



STEM-EDP Research Trends in Science Education: A Systematic Review from 2016 – 2025

Frendi Ihwan Syamsudin^{1*}, Ketang Wiyono¹, Evelina Astra Patriot¹, Ismet¹, Saparini¹, Azlan Kamari²

¹Universitas Sriwijaya, Indralaya, Indonesia

²Universiti Pendidikan Sultan Idris, Tanjung Malim, Malaysia



DOI : <https://doi.org/10.26740/jpps.v15n1.p65-82>

Sections Info

Article history:

Submitted: September 16, 2025
Final Revised: February 26, 2026
Accepted: April 09, 2026
Published: May 05, 2026

Keywords:

Research Trends
STEM-EDP
Science Education
Systematic Review
Vos Viewer

ABSTRACT

Objective: This study aims to analyze the research trends, characteristics, and development patterns of Science, Technology, Engineering, and Mathematics integrated with the Engineering Design Process (STEM-EDP) in Science Education from 2016 to 2025. **Method:** A Systematic Literature Review (SLR) combined with bibliometric analysis was conducted using VOSviewer. A total of 101 articles indexed in the Springer database were selected based on predefined inclusion and exclusion criteria. The analysis focused on annual publication trends, keyword frequency, research methods, authorship patterns, geographical distribution, citation rankings, and journal productivity. **Results:** The findings indicate a consistent upward trend in STEM-EDP publications, with a projected peak in 2025. Qualitative research methods dominate the field (80.19%), reflecting the exploratory nature of STEM-EDP studies. Single-authored publications are most common, while the Americas – particularly the United States – contribute the highest number of publications. The most cited authors are Kelly C. Margot and Todd Kettler (179 citations). The International Journal of Technology and Design Education is identified as the most productive journal. Keyword mapping reveals that STEM-EDP remains in an emerging research cluster, frequently associated with project-based learning and creative thinking. **Novelty:** This study provides a comprehensive bibliometric mapping specifically focused on STEM-EDP within Science Education using the Springer database for the 2016–2025 period. Unlike previous reviews that examined general STEM research, this study highlights the distinct integration of the Engineering Design Process and identifies emerging thematic directions and methodological gaps for future research.

INTRODUCTION

STEM is an integrated problem-based learning approach that combines four disciplines, namely science, technology, engineering, and mathematics (Wilson, 2021). It prepares students with competencies relevant to the demands of the 21st century workforce (Han, 2022; Liao, 2020). It also develops creativity and higher-order thinking skills (Rustan, 2020; So, 2022; Van Laar, 2020). Therefore, STEM functions as an integrative approach that promotes 4C skills (critical thinking, creativity, collaboration, and communication) through interdisciplinary problem solving.

Effective STEM implementation requires a structured learning framework that meaningfully connects its four components. Science develops students' ability to analyze phenomena critically. Technology builds students' capacity to utilize and evaluate technological innovations. Engineering trains students to design and develop solutions. Mathematics supports students in reasoning, analyzing data, and interpreting solutions (Kelley, 2021; Honey, 2020). When educators integrate these components effectively, STEM learning enhances scientific literacy, conceptual understanding, collaboration, and problem-solving skills (Falloon, 2020; Mafugu, 2022; Margot, 2020).

STEM is an educational approach rather than a specific instructional model. Therefore, teachers need an operational framework that translates interdisciplinary integration into systematic learning steps. One widely adopted framework that integrates STEM components is the Engineering Design Process (EDP) (Wendell, 2017). The EDP provides structured and iterative stages that guide students in solving real-world problems by designing, testing, and refining product prototypes (Purzer, 2015).

The EDP begins with observing phenomena and identifying problems (Arik, 2022; Han, 2019; Cunningham, 2020; Pleasants, 2021). Students generate ideas, design solution schemes, determine procedures, and collect relevant data (Ehsan, 2021; Hughes, 202, 2021; Guzey, 2020). They analyze the collected data to produce evidence-based conclusions (Capobianco, 2022; Deniz, 2020; Crismond, 2021). Finally, students present and defend their findings and revise their designs when necessary (Chiang, 2022; Lin, 2016; McFadden, 2019; Berland., 2022). Through this structured and evidence-based process, STEM-EDP learning strengthens inquiry skills, innovation capacity, and reflective problem solving in Science Education.

Although research on STEM and EDP has increased significantly in recent years, few studies systematically map publication trends, research focus, and thematic development of STEM-EDP in Science Education. Most previous studies examine implementation effectiveness or student outcomes instead of providing a comprehensive bibliometric overview of research development in this field. Therefore, this study offers novelty by conducting a comprehensive bibliometric analysis of STEM-EDP research trends in Science Education during the period 2016–2025 based on Springer-indexed publications. This study maps annual publication trends, keyword frequency, thematic clusters, and research development patterns. The findings identify research gaps and provide strategic directions for future STEM-EDP studies in Science Education. Accordingly, this study seeks to answer the following research questions:

- How has STEM-EDP research in Science Education evolved during 2016–2025 in terms of annual publication growth and overall development patterns?
- What are the major bibliometric characteristics of STEM-EDP research in Science Education from 2016–2025, including keyword usage, research methods, authorship patterns, citation impact, and journal productivity?
- How is STEM-EDP research in Science Education geographically distributed across continents and countries during 2016–2025, and which regions contribute most significantly?
- What thematic research trends and emerging topics can be identified through VOS Viewer network visualization of STEM-EDP publications in Science Education?

RESEARCH METHOD

General Background

This study employed a Systematic Literature Review (SLR) combined with bibliometric analysis to answer the research questions related to STEM-EDP in Science Education. The SLR approach was conducted following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Moher et al., 2009) to ensure transparency, replicability, and methodological rigor. The review process consisted of four main stages: identification, screening, eligibility, and inclusion. A complete PRISMA flow diagram is presented in Figure 1 to illustrate the selection process and the number of articles at each stage.

