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Global trends in stem education research (2000–2018): A systematic journal-based study

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Abstract: Researchers published in 36 publications to conduct a thorough analysis of the state of STEM education research from 2000 to 2018, according to Lin, et al. [1]. Unlike previous literature assessments that concentrated on a single discipline or journal, this review synthesizes trends in authorship geography, methodological approaches, thematic focus, and disciplinary representation. According to the study based on English [2] there has been a notable increase in STEM education research since 2010, as evidenced by the expansion of the STEM label's usage, the rise in empirical work—especially quantitative work—and the preponderance of American writers. Policy, curriculum, and K–12 education were the main areas of inquiry, and seven significant thematic groups were found based on National Research Council [3]. While highlighting the dynamic and growing nature of STEM education research, these findings also point to limitations in theme diversity and global representation. These findings' ramifications are examined in light of policy formation, educational equity, and the international exchange of knowledge.

Keywords: *ICT: Information and communications technology, IJ-STEM: International Journal of STEM education, K-12: Kindergarten–grade 12, SMET: Science, Mathematics, Engineering, Technology, STEAM: Science, Technology, Engineering, Arts, Mathematics; STEM: Science, Technology, Engineering, Mathematics.*

1. Introduction

Understanding the trends and state of scholarship in any educational domain is essential for guiding research agendas, policy formation, and pedagogical innovation according to [4]. STEM education, though relatively new as a defined interdisciplinary field, has seen exponential growth in global interest over the past two decades. Based on statements in [5]. Governments, educators, and industries increasingly view STEM based on Kilpatrick [6] as central to equipping students with critical thinking, problem-solving, and innovation skills necessary for participation in a competitive, technology-driven world economy which is indicated in Thibaut, et al. [7]. STEM education is affected by this. In educational research at Li [8] systematic reviews are frequently conducted to examine the status and developments in particular fields. For instance, scholars examined trends in the use of technology in mathematics education [5, 9] and reviewed the historical evolution of research in mathematics education [6]. Since Tsai and Lydia Wen [10] and his colleagues have reviewed journal articles every five years to summarize research trends in scientific education (i.e., 1998–2002, 2003–2007,

2008–2012, and 2013–2017), based on entries in the Journal of Research in scientific Teaching, the International Journal of Science Education, and Science Education (e.g., [1, 10]) three major journals for scientific education. Minner, et al. [11] examined inquiry-based science instruction from 1984 to 2002, whereas Erduran, et al. [4] examined argumentation in science education research from 1998 to

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2014. In engineering and technology education, there are also a lot of literature reviews and syntheses (e.g., [12, 13]).

However, based on Gonzalez and Kuenzi [14]. STEM education remains a complex and contested domain. It encompasses a broad spectrum of disciplines—science, technology, engineering, and mathematics—but there is no universally accepted framework for integration across these areas based on Borrego, et al. [12]. According to National Research Council [3]. Debates continue over what qualifies as "authentic" STEM learning, how to measure STEM competence, and how to balance disciplinary depth with interdisciplinary breadth based on Brown [15]. Moreover, emerging variants like STEAM (which adds the arts) and STEMM (including medicine) further complicate definitions.

Previous reviews based on Henderson, et al. [16] have contributed valuable insights into aspects of STEM education. For example, Henderson, et al. [16] explored instructional reform in post-secondary STEM, while Margot and Kettler [17] examined teacher attitudes. Yet, most of these studies focus on narrow themes, single journals, or limited timeframes. As a result, the broader contours of the field—especially its thematic diversity, methodological trends, and global authorship—remain underexplored.

When a discipline is established and its scope is well defined, reviewing the research advancement in that field is quite simple. STEM education is not a clearly defined field, in contrast to discipline-based education research [3].

This study addresses this gap by offering a journal-based, multi-dimensional analysis of 798 STEM education articles published from 2000 to 2018. By examining patterns across journals, disciplines, regions, and topics based on Howard, et al. [18] this research provides a comprehensive snapshot of how STEM education scholarship has evolved and where future research efforts should be directed.

