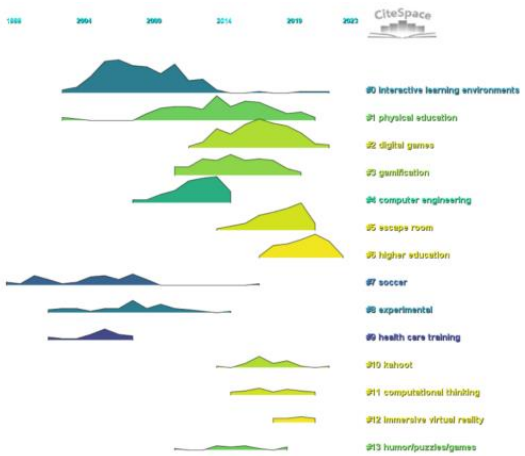


Figure 14. Volcano Plot of Co-cited Literature

We conducted co-citation reference clustering and temporal clustering analysis (Figures 13 and 14). Our findings indicate that early research hotspots included topics such as "interactive learning environments" (cluster0) and "soccer" (cluster7). Mid-term research focal points encompassed "computer engineering" (cluster4), "experimental" (cluster8), and "health care training" (cluster9).

Current hot topics and trends in the field include "physical education" (cluster1), "digital games" (cluster2), "gamification" (cluster3), "escape room" (cluster5), "higher education" (cluster6), "kahoot" (cluster10), "computational thinking" (cluster11), "immersive virtual reality" (cluster12), and "humor/puzzles/games" (cluster13). These clusters represent the diverse and evolving areas of interest within the gamification and educational technology fields, highlighting how these topics have shifted and expanded over time.

Table 6. Co-citation Table of Literature

Rank	Title	Journal IF (2021)	Author (s)	Total citations
1	Challenging games help students learn: An empirical study on engagement, flow and immersion in game-based learning	COMPUTERS IN HUMAN BEHAVIOR (IF=9.9)	Hamari J	46
2	Digital Game-Based Learning in high school Computer Science education: Impact on educational effectiveness and student motivation	COMPUTERS & EDUCATION (IF=12.0)	Papastergiou M	43
3	How gamification motivates: An experimental study of the effects of specific game design elements on psychological need satisfaction	COMPUTERS IN HUMAN BEHAVIOR (IF=9.9)	Sailer M	43
4	An update to the systematic literature review of empirical evidence of the impacts and outcomes of computer games and serious games	COMPUTERS & EDUCATION (IF=12.0)	Boyle EA	42
5	A systematic literature review of empirical evidence on computer games and serious games	COMPUTERS & EDUCATION (IF=12.0)	Connolly TM	41
6	The impact on nursing students' opinions and motivation of using a "Nursing Escape Room" as a teaching game: A descriptive study	NURSE EDUCATION TODAY (IF=3.9)	Gomez-Urquiza, Jose L	39
7	Digital Games, Design, and Learning: A Systematic Review and Meta-Analysis	REVIEW OF EDUCATIONAL RESEARCH (IF=11.2)	Clark DB	39
8	Assessing the effects of gamification in the classroom: A longitudinal study on intrinsic motivation, social comparison, satisfaction, effort, and academic performance	COMPUTERS & EDUCATION (IF=12.0)	Hanus MD	38
9	A review of the game-centred approaches to teaching and coaching literature since 2006	PHYSICAL EDUCATION AND SPORT PEDAGOGY (IF=3.6)	Harvey S	37
10	Gamified learning in higher education: A systematic review of the literature	COMPUTERS IN HUMAN BEHAVIOR (IF=9.9)	Subhash S	36

