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Publication Trends from STEAM in Education from Scopus Database: Bibliometric Analysis

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Abstract: The objective of this study is to shed light on the domain of STEAM education research by employing a three-pronged strategy. This article provides a bibliometric analysis of STEAM education literature by focusing on three major research questions (RQs): RQ1. How has research on STEAM education progressed? RQ2. Who is the most influential in STEAM education research? RQ3. Which affiliations and countries are contributing to STEAM in education? This study combines quantitative analysis with descriptive methods. The evolution of STEAM education and the pattern of publishing found in Scopus, which is determined by research connections, research themes, and scientific journals, are of interest to researchers. Throughout this research, the Bibliometrix R-tool and the BiblioShiny software packages were utilized, one at a time, for data analysis, reduction, visualization, and mapping, respectively. In response to RQ1, this study found the Annual Growth Rate to be 24.19%. This finding is based on the trend of publications in STEAM in Education. The results indicate that there has been an increase in the number of journal articles devoted to this subject, which are frequently disseminated. The second question this research aims to answer is which areas of STEAM education research have the most influence. While Piperopoulos P has the top spot for the most globally mentioned documents, Perignat E holds the top spot for the most locally cited papers. In the meantime, Herro D is a writer who has contributed to the study done in the field of STEAM education. As for RQ3, it can be noted that Jeju National University and the Korea National University of Education are the top two campuses in the world regarding STEAM in Education research publications, both of which are located in South Korea.

Keywords: Bibliometric; Science education, Scopus; STEAM education

Introduction

Over time, research in the STEAM fields has not matured into a well-established and fruitful section of the academic landscape (Marín-Marín et al., 2021). The topics of science, technology, engineering, and mathematics are referred to as the STEM fields, and the term "STEAM" is used to highlight how the arts or art practices (and sometimes, more broadly, the humanities and social sciences) connect with the STEM fields (Colucci-Gray et al., 2017).

The STEAM framework is conceived in a way that is both pedagogical and mutually instrumental. STEAM framework signifies that neither the STEM fields nor the arts are privileged over the other, but rather that all fields are equally in play, with the potential for revolutionizing educational policy and practice (Mejias et al., 2021). The many ways STEAM is taught in education and the many different reasons it is taught at all levels of the school system. STEAM in education shouldn't come as a surprise because as additional topic areas and knowledge domains are incorporated, more opportunities and difficulties are brought into play (Herranen et al., 2021).

Learning in science, technology, engineering, mathematics, and the arts and humanities (also known as STEAM learning) has become increasingly popular in elementary, middle, and high schools in the past ten years. The case, including studies in humanities and the arts in STEM education at the undergraduate level, was

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investigated in a report published by the National Academies in 2018 (Lindsay, 2021). Children are naturally inclined to explore and experiment with the world around them, making the STEAM philosophies second nature to them. Educators have more alternatives at their disposal when it comes to presenting STEM ideas to students, particularly at the primary and early childhood levels, when those ideas are supplemented with art (White et al., 2021).

The literature contains a few systematic literature reviews that are associated with STEAM. Previous researchers, such as (White et al., 2021), used a PRISMA review to synthesize the current empirical evidence on incorporating interdisciplinary learning via a STEM/STEAM approach in high-school environments. Using a scaffolding system, incorporating interdisciplinary learning via a STEM/STEAM approach in high-school settings. In the meantime, (Aguilera et al., 2021) used SLR and concluded that arguing for the implementation of STEAM education over STEM education to develop or promote student creativity is not in agreement with the evidence from the empirical studies. This conclusion was reached as a result of the fact that STEAM education is less effective at developing or promoting student creativity than STEM education.

Bibliometric analysis has been utilized in a number of the research that has been conducted on STEAM education. The first is a study from (1) that investigated the field of education of STEAM, started its work in 2006 and has continued its work without interruption up to the current day by utilizing the Web of Science database. Next, is a study done by Santi et al. (2021) that looks at STEAM in South Korea using the VosViewer program. This research looks at how South Korea is quickly becoming the most productive country in the STEAM field in school.

In addition, the future emergence of research fields can be identified as research trends that typically contribute to the growth and transformation of curricula. This article provides a bibliometric analysis of STEAM education literature by focusing on three major research questions (RQs): RQ1. How has research on STEAM education progressed? RQ2. Who is most influential in STEAM education research? RQ3. Which affiliations and countries are contributing to STEAM in education?

