Gamification in mathematics education: a bibliometric analysis

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A B S T R A C T
The aim of this research was to identify patterns in the authors' use of keywords from research publications on gamification in mathematics learning; this would allow us to gauge the productivity and influence of this field of study. For the purpose of doing bibliometric analysis, data from Scopus ranging from 2017 to 2022 was utilized. Included in this investigation were forty-two research articles over the full time period, making the total number of documents included in this study n = 42. Following the execution of the search procedure, the data were taken from Scopus utilizing the.csv file format, and afterwards, they were imported into a spreadsheet utilizing Microsoft Excel. The date for the gathering of data as well as the analysis is the 18th of August in 2022. The SciVal system (https://www.scival.com/) was utilized as a research tool for the goal of analyzing bibliographic indicators. A bibliometric analysis of our publications in gamification in mathematics learning research allows us to conclude that the number of publications is increasing every year. Although the publication activity of indexed scientists in Scopus is still low in this study. Study on gamification in mathematics education is the most researched topic in the social sciences. Dureva is the author of the most impactful publications on gamification of mathematics education. Study from (Yildirim, 2017) is the most cited publication. Both Bina Nusantara University in Indonesia and South-West University Neofit Rilski in Bulgaria are universities that have produced two scholarly documents each, making them the only two universities in the world to share this output. The journal Advances in Intelligent Systems and Computing has the most scholarly output and is the most visited on its journal website. The finding that this research can give a basis for selecting the research that will be carried out by raising the topic of gamification in mathematics education is the consequence that was derived from this research. Because certain keywords in the field of research on the gamification of mathematics education are always subject to change. In addition, this research on bibliometric analysis can be utilized for systematic literature research and meta-analysis linked to gamification in mathematics education, and it can also be used to improve research that has already been conducted.

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1. INTRODUCTION

The educational system has great potential for the implementation of the concept of "gamification," which strives to improve the user experience and engagement with a system. This is an active area of study since researchers are constantly looking for new ways to enhance the educational experience for students. While all studies on "Gamification in education" have the same overarching goal of making learning more fun and engaging, they are still in their infancy. There are a number of holes in the research on gamification in the classroom (Surendeleg et al., 2014).

The term "gamification" refers to the application of "game qualities," as described by the "Bedwell taxonomy," to an activity that is not itself a game (Landers, 2014). From the point of view of the learner, gamification is an interactive instrument for the acquisition of prior mathematical concepts, including those of Basic Mathematics and Mathematical Components (Salvatierra Melgar et al., 2021).

Several bibliometric analysis studies on gamification have been published, including (parreno) which shows an increased academic interest in gamification in education over the last 5 years. Bibliometric analysis will aid young and senior academics, practitioners, funding agencies, and policymakers, according to (Trinidad) research. No studies exist on gamification in math instruction. However, there are no published studies on gamifiction with mathematics education.

Hence, the aim of this research was to identify patterns in the authors' use of keywords from research publications on gamification in mathematics learning; this would allow us to gauge the productivity and influence of this field of study. The production of an institution or journal can be more accurately reflected and future plans made through bibliometric analysis of such articles. There have been no bibliometric studies that have included or looked at the journal's output, despite its significance in the subject of gamification in mathematics education research. Therefore, this research will be doing a bibliometric review of Scopus-related articles published between 2017 and 2022.

2. METHOD

For the purpose of doing bibliometric analysis, data from Scopus ranging from 2017 to 2022 was utilized. Included in this investigation were forty-two research articles over the full time period, making the total number of documents included in this study n = 42. All of the information that was needed for this study was located by using the Scopus database, which is owned and operated by the American publishing company Elsevier. "gamification" and "mathematics education" or "mathematics learning" or "mathematics teaching" is the string formula that is used for searching for data in Scopus. Alternatively, "mathematics learning" can be used.

Following the execution of the search procedure, the data were taken from Scopus utilizing the.csv file format, and afterwards, they were imported into a spreadsheet utilizing Microsoft Excel. The date for the gathering of data as well as the analysis is the 18th of August in 2022. The SciVal system (https://www.scival.com/) was utilized as a research tool for the goal of analyzing bibliographic indicators. The assessment instrument known as SciVal is used for scientific production. Investigating bibliometric indicators such as the number of publications, most productive institutions, most productive countries, types of collaboration (national, international, institutional, and single author), most cited articles, and authors with the highest

scientific output can be accomplished with the assistance of this tool. There is a table that provides an overview of the information for each bibliometric indicator, with the information being broken down by frequency and percentage (Supriyadi, 2022).