1.2.4. Keyword analysis

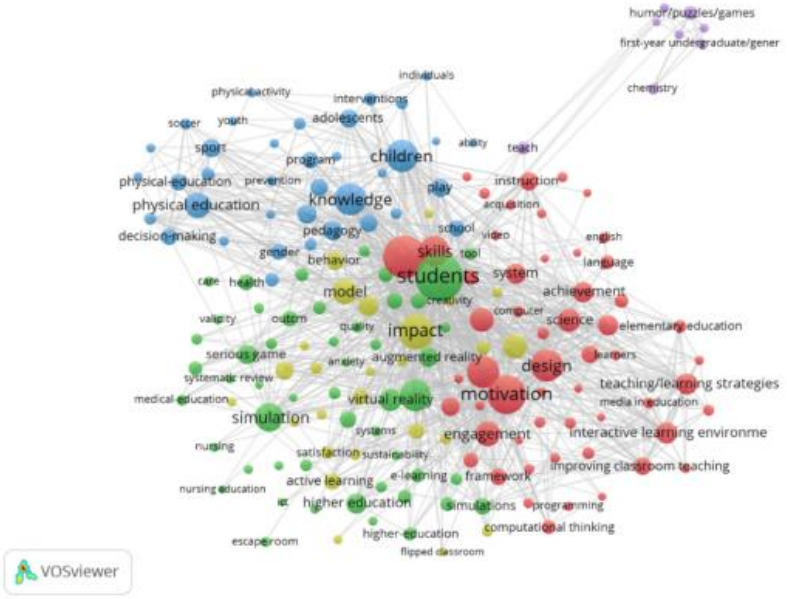


Figure 15. Network Diagram of High-Frequency Keywords

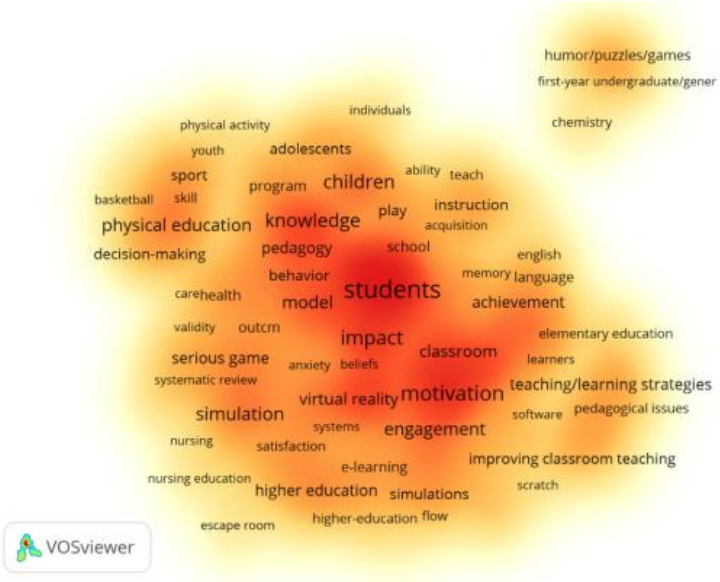


Figure 16. Keyword Density Map

By analyzing keywords, we can quickly understand the state and developmental directions of a field. Based on the co-occurrence of keywords in VOSviewer, the most popular keywords are "students" (463 occurrences), followed by "performance" (378), "motivation" (321), and "impact" (275) (Figures 15 and 16). We removed irrelevant keywords and constructed a network consisting of 177 keywords that appeared at least 14 times, resulting in five distinct clusters:

Cluster 1 (Red) includes 55 keywords such as performance, motivation, engagement, technology, design, mathematics, science, game design, self-efficacy, scratch, skills, literacy, achievement, language, computer, feedback, and media in education.

Cluster 2 (Green) contains 51 keywords, including students, serious games, simulation, management, tools, sustainability, challenges, outcome, validation, gaming, nursing, health, support, and care.

Cluster 3 (Blue) comprises 37 keywords such as pedagogy, children, program, physical education, competence, gender, risk, adolescents, autism, benefits, school, decision-making, sport, and exercise.

Cluster 4 (Yellow) features 26 keywords including acceptance, behavior, efficacy, game theory, impact, internet, models, participation, perspective, satisfaction, and student engagement.

Cluster 5 (Purple) has 8 keywords: chemistry, teach, organic chemistry, second-year undergraduate, humor/puzzles/games, high school/introductory chemistry.

