IJEMST International Journal of Education in Mathematics, Science and Technology

www.ijemst.net

A Bibliometric Study on Science, Technology, Engineering, and Mathematics (STEM)

Meria Ultra Gusteti [1] *, Amran Md. Rasli [2], Widdya Rahmalina [3], Khairul Azmi [4], Asrina Mulyati [5], Suci Wulandari [6], Rahmatul Hayati [7], Raveena Ramadhani [8]

[1] Mathematics Education, Universitas Adzkia, Padang, Indonesia, 0009-0009-7639-3430
[2] Faculty of Business and Communication, INTI International University, Negeri Sembilan, Malaysia, 0000-0002-4847-4614
[3] Mathematics Education, Universitas Adzkia, Padang, Indonesia, 0009-0009-3815-8229
[4] Mathematics Education, Universitas Adzkia, Padang, Indonesia, 0009-0009-6304-5840
[5] Mathematics Education, Universitas Adzkia, Padang, Indonesia, 0009-0009-5743-7290
[6] Mathematics Education, Universitas Adzkia, Padang, Indonesia, 0000-0002-7810-100X
[7] Mathematics Education, Universitas Adzkia, Padang, Indonesia, 0000-0002-4940-5194
[8] Mathematics Education, Universitas Adzkia, Padang, Indonesia, 0009-0009-9316-1797
* Corresponding author: Meria Ultra Gusteti (meria.ug@adzkia.ac.id)

Article Info

Article History

Received:
30 September 2025

Revised:
13 January 2026

Accepted:
5 February 2026

Published:
27 March 2026

Keywords

STEM
Bibliometric
Collaboration
Education policy
Scopus

Abstract

This article presents a synthesis of current trends in STEM research, concentrating on how professional development affects teachers' opinions and involvement using bibliometric analysis. The main focus of education and technical growth is STEM, or science, technology, engineering, and mathematics. This article provides an in-depth review of the latest research and innovative developments. The study of STEM's influence on government policy gives insight into government responses to STEM trends through changes in education policy and the support of stakeholders. The bibliometric study starts by firstly reviewing publications on STEM in journals indexed by Scopus by examining patterns of fluctuation and balance every year for the last ten years. Second, The Sustainability journal has published the most articles on STEM. Third, with a total of 287 citations, the majority of citations are focused on papers released in 2018. Fourth, student, learning, and STEM are the author keywords that are most frequently employed. The necessity of education policy congruence and the significance of ongoing support and training for STEM teachers' professional growth are emphasized. and adequate support from the Indonesian perspective. Recommendations include enhancing teacher training programs, promoting interdisciplinary approaches, and strengthening partnerships between academia, industry, and government to advance STEM education in Indonesia.

Citation: Gusteti, M. U., Rasli, A. M., Rahmalina, W., Azmi, K., Mulyati, A., Wulandari, S., Hayati, R., & Ramadhani, R. (2026). A bibliometric study on Science, Technology, Engineering, and Mathematics (STEM). *International Journal of Education in Mathematics, Science and Technology (IJEMST), 14*(3), 892-906. https://doi.org/10.46328/ijemst.5763

ISSN: 2147-611X / © International Journal of Education in Mathematics, Science and Technology (IJEMST).

Introduction

STEM, which stands for science, technology, engineering, and mathematics, is regarded as the main area of attention in the fields of technology development and education. This field's skills are seen to be crucial for overcoming the difficulties of the twenty-first century. (Bartels, 2019; Henry, 2021; López, 2022; Nurtanto, 2020; Shaby, 2021). STEM forms the foundation for innovation, enables the solving of complex problems, and drives technological advances that will shape the global future (Chakraverty, 2019; Fuesting, 2019; Grinis, 2019; Wang et al., n.d.).

Educators' views of STEM education in grades K-12 are influenced by their experience and the role of learning professionals. (Falloon et al., 2020a). Interdisciplinary linkages, ambitious teaching strategies, and practical problem-solving skills are common themes that show up. Regarding STEM advancements, STEM instruction, and the advantages of integrating STEM, the importance of incorporating these elements into educational practices (Bryan & Guzey, 2020; Belfield & Brock, 2023). There needs to be a framework to advance STEM literacy in grades K-12 (Falloon et al., 2020b). There is a need to give greater focus to STEM integration, especially in the context of mathematical and engineering disciplines. (English, 2016).

The article titled "STEM" in-depth reviews recent research and innovative developments. By outlining key trends and presenting a synthesis of data from relevant articles, the central role of STEM in addressing the complex challenges of the 21st century can be understood. Studies show that integrating STEM into the ed. Jamaludin education system can improve students' skills and knowledge. Through citation analysis, Additionally, this essay will talk about the extent to which research and contributions in STEM have influenced the global outlook on science and technology. From here, it can be seen to what extent the influence of STEM penetrates various sectors, including industry, education, and government policies. A series of meta-analyses and syntheses have consistently demonstrated the positive impact of Computer-Aided Collaborative Education (CSCL) in STEM education. (Jeong et al., 2019; McKeown et al., 2017). Furthermore, there is a need for different strategies to build learning, based on a combination of technology, pedagogy, and types of collaboration. By digging deeper into the trends and citations of the article titled "STEM," insights into the future direction of research and innovation can be gained. This article becomes a window into the dynamic world of STEM, highlighting current challenges and new emerging opportunities. Let's dive together into the journey of STEM in carving its mark in the evolution of knowledge and guiding us towards a more sophisticated future.

Based on some of the research outlined earlier, there is a great opportunity for further research on STEM, especially in the context of mathematics. With rapid technological advancements, this development can inspire researchers and practitioners from various disciplines to explore the role of mathematics as a whole, starting from 2014 to 2023. The research aims to address the following questions related to STEM publications between 2014 and 2023: What trends are observed in the publication of STEM articles during this period? Which journals have been the most prolific in publishing STEM articles? What is the total number of citations received by STEM articles published between 2014 and 2023? Which keywords are most frequently used by authors of STEM articles? during this timeframe?

