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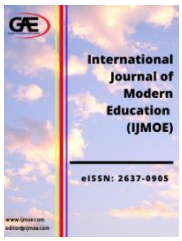

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UNLOCKING THE DYNAMIC OF STEM EDUCATION IN MALAYSIA: A BIBLIOMETRIC STUDY

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Abstract:

A bibliometric analysis was done to unlock the dynamic of STEM education in Malaysia by revealing the performance and science mapping of the published document in the Web of Science Core Collection for all years refined to only Malaysian published documents. The publication trend of STEM education in Malaysia shows a rise and fall between 2019 and 2023 with an overall publication trend and citation decline after reaching its apex in 2018 and 2021 respectively. Among the states in Malaysia, Selangor exhibits the highest total citation and document count with 178 and 33 respectively compared to other states with Universiti Kebangsaan Malaysia highly contributing to the percentage. Other illuminated data include the performance of organisations, authors and finally the percentage of funding. Furthermore, keyword analysis is illustrated through the science mapping highlighting the STEM education in Malaysia revolving around the interests of sustainable development. Limitations of the studies included the dataset received only from the Web of Science database and not from any other source, for example,

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Scopus or Google Scholar. The value of the articles lies in assessing the Malaysian tertiary research progress and its impact surrounding the topic of STEM Education in Malaysia.

Keywords:

Bibliometric Analysis, Malaysia, STEM Education, VOSviewer, Web of Science

Introduction

In Malaysia, Science, Technology, Engineering and Mathematics (STEM) education refers to the teaching and learning of the respective fields to equip the learner particularly primary and secondary school students with critical thinking and problem-solving skills (Siregar et al., 2023). These efforts point toward preparing students for a skilled workforce and meeting the industrial demands for Industrial Revolution 4.0 (IR4.0) (Maria et al., 2018). The importance of STEM education lies in the emergence of emerging technologies associated with IR4.0 that directly change the industry landscape (Zahari & W. Muhamad Radzi, 2021). In the landscape of IR4.0, high-tech instrumentation and methods play a major role and the demand for highly competent personnel to handle such specialized equipment is scarce. And thus, illuminating the need to nurture STEM education to ensure a steady flow of qualified individuals for these roles (Azmi et al., 2018).

At the forefront of the world's future, the importance of STEM is not only related to the workplace and IR4.0 but also lies in the ability to make the world a better place to live. In aspiring to equip individuals with the skills essential for the workplace, educational institutions hold the aspiration to cultivate these capabilities that contribute to societal betterment (Siew-Eng et al., 2015). Such proficiencies encompass critical thinking, effective communication skills, and interdisciplinary knowledge (Santos et al., 2023). STEM education cultivates talents and nurtures the future generation, empowering them to effectively address global challenges and devise innovative solutions (Ismail & Yusof, 2023).

There has been an effort made to ensure the rise of STEM education in Malaysia. Prominently, was the 60:40 ratio policy in 1967 by the Malaysian Planning Committee of Higher Education, aiming to balance student enrolment between STEM and arts streams. However, to date, the intended ratio has not been fully achieved (Chua & Choong, 2019; Suhanna Zainudin et al., 2015). A study in 2022 uncovered notable variations in student engagement with STEM subjects, reaching its high point at 48.15% in 2012 and experiencing a decline to 40.95% in 2021 (Idris et al., 2023a). Moreover, it was stated that the decline was due to the deficiency of competent teachers, weak ICT skills of students in rural areas, absence of proper facilities to implement the STEM learning standard and lack of interest among students (Idris et al., 2023b). On the other hand, among contributing factors, teacher roles significantly impact students' interest and perceptions toward STEM subjects (Ong & Ling, 2020). Therefore, the Program Duta Guru (PDG), a joint initiative between Petronas through Yayasan PETRONAS and the Ministry of Education Malaysia, aims to empower 4,500 teachers to become highly proficient STEM educators and role models was executed recently to achieve the previously stated 60:40 STEM enrolment (Yayasan PETRONAS, 2021).

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Research Questions

With alignment to the United Nations initiatives Sustainable Development Goal (SDG-4) to ensure quality education and promote lifelong learning opportunities, the studies aim to provide bibliometric analysis regarding STEM education and is the first bibliometric analysis focusing on STEM education, uniquely narrowed to the context of Malaysia. To begin, a comprehensive bibliometric analysis to address key inquiries relevant to STEM education within Malaysia covering all years gathered through the Web of Science (WoS) Core Collection database. The investigation seeks to illuminate the following aspects:

1. What are the overall publication trends of STEM education in Malaysia?
2. Which state in Malaysia exhibits the highest volume of WoS publications?
3. Which organisation in Malaysia has the most influential and prolific STEM education through publication output and total citations respectively?
4. Which journals are active within the scope of published documents on STEM education?
5. Which author has the most significant WoS total citation, total publication, and citation rates per year in the field?
6. A brief assessment of research funding in STEM education in Malaysia
7. Uncovering the keyword and co-occurrence pattern prevalent in publications centred on STEM education.

These inquiries provide a framework for the bibliometric analysis and the key to unlocking the dynamic of STEM education in Malaysia.

