

Research Trends

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**Research Trends and Applications of Gamification
in Higher Education: A Bibliometric Analysis
Spanning 2013–2022**

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Abstract—Gamification plays an essential role in supporting educational goals. Existing literature confirmed that gamification has been widely used to elevate student achievement in many fields. This study examines the current status and research trends of gamification applications in higher education by conducting a comprehensive bibliometric analysis during the period 2013–2022. This study focuses on publication language, growth rates, most frequent author keywords, most cited papers, most prolific authors, most impactful journals, most productive institutions, and most active countries. For bibliometric mapping analysis, a total of 819 peer-reviewed journal articles were retrieved from the Scopus database. The results showed that: (1) the majority of the manuscripts are written in English, (2) the peak of publication is 2021 with 216 papers, (3) gamification, higher education, and motivation have been the most used keywords, (4) the works of Domínguez et al., de-Marcos et al., and Buckley and Doyle have been the most frequently cited documents, (5) de-Marcos, Bo, and Pérez-López have been the most important authors, (6) *Sustainability*, *International Journal of Emerging Technologies in Learning*, and *Journal of Chemical Education* have been among the top journals, (7) Universidad de Granada, Universidad de Sevilla, and Tecnológico de Monterrey have been the top institutions, and (8) Spain, the US, and the UK have been the most important countries in this area. This study offers a useful contribution in the area and provides a comprehensive overview, scientific landscape, and future direction of the field.

Keywords—research trends, bibliometric analysis, gamification, higher education

1 Introduction

Higher education institutions around the world have recognized the importance of employing technology to support more engagement in learning [1]. This may be the fact that the effective use of ICT in technology-enhanced learning provides a meaningful and authentic learning experience for students [2]. Extensive use of technology has also reduced the dominance of conventional teaching methods and improved

student achievement [3]. Without a doubt, in the coming years, technology will affect the learning experiences of college and university students in many ways. Interestingly, educational gamification has gained popularity and been applied in higher education. Gamification offers a rich and valuable learning experience and supports the acquisition of scientific knowledge and 21st century skills. Previous studies highlighted that gamification can support educational goals, for example increasing motivation and achievement [4][5], competence [6], positive attitude [7], engagement [5][8][9], and self-confidence [10]. Existing literature also noted that gamification has been used to improve student achievement in various content areas, including science [4][10], ICT [11], engineering [8], and mathematics [12]. Through gamification, digital technologies offer students an authentic learning experience [13].

Nowadays, gamification plays a crucial role in supporting student learning. Since its introduction in the early 2000s, gamification has become increasingly widely accepted in the scientific community and has grown rapidly as ICT advances [14]. So far, the definition of gamification in the existing literature varies; there is no universal convergence of definitions. In general, gamification is conceptualized as the use of game design elements in non-game environments [15] to provide an immersive learning experience for students. More specifically, Kapp [16] proposed gamification as “using game-based mechanics, aesthetics, and game thinking to engage people, motivate action, promote learning, and solve problems” (p. 10). In essence, educational gamification aims to embed a fun and motivating game component into real-life learning environments to create more active, engaging, and entertaining learning situations [17]. It turns the learning and teaching process into a more motivating and enjoyable experience. Gamification is suitable for active learning because it provides a safe and inspiring environment to explore, make complex decisions, and think about the impact of their behavior [18]. From the point of view of social constructivism, educational games offer the creation of an engaging, authentic, complex, and collaborative space for reflection and learning for both students and teachers [19].

Previous evidence on the application of gamification has been well documented. In a bibliometric study, Khatibi et al. [20] investigated the applications of gamification in higher education between 2010 and 2020 from the Web of Science (WoS) database. With this study, research trends, publication types, the most prolific countries, source titles, organizations, author keywords, and cited publications were revealed. Similarly, Trinidad et al. [21] also reviewed 4706 documents on gamification from the WoS database (1900–2019) and revealed that this topic is growing rapidly. The findings of the study provided important insights related to the most influential countries, publications and sources, authors and keywords, networks of collaboration, and hot topics. Furthermore, López-Belmonte et al. [22] conducted a bibliometric analysis of the development of gamification in learning between 2011 and 2019 from the WoS database. They reported that this topic is gaining momentum. Recently, Behl et al. [23] presented emerging trends of gamification and e-learning for young learners using systematic review and bibliometric analysis based on 222 selected papers published between 2015 and 2020. They emphasized future research themes of personalization, elements of the game, styles of the learner, and engagement of the learner. Earlier studies have contributed to the growing body of research on the applications of gamification in higher education.

In general, bibliometric research on the use of gamification has been reported up to 2020. To the best of our knowledge, there are no bibliometric studies of the applications of gamification in the field of higher education in the last five-year period. Thus, this study is the first to carry out a bibliometric mapping analysis in the field. Note that the bibliometric review provides a comprehensive overview of the scientific productions to uncover research activity over time and identify the most prominent authors and affiliations [24]. Since previous bibliometric studies (e.g., [20][21][22]) have focused on trends in gamification research from the WoS database, the current study, as recommended by Trinidad et al. [21], used the Scopus database. Scopus is the largest database with abstracts and citations from more than twenty-five thousand active peer-reviewed journals and seven thousand publishers [25]. Analyzing peer-reviewed journal articles indexed in reputable databases allows researchers to capture the most relevant trends in the field. In the previous literature, Swacha [26] also performed a bibliometric analysis of 2517 publications on gamification in education from the Scopus database (1900–2020). He revealed important information about the geographic distribution of publications, forms of publication, research areas and topics, the most active institutions and authors, research collaboration, and research impact. Due to the fact that Scopus is continuously updated daily [25], the results obtained using the same command during search queries performed at different times may vary slightly. Thus, this study is intended to provide an overview of recent research and offer new directions in the field of gamification, particularly in higher education. Moreover, our findings may serve as a starting point for future researchers in this area.