Different viewpoints on STEM and STEM education, the history of STEM education as the name describes is rather recent. The United States National Science Foundation (NSF) first included engineering and technology alongside science and mathematics in undergraduate and K–12 education in the 1990s, which sparked interest in assisting students in learning across STEM subjects [3]. Other organizations, like the US Congress, adopted the abbreviation SMET (science, mathematics, engineering, and technology), which it created (e.g., [19]). To replace SMET, NSF also created the abbreviation STEM, which has since become standard (e.g., [2]). There isn't, however, agreement on which fields belong in STEM. The STEM fields listed by NSF, however, differ from those listed by other federal organizations. At least two US organizations, the Department of Homeland Security and Immigration and Customs Enforcement, employ a more restrictive definition that leaves out social sciences, according to Gonzalez and Kuenzi [14]. Using words like multidisciplinary, interdisciplinary, and transdisciplinary, researchers also have varied perspectives on integration across STEM fields [20]. These are but two illustrations of the ambiguity and difficulty in defining and characterizing what STEM is.

Education in the individual STEM disciplines, such as science, technology, engineering, and mathematics, as well as interdisciplinary or cross-disciplinary combinations of the individual STEM disciplines, can be considered STEM education from a broad and inclusive perspective [2, 8]. However, some people may believe that STEM education exclusively refers to cross- disciplinary or interdisciplinary combinations of the many STEM fields [21-23] As long as publications are ready to accept the position as related to STEM education, these diverse viewpoints enable scholars to publish articles in a wide range of diverse journals.

reviews on STEM Education

A search for reviews of research on STEM education turned up several reviews (e.g., [7, 15, 16, 24-26]) that might offer methods for identifying publications. Brown [15] review looked at the body of research on STEM education. By limiting the review to publications in eight journals—two in each subject, one academic research journal (like the Journal of Research in Science Teaching), and one practitioner journal (like Science Teacher)—he was able to address the ambiguity and complexity. To find and include papers that writers self-identified as being related to STEM education, Mizell and Brown employed the same criterion, i.e., whether the authors included STEM in the title or authorsupplied keywords. They discovered that, in contrast to Brown's findings, a significantly greater number of STEM articles were published in a shorter amount of time and by academics from a wider range of institutions. While Brown [15] both tended to imply that STEM education primarily consists of interdisciplinary or cross-disciplinary combinations of the various STEM disciplines, their methodology involved choosing a small number of journals based on individual disciplines and then choosing articles that the authors self-identified as being related to STEM education.

Other reviews (e.g., [26]) concentrated on difficulties in STEM education as opposed to reviews on STEM education generally. Henderson, et al. [16] for instance, conducted a review of 191 conceptual and empirical journal articles published between 1995 and 2008 that concentrated on instructional changes in undergraduate STEM courses. Margot and Kettler [17] examined 25 empirical journal publications published between 2000 and 2016 to determine what is known about teachers' values, beliefs, perceived obstacles, and support needs in relation to STEM teaching. The researchers were able to restrict the number of publications they looked at because of the emphasis of these studies, and they typically utilized keyword searches of specific databases to find articles about STEM education. This method was employed by some researchers to find only journal publications [27] while others chose and examined sources outside of journals [25].

This section's discussion offers several potential explanations for why there isn't a comprehensive literature assessment of STEM education research and development: (1) There are a variety of viewpoints regarding STEM and STEM education that make it challenging to define the scope of a literature review; (2) STEM education has a brief but quick development history when compared to other discipline-based education (such as science education); and (3) it can be challenging to determine how to define the scope of the literature review. However, based on current journal publications, neither the first strategy of choosing a small number of distinct discipline-based journals nor the second strategy of choosing a particular focus for the review results in a method that offers a broad overview of the development of STEM education scholarship.

1.1. Current Reviews

When defining the parameters of this review, two problems were found.

What time frame ought to be considered?
Which publications are going to be chosen for review?

1.2. Time Period

First, we tackle the simple one. The abbreviation STEM did exist until the early 2000s, as was previously mentioned. The acronym is symbolic and aids in drawing attention to initiatives in STEM education, even though its existence does not produce scholarship on students' learning in STEM fields. It makes sense to begin with the year 2000 since we wish to look at the state and developments in STEM education. After that, we may locate certain research articles using the STEM acronym as an identification, just like other people have done (e.g., [15]). We decided to conclude our review, which started in 2019, at the end of 2018.

