Asian Journal of Research in Education and Social Sciences
e-ISSN: 2682-8502 | Vol. 6, No. 7, 67-77 2024
https://asianscholarsnetwork.com/asnet-journals
SPECIAL ISSUE: International Conference on Education 4.0 2024 (INCOED 4.0 2024)

Exploring Trends and Challenges in STEM Education: A Bibliometric Perspective

Ng Yu Jin[1*], Sarfraz Aslam[1], Mallika Vasugi V.Govindarajoo[1], Norwati Roslim[2]

[1] Faculty of Education and Humanities, UNITAR International University, Kelana Jaya, Malaysia
[2] Academy of Language Studies, Universiti Teknologi MARA (UiTM), Cawangan Negeri Sembilan, Kampus Rembau, Malaysia

*Corresponding Author: yujin.ng@unitar.my

Received: 5 October 2024 | Accepted: 6 December 2024 | Published: 20 December 2024

DOI: https://doi.org/10.55057/ajress.2024.6.7.8

Abstract: *This study provides a comprehensive reference for language and linguistics researchers focused on research within STEM education. The research has three key objectives: to analyze trends in learner corpus research related to STEM education, identify critical areas within this domain, and uncover major challenges faced by researchers. This study examines the publications concerned with STEM education through a bibliometric methodology, based on data provided by the Scopus database, and displaying the outcomes with the use of VOSViewer software. By articulating intricate information in a clear and scholarly way, this study is a substantial source for those researchers concerned with articulating scholarship in the field of STEM education. It also deepens the understanding of current research trends and extends the present concordance in STEM education through bibliometric methods. This study highlights an increasing interest in the field of STEM education, which deserves a deeper probe. The bibliometric outcome could serve as a foundational reference for future researchers involved in meta-analysis and systematic literature review studies. In addition, this study identifies the prevailing research gaps, which indicate the need for further research, especially in academic environments. Future studies could examine journals indexed across more databases to enhance understanding of the metadata, offering insights for researchers, practitioners, funders, and policymakers regarding current and future research directions.*

Keywords: STEM education, bibliometric analysis, VOSViewer, engineering education mathematics education

1. Introduction

STEM education, which stands for Science, Technology, Engineering, and Mathematics, is gaining widespread recognition worldwide, from early childhood programs all the way up to universities (Kennedy & Tunnicliffe, 2022; Takeuchi et al., 2020). Equipping students for professional paths within STEM disciplines has emerged as a significant international objective, resulting in various initiatives focused on enhancing students' academic competencies in these domains (Thibaut et al., 2018). In the U.S., STEM education at the K-12 level has evolved into a more integrated approach, often referred to as "integrated STEM education" (Kennedy & Odell, 2014; Roehrig et al., 2021).

Students studying in STEM fields gain valuable skills that help them tackle everyday challenges and make well-informed decisions (Morrison, 2006). Moreover, these students tend to have better job prospects (Zollman, 2012). The goal of STEM education is to address both the social and individual needs of students, shaping them into active and capable citizens who can navigate their environment effectively (Zollman, 2012). Schools and universities are also tasked with boosting economic competitiveness while promoting sustainable practices (Abad-Segura & González-Zamar, 2021). As STEM education continues to gain global importance, research in this field has become more crucial (Li, 2018). A simple Google search with keywords like "STEM" or "STEM education research" results in over 4.5 billion hits in less than a second. This shows the rapid growth of the discipline and the extensive number of research being conducted.

Corpus research gives scholars enormous insight, but more particularly for those who are focused on pedagogic approaches within STEM education. Many researchers point out the value of corpus research: "the reliability of corpus research as an investigating tool" (Nguyen et al., 2018), "useful and re-use value of data in many ways" (Odebrecht et al., 2017), and "influence in many areas of academia" (Murakami et al., 2014). Further, corpus research closes the gap between research and teaching, particularly in the study of the English language, according to Zagrabelsky et al. (2022), opens new perspectives for research by Honnibal et al. (2007), and advances empirical research in corpus-based translation as stated by Granger et al. (2020). Within this framework, articles related to STEM education were gathered and digitized.