3. RESULTS AND DISCUSSION

Education in the industrial period 4.0 and society 5.0 will not be complete without the incorporation of technology into the classroom. In the 21st century, one of the most important aspects of new methods of teaching and learning is the incorporation of game elements. The utilization of gamification within the educational system is a crucial condition for the development of students' capacities to know digital learning, particularly with regard to the learning of mathematics. For this reason, it is essential to do bibliometric analysis in order to ensure that the topic of gamification in the context of learning mathematics is still pertinent.

Study on gamification in mathematics learning is the most researched topic in the social sciences, as shown by the statistics in Figure 1. This research accounts for 59.5% of the total number of publications contained in the Scopus database. The field of computer science comes in second with 54.8%. This is to be anticipated due to the fact that the concept of gamification itself originates from computer science, which has evolved into a discipline that is utilized by major economies and industrialized nations.

The educational system in Spain was one of the first in the world to include elements of gaming into mathematical instruction. These findings were extracted from a publication written by (González et al., 2014) and was titled "Gamification in Intelligent Tutoring Systems." The results of his study indicate that students make inappropriate use of these systems, maybe as a result of boredom, a lack of interest or motivation, and monotony. These, along with a number of other factors, cause students to behave incorrectly when dealing with these kinds of systems. As a result of this, we propose in this paper a conceptual architecture design for an Intelligent Tutorial System (ITS) called as EMATIC (Mathematics Education through ICT) that incorporates elements of gamification as essential components of the system.
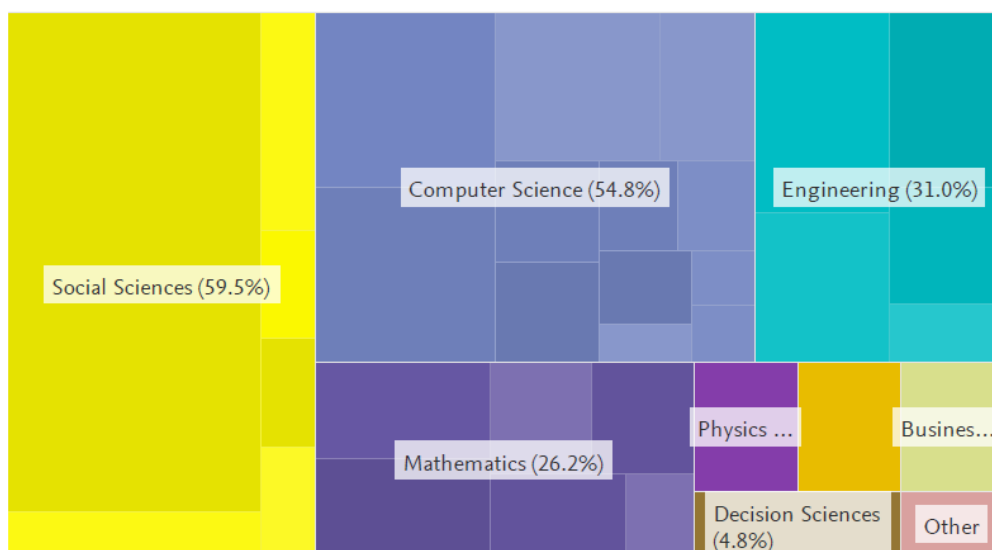

Figure 1. Topic Gamification in Mathematics Education from Scival

During the course of the research, a total of 42 documents that were published in the Scopus database were accessed, which resulted in a total of 319 citations for publications in research

pertaining to the gamification of mathematics education. Within the confines of this investigation, there are a total of six authors who have each produced two articles; their names are Dureva, Chandra, Samardzhiev, Stoyanova, Udjaja, Guizot, and Lanuza. Each of these authors contributed to this investigation. Despite the fact that it has only published a single article, Yldrm has the most citations and is therefore the winner in this category. Yldrm has 131 citations, however Dureva and Chandra only have 20 and 30 respectively, which is a significant difference between the three.