2. Methods

To capture a holistic picture of STEM education research, we adopted a journal-based systematic review methodology. This approach avoids the limitations of database keyword searches, which can overlook relevant studies due to inconsistent indexing and variable terminology. Therefore, we searched Google to find all education journals whose titles included two, three, or all four STEM subjects. For instance, we searched Google for any possible combination of the three fields of science, engineering, mathematics, and technology1 that could be found in the title of a publication. Furthermore, we looked for potential publications using the term STEAM in the title. Traditional discipline-based education journals, like the Journal of Research in Science Teaching, may have published articles on STEM education research since STEM education is sometimes seen as including discipline-based education research. As a result, we added a few more popular discipline-based education research publications, such the Journal of Engineering Education, to the list in addition to choosing a couple from the list. Because some general education research publications, particularly those that are well-known, have published articles about STEM education research. As a result, we found and chose a handful of the journals where we found some articles about STEM education research.

Table 1.
List of 36 authorised journals applied in various subjects using STEM Technology.

No	Journal name	No of subjects*	Start year	OA or not
1.	African Journal of Research in Mathematics, Science and Technology Education	3	1997	No
2.	American Educational Research Journal	0	1964	No
3.	British Journal of Educational Technology	1	1970	No
4.	Canadian Journal of Science, Mathematics and Technology Education	3	2001	No
5.	Computers & Education	1	1976	No
6.	Educational Technology Research and Development	1	1953	No
7.	Eurasia Journal of Mathematics, Science and Technology Education	3	2005	Yes
8.	European Journal of Engineering Education	1	1975	No
9.	European Journal of STEM Education	4	2016	Yes
10.	International Journal of Cognitive Research in Science, Engineering and Education	2	2013	Yes
11.	International Journal of Education in Mathematics, Science, and Technology	3	2013	Yes
12.	International Journal of Engineering Education	1	1985	No
13.	International Journal of Innovation in Science & Mathematics Education	2	1997	Yes
14.	International Journal of Mathematical Education in Science and Technology	3	1970	No
15.	International Journal of Science and Mathematics Education	2	2003	No
16.	International Journal of Science Education	1	1979	No
17.	International Journal of STEM Education	4	2014	Yes
18.	Journal for STEM Education Research	4	2018	N o
19.	Journal of Computers in Mathematics and Science Teaching	3	1981	N o
20.	Journal of Engineering Education	1	1912	N o
21.	Journal of Pre-College Engineering Education Research	1	2011	Yes
22.	Journal of Professional Issues in Engineering Education and Practice	1	1956	No
23.	Journal of Research in Science Teaching	1	1963	N o
24.	Journal of Research in STEM Education	4	2015	Yes
25.	Journal of Science Education and Technology	2	1992	N o
26.	Journal of STEM Education	4	2000	Yes
27.	Journal of STEM Outreach	4	2018	Yes
28.	Journal of STEM Teacher Education	4	1998	Yes
29.	Journal of Technology and Science Education	2	2011	Yes
30.	Research in Science and Technological Education	2	1983	N o
31.	School Science and Mathematics	2	1901	N o
32.	Science Education	1	1916	N o
33.	Technology, Pedagogy and Education	1	1992	N o
34.	The Journal of Educational Research	0	1920	N o
35.	The STEAM Journal	5	2013	N o
36.	World Transactions on Engineering and Technology Education	2	2002	Yes

Following the above three steps, we identified 45 journals (see Table 1).

Journal and article Identification: A list of 45 journals was compiled through a combination of expert consultation, citation tracking, and web-based searches. Journals were selected if they had a history of publishing articles in STEM or STEM-related fields and if they were peer-reviewed and published in English.

Inclusion Criteria: Articles were included if they explicitly referred to STEM, STEAM, or related acronyms in the title or abstract which are included in Sochacka, et al. [28]. Only full-length peer-reviewed journal articles published between January 2000 and December 2018 were considered. Editorials, book reviews, and conference abstracts were excluded.