Methodology

In the analysis, publication on STEM education in the Web of Science (WoS) Core Collection database was examined using bibliometric analysis. The measurements used to assess the publication's performance are citations, number of published documents and the author keywords with additional information that can be derived from research funding, source title and research area (Donthu et al., 2021). To date, a bibliometric analysis of STEM education in Malaysia has been notably absent. This study represents the pioneering effort to fill this gap by conducting the first bibliometric analysis within the Malaysian context. The overview of the methodology is simplified based on Figure 1. The details of the search term and refinement are described in consecutive subsections. In data collection, a series of on-website refined tools on WoS has been employed to filter the unrelated dataset. After the filtration, the relevant dataset is marked and transferred to a dedicated “Marked List” within the WoS website for more systematic data storage. Afterwards, the file for performance analysis can be exported in the form of Microsoft Excel (.xls) while for science mapping in the form of a tab-delimited text file (.txt). The bibliometric analysis in the study utilizes two software which are Microsoft Excel Worksheet and VOSviewer (1.6.19 version). Each software has its uses in determining the performance of the topic in the study.

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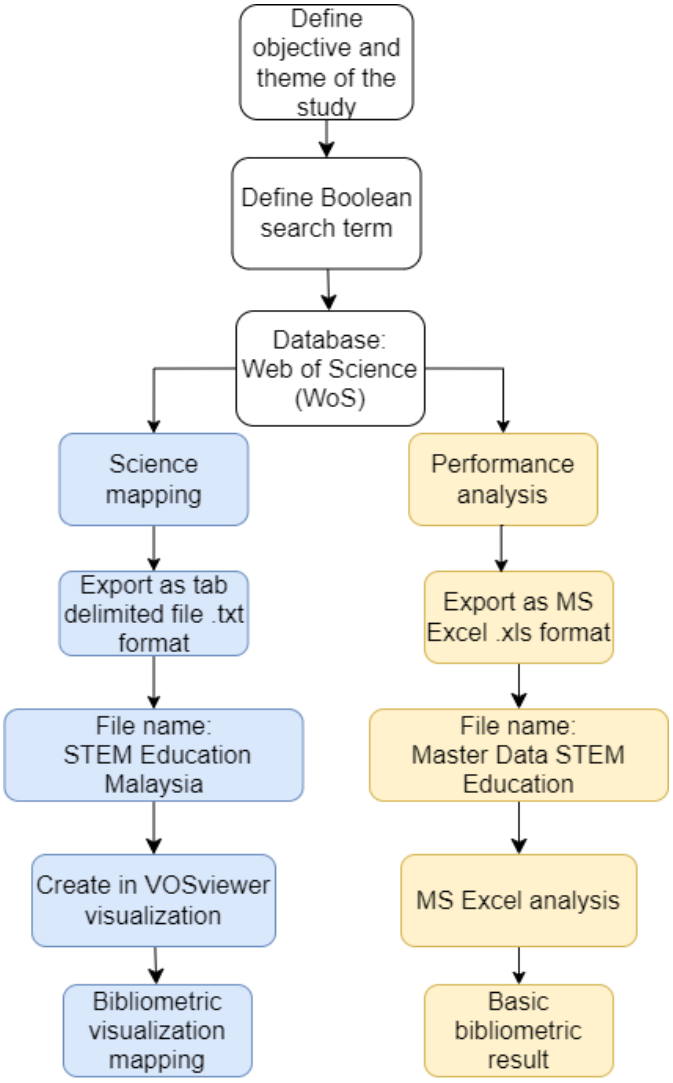

Figure 1: Simplification of Methodology

Data Collection

WoS database was used as the source of data set due to its reputation for storing a wide collection of academic records of the highest quality standards and mostly accepted for scientific publication analysis (Yan & Zhiping, 2023). Thus, using WoS can significantly simplify the bibliometric analysis, leveraging its massive collection and usage in numerous bibliometric studies (Ang et al., 2022; Jamali et al., 2017). Since the topic of the study is STEM education, specific search queries were employed using the designated Boolean search term, as detailed in Table 1. resulting in a total of 4,145 results. The search inquiries were further filtered to include only Malaysia and the result was greatly reduced to 108. Due to convenience, a manual review of each document was conducted, resulting in the removal of eight unrelated documents during the data cleaning process. The decision to remove the document was induced by doubt regarding the authors' affiliations, as the organization did not appear to have originated in Malaysia, and the rest of the authors were non-Malaysian. Furthermore, the abstract of the article did not reflect the topic of STEM education in Malaysia and it was promptly removed. Next, the citation indexes present in all of the 100 documents collected were the Social Sciences Citation Index (SSCI), Conference Proceedings Citation Index – Science (CPCI-S), Emerging Sources Citation Index (ESCI), Conference Proceedings Citation

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Index – Social Science & Humanities (CPCI-SSH), Book Citation Index – Science (BKCI-S), Science Citation Index Expanded (SCI-EXPANDED) and Book Citation Index – Social Sciences & Humanities (BKCI-SSH). Next, all the 100 results are marked and transferred into WoS's "Marked List" where all the datasets can be exported into the respective data type (.txt and .xls). In short, the search approach for inquiring about the dataset followed a guideline contained in the Preferred Reporting Items of Systematic Reviews and Meta-Analysis (PRISMA) as simplified in the flow diagram in Figure 2.