Bibliometric mapping is frequently employed to analyze prevailing trends within research. Koskine et al. (2008) highlighted the following: with the ability to show disparities between institutions, bibliometric methods can be useful in research evaluation. Similarly, according to Ragadhita et al. (2021), bibliometric analysis is important since the emerging phenomena that have relevance today get highlighted. In applying bibliometric analysis to corpus linguistics over the past two decades, Crosthwaite et al. (2022) discovered the rise of research coming from single-country teams, while there were various leading researchers from China, Poland, South Korea, and Japan.

Wang et al. (2022) called for more international-domestic collaboration to review research in STEM education into English writing. Similarly, Ngoc and Barrot (2022) also found that research output and citations in ELT have increased in Southeast Asia. Singapore, Vietnam, and Malaysia are the top three countries in the region; however, regional collaboration remains very limited.

The central role research plays in influencing the direction of STEM education calls for this study on the comprehensive bibliometric performance of documents related to STEM education. The objectives are to:

1) To evaluate the growth and spread of STEM education research.
2) Identifying priorities in research in STEM education.
3) The research into principal obstacles encountered by scholars in this discipline.

2. Methodology

This paper focuses on the trends in research related to STEM education using a bibliometric analysis approach. For the purpose of data collection, Scopus will be selected, as it is considered one of the major multidisciplinary databases of abstracts and citations of various

literature types: journals, books, and conference proceedings. According to AlShehhi et al. (2022), the key research questions of the analysis are sought by answering the following:

Area 1: Number of publications by year, type of document, source titles, and the languages used.
Area 2: Subject areas covered and keywords analysis used in the research.
Area 3: Highly contributing countries, leading institutions, authorship collaborations, and citations metrics.

This study retrieved data using the "STEM Education" search term without filtering into document types, publication years, subject areas, and languages. A total of 2,140 documents published between 2003 and 2025 were retrieved for processing. The cleaned data were imported into the VOSviewer software version 1.6.19 to develop and visualize maps of bibliometric networks. This software also provides advanced text mining including the visualisation of co-occurrence networks of key terms identified from the scientific literature.

Three types of analysis were carried out using VOSviewer:
1) Co-authorship analysis: This examined the relationships between authors, their affiliations, and the countries they represent.
2) Co-occurrence analysis: This focused on all the keywords used within the research.
3) Citation analysis by country: This analyzed the research output and impact from different countries.

Through network and density visualization maps, the analysis provided insights into keyword usage, the countries contributing the most research, the primary institutions involved, and patterns in authorship and citations.

3. Findings and Discussion

This section shares the results of the bibliometric analysis, focusing on three main questions: (i) how research in STEM education has developed and been shared over time, (ii) what the primary topics explored within STEM education research are, and (iii) what key challenges researchers in this field face. In total, 2,140 documents were reviewed and analyzed for these insights.

(i) Evolution and Spread of STEM Education Research

The development and distribution of STEM education research were examined by looking at factors such as the number of publications per year, the titles of sources, the types of documents and sources, and the languages used in these publications. The data for this analysis was directly retrieved from the Scopus database, utilizing the 'analyze search results' function to provide insights into these trends.

a. Publications by year

Table 1 provides data on the number of annual publications in STEM education research from 2003 to 2025, highlighting a consistent increase in publications over the years. In 2003, two notable STEM education papers were published for the first time: "Engineering Insights: Developing STEM Education for Students with Disabilities Leads to K-16 Partnerships" and "Using LEGOS to Interest High School Students and Improve K12 STEM Education." These papers were indexed in the Scopus database. The search for this study was conducted on August 21, 2024, meaning that some journals had already released issues for 2025, all of which were

included in the analysis. Figure 1 illustrates the number of documents published each year from 2003 to 2025.