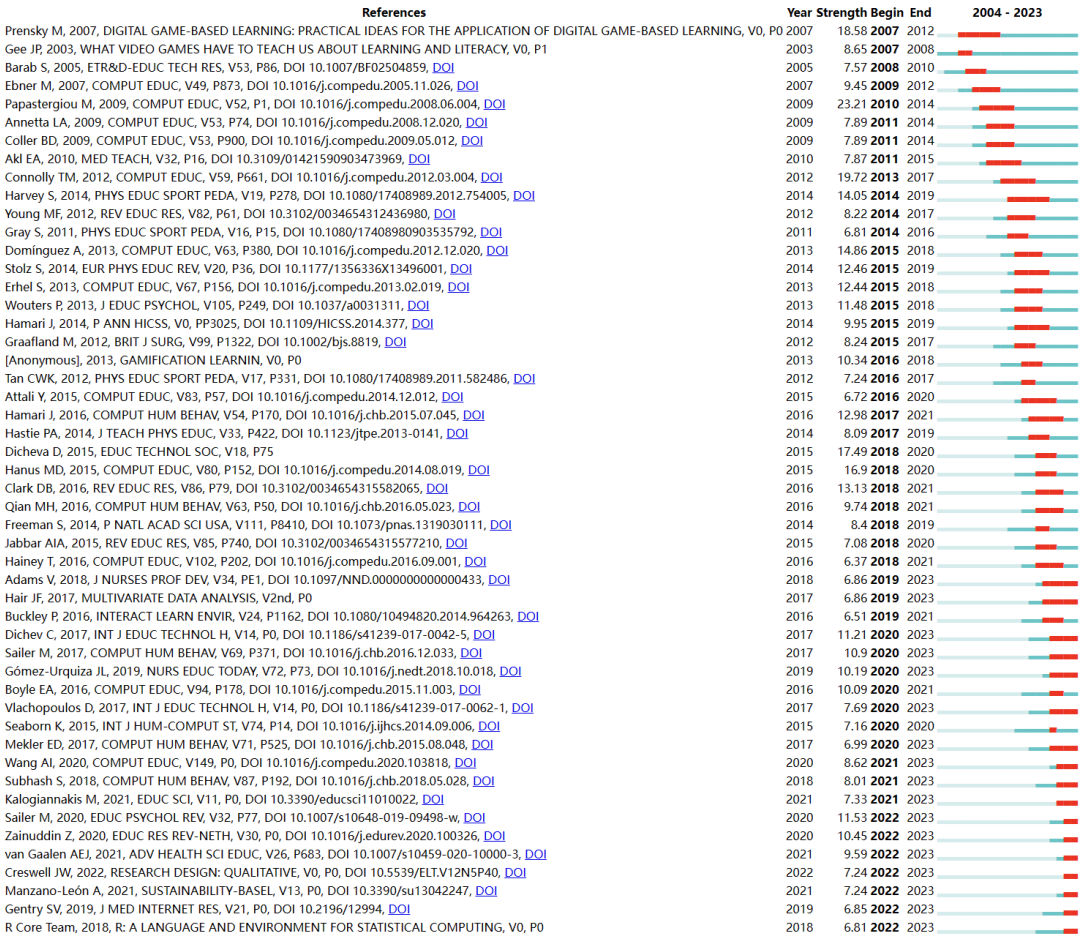
We used CiteSpace to create a volcano plot to visually display how research hotspots have shifted over time (Figures 17 and 18). This analysis helps highlight the breadth of topics within gamified education, showcasing its interdisciplinary nature and the variety of contexts in which it is applied.