According Raman et al. (2022), Scopus was used to acquire bibliographic data for this study because it meets high-quality requirements for indexing (Donthu et al., 2021; Paul et al., 2021; Supriyadi, 2022) and its journals are more inclusive. Scopus is the most popular citation and abstract database and covers many topics (Amrutha et al., 2020). Bibliographic study and citation analysis of scientific journal articles can benefit from bibliometrics. Bibliographies can be studied by kind, topic, researcher's country, journal, and article language (Kuzior et al., 2022; Nandiyanto et al., 2022). The bibliometric analysis quantifies bibliographic data. Bibliometrics evaluates writing using statistics. Bibliometric analysis helps increase research quality (van Raan, 1999).

The objective of this study is to shed light on the domain of STEAM education research by employing a three-pronged strategy. Firstly, it aims to assess the historical development of this field to discern patterns and provide direction for future studies. Secondly, it aims to identify the most prominent scholars and institutions in this area to improve the quality of research and facilitate informed decision-making. Lastly, it aims to conduct a comprehensive analysis of contributions on a global scale to identify key stakeholders and potential avenues for collaboration. The objective of this study is to enhance the development of the STEAM field, foster global cooperation, and provide insights for policy-making by examining the trajectory, key contributors, and geographical distribution of STEAM research. The ultimate goal is to advance STEAM education on a global scale.

Method

The purpose of this bibliometric study was to carry out an examination of the past academic work that has been done on the subject of STEAM education. In order to conclude a bibliometric study, the first thing that needs to be done is to generate a comprehensive list of the publications that have the potential to be a part of our sample. This can be done by selecting all of the publications that meet the criteria for inclusion in our sample. This is the very first thing that needs to be done in order to proceed (Oermann et al., 2008).

This study combines quantitative analysis with descriptive methods. Both the evolution of STEAM education and the pattern of publishing that can be found in Scopus, which is determined by research connections, research themes, and scientific journals, are of interest to researchers. Throughout the course of this research, the Bibliometrix R-tool and the BiblioShiny software packages were utilized, one at a time, for the purposes of data analysis, reduction, visualization, and mapping, respectively. R-Studio, which was a version of Bibliometric, was utilized in order to carry out the analysis of the full article mapping. Bibliometric was the software that was utilized (Aria et al., 2017; Cuccurullo et al., 2016).

This study includes Scopus data from August 12, 2022. "STEAM" in "education" is used to find relevant

publications for this research in the keyword list, abstract, and title. Scopus searched for "STEAM" in "education". Then Scopus filters were used. The search included all Scopus journals and articles. This permits the search engine to find the oldest studies. Data was processed in several ways to answer RQs. Scopus results were gathered through the analyze search results tool. Data sets were exported in CSV format. The findings file was reviewed for proportions and percentage distribution. We utilize biblioshiny in RStudio to compute citation metrics and other frequencies and show bibliometric networks because it's a free tool. This study will improve and expand findings on STEAM literature trends.

Result and Discussion

RQ1. How has Research on STEAM Education Progressed?

There has been a total of 258 research projects conducted on the topic of STEAM education, and a total of 529 documents have been published over the course of time, as indicated by the information that is presented in Table 1. This data was collected throughout the course of the previous ten years. In addition, 24.19 per cent of the total number of years have gone since the first publication of these materials, making that the average amount of time that has elapsed since then. This means that the first publishing of these materials occurred approximately 24.19 years ago. It is anticipated that between the years 2006 and 2022, there will be a gradual drop in the average number of citations related with a publication and that this drop will amount to 5.355% each year. This drop is projected to occur between the years 2006 and 2022. This decrease is anticipated to take place during the years 2006 and 2022.

Table 1. Main Information about STEAM in Education Research

Description	Results
Timespan	2006:2022
Sources (Journals, Books, etc)	258
Documents	529
Annual Growth Rate %	24.19
Average citations per doc	5.355
References	15075
Article	245
Book	4
book chapter	15
conference paper	237
conference review	13
Editorial	4
Note	3
Review	8

In the next table, Table 2, the information that correlates to the top 10 statistics that are associated with STEAM education. The following is a breakdown of these figures in its many components: On the basis of these, we arrived at the conclusion that the publication known as Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) was the one that had published the most papers in total, which brought to a grand total of 34. This conclusion was reached because this publication was the one that had the most subseries. Because this publication contained two different subseries, namely Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics, it was possible to arrive at the conclusion that was presented here. This discovery was made possible by the fact that this publication featured both Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics. It was this publication that ultimately led to this conclusion.

