

The Implementation of Spectrophotometers in STEM-Based Physics Education: A Bibliometric Analysis

Fakhira Nursabrina*, Bambang Heru Iswanto, Hadi Nasbey, and Firmanul Catur Wibowo

Master of Physics Education Study Program, Faculty of Mathematics and Science,
Universitas Negeri Jakarta, Jakarta, Indonesia

*fakhiranursabrina0517@gmail.com

Article Info	Abstract
Article history: Received: June 4, 2025 Accepted: July 10, 2025 Published: November 3, 2025 Keywords: Bibliometrics Light Spectrum Physics Education Scopus Spectrophotometer This article is licensed under a creative commons attribution-share alike 4.0 international license © 2025 Jurnal ilmiah Pendidikan Fisika	The paucity of scientific research focusing on the integration of spectrophotometers within STEM-based physics education highlights a significant gap in the existing literature. This underexplored area holds considerable potential, as the application of spectrophotometric tools in instructional settings may enhance students' scientific competencies and critical thinking skills. This study aims to address an unresolved research gap by conducting a comprehensive data analysis, combining various analytical techniques to obtain more accurate and comprehensive results regarding the implementation of spectrophotometry in STEM-based physics education. Bibliometric analysis was conducted on articles, conference papers, book chapters, and reviews. The research method used in this study combines quantitative analysis and descriptive methods. The results showed an annual growth rate of 29.24% with an average of 4,568 citations per document. China dominated journal publications with 71 articles, while Indonesia contributed 35 articles. This indicates that, especially in the realm of education, this topic is rarely explored in Indonesia. Data show that research on STEM and spectrophotometry continues to increase, except in 2022, when it experienced a significant decline, followed by a notable increase in 2024, compared to previous years, with 119 documents. Furthermore, WordCloud and co-occurrence network data indicate that STEM and spectrophotometry in physics education are under-researched topics. The topics most frequently researched in these articles are non-educational, such as spectrophotometry for humans, animals, or metabolism. This research recommends that the topic of spectrophotometry in STEM-based physics education should be further explored. Practically, these insights may serve as a foundation for educators and curriculum developers to begin incorporating laboratory tools, such as spectrophotometers, into physics instruction to foster 21st-century skills—particularly scientific literacy, problem-solving, and students' critical thinking abilities.
To cite this article: Nursabrina, F., Iswanto, B. H., Nasbey, H., & Wibowo, F. C. (2025). The Implementation of Spectrophotometers in STEM-Based Physics Education: A Bibliometric Analysis. <i>Jurnal Ilmiah Pendidikan Fisika</i>, 9 (3), 376-389.	

INTRODUCTION

Science, Technology, Engineering, and Mathematics (STEM) education has become a central focus in modern education. The STEM approach emphasizes cross-disciplinary integration to solve real-world problems holistically (Fadillah, 2024; Saputri et al., 2023).

One of the innovations that supports the effectiveness of STEM learning is the use of simple, homemade spectrophotometers. [Khandelwal et al. \(2022\)](#) demonstrated that DIY spectrophotometers can be utilized in modern physics demonstrations, such as spectrum separation and quantum principles, with reasonably accurate data. These studies reinforce the findings of [Shidiq et al. \(2021\)](#), who noted that various simple spectrophotometer instruments have been used in the teaching of chemistry and other STEM fields, thereby opening up broad opportunities for the development of innovative, affordable, and contextually relevant teaching tools. Thus, a STEM learning approach that incorporates simple technologies, such as spectrophotometers, not only enhances conceptual understanding but also equips students with essential 21st-century skills, including critical thinking, problem-solving, and digital literacy, which are highly needed in the era of globalization ([Rizqi & Rahmah, 2023](#)).

In Indonesia, with its abundant natural resources and significant economic potential, STEM education can serve as a key driver for fostering innovation, enhancing national competitiveness, and addressing various challenges such as climate change and environmental issues ([Iswahyudi et al., 2023](#)). This aligns with the findings of [Maspul \(2024\)](#), who stated that the STEM education approach empowers students to become agents of change in responding to environmental issues through the integration of real-world problem-based learning. In this context, STEM education not only enhances critical thinking and problem-solving skills but also fosters environmental awareness, encouraging students to actively engage with their communities. Therefore, strengthening STEM education represents a strategic step toward addressing global challenges through contextual and sustainable educational innovation.