Literature Review

An in-depth literature review of "STEM" Articles provide insight into a number of significant topics. For instance, a number of studies have examined how science instructors see STEM education, emphasizing both its advantages and disadvantages. The need for a professional development model to support teachers in enacting STEM education (El-Deghaidy & Mansour, 2015; Bohrnstedt et al., 2023). Although teachers in the United Arab Emirates (UAE) have a positive attitude towards STEM, they face challenges such as documentation and lack of time. (Hamad et al., 2022). Primary school teachers noted their initial aversion to STEM and the need for support in overcoming barriers. (Samara & Kotsis, 2023). The importance of teacher preparation for integrated STEM education, focusing on concept knowledge, curriculum knowledge, and implementation knowledge (Fırat, 2020). These studies collectively underscore the necessity of continual assistance and professional growth for educators to successfully execute STEM instruction.

Various studies have explored the use of tablets and applications Regarding early childhood education, especially in the domains of robotics, mathematics, STEM, and literacy. (Yang et al., 2024). This technology has the capacity to enhance kids' educational experiences. There are benefits to using tablets in math learning, including increased collaboration and engagement. (Kaggwa et al., 2023; Svela et al., 2019). Tablets and apps have the opportunity to engage children with disabilities and pre-service teachers in robotics-based activities, respectively (Howard & Park, 2014). Overall, these studies emphasize the positive impact of tablet use and apps in early childhood education, especially in STEM and literacy contexts. Numerous research has looked into how professional growth affects teachers' views on STEM education. Teachers' understanding of integrated STEM education develops throughout a 3-week professional development program, with their conceptual models becoming more complex. (Ring et al., 2017). Improved perceptions of science teachers regarding E-STEM, especially in disadvantaged schools, after they attend professional development programs (Amoa-Danquah, 2023; Aydogdu et al., 2020). Professional development has a beneficial effect on teachers' perceptions, efficacy, and confidence. of STEM. (George et al., 2020). The significance of successful professional development in STEM teaching and pointed out the necessity of many formats in addition to consideration of contextual factors. (Goodenough et al., 2014).

Meanwhile, the study of the influence of STEM on government policy provides a perspective on government responses to STEM trends through changes in education policy and industry support. This literature review provides a strong theoretical foundation for "STEM" articles, helping to form an in-depth understanding of the developments, influences, and ramifications of STEM trends across several domains.

Method

This study uses bibliographic research methodology and makes use of explicit and methodical mapping procedures that are drawn from. (Andrade-Arenas et al., 2023a; Angraini et al., 2024; Cansız Aktaş, 2022; Gusteti et al., 2024; Julius et al., 2021; Karampelas, 2023; Kartika et al., 2023; Rafiq et al., 2023; Triyono et al., 2023; Utami et al., 2023a, 2023b). This study applied bibliographic design using systematic and explicit attribution methods (Andrade-Arenas et al., 2023b;; Sofwan et al., 2024). The literature review stage follows four steps, along

with research conducted (Huan et al., 2022; Julia et al., 2020). These stages involve (1) search steps, (2) bibliographic filters, (3) complete bibliographies, and (4) bibliographic evaluation. The Publish or Perish (PoP) program is used in this study's search strategy to go through bibliographic databases. Because Scopus is one of the largest databases offering peer-reviewed literature, it was selected as a database source for reference searches using PoP apps (Khusna et al., 2024; Suseelan et al., 2022). Therefore, Scopus became the only database used in this study. Certain criteria were set for all bibliographies to be included in the analysis, involving three main aspects: (1) Bibliography-type journals only, (2) Article titles containing the phrase "STEM", and (3) Search year ranges were limited from 2014 to 2023 (last 10 years).

Search Procedure

The software tool Bibliographic databases were explored using Publish or Perish (PoP)., particularly focusing on Scopus. These databases are recognized as the leading sources of peer-reviewed scholarly works. The preference for Scopus is attributed to its wider range of content compared to other databases (Andrade-Arenas et al., 2023b). Remarkably, they hold about 70% more publications than the Web of Science (Julia et al., 2020). In this study, specific criteria were set for including bibliographies, such as the inclusion of only journal types, article titles featuring "STEM Education," and a search period limited to the last decade, from 2014 to 2023. Figure 1 shows how to use the PoP program for a bibliographic search.

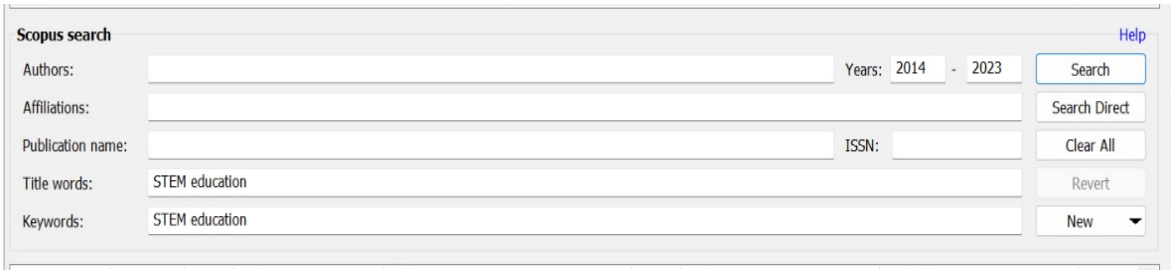

Figure 1. Search for the PoP Application Bibliography

Bibliographic reference search results are saved in the app and exported into CSV file format, which is then opened in the Excel application. Files that have been saved are checked and given additional metadata.

Filter Bibliography

Three criteria are used to choose a bibliography:

(1) it must include the context of STEM education;

(2) it must be written in English; and

(3) it must be published by a publisher of a recognized bibliographic database.

The Scopus database, which is taken from the PoP program, is used to monitor each bibliography that is to be included or removed from the bibliographic analysis process. The article type is the sole reference type selected. Because they are conference papers, mistakes, notes, editorials, reviews, clones, or publications without abstracts attached, some of the reference lists that are shown during the PoP application search process are not chosen. The

PoP application's first search yielded 1,730 reference lists, which were then divided into 869 chosen reference lists. Because they did not meet the requirements, 861 reference lists weren't chosen. The total number of referrals produced by searches using PoP apps each year is displayed in Table 1.