Data Collection and Coding: The final dataset included 798 articles from 36 journals. Each article was coded independently by two reviewers in five dimensions:

- Disciplinary Scope – – Articles were categorized based on the number of STEM domains addressed (1 to 4) and whether non-STEM fields were included (e.g., arts or medicine) based on [19].
- Thematic Focus – Articles were classified into seven pre-defined thematic categories, such as curriculum and assessment, teacher education, learning environments, equity issues, and higher education.
- Methodology – – Each article was labeled as quantitative, qualitative, mixed methods, or non-empirical.
- Authorship Geography- Two models were used: one attributing equal credit to all countries represented by authors, and one giving full credit to the first or corresponding author.
- Collaboration Type – – Articles were coded as single-author, domestic collaboration, or international collaboration.

  Reliability Measures The inter-rater agreement was 89.5%, with discrepancies resolved through collaborative review and consensus discussion. Data were analyzed using descriptive statistics, thematic mapping, and cross-tabulation.

3. Results

3.1. Growth in Publications

The review revealed a dramatic increase in the volume of STEM education research over the 18-year period. From fewer than 20 articles annually in the early 2000s, the output surged to over 120 articles in 2018. As shown in Figure 1, the number of STEM education publications increased dramatically, especially after 2010. This trend mirrors increased government investment in STEM education and growing scholarly interest in interdisciplinary education.

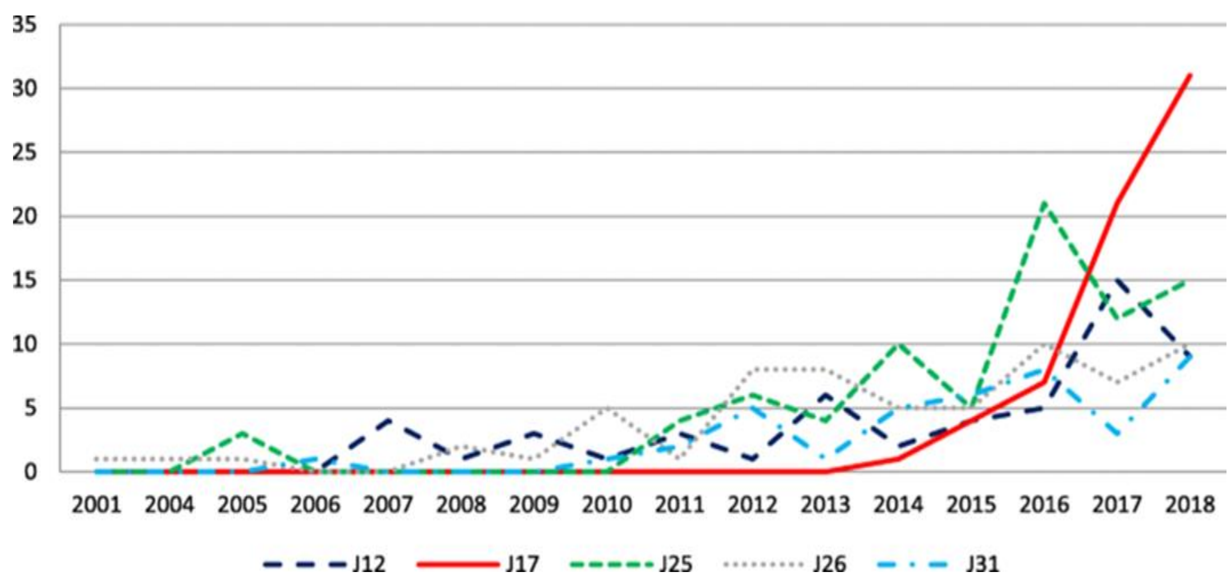

Figure 1.
Growth in publications in the years between 2000-2018.

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3.2. Use of the Term STEM

Of the 798 articles, 549 (69%) used "STEM" in the title, while 249 (31%) used it in the abstract only based on Margot and Kettler [17]. This pattern suggests that while the term is widely adopted, its use may be more strategic or rhetorical than reflective of integrated content indicated in Li and Schoenfeld [29]. Articles according to Singer, et al. [30] which has included the term only in the abstract often focused on single disciplines, raising concerns about overextension of the label.