Previous bibliometric studies have detailed the current state of gamification use in higher education; as such, they provide a valuable contribution to trends in this area. When publication trends in earlier studies were investigated [20][21][22][26], it was seen that the main variables studied were similar to those in the current study. Without a doubt, the increasing amount of empirical research on the use of gamification requires a comprehensive synthesis. Therefore, a systematic bibliometric review of gamification research should be carried out. In this review, we proposed an objective to broadly capture the current dynamics and research patterns of gamification applications in higher education in the past decade. The study reflects the growth and trends of gamification application research with respect to language, annual production, most used keywords, most cited documents, most prolific authors, most active journals, most productive institutions, and most prolific countries. Taking into account recent peer-reviewed journal papers regarding the application of gamification in learning, the present review is intended to complement previous evidence and enhance the existing literature on publication trends and current patterns of gamification in higher education. The research questions guiding the current study were posed as follows:

- RQ1: Which publication languages are used the most frequently related to the research on gamification applications in higher education?
- RQ2: How many publications in the field were published from 2013 to 2022?
- RQ3: Which keywords do authors on the applications of gamification in higher education use the most frequently?
- RQ4: Which research documents are cited the most frequently by authors?
- RQ5: Who are the most-cited authors in publications on the use of gamification in higher education?

- RQ6: What are the most active journals concerning the production of research papers in this area?
- RQ7: Which institutions contribute the most publications over the last 10-year period?
- RQ8: What are the most prolific countries in terms of the production of research papers?

2 Methods

2.1 Study design

This systematic review aims to understand the evolution of the use of gamification in higher education. In this scope, we took the journal literature on gamification applications in higher education as the object of research. To this end, the scientific literature from the Scopus database 2013–2022 was extracted. In this bibliometric analysis, we used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA; [27]) guidelines to present a comprehensive overview of the literature on the use of gamification in higher education. The entire procedure for conducting bibliometric mapping analysis based on the PRISMA protocol is presented in Figure 1. This protocol was implemented to minimize bias and report findings transparently and credibly. As suggested by McBurney and Novak [28], research trends and publication characteristics of an academic field can be explored quantitatively using the bibliometric analysis method. The bibliometric analysis provided systematic information that outlines quantitative publications and helps researchers to determine research trends and patterns in a particular field.

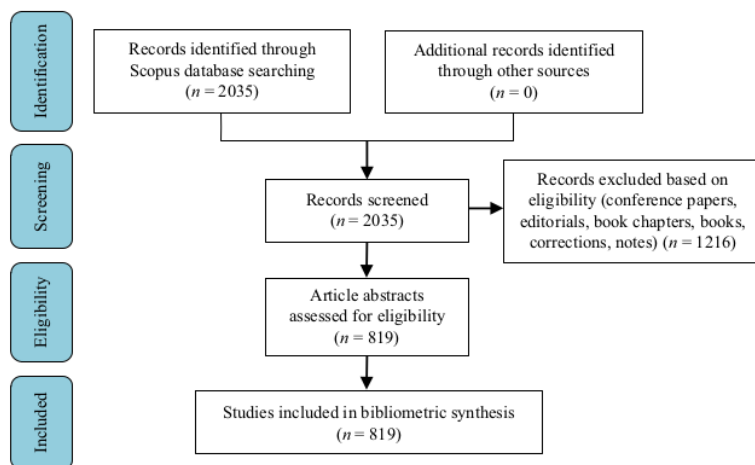


Fig. 1. PRISMA flow diagram of the present study

2.2 Procedure

The documents selected in this study were retrieved from the Scopus database (<https://www.scopus.com/>) on April 16, 2022. Using the advanced search function, the search string encompassed a combination of compound keywords combined with the OR and AND operators. The command is as follows: TITLE-ABS-KEY (("gamif*") AND ("higher education" OR "tertiary education" OR "universit*" OR "undergraduate*" OR "college*")) AND (LIMIT-TO (DOCTYPE,"ar")). To extend the search, the asterisk (*) symbol replaced any group of characters. For example, gamif* would find gamification, gamified, gamify, gamifying, etc. The inclusion criteria were selected articles containing one of the keywords either in the title, abstract, or keywords. The variables examined were publication language, year of publication, used keywords, cited documents, cited authors, active journals, productive journals, and prolific countries. We then extracted the frequency of each variable. To map trends in this area, the indexes were analyzed quantitatively.

In the search process, no specific timeframe was used. The bibliometric analysis included published documents across all years. Interestingly, the first paper was published in 2013. Therefore, the time of data collection in this study was 2013–2022 at a 10-year interval. After an initial search, a total of 2035 papers were accessed from 2013 through 2022 (in press included). In this review, the document type was determined as journal articles. Among the document types, conference papers, books, book chapters, theses, editorials, corrections, and letters were then excluded from the study. We performed Scopus filters to exclude 1216 irrelevant works, including editorials, comments, and book reviews. After excluding works not related to the research objectives, a total of 819 articles were eventually extracted. Of all the sampled articles, each data including the citation information, bibliographical information, and abstract and keywords was downloaded. Then, the file was uploaded to the Visualization of Similarities (VOS) viewer.

2.3 Data analysis

In order to answer the research questions, the final articles were read thoroughly to extract the relevant data. Data were also studied during the analysis process. To run the analysis on bibliometric software, we extracted information from the Scopus database into comma-separated values (file .csv) and research information systems (file .ris) formats. Data were then analyzed including descriptive statistics, citation analysis, and co-citation analysis. Descriptive statistics (e.g., frequencies and percentages) were executed to assess the results. Quantitative information such as annual publication growth, the sources with the top publication volumes, and the institutions or authors with the highest productivity was presented. Citation analysis refers to the number of times an author was cited in other Scopus-indexed works. To assign the authorship of each paper, all individuals identified as authors in the sample papers were counted equally.