Table 1. Bibliographic Selection Results

Year of Publication	Inclusion	%	Exclusion	%	Total
2014	32	28.8	79	71.2	111
2015	46	33.8	90	66.2	136
2016	50	35.2	92	64.8	142
2017	45	31.9	96	68.1	141
2018	90	45.0	110	55.0	200
2019	93	46.5	107	53.5	200
2020	125	62.5	75	37.5	200
2021	130	65.0	70	35.0	200
2022	145	72.5	55	27.5	200
2023	113	56.5	87	43.5	200
Total	**869**		**861**		**1,730**

As seen in Table 1, the quantity of article publications peaked between 2018 to 2023 with each year publishing 200 articles on STEM, and the lowest number occurred in 2014, with only 111 articles. From the visualization, it can be seen that from 2014 to 2016 the number of articles about STEM always increased. However, in 2017, there was a decline in article publications, and from 2018 to 2023 there was another increase in the publication of articles about STEM. From the table, it can be seen that the number of Exclusion is higher than Inclusion, with a total of 861 articles, while Inclusion is 869 articles. It can be concluded that the number of inclusions and exclusions has only a small comparison.

Bibliography Completeness

To perform filtered bibliographic analysis, metadata is reviewed and finalized. Aspects like the paper title, author name, publishing country and institution, abstract, author keywords, article link, publisher, and year of publication are all examined in the review. A bibliographic analysis is carried out following the completion of the metadata.

Bibliometric Analysis

The following four criteria served as the foundation for the bibliographic analysis: (1) publication patterns; (2) top STEM article publishing journals; (3) top STEM article citations; and (4) most often used keywords in STEM author publications. Bibliographic analysis is carried out and the findings are seen using the VOS viewer tool. Large data sets may be processed quickly and effectively using VOSviewer, which also offers a variety of visualizations, analysis, and observations. Furthermore, VOSviewer may generate publication, author, and journal maps using distributed channel-centric keyword maps or shared citation systems. The EndNote bibliographic file

is the sort of file that is loaded into the VOSviewer program for examination.

Results and Discussion

Publication Trend-Based Analysis

More research is required to examine the patterns of STEM-related journal publications from 2014 to 2023. There has been a rise and fall in the quantity of publications across the time frame. There was an increase from 2014 to 2016, a decrease from 2017, and again increase from 2018 to 2023. The years 2018 to 2023 recorded the highest number of publications. Therefore, it can be concluded that the interest and popularity of research on STEM topics will reach its peak in 2018 to 2023.

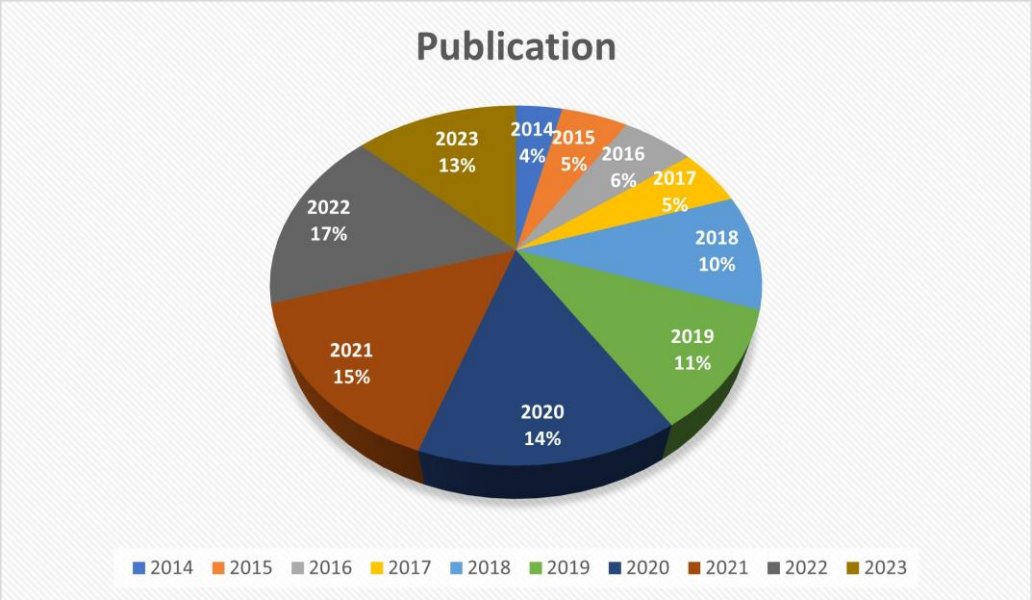

Figure 2. Publication Trends per Year

The following details may be inferred from Figure 2. The number of publications increased from 4 percent in 2014 to 6 percent in 2016. 2017 had a little decline of 5%, however beginning in 2018, this trend flipped and there was a notable gain. There was a steady increase from 2018 to 2022, with 2022 having the most publications (17%). In 2023, it dropped to 13% from its highest point the year before. This suggests that, although there has been some yearly variation, there has been a general rising trend in the publication of STEM-related journal papers over this time. The period from 2018 to 2022 marks a striking increase in publication numbers, indicating a growing interest and prominence in STEM research during these years.

Subsequent data showcase the top 10 journals that published articles on STEM research from 2014 to 2023. This research highlights a widespread ambition to understand and advance STEM competencies across various aspects of life. Table 2 indicates that the top 10 journals are as follows: Sustainability (Switzerland) has the most articles (33 total), followed by Education Sciences (32 total), the Eurasian Journal of Mathematics, Science and Technology Education (20 total), and the International Journal of Science and Mathematics Education (11 total).