Table 2. Most Relevant Sources about STEAM in Education Research

Sources	Articles
Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)	34
ACM International Conference Proceeding Series	23
Advances in Intelligent Systems and Computing	11
Communications in Computer and Information Science	11
Education Sciences	10
Eurasia Journal of Mathematics, Science and Technology Education	10
Asia-Pacific Science Education	9
IEEE Global Engineering Education Conference, Educon	9
Information (Japan)	9
Journal of Physics: Conference Series	9

To be more specific, this revelation came about as a direct consequence of the merging of the two series. After that came the ACM International Conference Proceeding Series, which throughout the course of its existence, wound up publishing a total of 23 distinct works over the duration of its existence. It was reported that ten articles were published in the journal Education Sciences, 11 articles were reported to have been published in the journal Advances in Intelligent Systems and Computing, and 11 articles were reported to have been published in the journal Communications in Computer and Information Science. It was claimed that a total of 31 papers had been distributed throughout the three publications that make up the papers.

These three publications were comparable to one another since each issue of each periodical featured an equal number of pieces that were written specifically for that publication. Due to the fact that each of these four publications, Asia-Pacific Science Education, IEEE

Global Engineering Education Conference, Information (Japan), and Journal of Physics: Conference Series, contributed nine articles, there is a tie for the tenth and final spot on the list of the top sources. This tie is the result of the fact that there is a tie for the tenth and final spot on the list of the top sources. Due to the fact that each of these publications contributed nine unique pieces, a tie for first place was ultimately determined. They are currently in the same dilemma together as a result of the mutual dishonor that they have brought upon themselves. Within the pages of each of these publications, there is a total of nine original content pieces that have been published.

RQ2. Who is Most Influential in STEAM Education Research?

The research results presented in table 3 indicated that STEAM in Education, which accounted for the majority of Global Cited Documents, provided a diverse selection of articles. After (Piperopoulos et al., 2015) came (English, 2017) in second position. This publication received 117 total citations and 19.50 per cent of the total citations for the year. Piperopoulos et al. (2015) has triumphed over the competition and taken first place. The following paper, which was written by Perignat et al. (2019) and published in Think Skills Creat (which has a total of 106 citations and a citation count of 26.50% each year), has a higher overall citation count than (English, 2017), which only received 19.50% of citations. The publication from Perignat et al. (2019) has a total of 106 citations; each year, it receives a citation count of 26.50%. 81 total citations and 11.57 percentage of total citations per Year for (Liao, 2016), (total citations: 68; percentage of citations obtained annually: 9.71%), Liao (2016) and Quigley et al. (2016) article in the Journal of Science Education and Technology garnered 68 citations overall.

Table 3. Most Global Cited Documents about STEAM in Education Research

Sources	TC	TC/ Year
Piperopoulos P, 2015, J Small Bus Manage (Piperopoulos et al., 2015)	316	39.50
English Ld, 2017, Int J Sci Math Educ (Cuccurullo et al., 2016; English, 2017)	117	19.50
Perignat E, 2019, Think Skills Creat (20)	106	26.50
Liao C, 2016, Art Educ (Liao, 2016)	81	11.57
Quigley Cf, 2016, J Sci Educ Technol (Quigley et al., 2016)	68	9.71
Park H, 2016, Eurasia J Math Sci Technol Educ (Park et al., 2016)	58	8.29
Tsai M-J, 2019, J Educ Comput Res (Tsai et al., 2019)	57	14.25
Harris A, 2018, J Educ Change (Harris et al., 2018)	54	10.80
Kim Y, 2012, Commun Comput Info Sci (Y. Kim et al., 2012)	52	4.73
Shatunova O, 2019, J Soc Stud Educ Res (Shatunova et al., 2019)	47	11.75

A listing of the ten authors who contributed to the investigation of steam education may be found in Table 4 of the most locally mentioned authors. As a consequence of these factors, we are now in a position to explore the top highest publications that were authored by the author Perignat (45), followed by Liao C (28). Herro D and Allina B have 11 local citations, Jho H and Quigley CF have ten local citations, and Kim PW and Kang N-H have eight local citations. Jho H and Quigley CF are in third place with ten local citations. In the table with eight authors, the remaining four authors all have the same number and types of publications. They are as follows: Harris A and Thuneberg HM, who have accumulated 13 local citations; Herro D and Allina B, who have accumulated 11 local citations.