Table 1: Search Inquiries in Web of Science

Topic	**STEM Education**
Boolean search term	"STEM Education"
Countries/ Region	Malaysia
Timespan	All years
Document types	All types
Indexes	SSCI, CPCI-S, ESCI, CPCI-SSH, BKCI-S, SCI-EXPANDED, BKCI-SSH

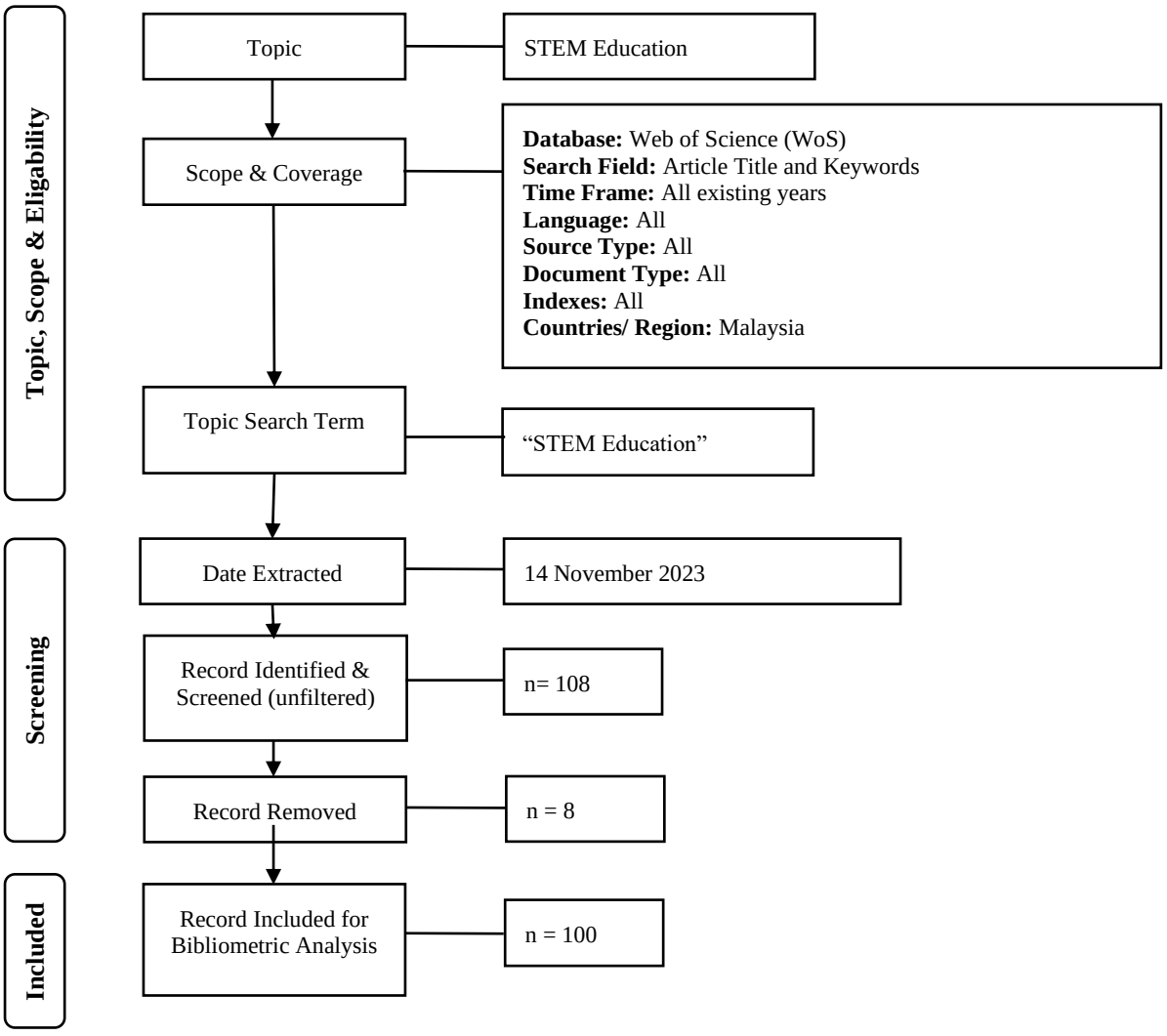

Figure 2: PRISMA Flow Diagram

Source: Adapted Accordingly from Ishak (M. S. Ishak et al., 2023)

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Data Analysis

The procedure applied to analyse the dataset consists of two kinds, which are performance analysis and science mapping. In the performance analysis, Microsoft Excel is used to analyse the dataset with several attributes and compare it with others through "sort & filter" tools. Times cited, number of documents per organization and country, funding information, source title, research area and year published were analysed. Another attribute such as state in Malaysia was created manually by taking the state of affiliation of the first author or the successive author if the first author is not from Malaysia. These additional attributes are created to assess the performance of the state in Malaysia in terms of time cited and total publication manually with the help of Microsoft Excel. Although technically some of the co-authors might come from different states in Malaysia or even from overseas, a priority was given to the first author's affiliation or the second author and successively in that order to name the states of affiliation. Furthermore, VOSviewer was used in the performance analysis to identify the top 10 most influential and prolific organizations. This involved setting the VOSviewer interface "co-authorship" in the type of analysis and selecting "organization" on a unit of analysis. Similarly, the identification of the most influential and prolific authors followed a similar approach, with a change in the unit of analysis to "authors". The software produced a table that outlined the document, and citation counts for organizations (and authors if "author" was chosen as the unit of analysis). Subsequently, the table was filtered and arranged entries in descending order based on citation count and document count. The relevant information was then obtained and transferred into Microsoft Excel. Another attribute that was created in Excel was citation per year where the total citation of the documents is divided over the year the document has been published giving rise to how well-cited the documents are throughout their publication period.