The implementation of STEM education in Indonesia aligns with government efforts to improve the quality of education and prepare younger generations for the future. Through STEM learning, students are encouraged to think critically, creatively, and collaboratively in solving problems ([Hartini et al., 2020](#); [Novianti et al., 2023](#)). Through a systematic review, it was found that “STEM is recognized as an innovative learning method that integrates various disciplines to enhance 21st-century skills, such as critical thinking, problem-solving, and student creativity,” indicating the effectiveness of STEM education in enhancing 21st-century skills among secondary school students in Indonesia ([Cahyanti et al., 2024](#)). Moreover, STEM can foster students’ interest in science and technology, thereby promoting the emergence of a new generation capable of contributing to the advancement of science and technology in Indonesia ([Abas et al., 2024](#)). One of the tools with significant potential to support meaningful STEM learning is the spectrophotometer. A study by [Osterheider et al. \(2022\)](#) demonstrated that a simple LEGO-based spectrophotometer can be effectively used in the classroom to introduce physics principles related to light emission and transmission. Although constructed from easily accessible and low-cost materials, the device maintains high resolution, enabling students to perform real scientific measurements. Furthermore, [Castellanos \(2025\)](#) illustrated how student-developed homemade spectrophotometers, using devices such as smartphones or laptops, can be utilized in project-based learning activities to analyze light characteristics. Through these activities, students not only gain an understanding of wave and optics concepts but also develop critical thinking, problem-solving, and collaboration skills. These findings support the notion that integrating spectrophotometers into STEM education has the potential to transform physics instruction into a more contextual, exploratory, and applied approach.

The use of spectrophotometers in education enables students to grasp abstract concepts, such as light absorption, the electromagnetic spectrum, and the Beer–Lambert law, through direct experimental experience. [Delmonache et al. \(2024\)](#) demonstrated that

a DIY spectrophotometer built using inexpensive components and 3D printing can produce valid spectral data for various types of measurements, including UV-Vis absorbance and fluorescence. Through experiments involving spectrophotometers, students are able to develop a deeper understanding of the properties of light, its interaction with matter, and its applications across different scientific fields ([Suryana et al., 2024](#)).

In addition, the use of spectrophotometers can promote the development of essential scientific process skills, such as designing experiments, collecting and analyzing data, and drawing conclusions ([Nurocktavianti, 2022](#)). By conducting experiments using a spectrophotometer, students are encouraged to think critically, solve problems, and work collaboratively ([Pertiwi & Poluakan, 2022](#)). Furthermore, spectrophotometers can serve as a bridge between classroom learning and real-world applications, enabling students to see the relevance of physics concepts in everyday life ([Shofiyah et al., 2021](#)).

Research findings on the development of a simple LED spectrophotometer experiment kit for analyzing iron metal ions in water indicate that the spectrophotometer is suitable for this purpose. The kit is portable and affordable, as its components are detachable ([Jawad et al., 2021](#)). However, a limitation of this study is that the kit is only compatible with iPhone 5 devices. In addition, a study on the development of Spectro-Animation as a learning medium to enhance students' understanding of the Bohr atomic structure concept demonstrated that the use of Spectro-Animation, whose main instrument is the spectrometer, effectively supported the learning process. The study showed that this media could reduce students' misconceptions and that Spectro-Animation was effective and implementable in teaching the Bohr atomic structure ([Agustina et al., 2022](#)).

However, it is undeniable that there are still several gaps in the implementation and impact of physics education. Although do-it-yourself (DIY) spectrophotometers are considered to have great potential in supporting more contextual and cost-effective science learning, [Kolesnichenko et al. \(2023\)](#) emphasize that technical challenges such as limited instrument accuracy, the need for precise calibration, and variations in experimental results remain obstacles to effective classroom implementation. Therefore, further research is needed to comprehensively understand how spectrophotometers can be optimally utilized in STEM-based physics education. Research using bibliometric analysis offers advantages over other research approaches in terms of the volume of data obtained and the depth of examination, due to its capacity to store comprehensive data and its potential to make such data openly accessible to scholars ([Chen & Nguyen, 2024](#)).

To date, no study has focused on a bibliometric analysis of research trends in STEM education using spectrophotometers in the field of physics education. This study aims to address unanswered research questions through a comprehensive data analysis approach, integrating multiple analytical techniques rather than relying solely on a single method, to obtain more accurate and holistic results. Accordingly, this article conducts an in-depth Bibliometrix analysis of the implementation of spectrophotometers in STEM-based physics education from 2019 to 2024 ([Irawan & Purwasih, 2024](#)). The results of this study are expected to provide valuable recommendations for educators and researchers to optimize the use of spectrophotometers in physics education and to identify existing challenges in integrating this tool across various educational levels.