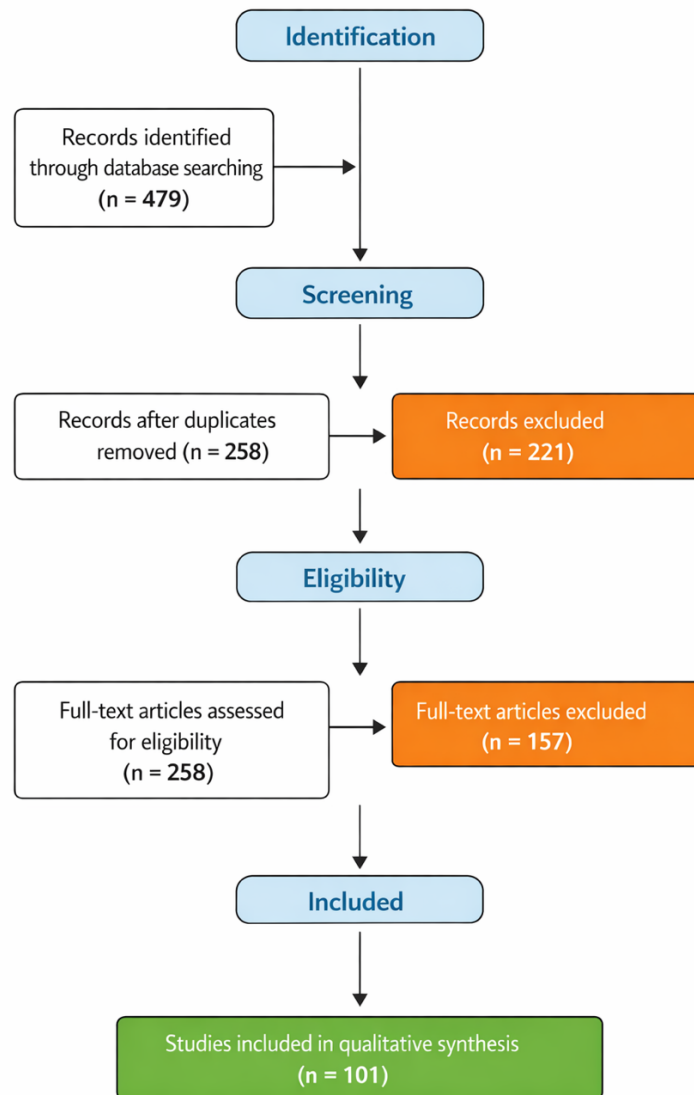


Figure 1. The PRISMA procedure of research

Search Strategy

The literature search was conducted in the SpringerLink database in October 2025. The search strategy was developed using Boolean operators to ensure a comprehensive and systematic retrieval of relevant publications related to STEM-EDP in Science Education. The search string applied was: ("STEM-EDP" OR "Engineering Design Process" OR "STEM Engineering Design") AND ("Science Education" OR "Science Learning" OR "Physics Education") AND (2016–2025). To refine the results and ensure relevance, several filters were applied, including subject area (Education), document type (research articles and review articles), language (English), and publication period (2016–2025). These criteria were established to obtain peer-reviewed scholarly works directly aligned with the research focus of this study.

Inclusion and Exclusion Criteria

This study examined all articles related to STEM-EDP in the field of Science Education from the Springer database published between 2016 and 2025. Articles relevant to the STEM-EDP topic were then selected for analysis based on their titles and abstracts, using the inclusion and exclusion criteria outlined in Table 1. Based on the initial finding, there

were 479 articles in Education with empirical data types and article reviews. After filtering, we eliminated 221 articles and took 258 articles. Then the researcher examined the titles and abstracts of articles related to STEM-EDP in Science Education so that 157 articles were eliminated, and 101 articles remained. A total of 101 articles were analyzed to answer eight research questions.

Table 1. Inclusion and Exclusion Criteria

Criteria	Period	Document Type	Language	Core Research
Inclusion	January 2013 - October 2022	- Article with empirical data and article reviews - Artikel was taken in education	English	- Field in Science Education - Focused on STEM-EDP
Exclusion	Before January 2013	- Book Chapter - Book - Conference Paper - Conference Proceedings	Not in English	- Outside of Science Education - Not focused on STEM-EDP

Instrument and Procedures

The instrument used in this research is a review sheet which contains indicators in the form of article title, journal name, research method, author's name, author's country and continent, and number of citations. The results of this review are outlined in a review sheet. The article selection process followed the PRISMA stages as follows in Figure 1 are

1. Identification Stage

The initial search yielded **479 articles** in the Education subject area.

2. Screening Stage

After applying document type, language, and year filters, **221 articles were excluded**, leaving **258 articles**.

3. Eligibility Stage

Titles and abstracts were independently screened based on relevance to STEM-EDP in Science Education. At this stage, **157 articles were excluded** because they did not meet the core research focus.

4. Included Stage

A total of **101 articles** met all inclusion criteria and were included in the final bibliometric analysis.

Inter-Rater Reliability and Reviewer Validation

To ensure reliability and minimize selection bias, the screening and eligibility processes were conducted independently by **two reviewers**. Disagreements were resolved through discussion until consensus was reached. Inter-rater reliability was calculated using Cohen's Kappa coefficient, resulting in a substantial agreement level ($\kappa > 0.75$), indicating strong consistency between reviewers.

Data Analysis

Data is processed using Vos Viewer. Vos Viewer can visualize the latest trends in STEM-EDP research, viral topics in in STEM-EDP research, and collaboration networks between article authors. Data analysis resulting from the Vos Viewer visualization was carried out in a qualitative descriptive manner to interpret the data by connecting previous theories

and previous research to answer research questions. Data was also processed using Ms. Excel to strengthen data quantitation, because the Vos Viewer that we use cannot yet display research collaboration networks between countries and publication collaboration networks between publishers, so by using Ms. Excel can deepen connected data analysis to understand current in STEM-EDP research trends.

RESULTS AND DISCUSSION

Results

Distribution of STEM-EDP Publications in Science Education by Year of Publication

The first research question analyzed in Figure 2 reflects the growth of STEM-EDP publications in Science Education from 2016 to 2025. Based on Figure 2, the results show that the number of articles published each year fluctuates. The highest publication in STEM-EDP Research in Science Education occurred in 2025. In 2016, articles published in scientific journals with two article titles decreased by 33% from 2017. In 2018 there was an increase of 33%. In 2019 there was a drastic increase to 9 articles, relatively stable in 2020, and only decreased by 1 article in 2021. In 2022 and 2023, it increased by 62% and 46.15%. In 2024 it will decrease by 35.71%. The highest publication occurred in 2025 with a percentage of 64.28%.