3.3. Disciplinary Breadth

Figure 2 illustrates that a majority of studies incorporated all four STEM domains, indicating a trend toward integrated approaches. A majority of the articles (61.2%) addressed all four STEM domains, showing a trend toward integrative approaches. However, 17.7% addressed only one STEM discipline, and 10.6% addressed two or three. An additional 10.5% of the articles incorporated non-STEM elements, such as arts or medicine, suggesting a broadening of the STEM conceptual umbrella.

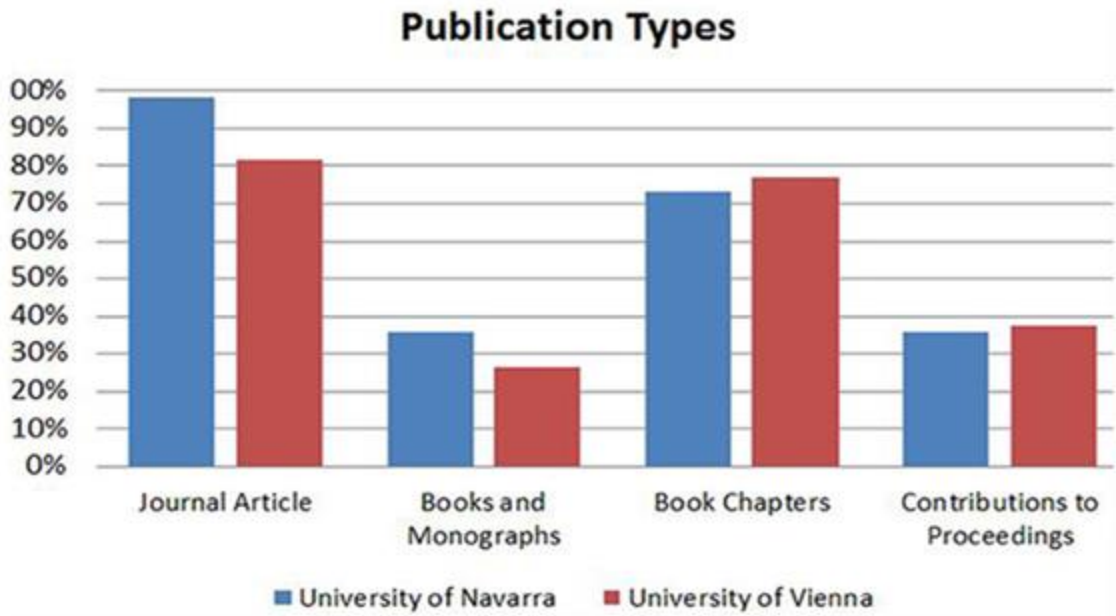

Figure 2.
list of publications based on the analysis of articles, chapter presented and proceedings.

3.4. Journal Characteristics

Journals were grouped into categories based on how many STEM disciplines they typically published. Subject-1 journals (focused on one STEM field) contributed the most articles (32.5%), followed by interdisciplinary journals (subject-4, 21.7%) and subject-2 journals (18.6%). This distribution shows the central role of traditional disciplinary journals in shaping STEM education scholarship.

3.5. Geographic Authorship

As shown in Figure 3, the United States overwhelmingly leads in STEM education research contributions which is included in Li [23]. The United States dominated authorship, accounting for approximately 75% of all contributions regardless of attribution method. Other notable contributors based on Kim, et al. [24] it is included Australia, the UK, Canada, and Taiwan. Sub-Saharan Africa, Latin America, and Southeast Asia were severely underrepresented, underscoring global disparities in scholarly production and dissemination which is represented in the paper [8].