As a quantitative method, the bibliometric analysis comprised co-authorship, keyword co-occurrence, citation, bibliographic coupling, and so on, to ensure rigor. As one of the most popular computer software, VOSviewer was performed to collect, analyze, create, and visualize bibliographic features in this study. VOSviewer was run

to express network visualization and graphical representation of the most employed keywords, words written in abstracts, and citation and co-citation analyses in the target papers. Specifically, this software was used to visualize co-occurrences of the author keywords, bibliographic coupling of the authors, and bibliographic coupling of the countries. VOSviewer software [29] was used in this study because of its popularity in publications using bibliometric analysis. We also employed Microsoft Excel to display tables and graphs in terms of the publication language, number of annual publications, most cited documents, prolific authors, relevant journals, productive institutions, and active countries.

3 Findings

3.1 Publication language

As aforementioned, the results of the analysis reflected the 819 papers on the applications of gamification in higher education over the study period. As shown in Table 1 (to answer RQ1), scientific research has been published in 12 different languages. Regarding the language of the document, 90.60% of papers were published in English, followed by Spanish (5.86%), and Russian (1.47%). Other languages were Portuguese ($n = 6$), Hungarian ($n = 3$), Turkish ($n = 2$), and Arabic, French, German, Italian, Persian, and Slovenian (1 paper each).

Table 1. Top 5 most used languages

Language	Documents	Percentage (%)
English	742	90.60
Spanish	48	5.86
Russian	12	1.47
Portuguese	6	0.73
Hungarian	3	0.37

3.2 Annual production

In order to address RQ2, we visualized the annual scientific output in the field of gamification applications. The results indicated that the count of publications differed throughout the year. As can be seen, the year 2021 had the highest number and 2013 had the lowest number of publications in gamification applications. By 2021, the number of published documents was around four times greater than in 2017. As shown in Figure 2, research on the use of gamification appeared to have started in 2013 ($n = 8$; 973 citations) with the work of Nahl and James [30] being the first paper recorded in that year. They studied how gamification strategies in online university courses can promote students' thinking and motivation.

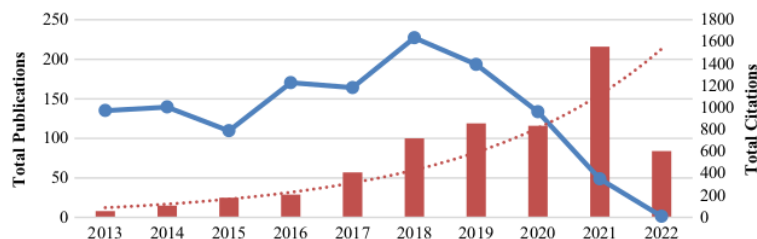


Fig. 2. Evolution of publication and citation (2013–2022)

Figure 2 summarizes most of the publications on the applications of gamification in higher education published after 2017. It shows steady growth since that year. The growth trajectory of the literature on the use of gamification in higher education began at a gentle pace between 2013 and 2017 but continued to gain momentum in the following years. Over the past decade, the highest number of citations was observed in 2018, with a total of 1636 citations (17.17%). Trend line analysis of citation counts implies an increased impact of gamification. Specifically, between 2018 and 2022 there were 685 works, representing 83.64% of the total publications, being the year 2021 with the highest publication to date (i.e., 216 papers, representing 26.37% of the total volume). The quantity of research evidence in this area continues to show a trend of robust growth, which is a positive response from the academic community in popularizing the use of gamification to date. It should be noted that, until 2021, the determination value (R^2) yields 0.97 revealing that the exponential trend line is reliable. The endpoint of data collection in this review was April 2022, which determines why only 84 documents (9 citations; 0.09%) appeared in 2022. Since the data was taken in the first quarter of 2022, it is expected that scientific contributions will continue to grow for the whole of 2022 and in the coming year.

3.3 Most used keywords

In response to RQ3, we consider the co-occurrence of each keyword. This analysis was conducted within the review to identify frequently employed words in the published articles. The nodes reflect the terms and the distance between nodes indicates the relationship for each term [31]. The size of the words reflects the frequency of appearance in reviewed studies and the greater number of associations with other words. Co-occurrences of the author keywords are then exhibited in Figure 3. By using VOSviewer, the minimum number of occurrences of a keyword was set as 5—the threshold value for our analysis—and the number of keywords to be selected was automatically given as 96. As a result of the analysis, there were twelve clusters in this visualization map. The most used keyword was “gamification” (510 occurrences, 756 total link strength). In addition, it was observed that “higher education” (104, 223), “motivation” (76, 180), and “game-based learning” (50, 134) were the most used keywords.

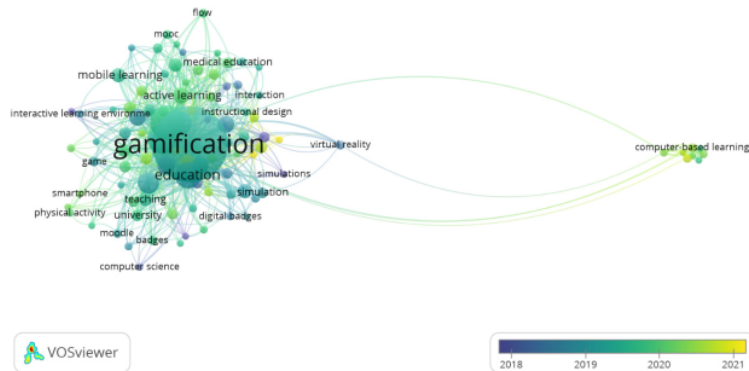


Fig. 3. Bibliometric map of author keywords co-occurrence

As detailed in Figure 3, the different colors reveal the publication date of reviewed documents in which these keywords appear. The yellow color exhibits keywords that are relatively recent in publications. This figure indicates that the most trending topics in publications in the field are “gamification”, “higher education”, “motivation”, and “game-based learning”. It is clear that gamification is the main keyword in gamification research in higher education.