Table 4. Most Local Cited Documents about STEAM in Education Research

Document	Local Citations
Perignat E, 2019, Think Skills Creat (20)	45
Liao C, 2016, Art Educ (Liao, 2016)	28
Harris A, 2018, J Educ Change (Harris et al., 2018)	13
Thuneberg Hm, 2018, Think Skills Creat (Thuneberg et al., 2018)	13
Herro D, 2017, Int J Stem Educ (Herro et al., 2017)	11
Allina B, 2018, Arts Educ Policy Rev (Allina, 2018)	11
Jho H, 2016, Eurasia J Math Sci Technol Educ (Jho et al., 2016)	10
Quigley Cf, 2016, J Sci Educ Technol (Quigley et al., 2016)	10
Kim Pw, 2016, Eurasia J Math Sci Technol Educ (P. W. Kim, 2016)	8
Kang N-H, 2019, Asia-Pacific Sci Educ (Kang, 2019)	8

The values of the author's h-index, g-index, and m-index, as well as the TC, NP, and PY start of the articles on astrovirus, are shown in this table 5 of the author's impact on astrovirus. This table is part of the author's

impact on astrovirus. The top position of author Herro D was the most outstanding values of h-index (6) then, followed by four authors with the same h-index (5) there are Barnes J, Jeon M, Park N, and Vasey E. The top position of author Herro D was the greatest value of h-index (6) then, followed by four authors with the same h-index (5). The author Herro D came in the first place, with the highest value of h-index (6), followed by four other authors who had the same value of h-index (5). It is essential to bring notice the fact that there are six authors who got the same value of g-index (7) and g-index (3) correspondingly. The m-index values were the same for the three different authors (0.714). According to the table, the TC with the highest total score consists of three authors (177, 151, and 97), followed by seven authors who contributed to the score. It is also significant to note that the same number of articles written by four distinct authors have been published in the same issue of the same publication since the year 2016: seven and four, respectively.

Table 5. Author Impact on STEAM in Education Research

Element	h_index	g_index	m_index	TC	NP	PY_start
Herro D	6	6	0.857	151	6	2016
Barnes J	5	7	0.714	53	7	2016
Jeon M	5	7	0.714	55	8	2016
Park N	5	9	0.455	177	9	2012
Vasey E	5	7	0.714	53	7	2016
Kim J	4	6	0.4	50	6	2013
Quigley Cf	4	4	0.571	97	4	2016
Cian H	3	3	0.75	35	3	2019
Conde Má	3	3	1	43	3	2020
Dagienė V	3	3	0.75	23	3	2019

RQ3. Which Affiliations and Countries are Contributing to STEAM in Education?

The contribution of relevant countries was estimated using a total of 231 articles that were published respectively for each of the 10 countries in the table, and we have ranked them according to the number of articles they contributed, the frequency with which they were published, the number of single country publications, the number of multiple country publications, and the ratio of multiple country publications utilizing the data that is available in table 6 located above. According to the conclusions of this investigation into steam education, the nation that produced the most publications was Korea (67), followed by China (59), and then the United States (39). Because it has the highest frequency (0.127%), single country publishing (63), multiple country publication (4), and percentage of multiple country publication (0.06%), Korea is rated top in the table. In addition, it has publications from most countries (4). As a direct result of this, it created the highest total number of articles (67), which places it in first place overall in terms of the total number of articles. The United States of America and China finished in second and third place in the competition, respectively. While China had multiple country publications and a high ratio of numerous country publications (the total number of multiple country publications was 5, and the ratio of multiple country publications was 0.112%), the United States only had single country publications and a low ratio of multiple country publications (the total number of single country publications was 38, and the ratio of multiple country publications was 0.074%) While China had multiple country publications and a high ratio of multiple country publications, the United States only had single country publications and a low ratio of multiple country publications. In contrast, the United States only had single country publications and a low percentage of numerous country publications.