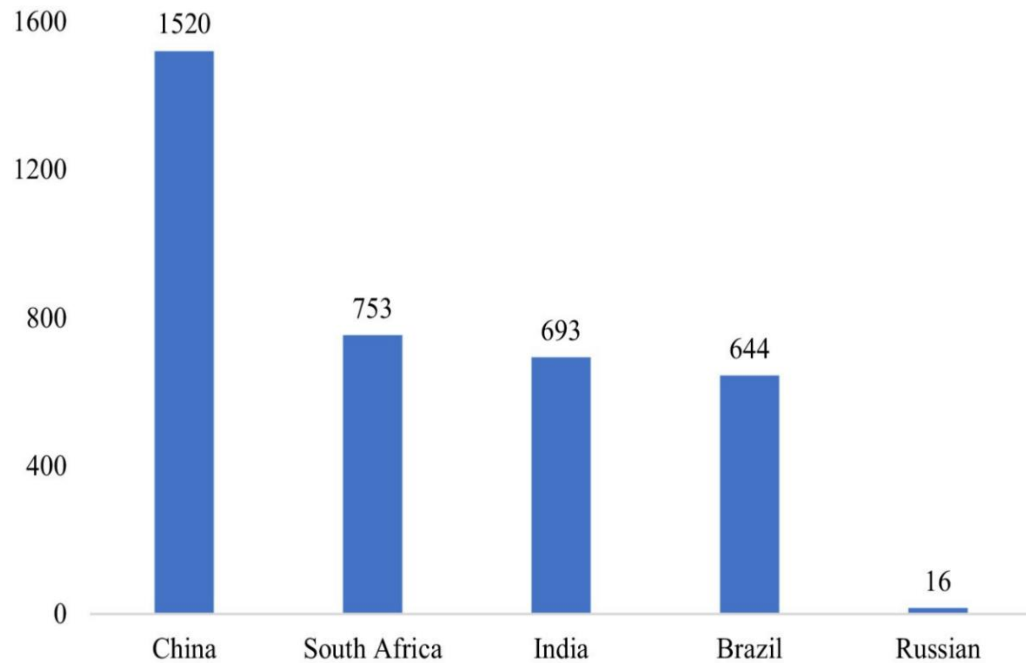

Figure 3.
Analytical review on STEM education research in BRICS countries.

3.6. Thematic Trends

Analysis of thematic focus showed that nearly half of the articles (47%) addressed curriculum, policy, or assessment. This was followed by K–12 teaching (12.9%), K–12 learning environments (12.2%), post-secondary education (9.5%), and cultural/gender issues (9.8%). Less common themes included professional development, epistemology, and interdisciplinary theory-building.

3.7. Research Methodology

Based on Li [31] Quantitative research was the fastest growing category, reflecting broader educational trends favoring evidence-based decision-making. Qualitative and mixed-methods research grew steadily but remained less dominant. Non-empirical work, including in Li, et al. [32] theoretical articles and literature reviews, declined as a percentage of total output over time.

3.8. Collaboration Patterns

Multi-authored articles accounted for over 83% of the sample, with domestic collaborations being more frequent than international ones which are included in Ring-Whalen, et al. [33]. However, the number of international co-authored papers increased steadily, suggesting gradual expansion of global research networks in STEM education.

3.9. Publication Used by Other Journals

Two general education research journals (referred to as "subject-0"), twelve journals with titles that contain one STEM discipline ("subject-1"), eight journals with titles that cover two STEM disciplines ("subject-2"), six that cover three STEM disciplines ("subject-3"), seven that contain the word STEM ("subject-4"), and one that focuses on STEAM education ("subject-5").

With the exception of the Journal of Pre-College Engineering Education Research, a subject-1 journal founded in 2011 that offered open access (OA), Table 2 demonstrates that both subject-0 and subject-1 journals were typically established, long-standing, and subscription-based. Although subject-2 and subject-3 journals were more recent than subject-0 and subject-1 journals, they still had a significant amount of mediocre history. Additionally, a few additional journals in these two categories offered open access. The majority of subject-4 and subject-5 journals had open access, and they had a brief history. The findings indicate that reputable journals tend to concentrate on specific fields of study or education research in general. A few years later, interdisciplinary and multidisciplinary education journals were established, and more recently, several STEM or STEAM publications were established.

Additionally, Table 2 reveals that around a quarter of the papers were published by subject-1, subject- 2, and subject-4 journals. Since we only chose a small number of journals in this category, the quantity of publications in subject-1 journals is intriguing. We probably did not include some STEM education articles published in subject-0 or subject-1 journals that we did not include in our study because we did not choose many of the other journals in the subject-1 category (as well as subject-0 journals) mediocre history.

Table 2.
Information about journals in different subject categories.