1.2.5. Co-cited References

Through CiteSpace analysis, we have identified the 50 most reliable citation bursts in the field of gamified education. Among them, the reference with the highest citation rate (23.21) is the paper titled "Digital Game-Based Learning in high school Computer Science education: Impact on educational effectiveness and student motivation" published in Computers & Education [13], authored by Marina Papastergiou. The game described in the study was designed based on the teaching objectives and content of high school computer science (CS) curriculum in Greece, and was compared with a similar application lacking gaming elements but with identical learning objectives and content. The research also investigated potential gender differences in the learning effectiveness and motivational appeal of games. The sample consisted of 88 students who were randomly assigned to two groups: one using the game application (Group A, n=47) and the other using the non-game application (Group B, n=41). Pre-tests and post-tests were conducted using the Computer Memory Knowledge Test (CMKT). Observations of students were also made during the intervention process, and post-intervention feedback questionnaires were administered to assess students' perceptions of the applications used. Data analysis revealed that the game-based approach was more effective in promoting students' understanding of computer memory concepts and motivating their learning compared to the non-game approach. Despite boys being more engaged, enjoying, and experiencing computer games more, as well as having richer initial computer memory knowledge, there were no significant differences between boys and girls in the learning outcomes obtained through game use, and the motivational effects of games were the same for both genders. The findings suggest that in high school CS education, educational computer games can be effectively utilized as engaging and motivating learning environments.

Among the 50 references, 49 were published between 2004 and 2023, indicating frequent citations of these papers over the past two decades. Importantly, 17 of these papers are currently experiencing citation peaks, indicating continued interest in gamified education research in the future.

We focused on the 50 keywords with the strongest bursts out of 552 in the field. These keywords represent current research hotspots in the field and indicate potential directions for future research.