Table 2. The STEM-related journals with the highest number of papers published between 2014 and 2023

Journal	Number of articles
Sustainability (Switzerland)	33
Education Sciences	32
Eurasia Journal of Mathematics, Science and Technology Education	20
International Journal of STEM Education	19
International Journal of Technology and Design Education	16
International Journal of Science Education	15
Journal of Turkish Science Education	13
Journal of Science Education and Technology	12
Journal of Baltic Science Education	11
International Journal of Science and Mathematics Education	11

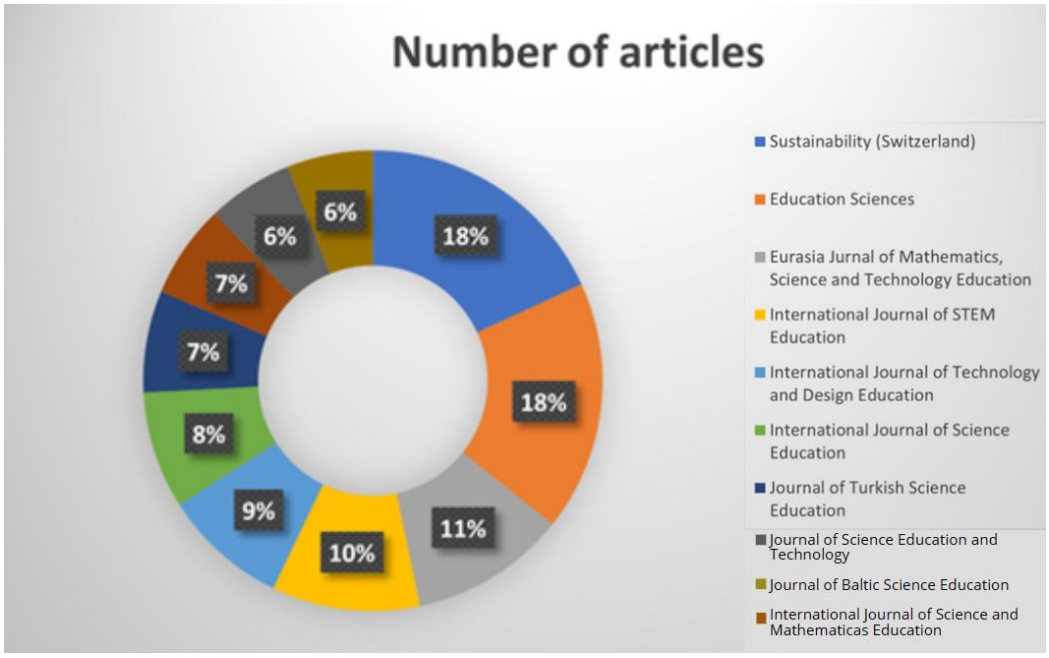

Figure 3. The Proportion of Journals That Have Published the Most Articles on STEM

Figure 3 visualizes the distribution of articles among the leading 10 journals that have featured research on STEM from 2014 to 2023. This chart demonstrates academic interest and efforts directed towards understanding and promoting STEM competencies, as seen in the percentages of published articles across these notable journals:

1. "Sustainability (Switzerland)" and "Education Sciences" are leading the chart, each with 18% of the published articles, indicating a significant contribution to STEM research in their respective domains.
2. With 11% and 10%, respectively, the "Eurasia Journal of Mathematics, Science and Technology Education" and the "International Journal of STEM Education" come in second and third, respectively, demonstrating their contributions to the dissemination of research that advances STEM education.
3. Other noteworthy journals that contribute to the wider discussion and investigation of STEM subjects are the "International Journal of Technology and Design Education," "International Journal of Science Education," and the "Journal of Turkish Science Education," with 9%, 8%, and 6% of the articles, respectively.

This distribution underscores the collective endeavor of these journals in advancing STEM research, reflecting a global ambition to integrate and enhance STEM skills in education and various sectors.

Citation Count Analysis (Annual Citations)

Here's the data detailing annual citation counts spanning from 2014 to 2023.

Table 3. The Annual Number of Citations

Publication Year	The quantity of references	The quantity of articles
2014	1,557	32
2015	1,441	46
2016	1,660	50
2017	1,771	45
2018	2,189	90
2019	1,939	93
2020	2,259	125
2021	1,089	130
2022	810	145
2023	124	113
Total	**14,839**	**869**

Table 3, which shows the number of articles produced year and the number of citations from 2014 to 2023, provides numerous important insights. Initially, there is a general increasing trend in citations, peaking in 2020 with 2,259 citations, suggesting that research in this field has been gaining more attention over the years. However, there was a noticeable decline in citations in the subsequent years, particularly in 2023 when citations significantly dropped to 124. This decline could be attributed to various factors, such as the recency of publications or shifts in research focus. Concurrently, there is a general rising tendency in the quantity of papers produced annually., indicating growing interest and research activity in this field. The ratio of citations to articles varies across the years, highlighting the varying impact of research over time. Overall, the table reflects a vibrant and active research community with a substantial impact, as evidenced by the total of 14,839 citations across 869 articles over the ten years.

The Top 10 Articles with the Most Cited

The 10 most quoted STEM articles are listed in Figure 4. First place goes to the article with the most citations, which was written by Ong et al. in 2018 and has 287 citations. Borrego came in second with 283 citations. In Figure 4, the highest number of citations first appeared in 2018 with 287 citations, which are related to writing (Ong et al., 2018). Meanwhile, the second-highest citation was recorded in 2014, attributed to works written by Borrego and Henderson (2014). On the other hand, there was the first lowest number of citations in 2017, which was related to publications by Blackburn (2017) with the number of citations of 162, the second lowest number

of citations published by Belland et al. (2017) with the number of citations of 167.