For the science mapping the VOSviewer was used to analyse the keyword. Keyword analysis aims to discover the concepts that have been explored on the topic of STEM education in Malaysia and how they are related. The thesaurus file is used in the VOSviewer to refine the analysis by focusing on the concept revolving around the topic. Grammatical pluralization words and similar meaning terms are adjusted, and countries' names are removed from the analysis due to not giving meaning to concepts revolving around the topic. On The VOSviewer interface, the type of analysis was set as "co-occurrence", and "author keywords" was set on the unit of analysis while counting method by "full counting". The minimum number of occurrences of a keyword was raised to three. Additionally, the presentation is limited to 18 keywords to improve the visibility of the connection.

Findings

Using the WoS database, a thorough examination into STEM education in Malaysia was carried out, producing an amount of 100 relevant publications as of 14 November 2023. This varied collection includes a range of document formats, such as letters, editorial materials, book chapters, reviews, conference papers, and articles. The primary language used in these publications is English, with a single document written in Malay and Indonesian. The field of STEM education in Malaysia involves 17 distinct research areas and comprises collaborative efforts traversing across 19 different countries. A total of 311 authors, both domestic and foreign, were identified in the study. It is noteworthy to note that 55 documents out of 100 have funding support. An overall citation count of 462 highlights the significance of these publications taken together. The summary of the information on STEM education topics acquired from WoS is simplified in Table 3.

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Table 3: Summary of Information from the STEM Education Search

Item	Productivity
Total documents	100
Document types	6
Language	3
Research area	17
Involved countries	19
Authors	311
Funded publication	55
Total overall citations	462

Publication Performance

Based on Figure 3, the first emergence of STEM education in journals through the WoS database started to appear in 2014, giving a hint to the starting point of STEM research topics in Malaysia. Even though the policy of 60:40 science stream to art stream ratio was put into motion in 1967, Malaysia did not use the term "STEM education" until 2012. During this year, Universiti Kebangsaan Malaysia carried out research to determine whether STEM education should be included in the curriculum, which helped to create a national education blueprint (Ahmad et al., 2019). In 2018, the publication count adds up to the highest 16 documents while total citation peaks significantly in 2021 with a total of 122 citations. However, the overall publication trend demonstrated fluctuations between 2019 and 2023, with the total citation experiencing a decline to only 21 citations per year after its pinnacle in 2021. This shows that Malaysian STEM education publication performance is still indifferent in the research field steered by the Malaysian local educational institution despite having been urged by the Ministry of Education through local news (Raj, 2023; Wen, 2023). In the examination of STEM education publications within Malaysian states shown in Figure 4, Selangor emerges as the foremost contributor, substantiated by a total citation of 178 and a substantial document count of 33 in the field. This emphasizes Selangor's significant commitment among other states to addressing STEM education challenges in Malaysia through scholarly contributions. Notably, Johor and Kuala Lumpur closely trail in their respective contributions to the numbers.

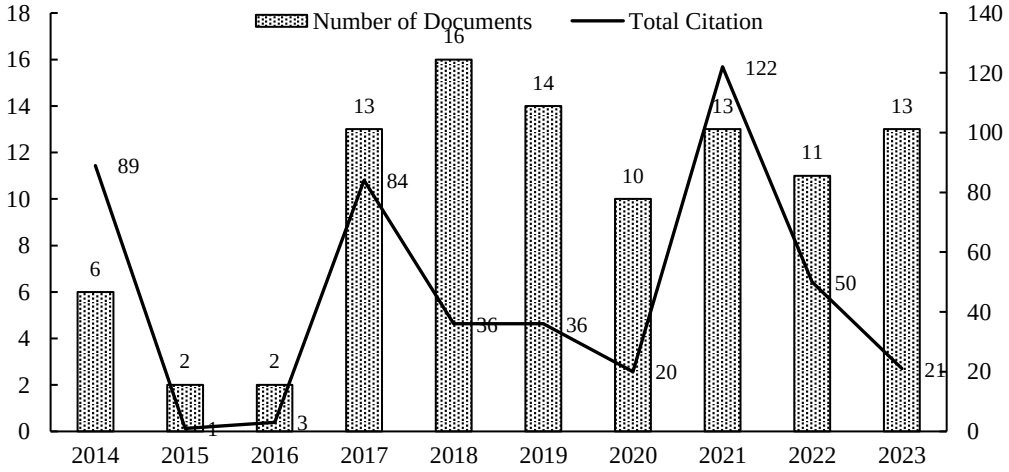

Figure 3: Total Citation and Number of Document Distribution over the Year

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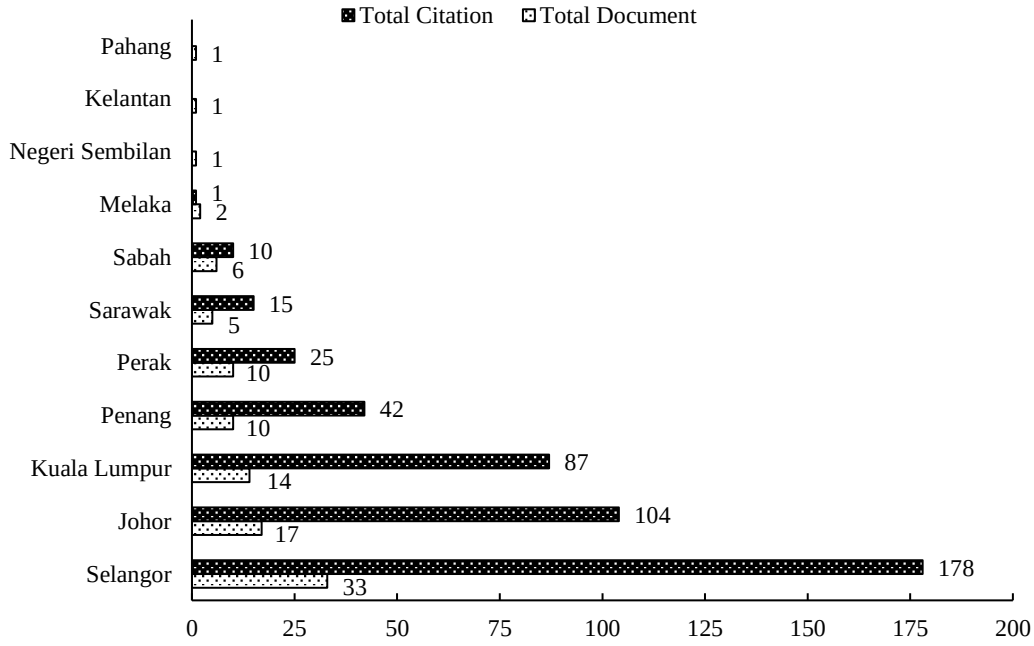