3.4 Most highly cited documents

With respect to RQ4, the documents with the highest number of citations are identified and shown in Table 2. This table reflects the papers with the highest citation frequency among gamification application papers since 2013. Note that the number of citations refers to a measure of impact.

Table 2. Top 15 most cited documents

#	Author	Title	Journal	Cites
1	Domínguez et al. [32]	Gamifying learning experiences: Practical implications and outcomes	Computers and Education	878
2	de-Marcos et al. [33]	An empirical study comparing gamification and social networking on e-learning	Computers and Education	317
3	Buckley & Doyle [34]	Gamification and student motivation	Interactive Learning Environments	222
4	Subhash & Cudney [35]	Gamified learning in higher education: A systematic review of the literature	Computers in Human Behavior	190
5	Christy & Fox [36]	Leaderboards in a virtual classroom: A test of stereotype threat and social comparison explanations for women’s math performance	Computers and Education	152

(Continued)

Table 2. Top 15 most cited documents (Continued)

#	Author	Title	Journal	Cites
6	de-Marcos, Garcia-Lopez, & Garcia-Cabot [37]	On the effectiveness of game-like and social approaches in learning: Comparing educational gaming, gamification & social networking	Computers and Education	151
7	Looyestyn et al. [38]	Does gamification increase engagement with online programs? A systematic review	PLoS ONE	132
8	Hew et al. [39]	Engaging Asian students through game mechanics: Findings from two experiment studies	Computers and Education	132
9	Nevin et al. [40]	Gamification as a tool for enhancing graduate medical education	Postgraduate Medical Journal	117
10	Yildirim [41]	The effects of gamification-based teaching practices on student achievement and students' attitudes toward lessons	Internet and Higher Education	116
11	Bonde et al. [42]	Improving biotech education through gamified laboratory simulations	Nature Biotechnology	110
12	Mora et al. [43]	Gamification: A systematic review of design frameworks	Journal of Computing in Higher Education	107
13	Licorish et al. [44]	Students' perception of Kahoot!'s influence on teaching and learning	Research and Practice in Technology Enhanced Learning	101
14	Bicen & Kocakoyun [45]	Perceptions of students for gamification approach: Kahoot as a case study	International Journal of Emerging Technologies in Learning	94
15	Huang et al. [9]	Investigating the effects of gamification-enhanced flipped learning on undergraduate students' behavioral and cognitive engagement	Interactive Learning Environments	93

Regarding the articles with the greatest influence based on the most number of citations, the top 15 works were taken. When examined by year of publication, the top 15 papers were published after 2013. As organized in Table 2, the first presents 878 citations, entitled “*Gamifying learning experiences: Practical implications and outcomes*”, in which the authors suggested that students who took gamified exercises scored higher on practical assignments, but they performed poorly on written assignments and participation [32]. Behind it is “*An empirical study comparing gamification and social networking on e-learning*”, a study carried out on how social networking and gamification affect the academic achievement and attitude of first-year undergraduate students [33], with a total of 317 citations. Then, the work entitled “*Gamification and student motivation*” studied how gamified learning interventions have a positive effect on students' learning outcomes [34], with 222 citations. As a result of the analysis, the total number of citations for 819 documents was found to be 9526. The highest number of citations was recorded in 2018, with 1636 citations. Among these publications, the average number of citations per article was 11.63. As of the first quarter of 2022,

the average annual citation was 952.60. The number of papers with at least 50 citations was 42 (5.13%), of which only 13 documents (1.59%) have over 100 citations. In contrast, 29.30% of publications ($n = 240$) have not been cited to date.

3.5 Most prolific authors

Addressing RQ5, information on the top 15 productive authors with the highest number of publications related to the applications of gamification in higher education is presented in Table 3. It should be noted that the quantity of publications is a measure of productivity.

Table 3. Number of publications in the top 15 authors

#	Author	Institution	Country	N	H-Index
1	de-Marcos, L.	Universidad de Alcalá	Spain	6	12
2	Boyle, S.C.	Loyola Marymount University	United States	5	12
3	Pérez-López, I.J.	Universidad de Granada	Spain	5	11
4	Bernik, A.	University North	Croatia	4	5
5	Earle, A.M.	Loyola Marymount University	United States	4	9
6	Hew, K.F.	University of Hong Kong	Hong Kong	4	38
7	Huang, B.	University of Hong Kong	Hong Kong	4	6
8	LaBrie, J.W.	Loyola Marymount University	United States	4	14
9	Mena, J.	Universidad de Salamanca	Spain	4	13
10	Vinichenko, M.V.	Russian State Social University	Russian Federation	4	17
11	Barata, G.	Universidade de Lisboa	Portugal	3	9
12	Domínguez, A.	Universidad de Alcalá	Spain	3	3
13	Fonseca, D.	Ramon Llull University	Spain	3	17
14	Fung, F.M.	National University of Singapore	Singapore	3	10
15	Gama, S.	Universidade de Lisboa	Portugal	3	10

It can be observed that the authors with the most publications were Luis de-Marcos with 6 articles, followed by Sarah Boyle and Isaac Pérez-López, with 5 articles each. The following authors were Andrija Bernik, Andrew Earle, Khe Hew, Biyun Huang, Joseph LaBrie, Juanjo Mena, and Mikhail Vinichenko, who had 4 articles each. The remaining authors in the top fifteen were Gabriel Barata, Adrián Domínguez, David Fonseca, Fun Fung, and Sandra Gama, with 3 works. Table 3 also highlights the most prolific authors by *h*-indexes. The *h*-index [46] is an index that measures the productivity and impact of a researcher's work published in the Scopus database. As can be seen in Table 3, the three authors who stood out the most were Hew (*h*-index = 38), Vinichenko (17), and LaBrie (14). More importantly, works written by Spain researchers had the highest number of publications ($n = 21$), followed by the US (13) and Hong Kong (8) researchers. By and large, 23.13% of authors ($n = 37$) produced at least 3 documents. Of the 160 authors, more than three-quarters ($n = 123$) of them have 2 articles.