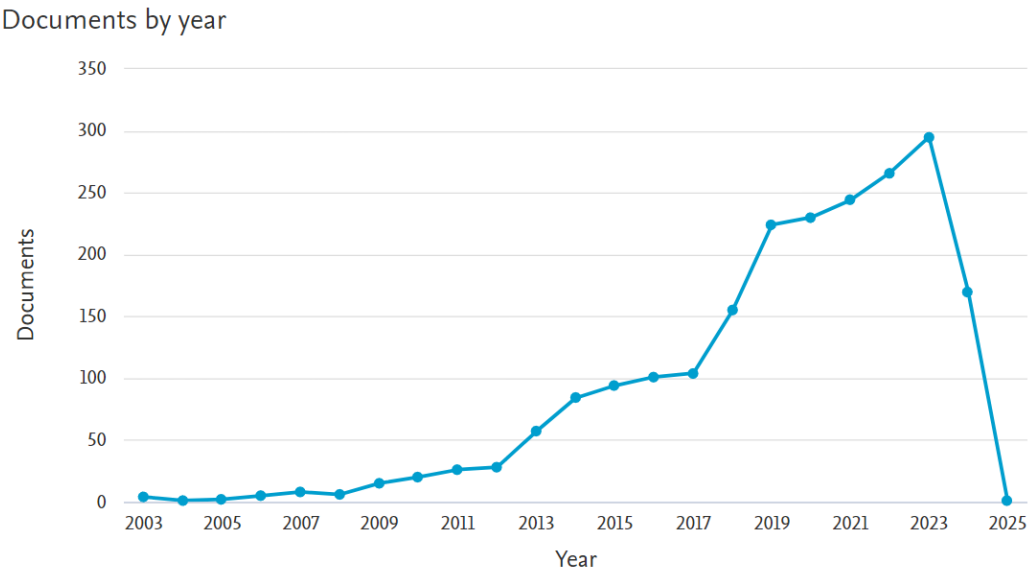

Figure 1: Documents by Year (2003 – 2025)

Table 1: Number of STEM education Research Publications by Year

Year	Number of documents	Year	Number of documents
2003	4	2018	155
2004	1	2019	224
2005	2	2020	230
2006	5	2021	244
2007	8	2022	266
2008	6	2023	295
2009	15	2024	170
2010	20	2025	1
2011	26		
2012	28		
2013	57		
2014	84		
2015	94		
2016	101		
2017	104		