#of subjects	# of journals	# of OA journals	Years of history (On average) *	# of STEM articles (%)
Subject-0	2	0	77	36 (4.5%)
Subject-1	12	1	53.3	259 (32.5%)
Subject-2	8	4	31.3	185 (23.2%)
Subject-3	6	2	24.5	92 (11.5%)
Subject-4	7	6	7.7	205 (25.7%)
Subject-5	1	0	6	21 (2.6%)

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The number of publications annually in each of the five previously mentioned categories (subjects 0 through 5) is displayed in Figure 5. The annual number of articles in subject-0 and subject-5 journals remained relatively constant during the study period. However, by the end of the study period, the annual number of publications in subject-2, subject-1, and subject-4 journals (all four domains) exceeded 40Though it increased, the annual number of publications in subject-3 journals was still below thirty. It can seem a little odd at first that during the past few years, the number of STEM education publications published annually in subject-1 journals has increased significantly faster than those in subject-2 journals. However, as Table 2 shows, these publications have a lengthy history and a solid reputation, so researchers want to publish their work there. The growth in subject-4 journals, as opposed to the trend in subject-1 journals, indicates that STEM education journals began to establish a distinct identity for disseminating and publishing STEM education research.

The number of publications on STEM education in each journal is displayed in Figure 6 with color-coded bars (yellow for subject 0; light blue for subject 1; green for subject 2; purple for subject 3; dark blue for subject 4; and black for subject 5). Regarding the total quantity of STEM education articles across categories or journals, there is no discernible trend; instead, performance varies greatly by journal. The findings suggest that the quantity of publications on STEM education may be significantly influenced by the capacity and willingness of each individual journal.

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The top nations and areas by number of publications are displayed in Table 3, where the authorship used the two previously mentioned ways to determine the nation or location. Depending on the approach, authors from the USA contributed roughly 75% of the work, with Australia, Canada, Taiwan, and the UK following closely after. The only continent not represented in the top ten nations or regions was Africa. The findings mostly align with trends documented in the IJ-STEM research [32]. A closer look at Table 3 shows that there are some differences between the two approaches in addition to the findings being reasonably consistent. For instance, Israel and If only the corresponding author was taken into account, Germany had greater publication credit; but, when co-authors were taken into account, South Korea and Turkey had more publication credit. Table 3's findings demonstrate the usefulness of each approach for examining and contrasting publications by nation, area, or organization according to authorship.

Table 3.
Top 10 authorship countries/regions for all 798 publications (2000-2018) using the two methods.

Rank	**Method 1**[a]		**Rank**	**Method 2**	
	Country	Score (%)		Country	Scores (%)
1	USA	603 (75.75%)	1	USA	596.28 (74.91%)
2	Australia	37 (4.65%)	2	Australia	38.29 (4.81%)
3	Canada	18 (2.26%)	3	Canada	18.42 (2.31%)
4	Taiwan	14 (1.76%)	4	Taiwan	13.76 (1.73%)
4	UK	14 (1.76%)	5	UK	12.83 (1.61%)
6	Spain	12 (1.51%)	6	Spain	12.53 (1.57%)
7	Israel	9 (1.13%)	7	South Korea	9.55 (1.20%)
7	South Korea	9 (1.13%)	8	Turkey	9.02 (1.13%)
9	Germany	8 (1.01%)	9	Israel	8.68 (1.09%)
9	Netherlands ands	8 (1.01%)	10	Netherlands ands	7.69 (0.97%)
9	Turkey	8 (1.01%)			

[a]Method 1 refers to the method where only the corresponding author (or the first author, if no specific indication was provided about the corresponding author) was credited, whereas method 2 refers to the case when all co-authors were credited. The same notations are used in Tables 4 and 5

Given that, as Fig. 1 illustrates, the number of publications annually has grown significantly since 2010, Table 4 displays the number of publications by country/region throughout the 2009–2018 timeframe, and Table 5 displays the number of publications by country/region during the 2014–2018 timeframe. Given that there have been more publications in STEM education in recent years, it is not surprising that the rankings in Tables 3, 4, and 5 are largely consistent. Meanwhile, it

Table 4.
Top 10 authorship countries/regions for 772 publications (2009-2018) using the two methods.