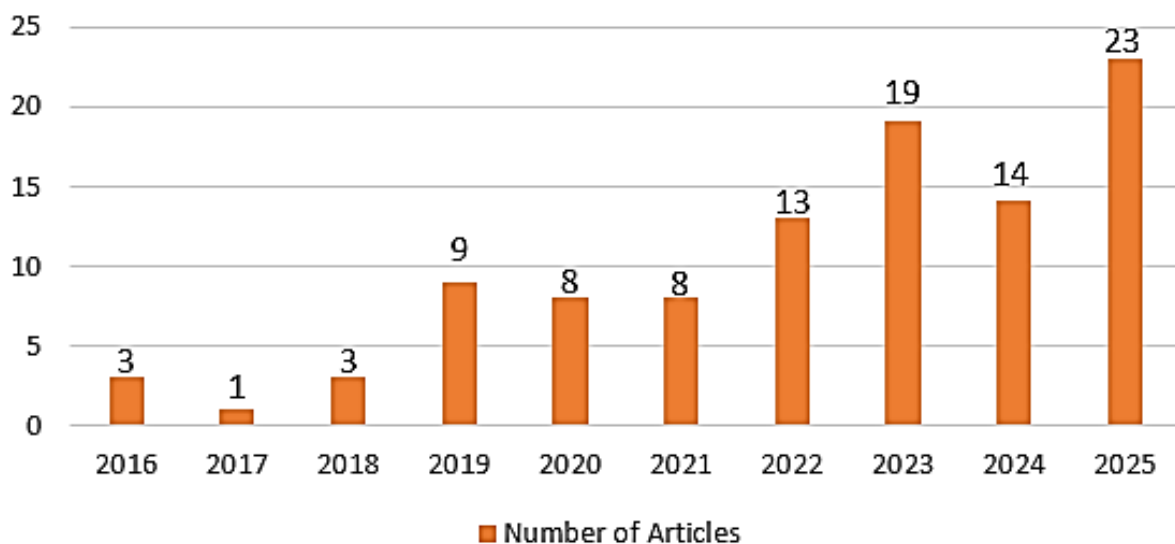


Figure 2. Number of Articles Published Related to STEM-EDP in Science Education.

Then, based on Vos Viewer analysis, the Network Visualization section relating to STEM-EDP publications in the field of Science Education based on publication year in the publication period 2016 to 2025 is shown in Figure 3. From the visualization results in Figure 3, it is known that there are 2 topics that are closely related to STEM-EDP, namely design thought and design process. This shows that the problem-solving process in STEM-EDP is carried out through a thinking process and a design process. So, in visualization, the Design Based Learning Approach appears as the latest approach to applying STEM-EDP in learning.

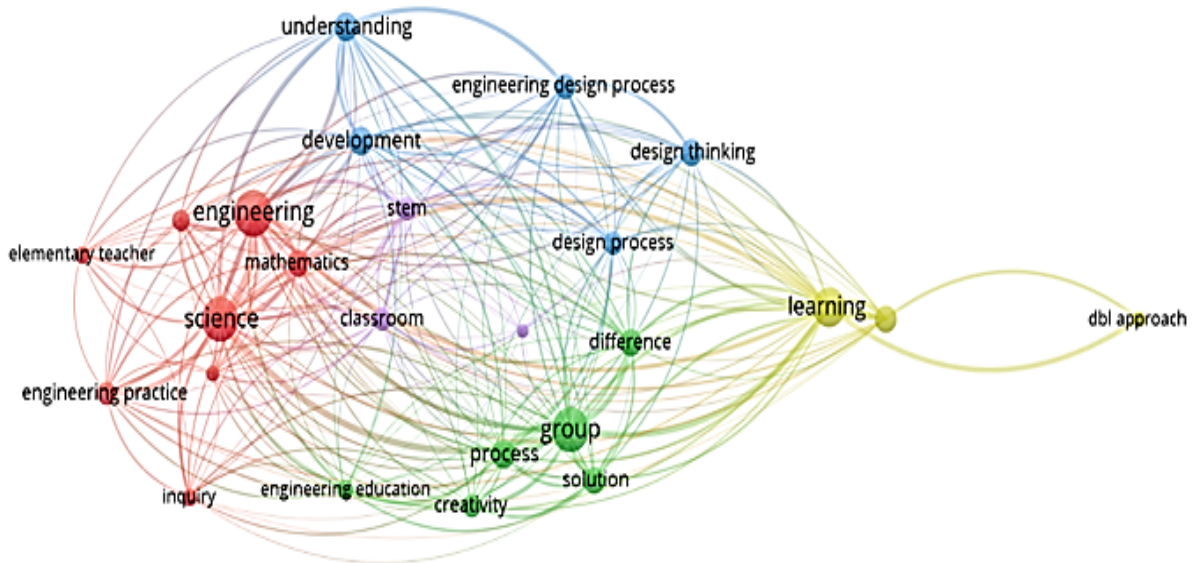


Figure 3. VOS Viewer Network Visualization of STEM-EDP Research Publications in Science Education by Year

Frequency of STEM-EDP Terms Used in Research in the Field of Science Education

Then the second research question analyzed in Figure 4 reflects the use of STEM-EDP in Science Education published from 2016 to 2025. Based on Figure 4, the distribution of articles published with and without STEM-EDP in Science Education fluctuated from 2016 to 2025. The highest number of articles of titles and abstracts containing STEM-EDP was in 2023, as many as 17 articles. It increased by 88.88% from the previous year and at least 0 articles in 2016 and 2017. In 2020-2022 there was a constant increase of 1 article.