References	Year	Strength	Begin	End	2004 - 2023
Prensky M, 2007, DIGITAL GAME-BASED LEARNING: PRACTICAL IDEAS FOR THE APPLICATION OF DIGITAL GAME-BASED LEARNING, V0, P0	2007	18.58	**2007**	2012	
Gee JP, 2003, WHAT VIDEO GAMES HAVE TO TEACH US ABOUT LEARNING AND LITERACY, V0, P1	2003	8.65	**2007**	2008	
Barab S, 2005, ETR&D-EDUC TECH RES, V53, P86, DOI 10.1007/BF02504859, DOI	2005	7.57	**2008**	2010	
Ebner M, 2007, COMPUT EDUC, V49, P873, DOI 10.1016/j.compedu.2005.11.026, DOI	2007	9.45	**2009**	2012	
Papastergiou M, 2009, COMPUT EDUC, V52, P1, DOI 10.1016/j.compedu.2008.06.004, DOI	2009	23.21	**2010**	2014	
Annetta LA, 2009, COMPUT EDUC, V53, P74, DOI 10.1016/j.compedu.2008.12.020, DOI	2009	7.89	**2011**	2014	
Coller BD, 2009, COMPUT EDUC, V53, P900, DOI 10.1016/j.compedu.2009.05.012, DOI	2009	7.89	**2011**	2014	
Akl EA, 2010, MED TEACH, V32, P16, DOI 10.3109/01421590903473969, DOI	2010	7.87	**2011**	2015	
Connolly TM, 2012, COMPUT EDUC, V59, P661, DOI 10.1016/j.compedu.2012.03.004, DOI	2012	19.72	**2013**	2017	
Harvey S, 2014, PHYS EDUC SPORT PEDA, V19, P278, DOI 10.1080/17408989.2012.754005, DOI	2014	14.05	**2014**	2019	
Young MF, 2012, REV EDUC RES, V82, P61, DOI 10.3102/0034654312436980, DOI	2012	8.22	**2014**	2017	
Gray S, 2011, PHYS EDUC SPORT PEDA, V16, P15, DOI 10.1080/17408980903535792, DOI	2011	6.81	**2014**	2016	
Domínguez A, 2013, COMPUT EDUC, V63, P380, DOI 10.1016/j.compedu.2012.12.020, DOI	2013	14.86	**2015**	2018	
Stolz S, 2014, EUR PHYS EDUC REV, V20, P36, DOI 10.1177/1356336X13496001, DOI	2014	12.46	**2015**	2019	
Erhel S, 2013, COMPUT EDUC, V67, P156, DOI 10.1016/j.compedu.2013.02.019, DOI	2013	12.44	**2015**	2018	
Wouters P, 2013, J EDUC PSYCHOL, V105, P249, DOI 10.1037/a0031311, DOI	2013	11.48	**2015**	2018	
Hamari J, 2014, P ANN HICSS, V0, PP3025, DOI 10.1109/HICSS.2014.377, DOI	2014	9.95	**2015**	2019	
Graafland M, 2012, BRIT J SURG, V99, P1322, DOI 10.1002/bjs.8819, DOI	2012	8.24	**2015**	2017	
[Anonymous], 2013, GAMIFICATION LEARNIN, V0, P0	2013	10.34	**2016**	2018	
Tan CWK, 2012, PHYS EDUC SPORT PEDA, V17, P331, DOI 10.1080/17408989.2011.582486, DOI	2012	7.24	**2016**	2017	
Attali Y, 2015, COMPUT EDUC, V83, P57, DOI 10.1016/j.compedu.2014.12.012, DOI	2015	6.72	**2016**	2020	
Hamari J, 2016, COMPUT HUM BEHAV, V54, P170, DOI 10.1016/j.chb.2015.07.045, DOI	2016	12.98	**2017**	2021	
Hastie PA, 2014, J TEACH PHYS EDUC, V33, P422, DOI 10.1123/jtpe.2013-0141, DOI	2014	8.09	**2017**	2019	
Dicheva D, 2015, EDUC TECHNOL SOC, V18, P75	2015	17.49	**2018**	2020	
Hanus MD, 2015, COMPUT EDUC, V80, P152, DOI 10.1016/j.compedu.2014.08.019, DOI	2015	16.9	**2018**	2020	
Clark DB, 2016, REV EDUC RES, V86, P79, DOI 10.3102/0034654315582065, DOI	2016	13.13	**2018**	2021	
Qian MH, 2016, COMPUT HUM BEHAV, V63, P50, DOI 10.1016/j.chb.2016.05.023, DOI	2016	9.74	**2018**	2021	
Freeman S, 2014, P NATL ACAD SCI USA, V111, P8410, DOI 10.1073/pnas.1319030111, DOI	2014	8.4	**2018**	2019	
Jabbar AIA, 2015, REV EDUC RES, V85, P740, DOI 10.3102/0034654315577210, DOI	2015	7.08	**2018**	2020	
Hainey T, 2016, COMPUT EDUC, V102, P202, DOI 10.1016/j.compedu.2016.09.001, DOI	2016	6.37	**2018**	2021	
Adams V, 2018, J NURSES PROF DEV, V34, PE1, DOI 10.1097/NND.0000000000000433, DOI	2018	6.86	**2019**	2023	
Hair JF, 2017, MULTIVARIATE DATA ANALYSIS, V2nd, P0	2017	6.86	**2019**	2023	
Buckley P, 2016, INTERACT LEARN ENVIR, V24, P1162, DOI 10.1080/10494820.2014.964263, DOI	2016	6.51	**2019**	2021	
Dichev C, 2017, INT J EDUC TECHNOL H, V14, P0, DOI 10.1186/s41239-017-0042-5, DOI	2017	11.21	**2020**	2023	
Sailer M, 2017, COMPUT HUM BEHAV, V69, P371, DOI 10.1016/j.chb.2016.12.033, DOI	2017	10.9	**2020**	2023	
Gómez-Urquiza JL, 2019, NURS EDUC TODAY, V72, P73, DOI 10.1016/j.nedt.2018.10.018, DOI	2019	10.19	**2020**	2023	
Boyle EA, 2016, COMPUT EDUC, V94, P178, DOI 10.1016/j.compedu.2015.11.003, DOI	2016	10.09	**2020**	2021	
Vlachopoulos D, 2017, INT J EDUC TECHNOL H, V14, P0, DOI 10.1186/s41239-017-0062-1, DOI	2017	7.69	**2020**	2023	
Seaborn K, 2015, INT J HUM-COMPUT ST, V74, P14, DOI 10.1016/j.ijhcs.2014.09.006, DOI	2015	7.16	**2020**	2020	
Mekler ED, 2017, COMPUT HUM BEHAV, V71, P525, DOI 10.1016/j.chb.2015.08.048, DOI	2017	6.99	**2020**	2023	
Wang AI, 2020, COMPUT EDUC, V149, P0, DOI 10.1016/j.compedu.2020.103818, DOI	2020	8.62	**2021**	2023	
Subhash S, 2018, COMPUT HUM BEHAV, V87, P192, DOI 10.1016/j.chb.2018.05.028, DOI	2018	8.01	**2021**	2023	
Kalogiannakis M, 2021, EDUC SCI, V11, P0, DOI 10.3390/educsci11010022, DOI	2021	7.33	**2021**	2023	
Sailer M, 2020, EDUC PSYCHOL REV, V32, P77, DOI 10.1007/s10648-019-09498-w, DOI	2020	11.53	**2022**	2023	
Zainuddin Z, 2020, EDUC RES REV-NETH, V30, P0, DOI 10.1016/j.edurev.2020.100326, DOI	2020	10.45	**2022**	2023	
van Gaalen AEJ, 2021, ADV HEALTH SCI EDUC, V26, P683, DOI 10.1007/s10459-020-10000-3, DOI	2021	9.59	**2022**	2023	
Creswell JW, 2022, RESEARCH DESIGN: QUALITATIVE, V0, P0, DOI 10.5539/ELT.V12N5P40, DOI	2022	7.24	**2022**	2023	
Manzano-León A, 2021, SUSTAINABILITY-BASEL, V13, P0, DOI 10.3390/su13042247, DOI	2021	7.24	**2022**	2023	
Gentry SV, 2019, J MED INTERNET RES, V21, P0, DOI 10.2196/12994, DOI	2019	6.85	**2022**	2023	
R Core Team, 2018, R: A LANGUAGE AND ENVIRONMENT FOR STATISTICAL COMPUTING, V0, P0	2018	6.81	**2022**	2023	