METHODS

The literature review design in this study involves the development of research findings on STEM-based education utilizing spectrophotometers through bibliometric analysis and the identification of trends in physics education research. This study combines quantitative analysis with a descriptive method. The article search was conducted using

the Scopus database on October 12, 2024. The collected data consisted of metadata retrieved from Scopus using the keywords "STEM" and "spectrophotometer," covering publications from 2019 to October 12, 2024. A total of 338 articles were retrieved and stored in CSV format. A thorough rechecking process was then conducted to ensure that all articles were indeed relevant to the specified keywords. The search focused on identifying trends in STEM education involving the use of spectrophotometers based on Scopus data. The collected data were analyzed using R Bibliometric software. R is an open-source programming environment widely used by researchers for data analysis, statistical modeling, reproducibility, and data visualization ([Wibowo et al., 2024](#)).

Among the various platforms for scholarly publications, Scopus is one of the largest and most internationally recognized databases. It provides access to thousands of academic journals, making it an essential reference source for researchers and academicians worldwide ([Majied, 2023](#)). This research utilizes the R-Tool bibliometric software known as Biblioshiny to calculate various key metrics, such as citation counts and frequency of research topics related to the literature trend of STEM and spectrophotometer usage in physics education. Moreover, this tool is highly advantageous due to its open-access availability for users across all academic levels ([Indri et al., 2023](#)). Subsequently, this analytical process is illustrated in Figure 1.

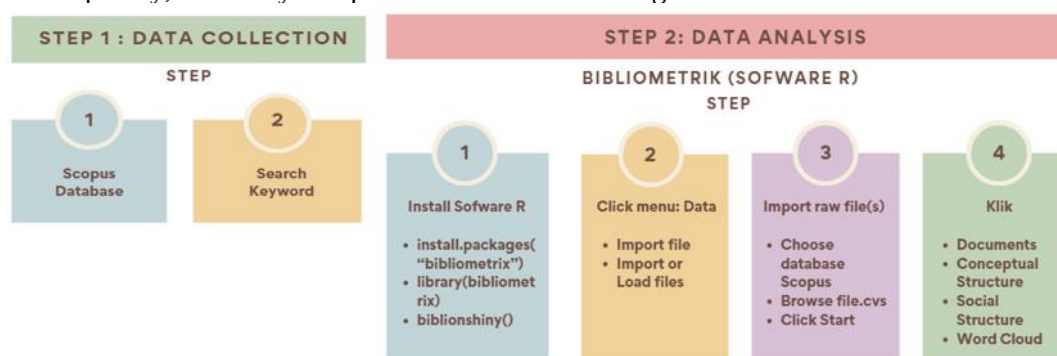


Figure 1 Bibliometric research design using R software

The design of this study began with two main stages: data collection and data processing. During the data collection stage, documents were retrieved from the Scopus database by restricting the publication period to October 12, 2024, using the keywords "STEM" and "spectrophotometer." In the data processing stage, the study employed bibliometric analysis using the Bibliometrix package in the R programming environment, accessed through the Biblioshiny web interface. To utilize Biblioshiny, several preparatory steps were undertaken, including downloading and installing the R programming language from the CRAN repository and installing RStudio from its official website. Within RStudio, the command `install.packages("bibliometrix")` was executed to install the necessary package, followed by the activation of the package using `library("bibliometrix")`. The command `biblioshiny()` was then run to launch the Biblioshiny interface. Prior to these steps, it was ensured that the computer was connected to the internet. Once the Biblioshiny website is open, click *Load Data* and upload the file to be analyzed using the previously obtained Scopus database, then click *Start*. The bibliometric analysis results will then be displayed, along with several available tools, including *Overview*, *Sources*, *Authors*, *Documents*, *Clustering*, *Conceptual Structure*, *Intellectual Structure*, and *Social Structure*. These tools can be utilized according to the specific needs of the analysis.

RESULTS AND DISCUSSION

The development of research on STEM and spectrophotometers has resulted in a total of 339 published articles between 2019 and October 12, 2024. The data indicate an annual growth rate of 29.24%, with an average of 4,568 citations per document. These findings suggest a consistent upward trend in STEM and spectrophotometer-related research each year. A total of 1,954 authors have contributed to publications in this field, comprising four types of documents: journal articles, conference proceedings, book chapters, and reviews. This figure reflects a growing academic interest in the topic, although its application in the educational context, particularly in Indonesia, remains relatively limited. To provide a comprehensive overview of the bibliometric analysis, the following Figure 2 presents key information regarding the number of sources, documents, authors, and annual publication growth from 2019 to October 12, 2024.