Table 1. Top 10 Top Authors Gamification in Mathematics Education

Name	Scholarly Output	Most recent publication	Citations	Citations per Publication	Field-Weighted Citation Impact	h-index
Dureva, Daniela	2(Stoyanova et al., 2017, 2018)	2018	20	10	2.3	6
Chandra, Natalia	2(Udjaja et al., 2018a, 2018b)	2018	30	15	1.2	4
Samardzhiev, Kostadin	2(Stoyanova et al., 2017, 2018)	2018	20	10	2.3	2
Stoyanova, Maya	2(Stoyanova et al., 2017, 2018)	2018	20	10	2.3	3
Udjaja, Yogi	2(Udjaja et al., 2018a, 2018b)	2018	30	15	1.2	7
Guizot, Vincent Sadino	2(Udjaja et al., 2018a, 2018b)	2018	30	15	1.2	1
Lanuza, Maryann H.	2(Lanuza, 2020; Lanuza et al., 2020)	2020	1	0.5	0.1	1
Botički, Ivica	1(Jagust et al., 2017)	2017	8	8	0.47	13
Tan, Chee Wei	1(Tan et al., 2017)	2017	1	1	0.26	31
So, Hyojeong	1(Jagust et al., 2017)	2017	8	8	0.47	24
Junaini, Syahrul N.	1(Yung et al., 2020)	2020	9	9	1.28	7
Robledo-Rella, Victor	1(Robledo-Rella et al., 2022)	2022	0	0	0	5
Guerrero-García, Josefina	1(González Calleros et al., 2019)	2019	5	5	0.67	7
Ramli, Nazirah	1(Ariffin et al., 2022)	2022	0	0	0	5
Subramaniam, Siva Kumar	1(Feroz et al., 2020)	2020	0	0	0	6
Yıldırım, İbrahim	1(Yildirim, 2017)	2017	131	131	9.43	6

Name	Scholarly Output	Most recent publication	Citations	Citations per Publication	Field-Weighted Citation Impact	h-index
Kaddari, Fatiha	1(Bouzid et al., 2017)	2017	3	3	0.3	2
Su, Chungho	1(Su, 2017)	2017	25	25	2.39	14
Jagušt, Tomislav	1(Jagust et al., 2017)	2017	8	8	0.47	6
Ramirez-de-Arellano, J. M.	1(Robledo-Rella et al., 2022)	2022	0	0	0	4

Table 2 Top 5 Most Cited Publications Gamification in Mathematics Education

Title	Authors	Year	Scopus Source title	Volume	Issue	Pages	Citations	Field-Weighted Citation Impact
The effects of gamification-based teaching practices on student achievement and students' attitudes toward lessons	Yildirim, I. (Yildirim, 2017)	2017	Internet and Higher Education	33	-	86-92	131	9.43
Gamification for elementary mathematics learning in Indonesia	Udjaja, Y.;Guizot, V.S.;Chandra, N. (Udjaja et al., 2018a, 2018b)	2018	International Journal of Electrical and Computer Engineering	8	5	3859-3865	30	2.41
Designing and developing a novel hybrid adaptive learning path recommendation system (ALPRS) for gamification mathematics geometry course	Su, C.-H. (Su, 2017)	2017	Eurasia Journal of Mathematics, Science and Technology Education	13	6	2275-2298	25	2.39
Digital escape room, using Genial.Ly and a breakout to learn algebra at secondary education level in Spain	Jiménez, C.;Arís, N.;Ruiz, Á.A.M.;Orcos, L. (Jiménez et al., 2020)	2020	Education Sciences	10	10	1-14	15	2.97
From here to there! Elementary: a game-based approach to developing number sense and early algebraic understanding	Hulse, T.;Daigle, M.;Manzo, D.;Braith, L.;Harrison, A.;Ottmar, E. (Hulse et al., 2019)	2019	Educational Technology Research and Development	67	2	423-441	15	2.7

Both Bina Nusantara University in Indonesia and South-West University Neofit Rilski in Bulgaria are universities that have produced two scholarly documents each, making them the

only two universities in the world to share this output. The Citation Count of the campus at Bina Nusantara University is 30, which is substantially higher than the Citation Count of the campus at South-West University Neofit Rilski, which is just 20. despite the fact that the Citation Count does not take into account any of the universities' own self-citations. On the other hand, South-West University Neofit Rilski has an advantage over Bina Nusantara University in terms of Views Count and Field-Weighted Citation Impact, with a total of 300 from Views Count and 2.30 from Field-Weighted Citation Impact, respectively.