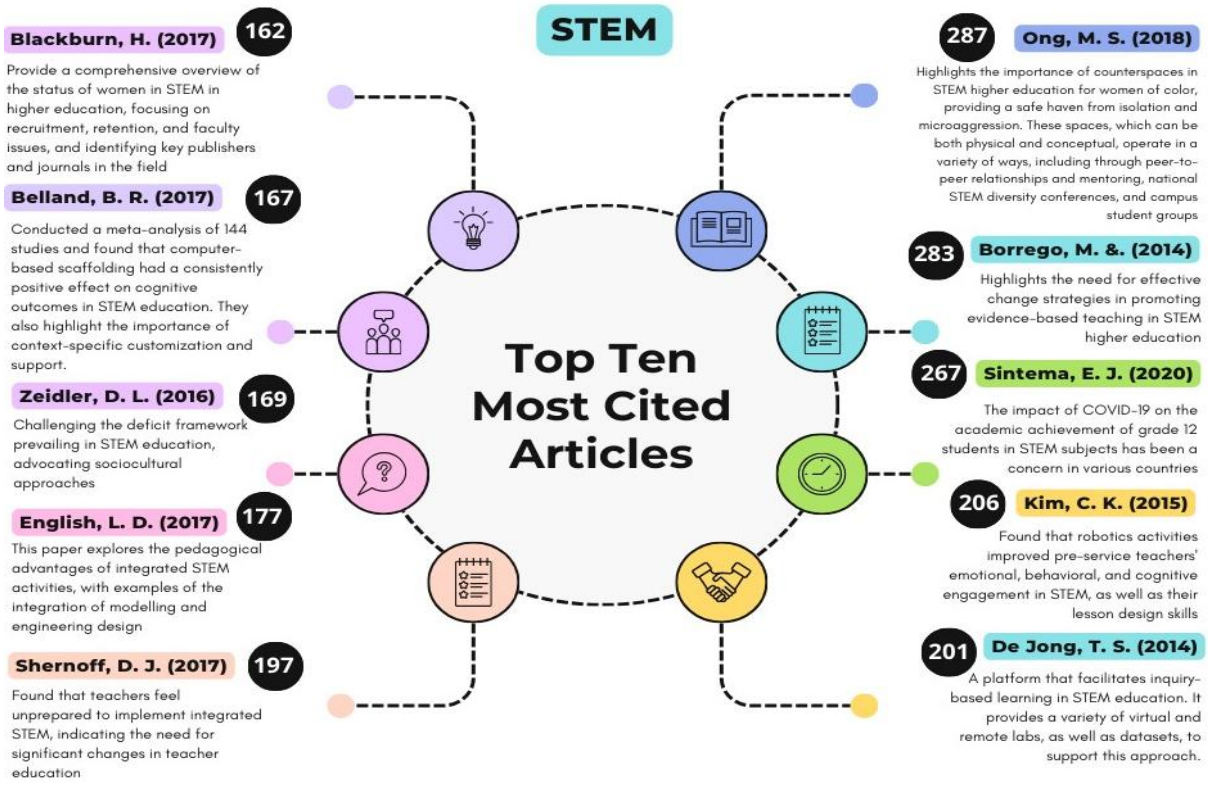

Figure 4. Most Cited Articles on STEM from 2014 to 2023

Author Keyword Based Analysis

Based on the author's keywords, an analysis was performed using the VOSviewer tool. By visualizing the interconnections between commonly used terms in publications, this tool provides insight into the primary topics and how they relate to one another within the study environment.

VOSviewer is a tool for creating network-based maps from scientific data. These maps are commonly used to visualize relationships between various entities, such as journals, researchers, articles, or keywords. In Figure 3, VOSviewer is used to create a keyword map of literature related to STEM education. Keywords shown on the map, such as "stem", "education", "technology", "engineering", and "science", are terms that often appear in the literature analyzed.

The lines between the nodes indicate relationships or connections between these themes. For instance, "student" is strongly connected to "learning", indicating that many discussions or publications involve the relationship between students and their learning processes within STEM fields.

The density of nodes and the thickness of the lines could represent the strength or frequency of the connections. Areas with more nodes and thicker lines suggest well-established research areas with many connections.