In this section, we also analyzed the collaboration network of the authors in the dataset. The minimum number of documents by a particular author was set as 3 and the minimum number of citations of an author was determined as 10. Figure 4 represents the entire collaboration network of 35 authors. As we can observe in this visualization map, there are 20 collaboration clusters, each with a different color. Each collaboration cluster has a different size and is mostly disconnected from other clusters. The larger the node size, the greater the number of author articles. Analyzing this figure, the main cluster has four authors, including de-Macros who are closely connected to Domínguez, García-Cabot, and García-Lopez with red nodes. The second cluster consisted of three authors: Barata, Gama, and Jorge with green nodes. The third cluster also included three authors: Boyle, Earle, and LaBrie, with blue nodes. As seen from the bibliometrics, 3 clusters consist of 3 authors, 6 clusters with 2 authors, and 10 clusters with 1 author. It can be concluded that the cooperation between gamification researchers is not strong enough. The fact is that studies in this area were carried out in small groups of one to four authors.

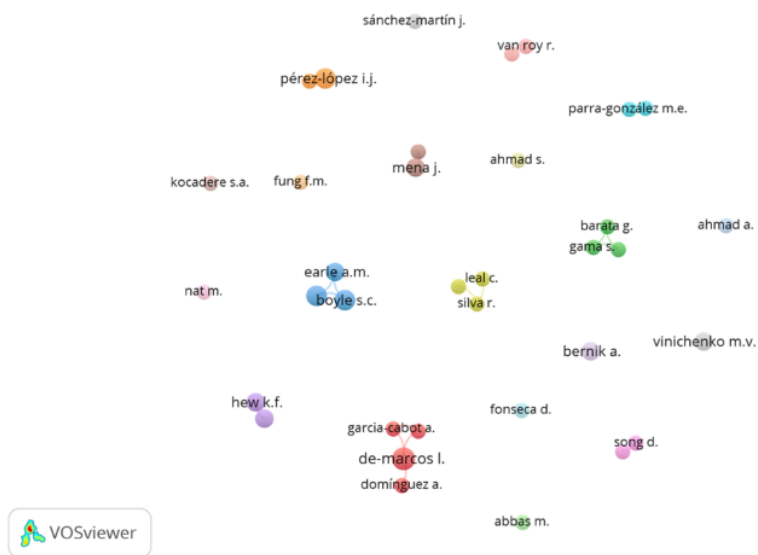


Fig. 4. Collaboration network of authors

3.6 Most relevant journals

As for RQ6, the top 15 most prolific journals regarding the number of publications, *h*-index, Scopus quartile (Q), SCImago Journal Rank (SJR), and home publishing are presented. The results are then listed in Table 4.

Table 4. Top 15 most active journals

#	Journal	N	H-Index	Q	SJR 2020	Publisher
1	Sustainability	21	85	Q1	0.61	MDPI
2	International Journal of Emerging Technologies in Learning	20	24	Q2	0.45	Kassel University Press
3	Journal of Chemical Education	16	84	Q2	0.50	American Chemical Society
4	Computers and Education	15	179	Q1	3.03	Elsevier
5	Education and Information Technologies	13	41	Q1	0.92	Kluwer Academic Publishers
6	Computer Applications in Engineering Education	13	29	Q2	0.48	John Wiley and Sons
7	Electronic Journal of E-Learning	11	24	Q2	0.57	Academic Publishing
8	Perspectives of Science and Education	10	5	Q2	0.18	LLC "Ecological Help"
9	Education Sciences	9	19	Q2	0.45	MDPI
10	Frontiers in Education	9	11	Q2	0.49	Frontiers Media
11	Computers in Human Behavior	8	178	Q1	2.11	Elsevier
12	IEEE Access	8	127	Q1	0.59	Institute of Electrical and Electronics Engineers
13	International Journal of Environmental Research and Public Health	8	113	Q2	0.75	MDPI
14	Nurse Education Today	8	78	Q1	1.40	Churchill Livingstone
15	International Journal of Game-Based Learning	7	16	Q3	0.39	IGI Global Publishing

According to data from the Scopus database, 161 different journals contributed to the accessed literature. As summarized in Table 4, *Sustainability* journal was the most active source with 21 documents. Other relevant sources included *International Journal of Emerging Technologies in Learning* with 20 documents and *Journal of Chemical Education* with 16 documents. The fourth and fifth most cited resources were *Computers and Education* and *Education and Information Technologies*, which had 15 and 13 documents, respectively. As indicated in Table 4, it was found that *Computers and Education* had the highest research *h*-index (179), followed by *Computers in Human Behavior* (178), and *IEEE Access* (127), which indicated that these three journals have had a significant influence on gamification research. When ranked by SJR, *Computers and Education* was the journal with the highest value (3.03). The second rank was *Computers in Human Behavior* with SJR 2.11. The third rank was *Nurse Education Today* with SJR of 1.40. SJR refers to the average number of weighted citations received by the source title in a year. All these indicators (i.e., *h*-index and SJR) demonstrate the impact and importance of academic journals in the field of gamification. Specifically, 4.97% ($n = 8$) sources contributed at least 10 papers and 20 (12.42%) sources contributed only one paper. Interestingly, most of the sources in the top 15 journals ranked highly in the Scopus journal rankings, including Q1 (6), Q2 (8), and Q3 (1). The Scopus

Q index is the ranking of a journal in a particular field, ranging from Q1 (most impactful) to Q4 (least impactful). The most active publishers to research gamification applications in higher education have been MDPI ($n = 3$) and Elsevier (2). The remaining publishers in the top fifteen were Academic Publishing, American Chemical Society, Churchill Livingstone, Frontiers Media, IGI Global Publishing, Institute of Electrical and Electronics Engineers, John Wiley and Sons, Kassel University Press, Kluwer Academic Publishers, and LLC “Ecological Help”, with 1 paper, respectively.