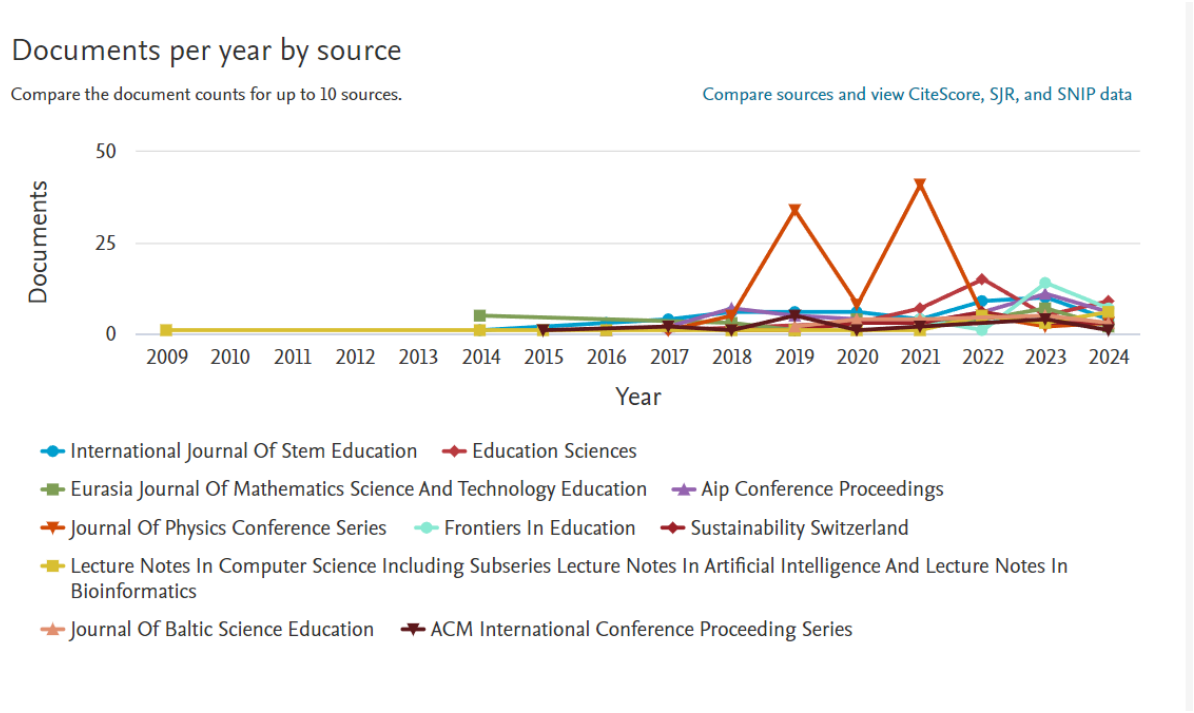

Figure 2: Top 10 Documents Per Year by Source (2009 – 2024)

Table 2: Top 10 Sources for STEM education Research

Source title	Number of documents
Journal of Physics Conference Series	99
International Journal of STEM Education	53
AIP Conference Proceedings	41
Education Sciences	40
Eurasia Journal of Mathematics and Technology Education	29
Frontiers in Education	26
Lecture Notes in Computer Science including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics	22
Sustainability Switzerland	20
Journal of Baltic Science Education	18
ACM International Conference Proceeding Series	17

Table 3: Sources for STEM Education Research

Source type	Number of documents	Percentage (%)
Conference Paper	765	35.7
Book Chapter	257	12.0
Editorial	78	3.6
Review	76	3.6
Book	45	2.1
Note	31	1.4
Conference Review	26	1.2
Erratum	17	0.8
Letter	11	0.5
Others (Short Survey, Retracted)	7	0.3

A deeper analysis of the data was carried out, categorizing the types of documents. The Scopus database primarily includes serial publications where the authors are also the researchers responsible for the presented findings. This analysis provided valuable insights into the volume of STEM education research and the types of publications. As shown in Figure 2, the largest portion of documents were original research articles, making up over half with 765 articles (35.7%), followed by 257 book chapters (12.0%). Other document types, such as reviews, books, conference reviews, errata, editorials, data papers, and notes, each accounted for less than 10% of the total.