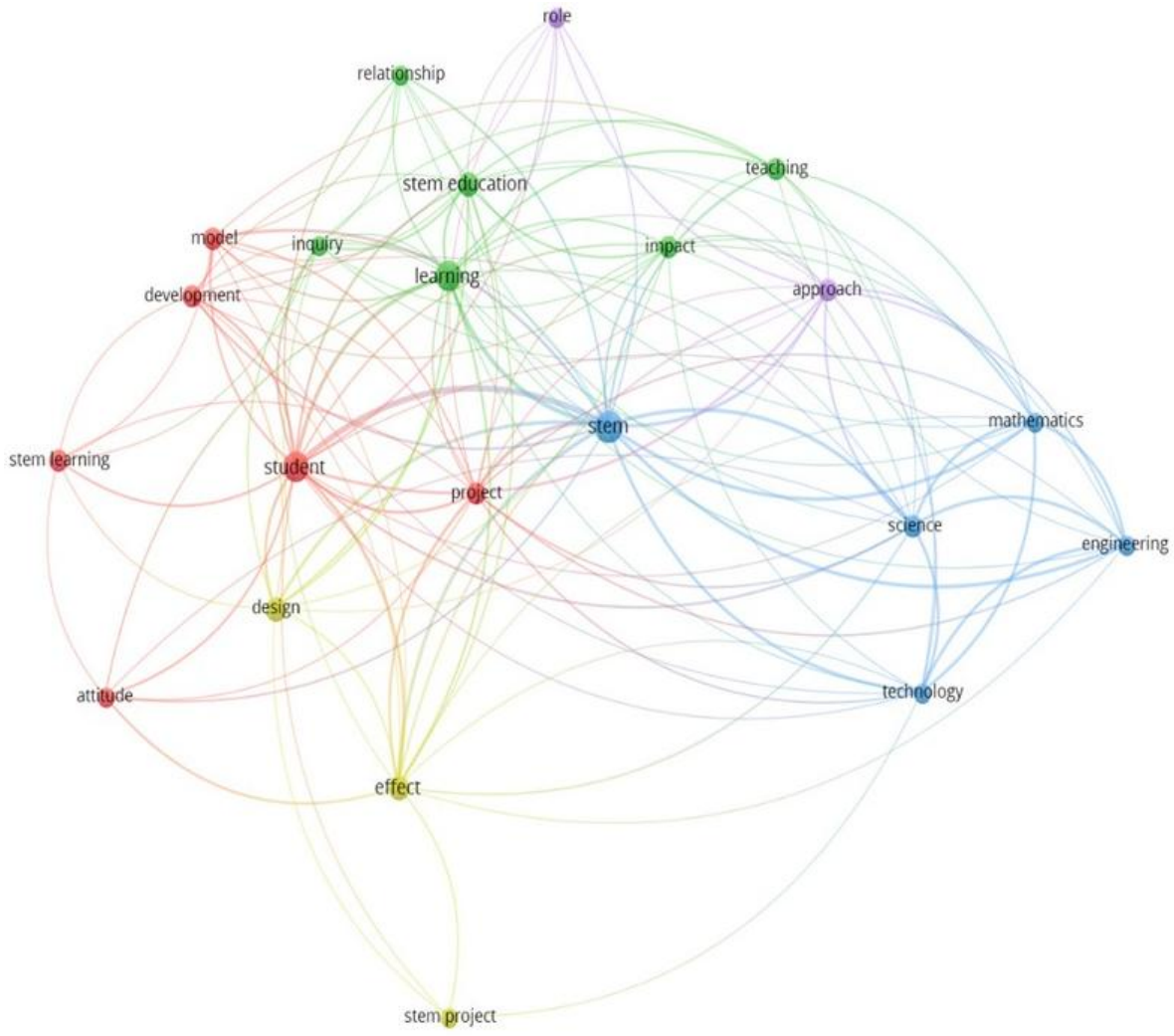

Figure 5. Author Keyword Network Visualization

Recommendations for Follow-Up Research

1. *Gap Analysis:* Identify areas with fewer connections to explore under-researched aspects or to find unique intersections between topics that could benefit from further study.
2. *Emerging Trends:* Look for emerging trends by examining the peripheral nodes that are beginning to form connections to the central clusters.
3. *Impact Studies:* The node "impact" connected to "STEM" and "education" suggests potential for studies that measure the impact of different STEM educational approaches or technologies.
4. *Curriculum Design:* The connection between "design" and "STEM education" could be explored to develop innovative STEM curricula that incorporate the latest findings in pedagogy and technology.
5. *Educational Technology:* Given the presence of "technology" and its connection to "STEM", there may be room for research into how emerging technologies are influencing STEM education.
6. *Interdisciplinary Projects:* The map suggests a relationship between subjects like "science" and "engineering". Research could explore interdisciplinary educational projects that bridge these subjects.
7. *Teacher Training and Development:* Since "teaching" is a visible node, investigating the professional

development of STEM teachers and how they can be better equipped to teach in a rapidly evolving educational landscape could be valuable.

In the last ten years, research on STEM in education only began in 2014 and was published in journals that are indexed by Scopus. Since then, there have been changes in STEM research, as seen by variations in the quantity of publications in 2023. Even Nevertheless, the overall number of published papers has increased, decreased, and increased again, reaching 869. This demonstrates that STEM education has not yet reached its full potential in recent years. Between 2017 and 2018, there was the most rise in publications throughout that period, with 45 papers. The trend pattern of this publication shows that the discussion about STEM needs to be increased again because it has not yet reached the expected level of popularity.

Although related articles are not as well-known, several journals have contributed to mapping research in STEM fields. In the last ten years, according to Table 2, the 869 journals that are listed on Scopus have made the most contributions to the publication of STEM-related papers. Researchers' choice of journals for publishing also reflects their reputation and credibility, including the publisher's trustworthiness (Julia et al., 2020). However, some journals cannot be controlled by management, causing dissatisfaction among those who use the Scopus index.

Of all the publications available, it can be identified which article has had the greatest impact on other research. The use of quotes is one of the parameters for evaluating the achievements of a scientist. As seen in Figure 3, the most impactful STEM articles were published in 2018, with 287 out of 200 papers receiving citations overall. Based on the article titles listed in Table 3, research in STEM fields has also delved quite deeply into STEM concepts in the context of education.

Certain keywords are most often utilized by authors when publishing STEM research findings; these keywords capture the spirit of the author and the sentence's overall meaning. (Julia et al., 2020). Certain keywords (author keywords) that the researcher uses in a research article indicate that they capture the core of the subject matter being examined. The phrase 'Student' from cluster 1 with six elements is the author's most utilized keyword in STEM study, as seen in Figure 4. The phrase 'Learning' from cluster 2 has six entries, making it the second biggest order. The phrase 'STEM' from cluster 3 has five elements and is the third highest order. It is evident from these three author keyword words that STEM education in his study is intimately tied to learning and the function that instructors play in the educational and technological worlds.

Conclusion

To summarize, the four questions asked at the beginning can be answered as follows. First, publications on STEM in Scopus-indexed journals show patterns of fluctuation and equilibrium every year for the last ten years. Second, The Sustainability journal has published the most articles on STEM. The top-ranked journal published 33 articles, while the tenth-ranked journal published only 11 articles. Third, many citations are concentrated on articles published in 2018, with a total of 287 citations. The most frequently cited articles are works (Ong et al., 2018).

With 287 citations. Fourth, the author keywords most used by the top three writers are student, learning, and STEM.

Limitations and Recommendations

The use of a single application for bibliometric analysis and restrictions on the range of other apps utilized are the study's limitations. Additionally, there are limitations on bibliographic data sources that are only sourced from Scopus. The breadth of study in this area is currently restricted, but it may be broadened by enhancing bibliometric mapping in the context of STEM research using apps or other techniques in addition to different bibliographic databases. Thus, there is need for additional development or enrichment of STEM bibliometric mapping. STEM research may hold the key to increasing the efficacy of the educational process. To uncover understudied topics and investigate new developments in STEM education, future research should concentrate on gap analysis. Research on the effects of different teaching strategies, including the use of AI technology, is required. It is crucial to create cutting-edge curriculum that includes the newest pedagogical and technical developments, such as artificial intelligence. Examining multidisciplinary initiatives and the use of instructional technology in STEM education might yield insightful information. Finally, to adjust to the changing educational landscape, research on teacher training and development with an emphasis on using AI tools is essential.

References

Amoa-Danquah, P. (2023). An Exploration of Impostor Syndrome in STEM and STEM Self-Efficacy in Adolescent Learners from a Teacher's Perspective. *European Journal of STEM Education*, *8*(1), 1–10. https://doi.org/10.20897/ejsteme/13303

Andrade-Arenas, L., Bogdanovich, M. M. M., Hernández Celis, D., Jaico, K. R., & Peña, G. B. A. (2023a). University learning style model: Bibliometrics and systematic literature review. *International Journal of Evaluation and Research in Education*, *12*(4), 2302–2315. https://doi.org/10.11591/ijere.v12i4.25859

Andrade-Arenas, L., Bogdanovich, M. M. M., Hernández Celis, D., Jaico, K. R., & Peña, G. B. A. (2023b). University learning style model: Bibliometrics and systematic literature review. *International Journal of Evaluation and Research in Education*, *12*(4), 2302–2315. https://doi.org/10.11591/ijere.v12i4.25859

Angraini, L. M., Susilawati, A., Noto, M. S., Wahyuni, R., & Andrian, D. (2024). Augmented Reality for Cultivating Computational Thinking Skills in Mathematics Completed with Literature Review, Bibliometrics, and Experiments for Students. *Indonesian Journal of Science and Technology*, *9*(1), 225–260. https://doi.org/10.17509/ijost.v9i1.67258

Aydogdu, B., Kasapoglu, K., Duban, N., Ay, T. S., & Ozdinc, F. (2020). Examining change in perceptions of science teachers about e-STEM. *Journal of Baltic Science Education*, *19*(5), 696–717. https://doi.org/10.33225/jbse/20.19.696

Bartels, S. L. (2019). Shaping Preservice Teachers' Understandings of STEM: A Collaborative Math and Science Methods Approach. *Journal of Science Teacher Education*, *30*(6), 666–680. https://doi.org/10.1080/1046560X.2019.1602803

Belfield, C. R., & Brock, T. (2023). How Important Are Community Colleges in Promoting STEM? *Community*

College Research Center, Teachers College, Columbia University, *November*.