Figure 2 Main information

Figure 2 presents the key bibliometric indicators derived from the analysis of 338 documents related to STEM and spectrophotometer research published between 2019 and October 12, 2024. The data were sourced from 245 distinct publication sources and involved a total of 1,954 authors. Notably, only five authors published as sole contributors, indicating a strong tendency toward collaborative research. The rate of international collaboration is recorded at 20.71%, while the average number of authors per document is 6.41, reflecting a high level of collaborative engagement. Furthermore, a total of 1,349 unique author keywords were identified, with an average document age of 1.83 years. Interestingly, the average number of citations per document stands at 4.568, and the annual growth rate of publications in this field is 29.24%. This figure highlights the dynamic development and collaborative nature of research within the domain. Subsequently, the relevant authors are presented in Figure 3, where their works have been published and indexed in Scopus.

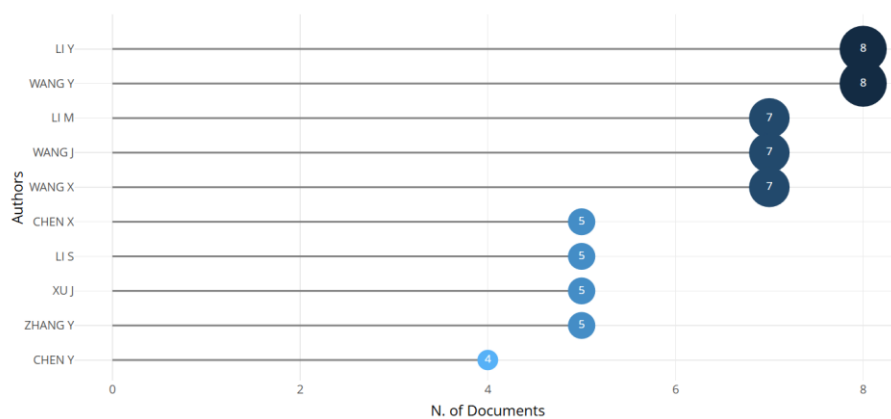


Figure 3 Bibliometric analysis of the most frequently publishing author

The relevant authors are presented in Figure 3, where their works have been published and indexed in Scopus. Authors with significant impact are represented by dark blue in the bar chart below. The diagram shows that the most influential authors are Li Y and Wang Y, each with eight scientific publications. These two authors stand out in terms of productivity and contribution to studies on STEM and spectrophotometers, as indicated by their top positions in the graph.

They are followed by three other authors, Lim, Wang J, and Wang X, each with seven publications, who also exhibit considerable influence, as marked by medium blue bars. In addition, five other authors—Chen X, Li S, Xu J, Zhang Y, and Chen Y have fewer publications. Among them, Chen Y is identified as having the lowest number of publications and impact, represented by light blue.

This color distribution not only indicates the number of published documents but also reflects the level of influence or citations these authors have received within the academic community. This visualization provides valuable insight into the key figures in STEM and spectrophotometer research, as well as the extent of their contributions to the development of literature in this field.

Next, Figure 4 presents the bibliometric analysis of the most relevant institutional affiliations in research related to STEM and spectrophotometers, based on the number of articles published and indexed in the Scopus database.