Institution	Scholarly Output ↓	Views Count	Field-Weighted Citation Impact (excl. self-citations)	Citation Count (excl. self-citations)
Bina Nusantara University	2	120	1.20	30
South-West University Neofit Rilski	2	300	2.30	20
Al Akhawayn University	1	92	0.30	3
Arab Academy for Science, Technology and Maritime Transport	1	3	0.00	0
Benemerita Universidad Autonoma de Puebla	1	163	0.67	5
Central China Normal University	1	10	0.00	0
City University of Hong Kong	1	29	0.26	1
European University of Lisbon	1	69	6.90	11
Ewha Womans University	1	80	0.47	8
Fiji National University	1	65	0.58	1

Figure 2. Top 10 Institutions gamification in mathematics Education from Scival

The following table is a list of the top ten journals that scholars in the subject of gamification in learning mathematics feel to be the most beneficial. The researchers came to the conclusion that, out of all the scientific publications, Advances in Intelligent Systems and Computing was the magazine that best met their needs. In comparison to the view counts of other publications, the journal Advances in Intelligent Systems and Computing has just 479. This is a significant difference. It was discovered that during the time period under consideration, publications that appeared in the journal known as International Journal of Electrical and Computer Engineering received the most citations, with a total of 30 excluding self-citations. This was the case. According to the Field-Weighted Citation Impact, the journal Advances in Intelligent Systems and Computing currently ranks first with a score of 2.17, while the journal Educational Technology Research and Development has a score of 1.98, which is close to the score of the

journal Advances in Intelligent Systems and Computing. It is essential to keep in mind the fact that a number of freshly established journals are currently ranked among the top 10 journals in their field.

Table 3. Top 10 Source Gamification in Mathematics Education

Scopus Source	Scholarly Output	Views Count	Field-Weighted Citation Impact (excl. self-citations)	Citation Count (excl. self-citations)
Advances in Intelligent Systems and Computing	3	479	2.17	27
ACM International Conference Proceeding Series	2	114	0.15	3
Educational Technology Research and Development	2	186	1.98	17
International Journal of Electrical and Computer Engineering	2	120	1.2	30
International Journal of Scientific and Technology Research	2	91	0.1	1
Lecture Notes in Computer Science	2	139	0.25	5
Proceedings of International Conference on Computational Thinking Education	2	41	0.26	3
2022 10th International Conference on Information and Education Technology, ICIET 2022	1	7	0	0
28th International Conference on Computer Theory and Applications, ICCTA 2018 - Proceedings	1	3	0	0
6th South-East Europe Design Automation, Computer Engineering, Computer Networks and Social Media Conference, SEEDA-CECNSM 2021	1	19	13.51	6

Table 4 lays out all the different forms of collaboration together with the bibliometric indicators that are associated with each of them. The majority of the evaluated papers have at least seven international collaborations (17.5%), followed by national collaboration (10 documents, or 25%), and then institutional collaboration (18 documents, or 45%). but only one author was credited for each of the five documents (12.5% of the total). Only institutional collaboration with scholarly output of 18 documents has resulted in 54 total citations, with three citations per publication and a field-weighted citation impact of 0.74, according to the research on the use of gamification in the teaching and learning of mathematics. This represents the largest percentage.

Table 4 Collaboration Gamification in Mathematics Education

Metric		Scholarly Output	Citations	Citations per Publication	Field-Weighted Citation Impact
International collaboration	17.5%	7	34	4.9	3.12
Only national collaboration	25.0%	10	69	6.9	2.24
Only institutional collaboration	45.0%	18	54	3	0.74
Single authorship (no collaboration)	12.5%	5	162	32.4	2.5

Elsevier Fingerprint Machine's text mining was used to perform the keyphrase analysis for 2017–2022. Through text mining and cluster analysis of specific key phrases in SciVal, essential concepts in the study domain were discovered in terms of the relevance and growth

rate of academic outputs (Fig. 3). Gamification, Mathematics, Mathematics Education, Learning Mathematics, Game, Serious Game, Elementary, Distance Education, Educational Technology, and Teaching came out on top when relevance was combined with growth rate to determine the rankings obtained from the results of research on gamification in mathematics learning. The rankings are as follows:

Figure 3. Key Phrases Gamification in Mathematics Education

4. CONCLUSION

A bibliometric analysis of our publications in gamification in mathematics learning research allows us to conclude that the number of publications is increasing every year. Although the publication activity of indexed scientists in Scopus is still low in this study. Study on gamification in mathematics education is the most researched topic in the social sciences. Dureva is the author of the most impactful publications on gamification of mathematics education. Study from (Yildirim, 2017) is the most cited publication. Both Bina Nusantara University in Indonesia and South-West University Neofit Rilski in Bulgaria are universities that have produced two scholarly documents each, making them the only two universities in the world to share this output. The journal Advances in Intelligent Systems and Computing has the most scholarly output and is the most visited on its journal website.

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