Table 6. Most Relevant Countries by Corresponding Author about STEAM in Education Research

Country	Articles	SCP	MCP	Freq	MCP Ratio
Korea	67	63	4	0.127	0.06
China	59	54	5	0.112	0.085
USA	39	38	1	0.074	0.026
Spain	16	12	4	0.03	0.25
Australia	10	8	2	0.019	0.2
Thailand	9	9	0	0.017	0
Japan	8	7	1	0.015	0.125
Turkey	8	6	2	0.015	0.25
Finland	7	5	2	0.013	0.286

On the other hand, China had multiple country publications and a high proportion of those publications relative to the total number of publications. Thailand, located in the sixth spot in the ranking, has no special conditions of possession (SCP), but the country has nine minor conditions of possession (MCP). Because Spain's MCP is identical to that of Korea's, the latter of which has 4 MCPs, the former shows that Spain's MCP is higher than that of Thailand, which is 0.25%, in the table

that includes the top 10 significant countries in steam education. Korea has 4 MCPs.

Table 7 lists the top twenty countries based on the total number of papers on STEM and STEAM education indexed in various publications. These papers were published in a variety of academic journals. These articles were retrieved from multiple scholarly journals. This list, which consists exclusively of nations that have, are arranged in descending order based on the total number of articles mentioned in their respective fields. The countries are presented in alphabetical order. Korea (Total citations: 453) is at the top of the list of countries, followed by the United States of America, the United Kingdom, Australia, and China as the countries contributing the most significant numbers of articles, but the United Kingdom had the highest 56.83% of the average article citations. Korea is followed by the United States of America, the United Kingdom, Australia, and China as the countries contributing the largest number of articles. This was to be anticipated, as it was expected that the United Kingdom would have the most significant percentage. It was also predicted that this would be the case. When the total number of citations from all sources is considered, it is shown that Korea is in the first place. On the other hand, it did not come in first place in terms of the Average Article Citations, which was 6.76%. Singapore had the third highest average percentage of cited articles (23.00%) while having the fewest citations (23) overall. This places Singapore in third place.

Table 7. Most Cited Countries about STEAM in Education Research

Country	TC	Average Article Citations
Korea	453	6.76
USA	405	10.38
United Kingdom	341	56.83
Australia	220	22.00
China	134	2.27
Spain	54	3.38
Belgium	32	8.00
Turkey	31	3.88
Lithuania	25	8.33
Singapore	23	23.00

The information that is given in the affiliations is the information that is most pertinent to the discussion that is currently taking place. According to Table 8, associated institutes of Jeju National University have produced the most articles (27), followed by the Korea National University of Education in terms of the overall number of publications. Table 8 also shows that the Korea National University of Education is the leader in education (20). Institutions like South China Normal University and Johannes Kepler University are examples of educational establishments that publish an equal number of academic articles and have an equal number of academic affiliations. Other such institutions include universities like the University of Michigan and the University of California (18). In the not-too-distant future, the vast majority of educational institutions will concentrate most of their extra publishing efforts on books and periodicals that are related to STEAM education.

Table 8. Most Relevant Affiliations about STEAM in Education Research

Affiliation	Articles
Jeju National University	27
Korea National University of Education	20
Johannes Kepler University	18
South China Normal University	18
Clemson University	17
Seoul National University	16
Ewha Womans University	14
Guangdong University of Technology	11
University of Split	11
National Cheng Kung University	10

Conclusion

In order to fulfill the aims of this study, an analysis of journal articles concerning the integration of Python into education in South Korea was conducted. Innovation in the field of learning media creation has increased for the use of Python in education in South Korea between 2014 and 2022. Adapting to South Korea's software education curriculum is the primary motivation for this innovation. The research approach is dominated by research and design, but the research topic is dominated by basic education research. The limitation of this study is the sources obtained from the Google Scholar and Academic Naver databases. For further research, it is hoped that other databases can be used to obtain sources such as Scopus, WOS, Demension and other reputable databases. In the meanwhile, the use of pythons to enhance students' computational thinking skills has the most potential for next research.

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Author Contributions

Edi Supriyadi, the first author, made significant contributions to the study's conception, execution, and manuscript writing. Those identified as the second to fourth authors, including Turmudi, Jarnawi Afgani Dahlan, and Dadang Juandi, provided guidance in the process of conducting research and preparing written articles.

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Conflicts of Interest
The authors assert that there is no presence of any conflict of interest.

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