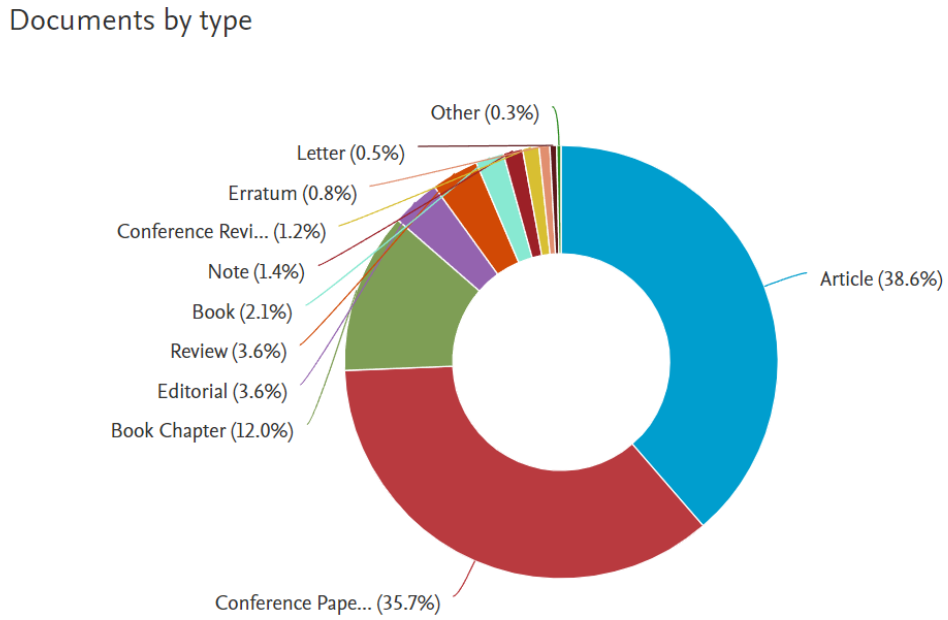

Figure 4: Documents by Type

b. Languages used in documents

As indicated in Table 4, the majority of publications related to STEM education are in English, accounting for 93.24% of the 2,115 documents. Spanish follows with close to 1%. The remaining publications are spread across eight other languages—French, German, Russian, Finnish, Czech, Estonian, Japanese, and Latvian—each making up less than 1%. While multiple languages are used for STEM education research, the contribution from non-English sources remains quite limited.

Table 4: Languages Used for STEM Education Research Publications

Language	Number of documents	Percentage (%)
English	2115	98.8
Spanish	14	0.65
Turkish	6	0.28
Portuguese	3	01.4
Russian	3	0.14
French	2	0.09
Croatian	2	0.09
Chinese	2	0.09
Lithuanian	1	0.045
German	1	0.045
Bulgarian	1	0.045

(ii) Key Areas of STEM Education Research

The core areas of STEM education research were analysed by looking at (a) subject areas, (b) keyword analysis, and (c) document titles.

a. Subject Area

The study categorized the documents according to their subject areas, as presented in Table 5. The analysis, based on data from the Scopus database using the 'analyze search results' function, revealed that STEM education research covers a broad spectrum of disciplines. Nearly 85% of the studies were related to the social sciences, making up 42.31% (770 articles) of the total publications. This was followed by a significant number of studies in the arts and humanities, accounting for 37.97% (691 articles). In contrast, computer science represented 11.48% (209 articles). Other fields, such as Business, Management and Accounting, Psychology, Mathematics, Engineering, Health Professions, Decision Sciences, and Economics, Econometrics, and Finance, each had fewer than 50 publications focused on STEM education.

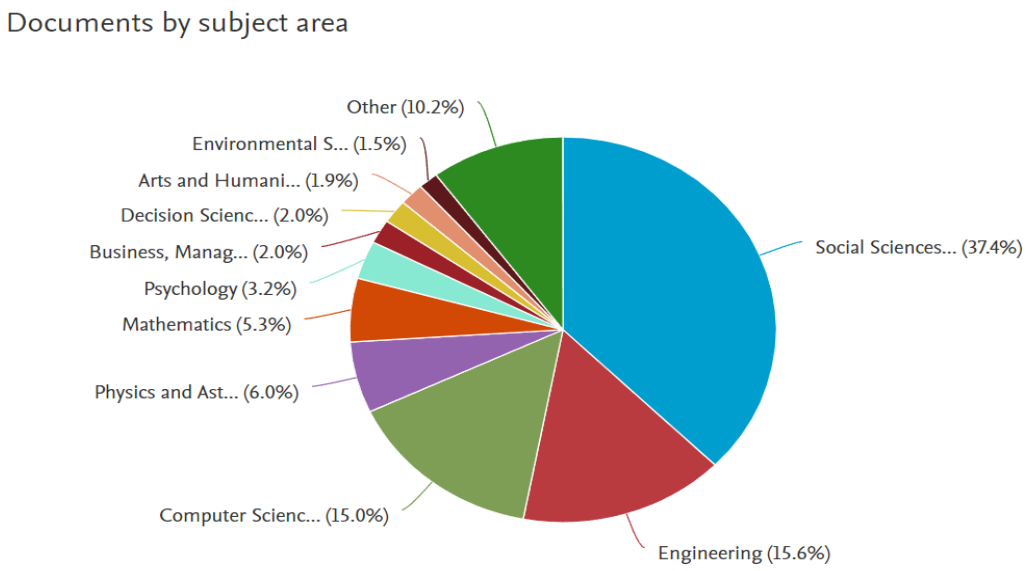

Figure 5: Documents by Subjects

Table 5: Subject Areas of STEM Education Research

Subject area	Number of documents	Percentage (%)
Social Sciences	1403	37.4
Engineering	586	15.6
Computer Science	564	15.0
Physics and Astronomy	224	6.0
Mathematics	200	5.3
Psychology	120	3.2
Business, Management and Accounting	75	2.0
Decision Sciences	74	2.0
Arts and Humanities	70	1.9
Environmental Science	56	1.5