Figure 4: Performance of STEM Education Publication in Malaysian States

Language of Documents and Research Area

According to the analysis shown in Table 4, English is the most common language used in the study, accounting for 98 of the 100 documents that were examined. The Malay and Indonesian combined only make up two of the 100 documents, a striking disparity. The journal publication standards that noticeably favour English over other languages are responsible for this widespread reliance on the English language (Rao, 2018). However, the widely accepted English as the mode of writing and academic communication is one of the global factors English is chosen (Bailey & Gorlach, 2010).

Table 4: Document Writing in Different Languages

Language	Total
English	98
Malay	1
Indonesian	1

An overall focus on STEM fields can be seen in Table 5, particularly in the field of "Education & Educational Research" with 54 frequencies which is followed by "Engineering" and "Computer Science" with 11 and nine frequencies respectively. By contrast, compared to the top three categories shown in Table 5, other study fields receive relatively less attention. The Malaysian places a strong emphasis on education and educational research, which is in line with a common concern: students' declining interest in science programs.

Table 5: Research Area Involving STEM Education in Malaysia

Research area	frequency
Education & Educational Research	54
Engineering	11
Computer Science	9

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Science & Technology	7
Business & Economics	4
Area Studies	3
Psychology	3
Social Sciences	3
Mathematics	2
Construction & Building Technology	1
Environmental Sciences & Ecology	1
Public Administration	1
Research & Experimental Medicine	1

Influential and Prolific Organizations

Analysis of the data from Table 6 indicates that Universiti Kebangsaan Malaysia has received a total of 168 citations followed by the university Universiti Malaya with 106 citations. Besides, there is a considerable gap between Universiti Teknologi Malaysia with a total citation of 58. In Table 7, Universiti Kebangsaan Malaysia achieved the highest citation, the document publication by the university is the highest among other local universities with 25 documents. Universiti Teknologi Malaysia and Universiti Malaya followed closely with 16 and 12 documents respectively. Among non-local universities involved in collaboration with Malaysian STEM education are Colorado State University, University of Nigeria and Universitas Riau.

Table 6: Top 10 Most Influential Organization

Rank	Organization	Citations
1	Universiti Kebangsaan Malaysia	168
2	Universiti Malaya	106
3	Universiti Teknologi Malaysia	58
4	Universiti Sains Malaysia	43
5	Universiti Tun Hussein Onn Malaysia	40
6	Colorado State University	40
6	University of Nigeria	19
7	Universiti Pendidikan Sultan Idris	14
8	Universiti Malaysia Sarawak	13
9	Universiti Malaysia Sabah	11
10	Tunku Abdul Rahman University	10
10	Universiti Putra Malaysia	10
10	Universiti Malaysia Terengganu	10
10	Universitas Riau	10

Table 7: Top 10 Most Prolific Organization

Rank	Organization	Documents
1	Universiti Kebangsaan Malaysia	25
2	Universiti Teknologi Malaysia	18
3	Universiti Malaya	12
4	Universiti Sains Malaysia	8
5	Universiti Malaysia Sabah	7
6	Universiti Pendidikan Sultan Idris	5
7	Universiti Teknologi Mara	4

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8	Tunku Abdul Rahman University	4
9	Universiti Putra Malaysia	4
10	Universiti Tenaga Nasional	3

Influential and Prolific Publications by Source Title

The analysed result in the section helps to identify the distribution of core source titles in STEM education in Malaysia. Table 8 rank the top 10 source title based on citation while Table 9 rank the top 10 source title based on the number of documents published. In Table 8 it was found that the accumulated citations from the publication published in the "Eurasia Journal of Mathematics Science and Technology Education" received an overall 139 citations, followed by the source title "International Journal of Technology and Design Education" which with 48 total citations. Among the source title that has been chosen for publication, the most selected source title is similar to the previous category with both "Eurasia Journal of Mathematics Science and Technology Education" and "International Journal of Technology and Design Education" recorded with six documents followed by "2017 7th World Engineering Education Forum (WEEF)", "Journal of Baltic Science Education" and "Proceedings of 2018 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (Tale)" all with four documents.