Figure 17. Top 50 references with the stongest citation bursts

2. Conclusion, Limitations and Direction for Future Research

2.1. Section Headings

This study conducted an in-depth visualization analysis of the trends, structure, and evolution of gamification research from 2004 to 2023 using data collected from the WoSCC database and employing bibliometric methods. Out of the initial 4993 articles, 4373 were selected for detailed analysis. Citation analysis was used to depict the main trends in gamification research, while co-word analysis revealed the core knowledge structure of the field. The University of California system emerged as the most prominent research institution due to its high productivity and influence, while the journal Computers & Education was identified as the most cited journal, reflecting its central position in gamified education research.

Analysis of author collaboration networks revealed a moderate level of collaboration within the field, particularly evidenced by four clusters formed around key figures such as Juho Hamari, generating a total of 19 links. This collaborative relationship highlights the close communication and cooperation within the gamified education research community. Further analysis also found influential institutions such as the University of California system and Ohio University system playing significant roles in advancing gamified education research, emphasizing the importance of collaboration with other institutions for academic progress and knowledge innovation.

Gamified education, as an effective strategy for enhancing learning motivation and engagement, has received increased attention, especially during the COVID-19 pandemic, when the rapid digital transformation of education accelerated the adoption of remote learning and digital tools. Future trends in education are expected to continue being profoundly influenced by technological advancements, with widespread applications of augmented reality, gamified learning, artificial

intelligence, and blended learning modes indicating a shift towards more interactive, efficient, and personalized education. Additionally, the connection between mental health and learning outcomes will receive more attention, further promoting students' overall development and improving learning effectiveness.

However, this study has some limitations due to objective factors. Firstly, the use of bibliometric analysis software imposes high standards and norms on data, leading to the exclusion of other databases (such as Scopus) to ensure the quality and completeness of the collected data, which may result in incomplete analysis. Moreover, quantitative analysis requires researchers to have a deep and comprehensive understanding of the field for data analysis and interpretation, which inevitably introduces subjectivity.

It is reasonable to believe that research combining education and gamification will continue dynamically, making this study significant for further deepening. In future research, it is essential to integrate literature from multiple databases to ensure the comprehensiveness of the selected data and actively communicate with scholars in the fields of educational big data and data mining to understand the cutting-edge dynamics of the field, enhancing and deepening the objective understanding of the field while minimizing subjectivity in analysis and interpretation.

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