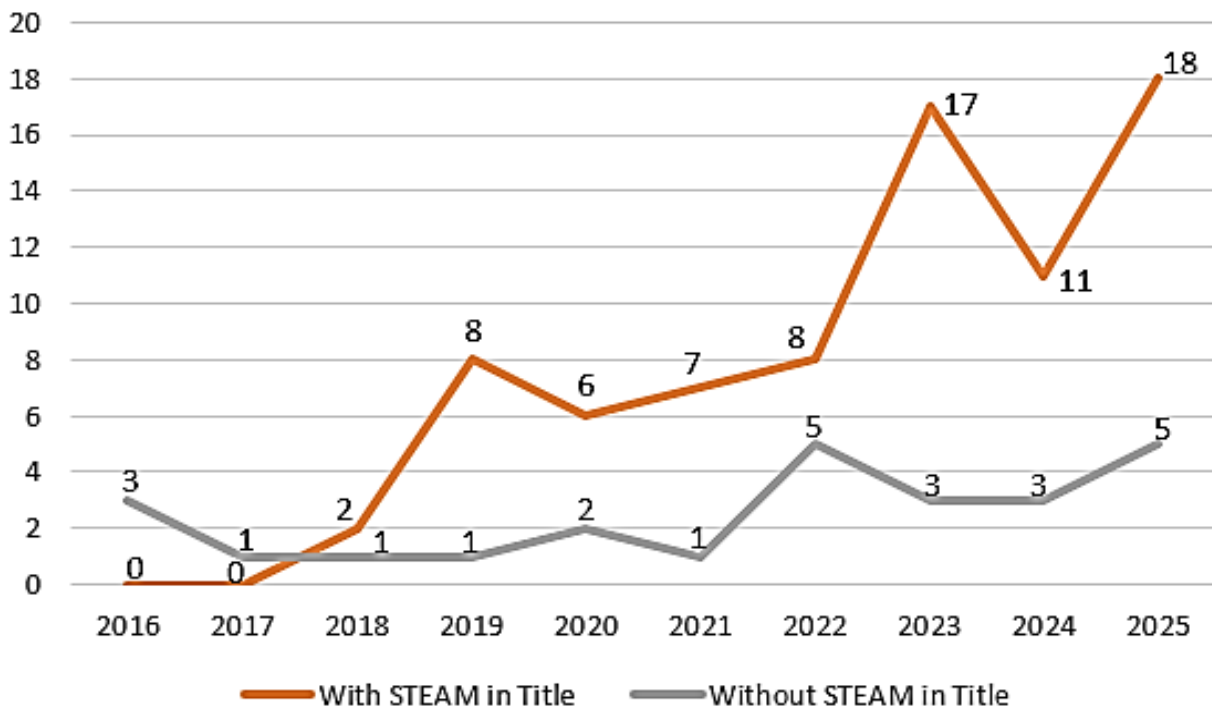


Figure 4. Number of publications with and without STEM-EDP in Title

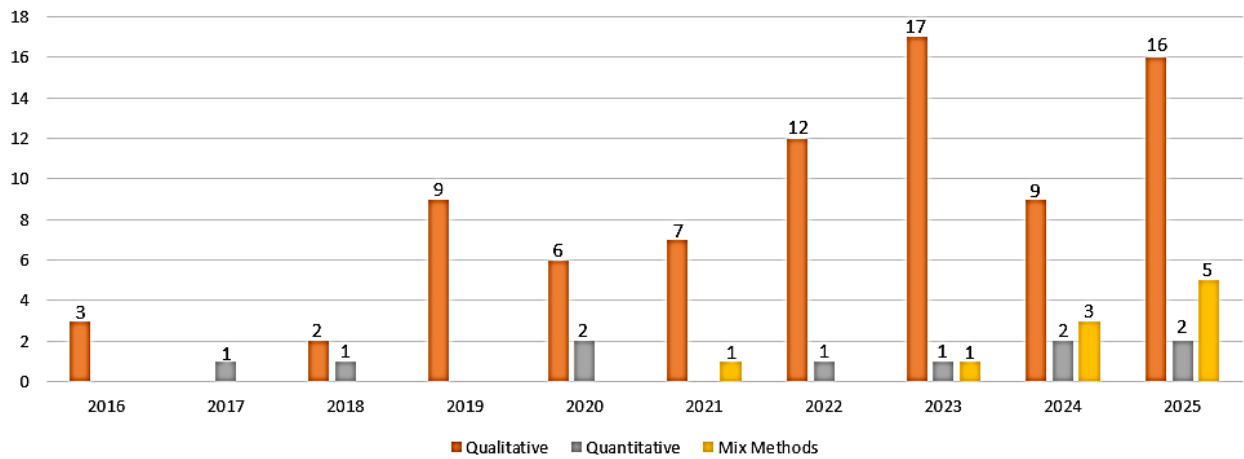


Figure 6. Distribution of Research Methods in STEM-EDP in Science Education

Number of Authors in STEM Education Publications

The fourth research question analyzed from Figure 7 presents the number of authors in STEM-EDP research in Science Education from 2016 to 2025. Based on Figure 7, the number of article authors varied from 2016 to 2025. The highest number of articles with a single author was in 2023 with a total of 5 articles then there were 4 articles written by a single author in 2020 and 2024. The number of articles with the two most authors was in 2022 with a total of 7 articles then there was 1 article written by two authors in 2015, 2018, and 2020. In 2025 there were 7 articles with the three most authors and 4 articles with the four most authors. The number of articles with the five most authors in 2023 with a total of 3, while the seven most authors in 2024 with a total of 2. The interesting thing is written by six to eight researchers with an almost uniform distribution of just one to two articles from 2016 to 2025.

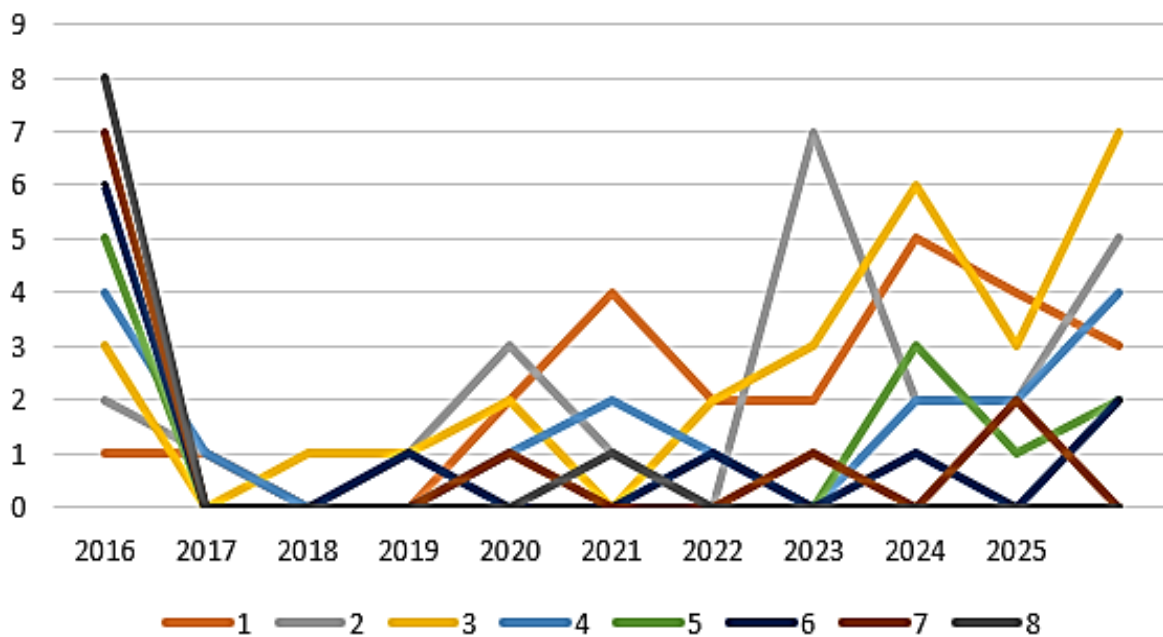


Figure 7. Number of Authors in STEM-EDP Research in Science Education

The Most Productive Continent in STEM-EDP Research

The fifth research question analyzed from Table 2 presents the ranking of article distribution on five continents in STEM-EDP research in Science Education from 2016 to 2025. Based on Table 2, America has the highest contribution compared to other continents in STEM-EDP Research in Science Education, as much as 51.49% of that number accounts for more than half of the total research articles analyzed by researchers. The Asian continent accounts for one-fifth of the total articles with a percentage of 21.78, the European continent accounts for one-sixth of the total articles with a percentage of 15.84%, and The Australian continent accounts for ten parts of the total articles with a percentage of 8.91%. Then the African Continent contributed the least number of articles related to STEM-EDP Research in Science Education, namely 1.98%. Thus, the highest contribution of STEM-EDP Research in Science Education for the last ten years is from America.