Rank	Method 1		Rank	Method 2	
	Country	Score (%)		Country	Scores (%)
1	USA	580 (75.13%)	1	USA	573.04 (74.23%)
2	Australia	37 (4.79%)	2	Australia	37.89 (4.91%)
3	Canada	18 (2.33%)	3	Canada	18.42 (2.39%)
4	Taiwan	14 (1.81%)	4	Taiwan	13.76 (1.78%)
5	UK	14 (1.81%)	5	UK	12.83 (1.66%)
6	Spain	12 (1.55%)	6	Spain	12.53 (1.62%)
7	South Korea	9 (1.17%)	7	South Korea	9.55 (1.24%)
8	Germany	8 (1.04%)	8	Turkey	9.02 (1.17%)
9	Israel	8 (1.04%)	9	Israel	8 (1.04%)
10	Nether lands ands	8 (1.04%)	10	Nether lands ands	7.69 (1.00%)
11	Turkey	8 (1.04%)			

Table 5.
Top 10 authorship countries/regions for 641 publications (2014-2018) using the two methods.

Rank	Method 1		Rank	Method 2	
	Country	Score (%)		Country	Scores (%)
1	USA	473 (73.79%)	1	USA	466.78 (72.82%)
2	Australia	30 (4.68%)	2	Australia	30.89 (4.82%)
3	Canada	17 (2.65%)	3	Canada	17.82 (2.78%)
4	UK	13 (2.03%)	4	Spain	12.53 (1.95%)
5	Spain	12 (1.87%)	5	UK	11.99 (1.87%)
6	Taiwan	11 (1.72%)	6	Taiwan	10.71 (1.67%)
7	South Korea	9 (1.40%)	7	South Korea	9.15 (1.43%)
8	Turkey	8 (1.25%)	8	Turkey	9.02 (1.41%)
9	German y	7 (1.09%)	9	Germany	6.89 (1.07%)
9	Malaysia	7 (1.09%)	10	Malaysia	6.68 (1.04%)
9	Netherlands	7 (1.09%)			

Interestingly, Table 5 shows some changes over the past few years, with Malaysia—but not Israel—entering the top 10 list when author credit was calculated using either approach.

4. Discussion

This study confirms the rapid expansion and increasing complexity of STEM education research. The rise in publication volume indicates growing institutional support and perceived relevance, but it also raises questions about coherence and quality across the field. The broad use of the STEM label, especially in articles focused on single disciplines, suggests a need for more rigorous definitions and standards which are insisted in Schreffler, et al. [27].

1. According to the paper [31, 34]. Curricular and policy concerns dominate the literature, reflecting the strategic importance of STEM education in national education reforms. Yet, the relatively low representation of equity, cultural issues, and postsecondary learning points to important gaps which are included in [27]. Expanding research in these areas is critical for ensuring that STEM education meets the needs of diverse learners and societies.
2. Methodologically, the shift toward quantitative approaches aligns with trends in evidence-based policy but may inadvertently marginalize rich qualitative insights indicated in Tsai and Lydia Wen [10]. Encouraging methodological pluralism and embracing mixed-methods research can offer more holistic understandings of STEM education phenomena.
3. The geographic skew in authorship highlights structural inequities in global knowledge production. Addressing this requires intentional efforts to support scholars in underrepresented regions through funding, collaboration, and equitable publishing practices.

5. Conclusion

This journal-based analysis of STEM education research over an 18-year period provides critical insights into the field's development, thematic orientation, and global reach included in Vasquez, et al. [20]. Our findings demonstrate that while the field is maturing in terms of volume and methodological rigor, it remains challenged by definitional ambiguity and geographic concentration.

To sustain and deepen the impact of STEM education research, future efforts must aim for greater inclusivity—both in terms of geographic representation and thematic diversity. According to Xu, et al. [13] and Thomas, et al. [35] it is promoting interdisciplinary integration, fostering methodological richness, and amplifying underrepresented voices are essential for the continued advancement of the field. As STEM education continues to evolve, ongoing meta-research such as this review will be crucial for ensuring that scholarly inquiry remains responsive to the complex demands of education in the 21st century.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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