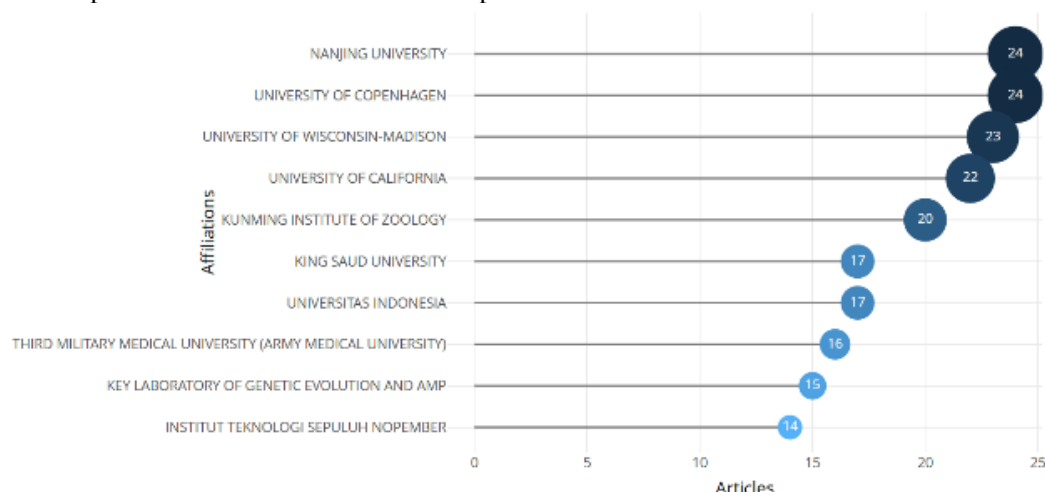


Figure 4 Bibliometric analysis of the most relevant affiliations

The analysis presented in Figure 4 highlights the ten institutions with the highest number of publications in the field of STEM and spectrophotometers between 2019 and October 12, 2024. The two most active institutions are Nanjing University and the University of Copenhagen, each contributing 24 articles. These are followed by the University of Wisconsin-Madison (23 articles), the University of California (22 articles), and the Kunming Institute of Zoology (20 articles). The list is predominantly comprised of foreign universities, indicating their strong interest and productivity in advancing this research area. Meanwhile, from Indonesia, Universitas Indonesia and Institut Teknologi Sepuluh Nopember (ITS) are also included in the list, contributing 17 and 14 articles, respectively. These data indicate that the contribution of institutions from Indonesia remains relatively low compared to foreign institutions. Scientometric analysis further reveals that Indonesian institutions have a limited presence in international scientific publications, particularly in the fields of STEM and instrumental technologies such as spectrophotometry, when compared to institutions from more developed countries. This

finding is consistent with the study by [Yudhoyono et al \(2025\)](#), which identifies a significant gap in Indonesia's contribution to global research output. Therefore, strategic efforts are necessary for higher education institutions in Indonesia to strengthen international collaboration and enhance both the quality and quantity of scientific publications. The bibliometric visualization also shows that institutions represented in dark blue correspond to the highest number of publications, while those in light blue reflect institutions with lower, yet still globally significant, levels of contribution.

Therefore, further encouragement is needed for higher education institutions in Indonesia to strengthen collaboration and to increase both the quantity and quality of scientific publications in the fields of STEM and spectrophotometry. In the visualization, dark blue represents institutions with the highest number of publications, while light blue indicates institutions with relatively lower, yet still significant, contributions in the global context. Table 1 below presents the contributions of the top ten countries in scientific publications related to STEM and spectrophotometers, based on the number of published articles, as well as the proportions of domestic collaboration (Single Country Publications/SCP) and international collaboration (Multiple Country Publications/MCP).

Table 1 Number of publications per year

Country	Articles	Articles %	SCP	MCP	MCP %
CHINA	71	21	63	8	11.3
INDIA	38	11.2	29	9	23.7
INDONESIA	35	10.4	34	1	2.9
USA	21	6.2	18	3	14.3
PAKISTAN	16	4.7	8	8	50
IRAN	12	3.6	10	2	16.7
TURKEY	11	3.3	9	2	18.2
NIGERIA	10	3	7	3	30
BANGLADESH	8	2.4	4	4	50
BRAZIL	7	2.1	6	1	14.3

Based on Table 1, China is the leading contributor in STEM and spectrophotometer research, with a total of 71 articles, accounting for 21% of all publications. Of these, 63 articles resulted from domestic institutional collaboration (SCP), while only 8 articles involved international collaboration (MCP), representing an 11.3% MCP rate. India ranks second with 38 articles (11.2%) but demonstrates a higher proportion of international collaboration, with 23.7% MCP. Meanwhile, Indonesia occupies the third position with 35 articles (10.4%), yet shows a very low level of international collaboration (2.9% MCP), indicating that the majority of research is still conducted within the country. Countries such as Bangladesh, Pakistan, and Nigeria stand out in terms of the proportion of international collaboration, with each having a 50% MCP, indicating that half of their publications are produced in partnership with researchers from other countries. This reflects a strategic effort to enhance global visibility through international cooperation. Conversely, countries like the USA and Brazil show moderate contributions both in terms of the number of articles and the level of international collaboration. The production of articles related to STEM and spectrophotometers from various countries is illustrated in Figure 5.