Table 2. Ranking of Productivity Continents Contributing to STEM-EDP Research

Rank	Continent	N of Articles	Percentage (%)
1	America	52	51,49
2	Asia	22	21,78
3	Europe	16	15,84
4	Australia	9	8,91
5	Africa	2	1,98

The Most Productive Countries in STEM-EDP Research

The sixth research question analyzed from Table 3 presents the ranking of article distribution in various countries in STEM-EDP research in Science Education from 2016 to 2025. Based on Table 3, the United States has the highest contribution compared to other countries in STEM-EDP Research in Science Education as much as 43.56% of that number is a contributor of almost half of the total research articles analyzed by researchers. Australia (9.09%), Taiwan (7.92%), and South Korea (7.07%) became contributors with a difference of 1 article for each country. Then Spain (4.95%), Canada and Hong Kong (3.69%), and Colombia (3.03%) each contributed with a difference of 1 article. Germany, England, and Sweden are ranked 8th with a value of 1.98%. And the last rank with a value of 0.99% is occupied by Brazil, Bulgaria, Denmark, Finland, India, Indonesia, South Africa, Iran, Egypt, China, and Turkey. Thus, the highest contribution of research related to STEM-EDP in Science Education for the last 10 years is in the United States.

Table 3. Ranking of Productive Countries Contributing STEM-EDP Research Articles

Rank	Country	N of Articles	Percentage (%)
1	United States	44	43,56
2	Australia	9	9,09
3	Taiwan	8	7,92
4	South Korea	7	7,07
5	Spanish	5	4,95

The Citation Rating

The seventh research question analyzed from Table 4 presents the distribution ranking of article citations in STEM-EDP Research from 2016 to 2025. Based on Table 4, the citations from the Springer database were taken from the first author only. The ranking of the number of citations into the top 15 ranks. Based on the results of the citation rankings, there are 7 published in the International Journal of STEM Education. The distribution of first author countries because of the ranking is 12 writers from the United States, 1 writer from Australia, 1 writer from Indonesia, and 1 writer from Canada. From Table 4, the authors with the most cited articles are Kelly C. Margot & Todd Kettler, namely 179 citations with an average of 45 citations per year. Their article was published in the International Journal of STEM Education, then followed by Lyn D. English with a total of 133 citations with an average of 22 citations per year. Interestingly, a writer from Indonesia is ranked 11th with a total of 40 citations, namely Bevo Wahono from the University of Jember. Then if identification concerning the research method, there are 13 articles with qualitative methods and two articles with quantitative methods. This finding also reinforces Figure 3 that qualitative methods are becoming a trend in STEM-EDP research in the field of Science Education today and in the future.

Table 4. First Author Citation Rating

Rank	Number of Citations	Publication years	Authors	Title
1	179	2019	Kelly C. Margot & Todd Kettler	Teachers' perception of STEM integration and education: a systematic literature review
2	133	2017	Lyn D. English	Advancing Elementary and Middle School STEM Education
3	129	2016	Dana L. Zeidler	STEM education: A deficit framework for the twenty first century? A sociocultural socioscientific response
4	97	2017	David J. Shernoff, Suparna S., Denise M. Bressler & Lynda G.	Assessing teacher education and professional development needs for the implementation of integrated approaches to STEM education
5	76	2020	Yeping Li, Ke Wang, Yu Xiao & Jeffrey E. Froyd	Research and trends in STEM education: a systematic review of journal publications

The Journal Rating

The eighth research question analyzed from Table 5 presents the ranking of journals that published articles in STEM-EDP Research from 2016 to 2025. Based on Table 5, the International Journal of Technology and Design Education is the most productive in publishing articles related to STEM-EDP in Science Education from January 2013 to October 2022 with a total of 22 articles followed by the International Journal of STEM Education with a total of 19 articles. Then three journals publish nine articles that rank 4th. Meanwhile, three journals only published one article related to STEM-EDP in Science Education in the last ten years.

Table 5. Ranking of Journals Publishing STEM-EDP Articles

Rank	Journal	N of Articles
1	International Journal of Technology and Design Education	22
2	International Journal of STEM Education	19
3	Journal of Science Education and Technology	13
4	Cultural Studies of Science Education	9
4	International Journal of Science and Mathematics Education	9
4	Science & Education	9
5	Canadian Journal of Science, Mathematics and Technology Education	8

Discussion

This research successfully presents a systematic review of previous literature, supported by bibliometric analysis using VOS Viewer, to map the potential development of STEM-EDP in the field of Science Education. The findings indicate that the volume of publications related to STEM-EDP has shown a steady increase over the years, with projections pointing to a publication peak in 2025. This trend demonstrates that STEM-EDP is not only an established area of inquiry but also an emerging research frontier with sustained scholarly interest. These findings are consistent with Hyun and Park (2020), who analyzed 434 articles from 2011 to 2017 and reported a continuous increase in STEM-related publications. The growth trajectory also resonates with Marín (2021), who examined 1,116 articles from 2006 to 2020 and found that STEM-EDP research expanded significantly between 2008 and 2019 before experiencing a slight decline in 2020, reflecting the dynamic nature of research productivity. Similarly, Irwanto (2021) confirmed that STEM-EDP publications continue to increase from 2010 to 2021, reinforcing the conclusion that this field is experiencing sustained expansion.

Importantly, the VOS Viewer visualization provides additional evidence of STEM-EDP's status as a renewable and evolving research trend (Irwanto, 2021). The presence of light-green clusters in the keyword mapping suggests that many of the themes associated with STEM-EDP remain relatively new and underexplored. This indicates substantial opportunities for future investigations, particularly in integrating STEM-EDP with other educational innovations such as project-based learning, inquiry-based approaches, and the cultivation of creative and critical thinking skills. From a broader perspective, the consistent growth in STEM-EDP publications underscores the increasing global recognition of its importance in addressing 21st-century educational challenges. The trend also highlights the role of STEM-EDP in fostering essential skills such as collaboration, creativity, problem-solving, and innovation competencies that are central to preparing learners for future workforce demands. Thus, the upward trajectory of STEM-EDP research not only reflects academic interest but also points to its strategic relevance in shaping science education practices worldwide.

The trend of STEM-EDP publications demonstrates a continuous upward trajectory, with a significant peak in 2020 reaching 133 articles. This surge suggests heightened scholarly attention toward integrating STEM with the Engineering Design Process as an instructional framework in Science Education. Marín (2021), in a comprehensive review of 1,116 articles spanning 2006 to 2020, observed that publications remained relatively stable between 2006 and 2008, then experienced steady growth from 2008 to 2019, before declining slightly in 2020. The fluctuation in 2020 can be interpreted as a temporary disruption influenced by global academic challenges, including shifts in research priorities and the impact of the COVID-19 pandemic on publication patterns.