b. Keyword Analysis

The principle behind keyword analysis is that the keywords chosen by the author should effectively represent the core topics of the article (Comerio & Strozzi, 2019). Figure 1 illustrates a network map of author keywords that appeared at least 10 times. The VOSviewer software was used to identify and visualize relationships between these keywords, displaying them in a way that shows their connections. The frequency of the keywords and their relation strength are, in turn, depicted through the use of several other elements in the map. This includes color, circle size, font size, and line thickness. Keywords that were used together often come under the same color. Such is the case when during this research, keywords such as "STEM education", "linguistics", "STEM education research", "second language acquisition", and "error analysis" was seen often together to reflect their relevance to each other and appearance either in the same or other papers (Sweileh et al., 2017).

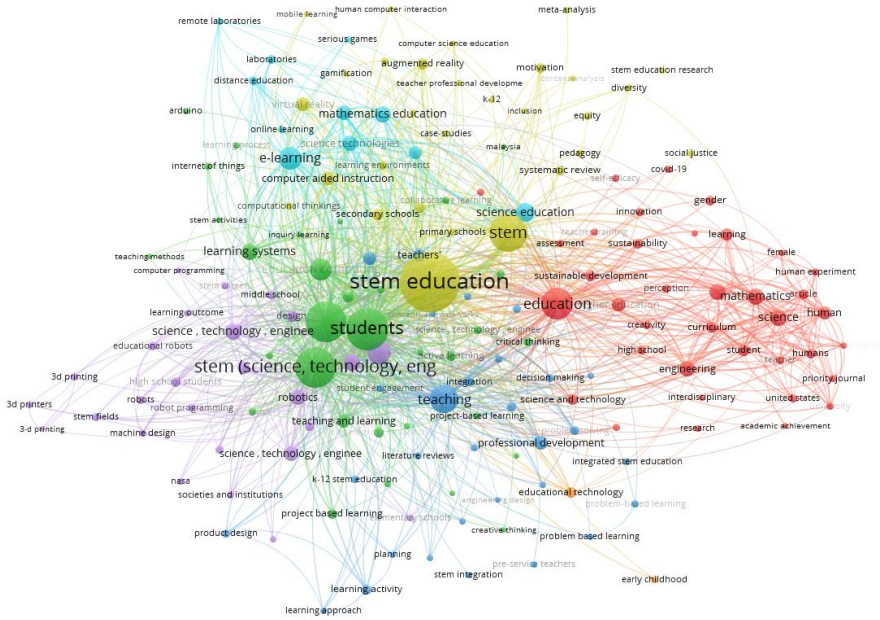

Figure 6: Network Visualization Map (Author Keywords with at least 10 Occurrences)

Co-occurrence analysis was carried out using the software VOSviewer, considering all keyword units throughout the publications. In that respect, a threshold of a minimum of 10 occurrences per keyword from among 6,791 keywords in 2,140 documents was considered for this analysis. Of these, 167 keywords met this threshold. For each of the 167 keywords, the total strength of their co-occurrence with other keywords was calculated, and the keywords with the highest link strength were highlighted. The most frequently used keyword in this field was "STEM education." Table 6 provides a list of the top twenty keywords used in the "STEM education" studies.