Table 8: Influential Source Title

Source Title	Citations
Eurasia Journal of Mathematics Science and Technology Education	139
International Journal of Technology and Design Education	48
Advanced Science Letters	40
Journal of Baltic Science Education	27
Research In Science & Technological Education	25
Studies In Higher Education	19
Chemistry Education Research and Practice	15
Journal of Engineering Science and Technology	14
Estudios De Economia Aplicada	13
Education and Information Technologies	10

Table 9: Prolific Source Title

Source Title	Documents
Eurasia Journal of Mathematics Science and Technology Education	6
Journal of Engineering Science and Technology	6
2017 7th World Engineering Education Forum (WEEF)	4
Journal of Baltic Science Education	4
Proceedings of the 2018 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (Tale)	4
Education and Information Technologies	3
International Journal of Technology And Design Education	3
Journal of Nusantara Studies-Jonus	3
Research in Science & Technological Education	3
Sustainability	3

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Authorship

The authorship section emphasizes the top 10 prolific authors that produce a large portion of STEM education-related research, the top 10 influential authors that receive considerable citations and the top 10 highly cited articles that are considered popular and relevant all the time. In Table 10, the result of prolific authors ranks both "Halim, Lilia" and "Osman, Kamisah" both affiliated with Universiti Kebangsaan Malaysia, Selangor as the most prolific authors in the category with seven published documents. Followed by "Ismail, Zaleha" from Universiti Teknologi Malaysia, Johor with six documents. In Table 11, the most influential authors are similarly held by the same person, "Halim, Lilia" and "Osman, Kamisah" with 123 and 121 citations respectively. Followed closely by "Shahali, Edy Hafizan Mohd" with 106 citations. Furthermore, the top five authors are all affiliated with Universiti Kebangsaan Malaysia and among others included in the table are Universiti Malaya and Universiti Teknologi Malaysia. In both Table 10 and Table 11, it is observed that Universiti Kebangsaan Malaysia was among the affiliations that highly contributed to most documents published and citations contributions.

Table 10: Prolific Authors

Authors	States	Affiliations	Documents
Halim, Lilia	Selangor	Universiti Kebangsaan Malaysia	7
Osman, Kamisah	Selangor	Universiti Kebangsaan Malaysia	7
Ismail, Zaleha	Johor	Universiti Teknologi Malaysia	6
Saat, Rohaida Mohd	Kuala Lumpur	Universiti Malaya	5
Said, Mohd Nihra Haruzuan Mohamad	Johor	Universiti Teknologi Malaysia	4
Tasir, Zaidatun	Johor	Universiti Teknologi Malaysia	4
Siew, Nyet Moi	Sabah	Universiti Malaysia Sabah	4
Ibrahim, Nor Hasniza	Johor	Universiti Teknologi Malaysia	4
Shahali, Edy Hafizan Mohd	Selangor	Universiti Kebangsaan Malaysia	3
Rasul, Mohamad Sattar	Selangor	Universiti Kebangsaan Malaysia	3

Table 11: Influential Authors

Authors	States	Affiliations	Citations
Halim, Lilia	Selangor	Universiti Kebangsaan Malaysia	123
Osman, Kamisah	Selangor	Universiti Kebangsaan Malaysia	121
Shahali, Edy Hafizan Mohd	Selangor	Universiti Kebangsaan Malaysia	106
Rasul, Mohamad Sattar	Selangor	Universiti Kebangsaan Malaysia	92
Zulkifeli, Mohd Afendi	Selangor	Universiti Kebangsaan Malaysia	63
Saat, Rohaida Mohd	Kuala Lumpur	Universiti Malaya	54
Ismail, Zaleha	Johor	Universiti Teknologi Malaysia	46
Said, Mohd Nihra Haruzuan Mohamad	Johor	Universiti Teknologi Malaysia	40
Tasir, Zaidatun	Johor	Universiti Teknologi Malaysia	40
Mustafa, Norazla	Johor	Universiti Teknologi Malaysia; Universiti Teknologi Malaysia	40

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Analysis of authorship takes a deeper dive into the evaluation of authors with the most citations per year contribution, a metric that measures citations accumulated from the year of article publication until the year 2023. Comprehensive data provided in Table 12 lists the top 10 highly cited articles on the topic of STEM education in Malaysia. From the table, it was revealed that Shahali et. al through an article titled "STEM Learning Through Engineering Design: Impact on Middle Secondary Students' Interest towards STEM" received the highest citation per year evaluation making the scholarly document well-engaged and frequently used by other researchers for reference in the field of STEM education in Malaysia. Another mention is the involvement of Colorado State University in the advancement of Malaysian STEM education. One of the authors in the document titled "Connecting the STEM Dots: Measuring the Effect of an Integrated Engineering Design Intervention" form a collaboration with University Tun Hussein Onn Malaysia reflecting the integration of STEM education in Malaysia with external collaborators.

Table 12: Top 10 Highly Cited Articles

	Author Full Names	Document Title	Affiliations	Citation	Citation per Year
1.	(Shahali et al., 2017)	STEM Learning Through Engineering Design: Impact on Middle Secondary Students' Interest towards STEM (2017)	Universiti Kebangsaan Malaysia	63	10.5
2.	(Gloria et al., 2021)	A Systematic Review of Augmented Reality in STEM Education (2021)	Universiti Malaysia Sarawak	13	6.5
3.	(Mohd Shahali et al., 2019)	Students' Interest Towards STEM: A Longitudinal Study (2019)	Universiti Kebangsaan Malaysia	22	5.5
4.	(Mustafa et al., 2016)	A Meta-Analysis on Effective Strategies for Integrated STEM Education (2016)	Universiti Teknologi Malaysia	37	5.3
5.	(Hernandez et al., 2014)	Connecting the STEM Dots: Measuring the Effect of an Integrated Engineering Design Intervention (2014)	Colorado State University	40	4.4
6.	(Jamali et al., 2023)	The Role of STEM Education in Improving the Quality of Education: A Bibliometric Study (2023)	Universiti Malaya	4	4.0
7.	(Chu et al., 2023)	A Review of STEM Education with the Support of Visualizing its Structure Through the	Universiti Pendidikan Sultan Idris	4	4.0