Similar findings were reported by Irwanto (2021), who showed that STEM-EDP research output consistently increased from 2010 to 2021. This pattern, corroborated by different data sources, reflects the growing recognition of STEM-EDP as a key research domain in Science Education. Importantly, such growth indicates not only expansion in quantity but also diversification of research themes, ranging from classroom-based empirical studies to broader theoretical explorations. The VOS Viewer analysis further strengthens this observation. The visualization of keywords by year reveals that STEM-EDP remains in the “emerging” cluster, represented in light green. In bibliometric mapping, this suggests that while the field has gained significant scholarly interest, many of its research trajectories are still developing and have yet to mature into “hot topics” (red clusters). Consequently, STEM-EDP can be considered a renewable research theme with considerable potential for exploration.

The combination of these findings suggests that STEM-EDP research is at a critical phase of development—beyond its initial stage but not yet reaching saturation. This explains why publication volumes continue to rise, as new sub-topics and interdisciplinary linkages (e.g., with project-based learning, digital tools, and creativity research) are being tested and refined. Such dynamics are typical of growing scientific fields, where expansion in output reflects both consolidation of prior work and the opening of new lines of inquiry. The distribution of published articles containing the term STEM-EDP in the field of Science Education between 2016 and 2025 demonstrates a fluctuating yet generally upward trend. The most notable increase occurred in 2023, with 17 articles recorded—an 88.88% rise compared to the previous year. This surge reflects a growing emphasis among researchers on explicitly situating STEM within the framework of the Engineering Design Process, possibly due to the increasing global discourse on innovation-oriented education and the integration of problem-solving models in science curricula. These findings resonate with Archila (2023), who reported that over the last decade, article titles referencing STEM-EDP showed a similar fluctuating pattern, with a peak in 2017 marked by an 11.76% increase. Likewise, Turner (2016) identified a comparable dynamic, noting that STEM-EDP publications peaked in 2015 with 16 articles, representing a 75% increase. Taken together, these studies highlight that fluctuations in STEM-EDP publications are not anomalies but rather a consistent feature of the field’s development, reflecting its evolving research agenda and responsiveness to educational trends.

The observed fluctuations can be interpreted in several ways. First, they may reflect shifts in educational policy and funding priorities that influence research productivity and thematic focus. For example, years of significant growth often coincide with increased attention to STEM integration in curriculum reforms and international education initiatives. Second, the decline or stagnation in certain years might be associated with competing research priorities (e.g., digital learning, computational thinking, or sustainability education) that temporarily divert scholarly focus. Third, the sharp increase in 2023 suggests renewed scholarly interest, possibly driven by post-pandemic educational restructuring and the urgent need for pedagogical models that emphasize creativity, problem-solving, and cross-disciplinary collaboration. The publication trend demonstrates a positive trajectory, as articles both with and without the explicit term STEM-EDP in their titles and abstracts show a gradual increase beginning in 2020 and projected to continue through 2025. This steady growth indicates that STEM-EDP has moved beyond being a marginal theme and is progressively gaining

recognition as a central strand in Science Education research. The trend aligns with Hyun and Park (2020), who documented a consistent rise in STEM-related publications over the past decade, as well as with Marín (2021), who reported significant growth between 2015 and 2019. These parallels suggest that the upward trajectory observed in this study reflects not only local or isolated developments but also a broader global momentum in STEM-EDP scholarship. The Vos Viewer analysis provides further evidence of this trend by showing that STEM-EDP remains in the “light green” cluster of research visualization. In bibliometric terms, this color signifies that the topic is relatively recent and has not yet reached saturation, thereby offering substantial potential for continued scholarly exploration. This emerging status positions STEM-EDP as a fertile domain for innovation, especially when connected to contemporary pedagogical frameworks such as project-based learning, inquiry-oriented approaches, and the cultivation of creative and critical thinking skills.

The observed pattern also indicates that STEM-EDP is transitioning from a conceptual framework into a more practical and application-driven research area. The growing number of studies that explicitly integrate engineering design principles into STEM pedagogy reflects a shift toward addressing real-world challenges, preparing students for future innovation, and fostering competencies aligned with 21st-century education goals. Consequently, the positive publication trend underscores not only the vitality of STEM-EDP as a research focus but also its strategic role in shaping the evolution of Science Education worldwide. The findings reveal that qualitative research methods dominate STEM-EDP studies in Science Education, accounting for 81 articles (80.19%). This strong preference suggests that researchers and educators prioritize exploratory and descriptive approaches to capture the complex, context-dependent processes involved in integrating engineering design into STEM pedagogy. In contrast, both quantitative and mixed methods were employed in only 10 articles each (9.91%), indicating that systematic measurement and statistical generalization are less frequently pursued in this field. This tendency is consistent with Hyun (2020), who found that 77.78% of STEM-EDP studies applied qualitative designs, and Park (2020), who also emphasized the predominance of qualitative approaches in STEM-EDP learning research. Similarly, Perignat (2019) reported that 13 out of 18 empirical studies adopted qualitative methods. The convergence of these findings across different studies highlights a global pattern: STEM-EDP research is still largely exploratory and conceptual rather than experimental or evaluative.

The dominance of qualitative methods can be attributed to the nature of STEM-EDP itself, which often involves examining classroom practices, teacher perspectives, curriculum development, and students’ problem-solving processes. Such dimensions are more effectively captured through interviews, observations, and case studies rather than standardized instruments. However, the relatively low number of quantitative and mixed-methods studies indicates a gap in empirical validation. Rigorous quantitative and mixed-method approaches are essential for testing the effectiveness of STEM-EDP interventions at scale, measuring long-term learning outcomes, and providing evidence-based recommendations for policy and practice. Therefore, while qualitative research continues to play a crucial role in deepening theoretical and contextual understanding, the field would benefit from a more balanced methodological landscape. Increasing the integration of quantitative and mixed-methods designs could strengthen the generalizability of findings and contribute to establishing STEM-EDP as a robust and

evidence-driven research domain in Science Education. Based on the number of authors in the STEM-EDP Education research in the field of Science Education for the period 2016 to 2025, it was found that articles with single authors were mostly published in this field. Interestingly, there are articles written by six to eight researchers with an almost uniform distribution of only one to two articles in the period 2016 to 2025. This is in accordance with research by Marín (2021) which found that single authors published the most articles with a total of 14 articles in from 2006 to 2021. Based on Vos Viewer's analysis, it shows that the authors cite each other as a form of STEM-EDP research collaboration in the field of science education.

The Americas and the United States have the highest contribution to STEM-EDP Education research publications in Science Education. This is like research by Marín (2021) where of the 1116 articles identified there were 562 articles published in America, 71 articles published in Spain, 50 articles published in Australia, and 45 articles published in England. Therefore, the American continent still dominates as the highest contributor to STEM-EDP research articles in Science Education. This aligns with Irwanto (2021), who reported that United States publishes the highest number of articles scientific disciplines. Research shows that the most productive authors are Kelly C. Margot & Todd Kettler, namely 179 citations with an average of 45 citations per year, so the authors' research has an impact. This is in accordance with research by Aksnes (2019) that the number of citations is generally considered a measure of the influence of a publication on its impact on people's lives. Thus, this shows that the article written by Kelly C. Margot & Todd Kettler has had a major impact on STEM-EDP research in the field of Science Education. The International Journal of Technology and Design Education is the most productive journal in publishing articles related to STEM-EDP in the field of Science Education in the period January 2013 – October 2022 with a total of 22 articles, followed by the International Journal of STEM Education with a total of 19 articles. So this journal has become a trend in publishing articles related to STEM-EDP Education in the field of Science Education in the last 10 years.