Belland, B. R., Walker, A. E., Kim, N. J., & Lefler, M. (2017). Synthesizing Results From Empirical Research on Computer-Based Scaffolding in STEM Education: A Meta-Analysis. *Review of Educational Research*, *87*(2), 309–344. https://doi.org/10.3102/0034654316670999

Blackburn, H. (2017). The Status of Women in STEM in Higher Education: A Review of the Literature 2007–2017. *Science and Technology Libraries*, *36*(3), 235–273. https://doi.org/10.1080/0194262X.2017.1371658

Bohrnstedt, G. W., Ogut, B., Yee, D., & Bai, Y. (2023). AP Calculus and Science Coursetaking: Their Relationships With Choosing a STEM Major and Expecting to Be in a STEM Occupation. *AERA Open*, *9*(1), 1–19. https://doi.org/10.1177/23328584231184426

Borrego, M., & Henderson, C. (2014). Increasing the use of evidence-based teaching in STEM higher education: A comparison of eight change strategies. *Journal of Engineering Education*, *103*(2), 220–252. https://doi.org/10.1002/jee.20040

Bryan, L., & Guzey, S. S. (2020). K-12 STEM Education: An Overview of Perspectives and Considerations. *Hellenic Journal of STEM Education*, *1*(1), 5–15. https://doi.org/10.51724/hjstemed.v1i1.5

Cansız Aktaş, M. (2022). Problem-posing research in mathematics education: A bibliometric analysis. *Journal of Pedagogical Research*, *6*(4), 217–233. https://doi.org/10.33902/jpr.202217414

Chakraverty, D. (2019). Impostor phenomenon in STEM: occurrence, attribution, and identity. *Studies in Graduate and Postdoctoral Education*, *10*(1), 2–20. https://doi.org/10.1108/SGPE-D-18-00014

El-Deghaidy, H., & Mansour, N. (2015). Science Teachers' Perceptions of STEM Education: Possibilities and Challenges. *International Journal of Learning*, *1*(1), 51–54. https://doi.org/10.18178/IJLT.1.1.51-54

English, L. D. (2016). STEM education K-12: perspectives on integration. *International Journal of STEM Education*, *3*(1), 1–8. https://doi.org/10.1186/s40594-016-0036-1

Falloon, G., Hatzigianni, M., Bower, M., Forbes, A., & Stevenson, M. (2020a). Understanding K-12 STEM Education: A Framework for Developing STEM Literacy. *Journal of Science Education and Technology, 29*(3), 369–385. https://doi.org/10.1007/s10956-020-09823-x

Falloon, G., Hatzigianni, M., Bower, M., Forbes, A., & Stevenson, M. (2020b). Understanding K-12 STEM Education: a Framework for Developing STEM Literacy. *Journal of Science Education and Technology*, *29*(3), 369–385. https://doi.org/10.1007/s10956-020-09823-x

Fırat, E. A. (2020). Science, Technology, Engineering, and Mathematics Integration: Science Teachers' Perceptions and Beliefs. *Science Education International*, *31*(1), 104–116. https://doi.org/10.33828/sei.v31.i1.11

Fuesting, M. A. (2019). Growing STEM: Perceived faculty mindset as an indicator of communal affordances in STEM. *Journal of Personality and Social Psychology*, *117*(2), 260–281. https://doi.org/10.1037/pspa0000154

George, B. T., Watson, S. W., & Peters, M. L. (2020). The Impact of Participating in a STEM Academy on Girls' STEM Attitudes and Self-efficacy. *Electronic Journal for Research in Science & Mathematics Education*, *24*(4), 22–49.

Goodenough, K., Pelech, S., & Stordy, M. (2014). in STEM Education : The Perceptions of Primary / Elementary Teachers. *Teacher Education and Practice*, *27*(1996), 402–424.

Grinis, I. (2019). The STEM requirements of "Non-STEM" jobs: Evidence from UK online vacancy postings. *Economics of Education Review*, *70*, 144–158. https://doi.org/10.1016/j.econedurev.2019.02.005

Gusteti, M. U., Rasli, A. Md., Wulandari, S., Mulyati, A., Hayati, R., Azmi, K., Elza, S. S., & Resi, N. (2024). Bibliometric Study on ChatGPT. *International Journal of Education in Mathematics, Science and Technology*, 1435–1450. https://doi.org/10.46328/ijemst.4447

Hamad, S., Tairab, H., Wardat, Y., Rabbani, L., Alarabi, K., Yousif, M., Abu-Al-Aish, A., & Stoica, G. (2022). Understanding Science Teachers' Implementations of Integrated STEM: Teacher Perceptions and Practice. *Sustainability (Switzerland)*, *14*(6), 1–19. https://doi.org/10.3390/su14063594

Henry, M. A. (2021). Quantifying fear of failure in STEM: modifying and evaluating the Performance Failure Appraisal Inventory (PFAI) for use with STEM undergraduates. *International Journal of STEM Education*, *8*(1). https://doi.org/10.1186/s40594-021-00300-4

Howard, A. M., & Park, H. W. (2014). Using Tablet Devices to Engage Children with Disabilities in Robotic Educational Activities. *Journal of Technology Ad Persons with Disabilities*, *2*, 96–107.