3.7 Most productive institutions

With regard to RQ7, Table 5 displays the distribution of countries, types of institutions, and the number of publications of the top 15 most prolific institutions. As listed in Table 5, all the top 15 institutions contributed 16.61% ($n = 136$) of the total papers.

Table 5. Top 15 most prolific institutions

#	Institution	Country	Types	Documents
1	Universidad de Granada	Spain	Public	17
2	Universidad de Sevilla	Spain	Public	15
3	Tecnologico de Monterrey	Mexico	Private	11
4	Universidad de Extremadura	Spain	Public	11
5	Universidad de Alcalá	Spain	Public	10
6	Kazan Federal University	Russian Federation	Public	10
7	International University of La Rioja	Spain	Private	9
8	Universidad de Murcia	Spain	Public	7
9	Universidad de Castilla-La Mancha	Spain	Public	7
10	Universidad de Almería	Spain	Public	7
11	Universidad Rey Juan Carlos	Spain	Public	7
12	Universiti Putra Malaysia	Malaysia	Public	7
13	Universiti Sains Malaysia	Malaysia	Public	6
14	Universiti Teknologi MARA	Malaysia	Public	6
15	Universidad Politécnica de Madrid	Spain	Public	6

Observing Table 5, the most prolific institution in this field was the Universidad de Granada, a public university with 17 papers. Its production rate slightly exceeded that of other institutions. The second-ranked institution was Universidad de Sevilla, with 15 documents. As a private university, Tecnológico de Monterrey was the third most productive institution with 11 works. Overall, there were only two private education institutions on the list above. As seen in Table 5, 86.87% of the universities were public research institutions, and thus we can conclude that public universities dominated the contribution to this domain. Of the 15 institutions, 10 were from Spain, and 3 were from Malaysia. In addition, Mexico and the Russian Federation were represented by 1 institution each.

3.8 Prominent contributing countries

Answering RQ8, the top 15 countries in terms of countries with the highest scientific production are presented in Table 6.

Table 6. Top 15 most prolific countries

#	Country	N of Papers	%	N of Citations	%
1	Spain	160	19.54	2811	29.51
2	United States	131	16.00	1984	20.83
3	United Kingdom	54	6.59	615	6.46
4	Malaysia	46	5.62	303	3.18
5	Russian Federation	43	5.25	150	1.57
6	China	29	3.54	107	1.12
7	Germany	26	3.17	237	2.49
8	Portugal	26	3.17	356	3.74
9	Canada	25	3.05	226	2.37
10	Turkey	24	2.93	418	4.39
11	Indonesia	21	2.56	49	0.51
12	Brazil	20	2.44	126	1.32
13	Australia	18	2.20	296	3.11
14	Hong Kong	18	2.20	341	3.58
15	Mexico	18	2.20	86	0.90

As listed in Table 6, the 15 most prolific countries/regions contributed 659 papers, or 80.46% of the total. Spain stood out from the rest, being the country with the largest number of papers ($n = 160$; 19.54%). The US collected the second largest number of documents (131; 16.00%) and the UK in the third position (54; 6.59%), although the level of scientific output is far from the first. Malaysia and Russian Federation had almost the same number of publications, 46 and 43 papers, respectively. The publications were then grouped by region. Of the top 15 most productive countries, 266 (32.48%) documents were produced in Western Europe, 156 (19.05%) in Northern America, 114 (13.92%) in Asia, and 43 (5.25%) in Eastern Europe. The next region was Latin America ($n = 38$; 4.64%), followed by the Middle East (24; 2.93%), and Pacific Region (18; 2.20%). In the Asian context, Malaysia has the highest contribution. Unfortunately, from this list, we did not find publications from African countries. Regarding citations by country, Spain is still the country with the highest number of citations with 2811 citations (29.51%), followed by the US with 1984 citations (20.83%) and the UK with 615 citations (6.46%). The remaining countries have citation counts between 49 (Indonesia) and 418 (Turkey).

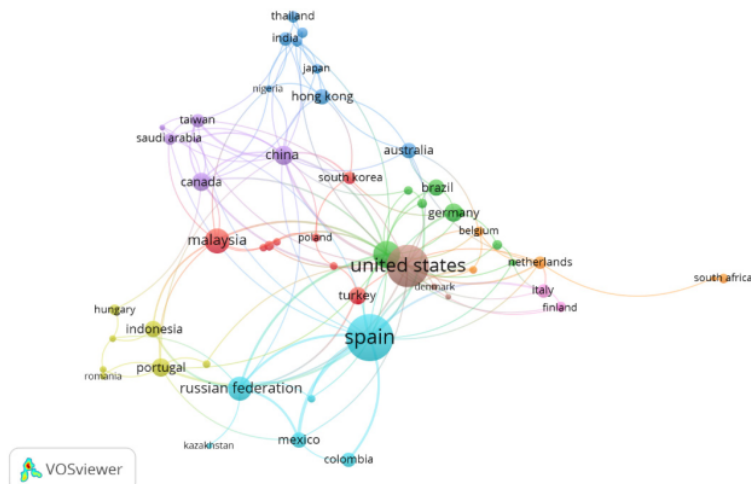


Fig. 5. Bibliographic coupling of the most productive countries

Finally, the bibliographic coupling of the countries is then presented. The minimum number of documents of a country was set as 3 and the minimum number of citations of a country was determined as 5. The number of countries to be selected was automatically given as 58. The number of publications and total link strength were then computed. The results of the analysis are shown in Figure 5. This figure can be seen along with the data according to Table 6. Looking at the graph, there were nine clusters for the authors. In the largest cluster, there were Cyprus, Lithuania, Malaysia, Pakistan, Poland, South Korea, Turkey, Ukraine, and the UAE. In addition, Austria, Brazil, Chile, France, Germany, Norway, Sweden, and the UK were included in the second cluster. Note that different colors exhibit different clusters. For example in Cluster 6, Spain, Colombia, Mexico, Ireland, Russian Federation, and Kazakhstan which are in blue were connected to each other. The top country in this list was Spain with 160 papers and 40 total link strength, followed by the US ($n=130$, 28 total link strength) and the UK (54, 32). The other countries were; Malaysia (46, 11), Russian Federation (43, 23), China (29, 30), Portugal (26, 11), Germany (26, 6), etc.