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		CiteSpace Software (2023)			
8.	(S. A. Ishak et al., 2022)	Rethinking the Ideology of Using Digital Games to Increase Individual Interest in STEM (2022)	Universiti Kebangsaan Malaysia	4	4.0
9.	(Goy et al., 2018)	Swimming Against the Tide in STEM Education and Gender Equality: a Problem of Recruitment or Retention in Malaysia (2018)	Universiti Malaya	19	3.8
10.	(Huri & Karpudewan, 2019)	Evaluating the Effectiveness of Integrated STEM-lab Activities in Improving Secondary School Students' Understanding of Electrolysis (2019)	Universiti Sains Malaysia	15	3.8

Funding Publications

As shown in Table 13 shows the percentage of funded publications among the overall STEM education publication in Malaysia the analysis reveals that 55% of STEM education publications in Malaysia have received funding, with a concentration of funded publications originating from Kelantan, Melaka, and Pahang. It is noteworthy that all publications from these regions have been fully funded. However, to equalize the funded publication with the impact it produces the citation per publication evaluation is formed. Based on the evaluation, Kuala Lumpur has demonstrated a remarkable production of high-impact publications, displaying a citation per publication of 6.2, surpassing the mean citation per publication ($\bar{x}$=2.6). It is significant to note that only 35.7% of its overall publications receive funding. Similarly, Johor closely follows with a citation per publication of 6.1 and a notable 76.5% of its publications secured funding. These findings suggest that while funding does not necessarily guarantee a direct influence on the citation an individual publication receives, it does influence advancing the overall progress of publications. Moreover, Malaysian local newspapers reported that the Ministries of Education and Science, Technology, and Innovation have allocated funds from the national budget for education reforms (Bernama, 2024; Jeevita & Rebecca, 2024). This is in alignment with the findings presented in Table 13, where more than half of the published documents indicate funding support, reflecting a concerted effort to advance STEM education.

Table 13: Funded Publication Contribution

States in Malaysia	Funded publication	Total Publication	Total citation	% funded publication	Citation per publication ($\bar{x}$=2.6)
Johor	13	17	104	76.5	6.1
Kelantan	1	1	0	100.0	0.0
Kuala Lumpur	5	14	87	35.7	6.2
Melaka	2	2	1	100.0	0.5

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Negeri Sembilan	0	1	0	0.0	0.0
Pahang	1	1	0	100.0	0.0
Penang	4	10	42	40.0	4.2
Perak	9	10	25	90.0	2.5
Sabah	4	6	10	66.7	1.7
Sarawak	1	5	15	20.0	3.0
Selangor	15	33	178	45.5	5.4
Total	**55**	**100**	**462**	**55.0**	**4.6**

Keywords Analysis

Author keywords through co-occurrence are used to identify the core information that reflects the main content of the articles. The node and label in the mapping represent the occurrence of a keyword, its size represents the frequency of occurrence while the colours represent the cluster or category. Additionally, the distance between the nodes indicates the degree of relatability in the keyword. The higher the occurrence of a keyword the bigger the node appeared in the network mapping. In the analysis among the total of 253 keywords listed, 18 of the keywords meet the requirement of the analysis. All the keywords in Figure 5 have a minimum of three frequencies per occurrence. The keyword analysis unveils the four colours red, green, blue, and yellow. The red cluster consists of six keywords such as education, integrated stem, mathematics, science, stem, and technology. The second cluster coloured green has five keywords such as interest towards the stem, non-formal learning, secondary education, stem education and sustainable development. The blue cluster has five items which are attitude, higher education, knowledge, primary school, and stem teaching. Finally, the yellow cluster has two items which are augmented reality and systematic review. From Figure 5, the keyword sustainable development, secondary education and interest towards STEM is located close to the stem education node indicating the most revolving topic around STEM education. It is highly suggestive that from the author's keywords in the green cluster, the research of STEM education in Malaysia is intricate to attain sustainable development through promoting STEM education at the secondary level to cultivate a skilled workforce for the national long-term growth since the majoring aspect solving the lack of STEM human capital is though improving the teaching and learning at secondary education (Azman et al., 2018). While speculation can be made from the blue cluster based on the keywords the cultivation of positive attitude toward STEM begins at the primary school level setting the foundation for a pursuit of knowledge in higher education thereby fostering the established knowledge on STEM teaching. It has been observed that this aligns with the STEM education framework in primary education in Malaysia, aiming to establish connections and foster a solid scientific foundation among students at this stage (Chong, 2019). In the yellow cluster, it was identified the keywords augmented reality and systematic review are newly emerged keywords that revolve around the topic. This suggests the new rising direction of STEM education. From the keyword analysis, it can be observed that the keyword integrated stem, higher education and stem teaching is located far from the stem education node, implying that the topic of integrated STEM education in Malaysia is lacking attention (Bahrum et al., 2017). Keywords listed in Table 14 show the author's keyword occurrence and link strength concerning other keywords in the study.