Table 6: Top Twenty (20) Keywords in STEM Education Research

No	Keywords	Occurrences	Total link strength
1	STEM education	873	3063
2	Students	437	2650
3	Engineering education	393	2447
4	STEM (science, technology, engineering and mathematics)	397	2166

5	Education	245	1479
6	Teaching	195	1369
7	STEM	352	1140
8	Curricula	137	883
9	E-learning	128	801
10	Education computing	122	793
11	Science education	90	501
12	Science technologies	62	490
13	Professional aspects	68	489
14	Science, technology, engineering and mathematics	67	463
15	Learning systems	69	460
16	Engineering and mathematics	53	442
17	Mathematics	66	439
18	Mathematics education	65	434
19	Technology	66	432
20	Engineering	62	430

(iii) Key Contributors to STEM Education Research

This study explored the patterns of scientific collaboration in STEM education research by analyzing the countries that contributed the most to this field.

a. Countries Leading in STEM Education Research

Table 7 presents the top 15 countries contributing to STEM education research, based on data from Scopus. The United States leads the list, followed by Australia, China, Thailand, Malaysia, Turkey, and Indonesia. Other notable contributors include Canada, Hong Kong, the United Kingdom, Spain, Germany, Greece, Taiwan, and Vietnam, each accounting for less than 20% of the total publications. This distribution highlights that STEM education research is being actively pursued across various regions worldwide.

Table 7: Geographic Origins of STEM education Research

Country	Number of documents
United States	811
Australia	117
China	105
Thailand	99
Malaysia	93
Turkey	88
Indonesia	84
Canada	63
Hong Kong	63
United Kingdom	59
Spain	55
Germany	51
Greece	48
Taiwan	48
Vietnam	37

The network visualization of the top 15 countries related to STEM education research was created using VOSviewer as presented in Figure 5.

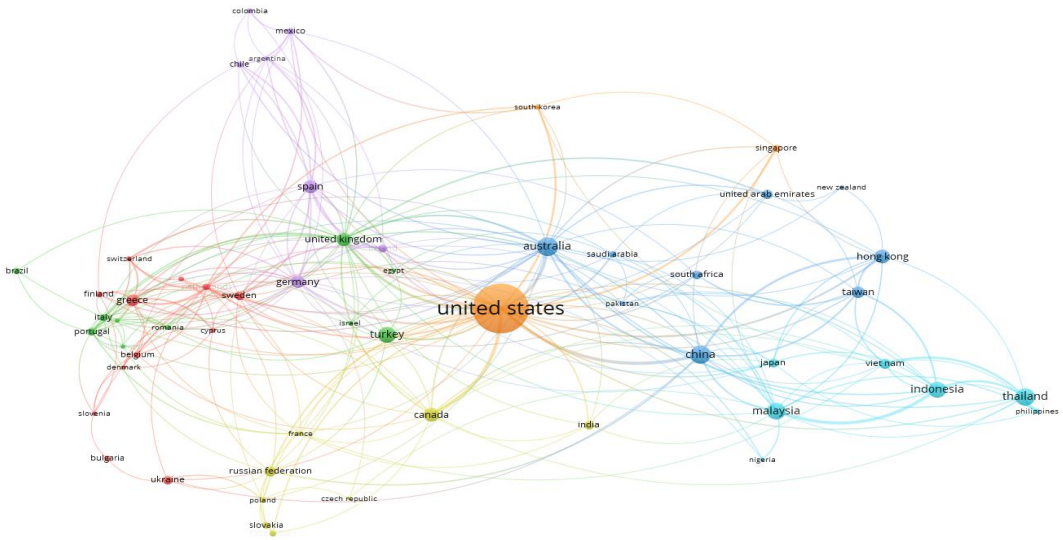

Figure 7: The Top 15 Countries Related to STEM Education Research.

4. Conclusion and Implications

In conclusion, this study enhances the understanding of current research trends in STEM education by applying bibliometric analysis, which broadens the existing knowledge in this field. The growing interest in STEM education underscores the need for more comprehensive research. This analysis provides a valuable baseline for future studies, encouraging researchers to expand the knowledge base through meta-analyses and systematic literature reviews. While the current research in STEM education is substantial, there is still a need for greater clarity and focus, particularly in academic contexts. Future studies should explore journals indexed across a wider range of databases to gain deeper insights into the metadata. These findings will be beneficial for researchers, practitioners, funders, and policymakers, offering guidance for both current and future research directions.