4 Discussion

In this study, we used the Scopus database to map trends in publications studying gamification applications in higher education over the last decade (2013–2022). This bibliometric review provided a comprehensive understanding of prior studies and some possible directions for further research in this area. Based on the results, the most frequently used language in publications is English with 742 published papers. Spanish ranked second with 48 papers, followed by Russian with 12 papers. It is aligned with

the main findings of earlier studies. For instance, regarding the main language of publication, López-Belmonte et al. [22] noticed that English (92%) was the most prominent language in this area, followed by Spanish (7%). It can be further seen that the majority of documents came from English-speaking countries such as the UK, Australia, the USA, and Canada. This reflects the dominance of the Anglo-Saxons in publications. Not surprisingly, English is seen as the international language of science as well as the main language for the dissemination of scientific knowledge to date. According to van Weijen [47], about 80% of all journals indexed by Scopus are published in English.

It is noteworthy that in 2013, only 8 papers were first recorded, indicating the beginning of the growth of publications in the field. All of these 8 articles have been cited 973 times to date. From 2013 to 2021, scientific production continues to grow. In 2021, 216 papers were published, which makes it the highest publication of this period. The results show growth in interest in the field. In the Swacha [26] study, the trend of gamification research from Scopus also began to develop after 2011. As such, it can be concluded that the number of works on gamification applications in higher education has increased rapidly. Since this bibliometric analysis was carried out until April 2022, it can be concluded that the number of publications in 2022 and beyond is expected to increase with time. As Figure 2 visualized, the number of publications in 2021 is much higher than in 2013. Therefore, the current findings confirm Price's Law which proposes that the growth of scientific outputs tends to double after 10 years [48]. The findings obtained in this context are supported by the literature (e.g., [21][22][26][49]). In a systematic review, Subhash and Cudney [35] reviewed 41 documents relating to gamified learning in higher education. They found that publications in this area have only received attention since 2013, but have increased rapidly in recent years. The increase in the number of publications may be due to the increasing interest of educators, researchers, and academic institutions around the world in the use of gamification in higher education [21][26]. Although the topic of gamification is relatively young, the widespread use of gamified mobile apps, both face-to-face in traditional classrooms and virtual learning environments [5][18][44][45], seems to have led to a sharp increase in gamification research in higher education.

The results of the bibliometric analysis showed that "gamification" is the most used keyword. As expected, other words like "higher education", "motivation", "game-based learning", "education", and "e-learning" were important terms that emerged in the study. This is also consistent with previous studies (e.g., [21][26]). In a study involving 2517 documents from Google Scholar, Scopus, and WoS databases, Swacha [26] asserted that the most frequently used keywords besides gamification were motivation and game-based learning. Similarly, Trinidad et al. [21] also pointed out that of the 20 most frequently used author keywords, motivation, serious games, education, game-based learning, learning, and e-learning were some of the most explored domains. It can be inferred that the terms "gamification", "higher education", "motivation", "game-based learning", "education", and "e-learning" have greater impact, suggesting the hot topics of gamification research in higher education. In brief, it indicates that this topic has gained an important place among educational technology researchers in the last decade [50]. The author keywords are considered essential to analyze in the current study due to the fact that the keywords of an author generally represent the

content of the paper [51]. As suggested by Wen and Huang [52], the author's keyword analysis is important to perform in order to evaluate the development of research topics.

Research trends in the field have been a topic of interest among scholars over the last decade across different regions. From the year distribution, the highly cited document is mainly concentrated in 2018. The highest number of citations per article so far belonged to Domínguez et al. [32] with 878 citations. This is followed by the paper of de-Marcos [33] with 317 citations and Buckley and Doyle [34] with 222 citations. It can be said that the paper written by Domínguez et al. [32] had a major impact on gamification research in the last ten years. The findings also confirmed a study conducted by Swacha [26], who reported that the work of Domínguez et al. [32] is the most cited document. In a similar vein, Trinidad et al. [21] also agreed that the most-cited papers published in the period 2011–2013 in this area belong to Domínguez et al. [32]. As mentioned by Aksnes et al. [53], the more citations the greater the effect of the research. In other words, the frequently cited articles imply the most influential scientific works in this field.

It is known that the most active contributors to research on gamification applications in higher education have been de-Marcos (6), Boyle (5), and Pérez-López (5). The following seven have 4 articles each and six have 4 articles each. As a matter of fact, Dr. Luis de-Marcos, from the Universidad de Alcalá (Spain), has written extensively on gamification, educational technology, and e-learning and has published his works in leading scientific journals. Existing literature (e.g., [21][26][49]) also reviewed articles written by these authors in the field of gamification. When examined by region/country, the fifteen scholars with the most production came from Spain, followed by the US and Hong Kong. This result shows the surge of interest in the subject. A possible reason may be the fact that Spain has a good scientific research system. With only about 1% of global research and development (R&D) spending, Spanish researchers generated 3.10% of global scientific output and 16.70% of publications in the most prestigious peer-reviewed journals [54]. According to the findings, it can be suggested that researchers from Spain have led publications in the field. In other words, they have made a significant contribution to the development of gamification research in higher education.