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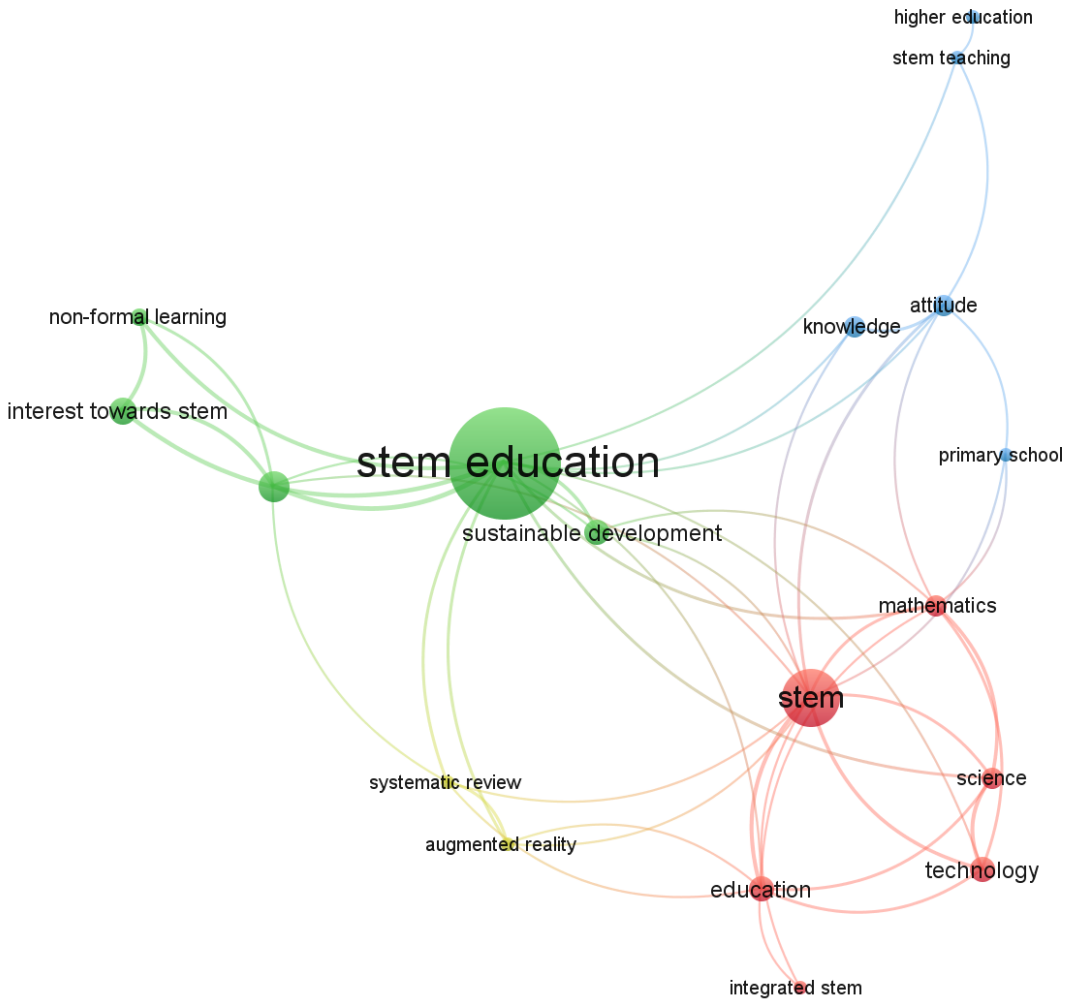

Figure 5: Science Mapping of The Co-Occurrence of Author Keywords.

Table 14: Author Keywords Minimum Three Occurrence

Keyword	Occurrences	Total link strength
stem education	44	31
stem	18	20
secondary education	8	15
education	6	13
interest towards stem	7	13
mathematics	5	13
science	5	13
technology	6	12
non-formal learning	4	10
attitude	5	8
systematic review	3	7
augmented reality	3	6
sustainable development	6	6
knowledge	5	4

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primary school	3	3
stem teaching	3	3
integrated stem	3	2
higher education	3	1

Conclusion

In conclusion, the overall publication trend of STEM education in Malaysia shows fluctuation between 2019 and 2023 with an overall publication trend and citation decline after reaching its pinnacle in 2018 and 2021 respectively. Among the states in Malaysia, Selangor exhibits the highest total citation and document count with 178 and 33 respectively compared to other states. Among the most influential and prolific organizations in the study is Universiti Kebangsaan Malaysia with a total accumulated citation of over 168 and 25 published documents. Moreover, the active journal publishing on STEM education among Malaysians is Eurasia Journal of Mathematics Science and Technology Education with 139 total citations and six published documents. Meanwhile, in terms of influential and prolific authors "Halim, Lilia" received the highest citation with 123 citations and the highest publication count with seven documents. Furthermore, in the citation per year category, the article titled "STEM Learning Through Engineering Design: Impact on Middle Secondary Students' Interest towards STEM" is among the well-engaged and frequently cited articles. The research funding in STEM education in Malaysia reveals that 55% of 100 published documents in Malaysia related to STEM education are funded. Finally, the keyword analysis highlights the point of research on STEM education in Malaysia's development aims to achieve sustainable development by encouraging secondary STEM education for the long-term growth of the country. While this study has yielded valuable insights, it is essential to recognize its inherent limitations. The data collection from the WoS might not represent the overall scattered publication of STEM education in Malaysia. Some scholars might prefer to publish in other journals for example Scopus or Google Scholar and therefore limitation is conceived as restricted to the sample obtained from WoS. However, the data obtained through the study on STEM education in Malaysia is practical and can be used for variable purposes such as research activities, informing educational policy, assisting in curriculum development, supporting funding agencies initiatives, and evaluation of quality assurance and accreditation bodies. This, allows the responsible parties to indicate the progress, assist in effective decision-making, identify research and development areas, and ultimately improve Malaysian education standards.

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