CONCLUSION

Fundamental Finding: This study provides a bibliometric overview of STEM-EDP research in Science Education from 2016 to 2025. The results show a steady increase in publications, indicating growing scholarly interest. Qualitative methods dominate the field, and keyword mapping positions STEM-EDP within an emerging research cluster.

Implication: The findings confirm the relevance of STEM-EDP in promoting 21st-century skills and strengthening innovation-oriented science learning. The upward trend also reflects its strategic role in advancing contemporary science education practices.

Limitation: This study is limited to selected databases, which may not represent all relevant publications. The dominance of qualitative studies may also limit the generalizability of findings. **Future Research:** Future studies should incorporate broader databases and employ more quantitative and mixed-method designs. Further investigation into STEM-EDP implementation across diverse contexts is needed to strengthen empirical evidence and practical application.

ACKNOWLEDGEMENTS

The authors would like to express their deepest gratitude to Universitas Sriwijaya for providing the opportunity and support to conduct this independent research. The

facilities, academic environment, and encouragement from the institution have been invaluable in completing this study.

REFERENCES

- Aksnes, D. W., Langfeldt, L., & Wouters, P. (2019). Citations, citation indicators, and research quality: An overview of basic concepts and theories. *SAGE Open*, 9(1). <https://doi.org/10.1177/2158244019829575>
- Archila, P. A., Restrepo, S., Truscott de Mejía, A. M., & Molina, J. (2023). STEM and Non-STEM Misconceptions About Evolution: Findings from 5 Years of Data. *Science and Education*. <https://doi.org/10.1007/s11191-023-00428-5>
- Arık, M., & Topçu, M. S. (2022). Implementation of engineering design process in the K-12 science classrooms: Trends and issues. *Research in Science Education*, 52(1), 21–43. <https://doi.org/10.1007/s11165-019-09912-x>
- Berland, L. K., Schwarz, C. V., Krist, C., Kenyon, L., Lo, A. S., & Reiser, B. J. (2022). Epistemologies in practice: Making scientific practices meaningful for students. *Science Education*, 106(2), 253–278. <https://doi.org/10.1002/tea.21257>
- Capobianco, B. M., & Radloff, J. (2022). Elementary preservice teachers' trajectories for appropriating engineering design-based science teaching. *Research in Science Education*, 52(5), 1623–1641. <https://doi.org/10.1007/s11165-021-10020-y>
- Chiang, F. K., Chang, C. H., Wang, S., Cai, R. H., & Li, L. (2022). The effect of an interdisciplinary STEM course on children's attitudes of learning and engineering design skills. *International Journal of Technology and Design Education*, 32(1), 55–74. <https://doi.org/10.1007/s10798-020-09603-z>
- Crismond, D., & Adams, R. (2021). The informed design teaching and learning matrix. *Journal of Engineering Education*, 110(1), 33–65. <https://doi.org/10.1002/j.2168-9830.2012.tb01127.x>
- Cunningham, C. M., & Carlsen, W. S. (2020). Teaching engineering practices. *Journal of Science Education and Technology*, 29(1), 1–10. <https://doi.org/10.1007/s10972-014-9380-5>
- Deniz, H., Kaya, E., Yesilyurt, E., & Trabia, M. (2020). The influence of an engineering design experience on elementary teachers' nature of engineering views. *International Journal of Technology and Design Education*, 30(4), 635–656. <https://doi.org/10.1007/s10798-019-09518-4>
- Ehsan, H., Rehmat, A. P., & Cardella, M. E. (2021). Computational thinking embedded in engineering design: capturing computational thinking of children in an informal engineering design activity. *International Journal of Technology and Design Education*, 31(3), 441–464. <https://doi.org/10.1007/s10798-020-09562-5>
- Falloon, G., Hatzigianni, M., Bower, M., Forbes, A., & Stevenson, M. (2020). 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>
- Fan, S. C., Yu, K. C., & Lin, K. Y. (2021). A Framework for implementing an engineering-focused STEM curriculum. *International Journal of Science and Mathematics Education*, 19(8), 1523–1541. <https://doi.org/10.1007/s10763-020-10129-y>
- Guzey, S. S., Moore, T. J., & Harwell, M. (2020). Building up STEM: An analysis of teacher-developed engineering design-based STEM integration. *School Science and Mathematics*, 120(3), 135–147. <http://dx.doi.org/10.7771/2157-9288.1129>

- Han, H. J., & Shim, K. C. (2019). Development of an engineering design process-based teaching and learning model for scientifically gifted students at the Science Education Institute for the Gifted in South Korea. *Asia-Pacific Science Education*, 5(1), 1–18. <https://doi.org/10.1186/s41029-019-0047-6>
- Han, J., Park, D., Hua, M., & Childs, P. R. N. (2022). Is group work beneficial for producing creative designs in STEM design education? *International Journal of Technology and Design Education*, 32(5), 2801–2826. <https://doi.org/10.1007/s10798-021-09709-y>
- Hsu, M. C., Chiang, C., & Liang, C. (2014). The mediator effects of imagination between learning environment and academic performance: a comparison between science and engineering majors. *International Journal of Technology and Design Education*, 24(4), 419–436. <https://doi.org/10.1007/s10798-014-9262-3>
- Hughes, B. S., Corrigan, M. W., Grove, D., Andersen, S. B., & Wong, J. T. (2022). Integrating arts with STEM and leading with STEAM to increase science learning with equity for emerging bilingual learners in the United States. *International Journal of STEM Education*, 9(1), 1-19. <https://doi.org/10.1186/s40594-022-00375-7>
- Hyun, J. S., & Park, C. J. (2020). Research Analysis on STEAM Education with digital technology in Korea to prepare for post-corona era education. *International Journal of Contents*, 16(3). <https://doi.org/10.5392/IJoC.2020.16.3.101>
- Irwanto, I. (2021). Research trends in technological pedagogical content knowledge (TPACK): A systematic literature review from 2010 to 2021. *European Journal of Educational Research*, 10(4), 2045–2054. <https://doi.org/10.12973/EU-JER.10.4.2045>
- Kelley, T. R., & Knowles, J. G. (2021). A conceptual framework for integrated STEM education. *International Journal of STEM Education*, 8(1), 1–13. <https://doi.org/10.1186/s40594-016-0046-z>
- Leung, A. (2020). Boundary crossing pedagogy in STEM education. *International Journal of STEM Education*, 7(1). <https://doi.org/10.1186/s40594-020-00212-9>
- Liao, C. (2020). From interdisciplinary to transdisciplinary: An arts-integrated approach to STEM education. *Art Education*, 73(3), 44–49. <http://dx.doi.org/10.1080/00043125.2016.1224873>
- Lin, H. (2016). Influence of design training and spatial solution strategies on spatial ability performance. *International Journal of Technology and Design Education*, 26(1), 123–131. <https://doi.org/10.1007/s10798-015-9302-7>
- Mafugu, T., Tsakeni, M., & Jita, L. C. (2022). Preservice Primary Teachers' Perceptions of STEM-Based Teaching in Natural Sciences and Technology Classrooms. *Canadian Journal of Science, Mathematics and Technology Education*, 22(4), 898–914. <https://doi.org/10.1007/s42330-022-00252-z>
- Marín-Marín, J. A., Moreno-Guerrero, A. J., Dúo-Terrón, P., & López-Belmonte, J. (2021). STEAM in education: a bibliometric analysis of performance and co-words in Web of Science. *International Journal of STEM Education*, 8(1). Science and Business Media Deutschland GmbH. <https://doi.org/10.1186/s40594-021-00296-x>
- Margot, K. C., & Kettler, T. (2019). Teachers' perception of STEM integration and education. *International Journal of STEM Education*, 7(1), 1–16. <https://doi.org/10.1186/s40594-018-0151-2>
- McFadden, J., & Roehrig, G. (2019). Engineering design in the elementary science classroom: supporting student discourse during an engineering design challenge.