Acknowledgement
The authors would like to thank UNITAR International University for providing the supports for this study.

References

AlShehhi, A. M. A. A., Nasir, B. B. M., Kilani, A., Abuhassna, H., & Awae, F. (2022). Exploring the Role of Diversity on Management and Attitude: A Bibliometric Analysis. International Journal of Academic Research in Progressive Education and Development, 12(10), 1217-1231.

Comerio, N., & Strozzi, F. (2019). Tourism and its economic impact: A literature review using bibliometric tools. Tourism economics, 25(1), 109-131.

Crosthwaite, P., Ningrum, S., & Schweinberger, M. (2022). Research trends in corpus linguistics: A bibliometric analysis of two decades of Scopus-indexed corpus linguistics research in arts and humanities. International Journal of Corpus Linguistics.

Granger, S., & Lefer, M. A. (2020). The Multilingual Student Translation corpus: a resource for translation teaching and research. Language Resources and Evaluation, 54(4), 1183-1199.

Honnibal, M., & Curran, J. R. (2007, June). Creating a systemic functional grammar corpus from the Penn treebank. in ACL 2007 Workshop on Deep Linguistic Processing (pp. 89-96).

Kennedy, T. J., & Sundberg, C. W. (2020). 21st Century Skills. In B. Akpan & T. J. Kennedy (Eds.), Science education in theory and practice: An introductory guide to learning theory. (Chapter 32, pp. 479–496). Springer Nature. http://doi.org/10.1007/978- 3-030-43620-9

Koskinen, J., Isohanni, M., Paajala, H., Jääskeläinen, E., Nieminen, P., Koponen, H., Tienari, P. & Miettunen, J. (2008). How to use bibliometric methods in evaluation of scientific research? An example from Finnish schizophrenia research. Nordic journal of psychiatry, 62(2), 136-143.

Murakami, A. (2014). Individual variation and the role of L1 in the L2 development of English grammatical morphemes: Insights from learner corpora (Doctoral dissertation, University of Cambridge).

Ngoc, B. M., & Barrot, J. S. (2022). Current landscape of English language teaching research in Southeast Asia: A bibliometric analysis. The Asia-Pacific Education Researcher, 1-13.

Odebrecht, C., Belz, M., Zeldes, A., Lüdeling, A., & Krause, T. (2017). RIDGES Herbology: designing a diachronic multi-layer corpus. Language Resources and Evaluation, 51, 695-725.

Ragadhita, R., & Nandiyanto, A. B. D. (2022). Computational bibliometric analysis on publication of techno-economic education. Indonesian Journal of Multidiciplinary Research, 2(1), 213-220.

Roehrig, G. H., Dare, E. A., Ellis, J. A., & Ring-Whalen, E. (2021). Beyond the basics: A detailed conceptual framework of integrated STEM. Disciplinary and Interdisciplinary Science Education Research, 3(1), 11. https://doi.org/10.1186/s43031- 021-00041-y

Sweileh, W. M., Al-Jabi, S. W., AbuTaha, A. S., Zyoud, S. E. H., Anayah, F. M., & Sawalha, A. F. (2017). Bibliometric analysis of worldwide scientific literature in mobile-health: 2006–2016. BMC medical informatics and decision making, 17, 1-12.

Wang, W., Zhao, J., & Wu, Z. (2022). A Bibliometric Analysis of Research Articles on Learner Corpus of English Writing (2012-2021). Open Journal of Modern Linguistics, 12(5), 588-604.

Zagrebelsky, M. T. P. (2003). Computer learner corpora, or how can we turn our students' interlanguage into a resource for EFL research and teaching?. Vigo International Journal of Applied Linguistics.

Harris, A. L., Lang, M., Yates, D., & Kruck, S. E. (2008). Incorporating Ethics and Social Responsibility in IS Education. Journal of Information Systems Education, 22(3), 183-189.

Harun, R., Hock, L. K., & Othman, F. (2011). Environmental Knowledge and Attitude among Students in Sabah. World Applied Sciences Journal, 14, 83-87.