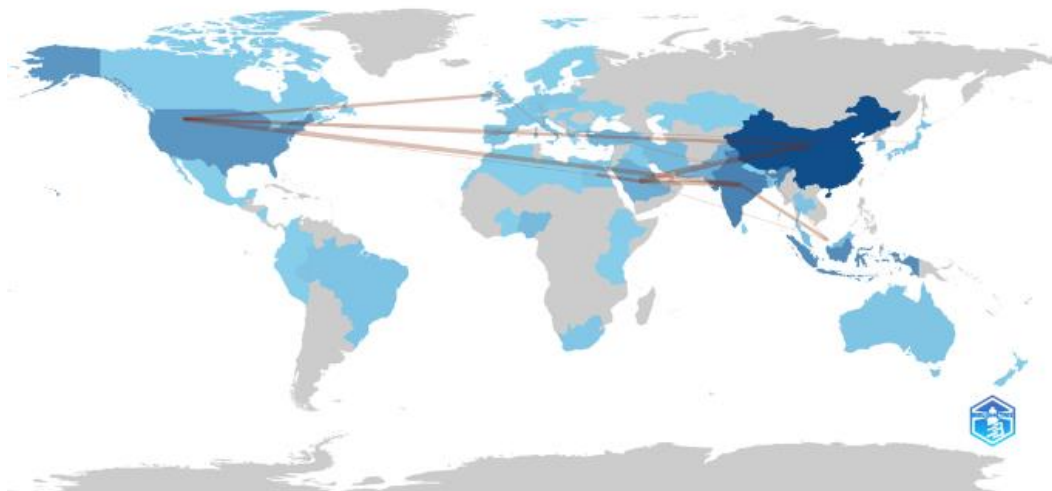


Figure 5 Publication output by country

The analysis of the global publication output map reveals a diverse distribution of contributions across the world. Countries with the highest number of publications are indicated by darker shades of blue. Based on this visualization, China emerges as the most prominent contributor, as reflected by its dominance in dark blue. This indicates that China has produced the largest number of publications on the topic of STEM and spectrophotometers. In addition, several other countries, such as India, Indonesia, and the United States, demonstrate significant research activity in this field, as represented by lighter shades of blue. Subsequently, the most frequently occurring words within the collection of publications are presented in the form of a word cloud in Figure 6.



Figure 6 Word cloud of STEM and spectrophotometer

Figure 6 presents a word cloud, which visualizes the most frequently occurring terms in publications related to STEM and spectrophotometry. The larger the font size of a word, the more frequently it appears in the analyzed articles. The most prominent and largest words include “*article*,” “*controlled study*,” “*human*,” “*nonhuman*,” and “*gene expression*.” This indicates that a significant portion of the research involves laboratory-based studies and experiments involving both humans and animals. The term “*controlled*

study” reflects the structured and systematic nature of much of the research. Terms such as “*human*,” “*nonhuman*,” “*male*,” “*female*,” and “*animal experiment*” suggest that a diverse range of research subjects is used, encompassing both human and animal models. Additionally, terms like “*gene expression*,” “*metabolism*,” and “*protein expression*” highlight a strong research focus on cellular, genetic, and biological processes, where spectrophotometers are employed to measure and analyze various biological substances. Technical terms such as “*real-time PCR*,” “*scanning electron microscopy*,” and “*Fourier transform infrared spectroscopy*” further suggest the utilization of advanced laboratory instrumentation. Moreover, the presence of terms like “*drug*” and “*drug effect*” indicates that spectrophotometry is also extensively used in pharmaceutical testing and health-related research. Overall, the figure illustrates that publications related to STEM and spectrophotometry predominantly focus on studies in the fields of biology, health sciences, and laboratory-based technology.

Then, Figure 7 shows a thematic map analysis that aims to identify research trends based on density and centrality. Themes in the upper-right quadrant, such as *human metabolism* and *human cells*, represent topics that are relevant and widely studied. On the other hand, STEM and spectrophotometer topics do not appear in any of the four main quadrants, indicating that these areas are still rarely explored. This suggests that the topic has strong potential to be developed as a new direction for future research.