Regarding the ranking of journals according to the volume of publications, it can be said that *Sustainability*, *International Journal of Emerging Technologies in Learning* (IJET), and *Journal of Chemical Education* (JCE) made the largest contribution. Earlier studies (e.g., [20][21][26][55][56]) also reviewed documents relating to the use of gamification in education in these peer-reviewed journals. The reason for this may be the fact that *Sustainability* is a prestigious academic journal that publishes semi-monthly scientific works—original papers, reviews, communications, and notes—and focuses on, one of its scopes, emerging new technologies in the education for sustainable development. Similarly, IJET and JCE, launched in 2006 and 1924, respectively, also focused on technology-enhanced learning environments. Another possible reason is that they had published more than ten editions a year which might explain their dominance in this field. This implies that these resources are leading in gamification applications in higher education. As detailed in Table 4, it was found that there are 5 journals from the US and 4 journals from the UK and Switzerland, respectively. These are one of the most productive countries in this area.

The most prolific institutions were the Universidad de Granada (Spain), followed by Universidad de Sevilla (Spain), Tecnológico de Monterrey (Mexico), and Universidad de Extremadura (Spain). As per records, the majority of the institutions with the highest number of publications were from Spain. The finding of this research confirmed Swacha [26], who also mentioned that Spain is the region with the most studies on gamification in higher education. Previous literature (e.g., [21][26][56]) also analyzed articles affiliated with these leading institutions in this field. According to the European Innovation Scoreboard [57], the innovation performance of Spain has continued to improve significantly over the last eight years (2014–2021). A possible reason may be that by 2020, Spain had invested more than €16 billion in R&D, an increase of about 6% from the previous year, which was the highest in the history of the country [54]. When institutions were clustered according to the continent, ten of the top 15 influential institutions were located in Western Europe, three in Southeast Asia, and each one in Eastern Europe and Latin America. It can be inferred that these institutions play a vital role in the formation of scientific communication in gamification applications in the field of higher education.

It is not surprising that the countries with the largest contributions to the study of gamification applications are Spain, the US, and the UK, which are leading the research in the field. This result demonstrates the global impact of studies conducted by leading researchers in these countries. This supports similar results highlighted in prior literature (e.g., [20][21][22][35][56]). For example, López-Belmonte et al. [22] reviewed 1220 publications from the WoS database in the period 2011–2019 and reported that the most contributing countries in gamification research are Spain, the US, and the UK. As mentioned earlier, it is not surprising that the top contributing author is from Spain. In other words, scholars from the developed economies of Spain and other Western countries contributed a significant number of publications related to gamification in higher education. This indicates that Spain plays a crucial role in establishing scientific relations with other countries around the world. A possible reason for the soaring number of published articles from Spain may be related to the increased budget for R&D in this area. According to Kolling et al. [58], in 2020 the Spanish government launched the new ‘Science, Technology, and Innovation Strategy’ for the period 2021–2027. It was intended to double the amount of public and private investment in R&D to 2.12% of GDP by 2027. The budget of the Spanish Ministry of Science and Innovation in 2021 increased by almost 60% compared to 2020. This might be the reason why Spain dominates scientific publications regarding gamification in higher education. In contrast, no African countries have contributed to gamification research in higher education. Accordingly, it can be concluded that there is a need to carry out more intensive research in Africa and other developing countries.

5 Conclusions and limitations

In conclusion, this bibliometric review offers a comprehensive overview of the development of publications on the use of gamification in higher education from 2013 to 2022. The search query in this area found 819 documents. Based on our analysis, the language frequently used in reporting research results is English. Scientific publications

were mostly concentrated between 2018 and 2022, accounting for 83.64% of documents published in this area. There was a sharp peak in 2021. The results indicate an accelerated increase in research outputs on gamification applications in higher education. Our results also highlighted that the popular research themes in gamification applications in higher education were “gamification”, “higher education”, “motivation”, and “game-based learning”. It is suggested these words are the center of the studies in this area. As a result of this review, the first document to appear is the work of Domínguez et al. [32], with a total of 878 citations, followed by the research paper of de-Marcos et al. [33], with 317 citations, and the work of Buckley and Doyle [34], with 222 citations. These three manuscripts are the most cited, according to the citation obtained from the Scopus database. De-Marcos, L., from Universidad de Alcalá-Spain, was the most prolific author with 6 documents. The second-ranked authors were Boyle, S.C., from Loyola Marymount University-US, and Pérez-López, I.J., from Universidad de Granada-Spain, with 5 articles, respectively. The most productive journal is *Sustainability* published by MDPI located in Switzerland. Other journals are the *International Journal of Emerging Technologies in Learning* (Kassel University Press, Germany), and the *Journal of Chemical Education* (American Chemical Society, US). Regarding the number of publications by institution, Universidad de Granada-Spain was found to be the most productive country with 17 works, while Universidad de Sevilla-Spain was the second most productive institution with 15 works, and Tecnológico de Monterrey-Mexico and Universidad de Extremadura-Spain were the third most productive country with 11 works, respectively. Notably, many of the articles were completed by scholars in Spain ($n=160$). A total of 131 articles were completed by researchers in the US. The last country in the top three was the UK, with 54 papers.

It should be noted that this review has some limitations as has been reported in the previous literature [35][59][60]. First, we only utilized bibliographic data from a single database, i.e., Scopus, which may not capture all publications in the literature related to the use of gamification in higher education. Future researchers might replicate our findings using other multidisciplinary databases, such as WoS, ScienceDirect, Google Scholar, etc. As we included only peer-reviewed journal articles in the current study, future studies could explore developmental trends of this field in other documents, such as books, book chapters, and conference proceedings. Nonetheless, we believe that our review provides the latest status and developments on the use of gamification in higher education and offers essential information for policymakers and educators to adopt gamification in teaching and learning. Also, this paper proposed a direction for future research in the field.

6 References

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