Huan, C., Meng, C. C., & Suseelan, M. (2022). Mathematics Learning from Concrete to Abstract (1968-2021): A Bibliometric Analysis. *Participatory Educational Research*, *9*(4), 445–468. https://doi.org/10.17275/per.22.99.9.4

Jeong, H., Hmelo-Silver, C. E., & Jo, K. (2019). Ten years of Computer-Supported Collaborative Learning: A meta-analysis of CSCL in STEM education during 2005–2014. *Educational Research Review*, *28*(August 2017), 100284. https://doi.org/10.1016/j.edurev.2019.100284

Julia, J., Dolifah, D., Afrianti, N., Isrokatun, I., Soomro, K. A., Erhamwilda, E., Supriyadi, T., & Ningrum, D. (2020). Flipped classroom educational model (2010-2019): A bibliometric study. *European Journal of Educational Research*, *9*(4), 1377–1392. https://doi.org/10.12973/eu-jer.9.4.1377

Julius, R., Halim, M. S. A., Hadi, N. A., Alias, A. N., Khalid, M. H. M., Mahfodz, Z., & Ramli, F. F. (2021). Bibliometric Analysis of Research in Mathematics Education using Scopus Database. *Eurasia Journal of Mathematics, Science and Technology Education*, *17*(12). https://doi.org/10.29333/EJMSTE/11329

Kaggwa, R. J., Blevins, A., Wester, E., Arango-Caro, S., Woodford-Thomas, T., & Callis-Duehl, K. (2023). STEM Outreach to Underresourced Schools: A Model for Inclusive Student Engagement. *The Journal of STEM Outreach*, *6*(1). https://doi.org/10.15695/jstem/v6i1.04

Karampelas, K. (2023). Examining the relationship between TPACK and STEAM through a bibliometric study. *European Journal of Science and Mathematics Education*, *11*(3), 488–498. https://doi.org/10.30935/scimath/12981

Kartika, H., Budiarto, M. T., Fuad, Y., & Bonyah, E. (2023). Bibliometrics Analysis of Research on Argumentation in Mathematics Education. *International Journal of Education in Mathematics, Science and Technology*, *11*(5), 1346–1365. https://doi.org/10.46328/ijemst.2904

Khusna, A. H., Siswono, T. Y. E., & Wijayanti, P. (2024). Research trends in critical thinking skills in mathematics: a bibliometric study. *International Journal of Evaluation and Research in Education (IJERE)*, *13*(1), 18. https://doi.org/10.11591/ijere.v13i1.26013

López, N. (2022). Revisiting critical STEM interventions: a literature review of STEM organizational learning. *International Journal of STEM Education, 9*(1). https://doi.org/10.1186/s40594-022-00357-9

McKeown, J., Hmelo-Silver, C. E., Jeong, H., Hartley, K., Faulkner, R., & Emmanuel, N. (2017). A meta-

synthesis of cscl literature in stem education. *Computer-Supported Collaborative Learning Conference, CSCL*, *1*, 439–446.

Nurtanto, M. (2020). The effect of STEM-EDP in professional learning on automotive engineering competence in vocational high school. *Journal for the Education of Gifted Young Scientists*, *8*(2), 633–649. https://doi.org/10.17478/JEGYS.645047

Ong, M., Smith, J. M., & Ko, L. T. (2018). Counterspaces for women of color in STEM higher education: Marginal and central spaces for persistence and success. *Journal of Research in Science Teaching*, *55*(2), 206–245. https://doi.org/10.1002/tea.21417

Rafiq, A. A., Triyono, M. B., Djatmiko, I. W., Wardani, R., & Köhler, T. (2023). Mapping the Evolution of Computational Thinking in Education: A Bibliometrics Analysis of Scopus Database from 1987 to 2023. *Informatics in Education*, *22*(4), 691–724. https://doi.org/10.15388/infedu.2023.29

Ring, E. A., Dare, E. A., Crotty, E. A., & Roehrig, G. H. (2017). The evolution of teacher conceptions of STEM education throughout an intensive professional development experience. *Journal of Science Teacher Education*, *28*(5), 444–467. https://doi.org/10.1080/1046560X.2017.1356671

Samara, V., & Kotsis, K. T. (2023). Primary school teachers' perceptions of using STEM in the classroom attitudes, obstacles, and suggestions: A literature review. *Contemporary Mathematics and Science Education*, *4*(2), ep23018. https://doi.org/10.30935/conmaths/13298

Shaby, N. (2021). Pathways of interest and participation: How STEM-interested youth navigate a learning ecosystem. *Science Education*, *105*(4), 628–652. https://doi.org/10.1002/sce.21621

Sofwan, M., Yaakob, M. F. M., & Habibi, A. (2024). Technological, pedagogical, and content knowledge for technology integration: a systematic literature review. *International Journal of Evaluation and Research in Education (IJERE)*, *13*(1), 212. https://doi.org/10.11591/ijere.v13i1.26643

Suseelan, M., Chew, C. M., & Chin, H. (2022). Research on Mathematics Problem Solving in Elementary Education Conducted from 1969 to 2021: A Bibliometric Review. *International Journal of Education in Mathematics, Science and Technology*, *10*(4), 1003–1029. https://doi.org/10.46328/ijemst.2198

Svela, A., Nouri, J., Viberg, O., & Zhang, L. (2019). A systematic review of tablet technology in mathematics education. *International Journal of Interactive Mobile Technologies*, *13*(8), 139–158. https://doi.org/10.3991/ijim.v13i08.10795

Triyono, M. B., Rafiq, A. A., Djatmiko, I. W., & Kulanthaivel, G. (2023). Vocational education's growing focus on employability skills: A bibliometrics evaluation of current research. *International Journal of Evaluation and Research in Education*, *12*(4), 1791–1809. https://doi.org/10.11591/ijere.v12i4.26001

Utami, N., Setiawan, A., & Hamidah, I. (2023). A bibliometric analysis of augmented reality in higher education. *Journal of Engineering Science and Technology*, *18*(3), 1599-1613.

Wang, C., Shen, J., & Chao, J. (2022). Integrating computational thinking in STEM education: A literature review. *International Journal of Science and Mathematics Education*, *20*(8), 1949-1972. https://orcid.org/0000-0003-3267-3261

Yang, H., Zhang, Q., & Shen, M. (2024). The Practice and Research of Junior High School Information Technology Project-Based Learning Based on Stem Education Concept. *International Journal of Technology in Education and Science*, *8*(1), 63-74.