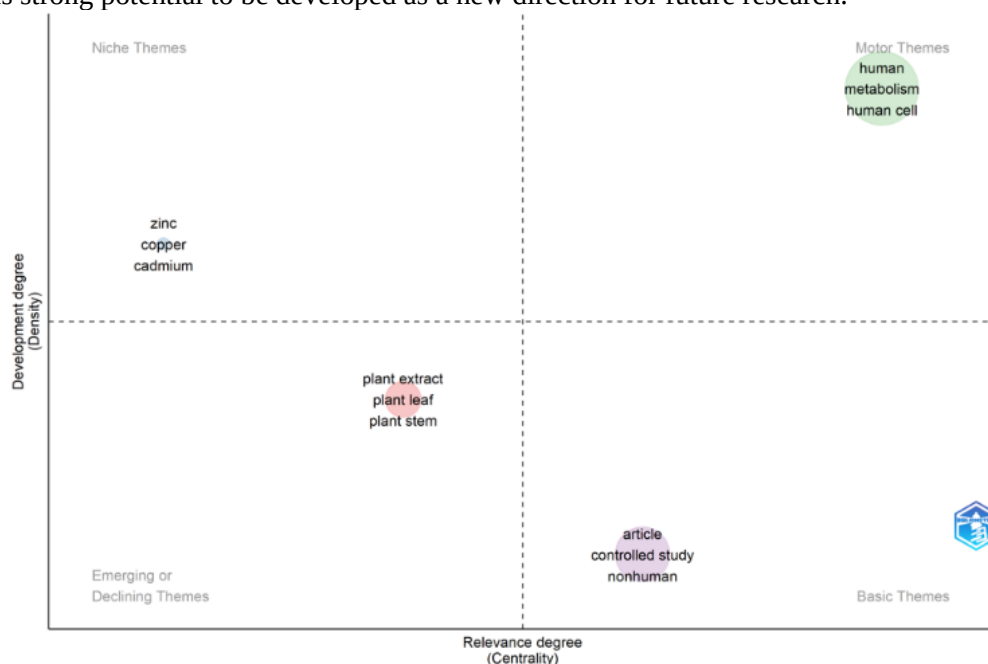


Figure 7 Thematic map bibliometric analysis

Thematic map analysis aims to identify potential research trends based on density and centrality. Density reflects the level of development of a particular theme; the higher the density line, the greater the number of related studies. Centrality, on the other hand, indicates the significance of a theme in relation to broader research areas. The further to the right the position of a theme in terms of centrality, the more substantial and influential it is considered to be (Ummah et al., 2023). The results presented in Figure 7 are divided into four quadrants based on density and centrality: (1) topics in the upper-right quadrant are considered well-developed and have attracted significant research attention; (2) topics in the lower-right quadrant are relevant and show potential for further investigation; (3) themes in the upper-left quadrant are less relevant and have either been infrequently

studied or already extensively explored; and (4) themes in the lower-left quadrant reflect a declining interest in the topic ([Pramono et al., 2022](#)).

The thematic map shows that the most extensively studied topics, such as human metabolism and human cells, are located in the upper-right quadrant. In contrast, STEM and spectrophotometer-related topics do not appear in any of the four main quadrants, indicating that these topics have been rarely explored. Therefore, STEM and spectrophotometry can be considered as emerging topics with strong potential for further research and academic investigation.

Next, Figure 8 presents a bibliometric analysis based on a co-occurrence network, which maps the relationships between keywords found in publications related to STEM and spectrophotometry. The network is divided into several color-coded clusters, each representing closely related research topics.

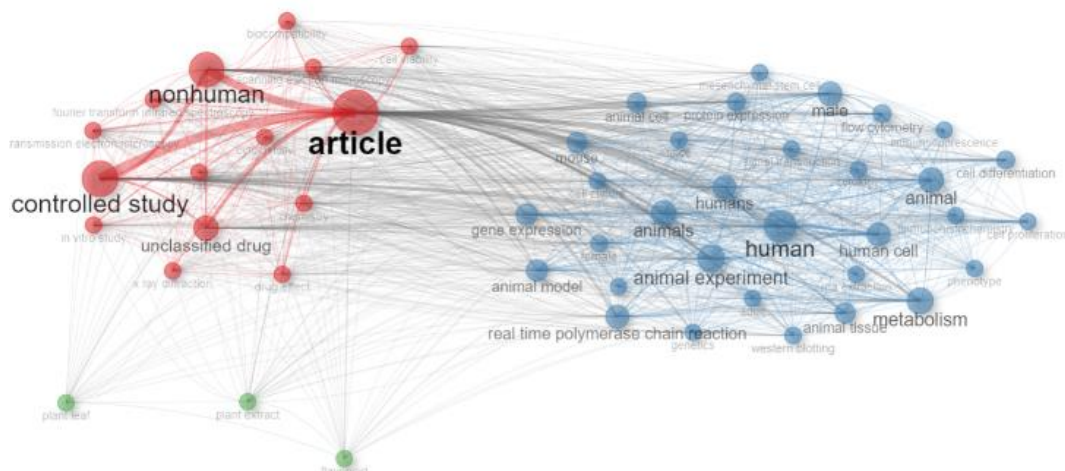


Figure 8 Co-Occurrence Network of STEM and Spectrophotometer

Figure 8 presents the results of a bibliometric co-occurrence network analysis, illustrating the relationships between keywords based on their frequency of co-appearance in scientific publications. The nodes in this network represent individual keywords, while the connecting lines (edges) indicate the frequency with which two keywords appear together within the same document. The size of each node reflects the frequency of the keyword's occurrence—the larger the node, the more frequently the term appears. The network is divided into several color-coded clusters, each representing major thematic areas. The red cluster includes keywords such as "article," "*controlled study*," and "*nonhuman*," indicating a predominance of experimental research involving nonhuman subjects. The blue cluster highlights biological and medical aspects, featuring terms like "human," "*animal experiment*," "*gene expression*," and "*metabolism*," which suggest that spectrophotometry is widely applied in cellular and biological studies. Meanwhile, the green cluster includes keywords such as "*plant extract*" and "*animal tissue*," reflecting research areas focused on natural materials and biological applications.