- International Journal of Technology and Design Education*, 29(2), 231–262. <https://doi.org/10.1007/s10798-018-9444-5>
- Park, W., Wu, J. Y., & Erduran, S. (2020). The Nature of STEM disciplines in the science education standards documents from the USA, Korea and Taiwan: Focusing on disciplinary aims, values and practices. *Science and Education*, 29(4), 899–927. <https://doi.org/10.1007/s11191-020-00139-1>
- Perignat, E., & Katz-Buonincontro, J. (2019). STEAM in practice and research: An integrative literature review. *Thinking Skills and Creativity*, 31, 31–43. <https://doi.org/10.1016/j.tsc.2018.10.002>
- Pleasant, J., & Olson, J. (2021). What is engineering? Elaborating the nature of engineering for K–12 education. *Science Education*, 105(5), 906–932. <https://doi.org/10.1002/sce.21655>
- Purzer, Ş., Goldstein, M. H., Adams, R. S., Xie, C., & Nourian, S. (2015). An exploratory study of informed engineering design behaviors. *Journal of Engineering Education*, 110(3), 633–658. <https://doi.org/10.1186/s40594-015-0019-7>
- Rustan, N. A., Winarni, R., & Yamtinah, S. (2020). Analysis of science process skill on science learning in primary school. *Proceedings of the 3rd International Conference on Learning Innovation and Quality Education (ICLIQE 2019)*. <https://www.atlantispress.com/proceedings/icliqe-19/125933450>
- So, K., & Park, N. (2022). Can teachers be change agents? A critical analysis of teacher Images in school reform policies. *Asia-Pacific Education Researcher*, 30(1), 1–12. <https://doi.org/10.1007/s40299-020-00536-8>
- Thahir, A., Anwar, C., Saregar, A., Choiriah, L., Susanti, F., & Pricilia, A. (2020). The effectiveness of STEM learning: Scientific attitudes and students' conceptual understanding. *Journal of Physics: Conference Series*, 1467(1). <https://doi.org/10.1088/1742-6596/1467/1/012008>
- Turner, K. L., Kirby, M., & Bober, S. (2016). Engineering design for engineering design: Benefits, models, and examples from practice. *Inquiry in Education*, 8(2). <https://eric.ed.gov/?id=EJ1171674>
- Van Laar, E., van Deursen, A. J. A. M., van Dijk, J. A. G. M., & de Haan, J. (2020). The relation between 21st-century skills and digital skills: A systematic literature review. *Computers in Human Behavior*, 72, 577–588. <https://doi.org/10.1016/j.chb.2017.03.010>
- Wendell, K. B., Wright, C. G., & Paugh, P. (2017). Reflective practices in elementary engineering design. *Journal of Engineering Education*, 109(2), 207–230. <https://doi.org/10.1002/jee.20173>
- Wilson, S. M. (2021). Realizing STEM's potential and promise. *Journal for STEM Education Research*, 4(2), 240–245. <https://doi.org/10.1007/s41979-021-00056-0>
- Wind, S. A., Alemдар, M., Lingle, J. A., Moore, R., & Asilkalkan, A. (2019). Exploring student understanding of the engineering design process using distractor analysis. *International Journal of STEM Education*, 6(1), 1–18. <https://doi.org/10.1186/s40594-018-0156-x>

***Frendi Ihwan Syamsudin (Corresponding Author)**

Physics Education Study Program, Faculty of Teacher Training and Education,
Universitas Sriwijaya, Indralaya,
Jl. Palembang–Prabumulih KM 32, Indralaya, Kabupaten Ogan Ilir, Sumatera Selatan, 30662,
Indonesia
Email: frendiihwan@fkip.unsri.ac.id

Ketang Wiyono

Physics Education Study Program, Faculty of Teacher Training and Education,
Universitas Sriwijaya, Indralaya,
Jl. Palembang–Prabumulih KM 32, Indralaya, Kabupaten Ogan Ilir, Sumatera Selatan, 30662,
Indonesia
Email: ketang_wiyono@fkip.unsri.ac.id

Evelina Astra Patriot

Physics Education Study Program, Faculty of Teacher Training and Education,
Universitas Sriwijaya, Indralaya,
Jl. Palembang–Prabumulih KM 32, Indralaya, Kabupaten Ogan Ilir, Sumatera Selatan, 30662,
Indonesia
Email: evelinaastrapatriot@fkip.unsri.ac.id

Ismet

Physics Education Study Program, Faculty of Teacher Training and Education,
Universitas Sriwijaya, Indralaya,
Jl. Palembang–Prabumulih KM 32, Indralaya, Kabupaten Ogan Ilir, Sumatera Selatan, 30662,
Indonesia
Email: ismet@fkip.unsri.ac.id

Saparini

Physics Education Study Program, Faculty of Teacher Training and Education,
Universitas Sriwijaya, Indralaya,
Jl. Palembang–Prabumulih KM 32, Indralaya, Kabupaten Ogan Ilir, Sumatera Selatan, 30662,
Indonesia
Email: saparini@fkip.unsri.ac.id

Azlan bin Kamari

Department of Chemistry, Faculty of Science and Mathematics,
Universiti Pendidikan Sultan Idris, Tanjung Malim,
Tanjung Malim, Perak, 359000, Malaysia
Email: azlan.kamari@fsmt.upsi.edu.my