Overall, the network indicates that spectrophotometry is predominantly utilized in biomedical and experimental research. However, the direct association with STEM approaches is not yet prominently visible within the network. This suggests a significant opportunity to expand interdisciplinary STEM-based research involving spectrophotometer applications.

Research related to STEM and spectrophotometry remains rarely explored by educational institutions. Therefore, implementing spectrophotometry in STEM-based

physics education represents a novel and promising area for further investigation, particularly within the academic and educational contexts.

CONCLUSION

Based on the bibliometric analysis of 338 articles, this study concludes that the implementation of spectrophotometers in STEM-based learning has shown a significant upward trend, with an annual growth rate of 29.24% and a notable surge in publications as of October 12, 2024. Although China dominates in terms of publication output, studies conducted in Indonesia—particularly within the educational context—remain limited and have not yet become a primary focus of research. This study employs a descriptive quantitative approach to provide a comprehensive overview of the topic's development while also identifying potential research gaps. However, the limited access to full-text documents in the Scopus database poses a constraint that should be acknowledged. Therefore, these findings may serve as a foundational reference for future research to broaden the scope of inquiry, utilize open-access data sources, and encourage similar studies within the context of Indonesian education.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest regarding the writing and publication of this article. All analyses and interpretations were conducted objectively and independently without any external influence.

AUTHOR CONTRIBUTIONS STATEMENT

All authors actively contributed to every stage of this research. Fakhira Nursabrina was responsible for conceptualizing the idea, collecting and analyzing the bibliometric data, and drafting the initial manuscript. Bambang Heru, Hadi Nasbey, and Firmanur Catur Wibowo contributed to data validation, results visualization, and final editing of the manuscript. All authors have read and approved the final version of the article.

ACKNOWLEDGMENTS

The authors express their sincere gratitude to all parties who supported the completion of this research, especially to Universitas Negeri Jakarta for providing access to data and research facilities. Special thanks are also extended to the journal reviewers and editors for their constructive feedback and corrections throughout the editing process of this article.

REFERENCES

- Abas, S., Alirahman, A. D., & Maburur, H. (2024). Humanizing stem-based learning (science, technology, engineering, and mathematics) for the transformation of islamic education in the 21st century. *Educan: Jurnal Pendidikan Islam*, 8(1), 98–120. <https://doi.org/10.21111/educan.v8i1.11429>
- Agustina, A., Anam, K., & Bulan, S. (2022). Fabrication of spektro-animation sebagai media pembelajaran untuk meningkatkan pemahaman siswa pada konsep struktur atom bohr. *Jurnal Diklat Keagamaan*, 16(2), 138–149.
- Cahyanti, N. A., Suyanto, S., Wantara, N., Begimbetova, G. A., Unayah, H., & Rasyid, & M. (2024). A systematic review of stem education implementation in indonesian high schools: Opportunities, challenges, and policy recommendations. *Jurnal Pendidikan MIPA*, 25(3), 1528-1443.

- Castellanos, A. R. R. (2025). Quantitative characterization of light through a homemade spectrometer : A STEM project-based learning activity. *Rev. Mex. Fis. E*, 22, 010205, 1–7.
- Chen, L. H., & Nguyen, H. T. T. (2024). Study trends and core content trends of research on enhancing computational thinking: An incorporated bibliometric and content analysis based on the scopus database. *Computers*, 13(4). <https://doi.org/10.3390/computers13040091>
- Delmonache, G., Gogoi, P., Ge, X., Wang, X., Snider, R., Cook, T. R., Wang, Z., & Li, Y. C. (2024). Multipurpose DIY spectrophotometer for teaching analytical chemistry. ChemRxiv.
- Fadillah, Z. I. (2024). Pentingnya pendidikan stem (sains, teknologi, rekayasa, dan matematika). *Journal Sains and Education*, 2(1), 1–8.
- Hartini, S., Mariani, I., Misbah, M., & Sulaeman, N. F. (2020). Developing of students worksheets through STEM approach to train critical thinking skills. *Journal of Physics: Conference Series*, 1567(4), 042029. IOP Publishing.
- Indri, F. R., Hadi, N., & Firmanul, C. W. (2023). Bibliometric analysis of STEAM in Physics Education: Exporing Scopus database on the last decades (2013-2023). *Prosiding Seminar Nasional Fisika*, 2(1), 145–154.
- Irawan, E., & Purwasih, R. (2024). Tren dan arah baru penelitian pendidikan matematika : Analisis bibliometrik publikasi terindeks scopus peneliti indonesia. *IMEJ: Indonesian Mathematics Education Journal*, 1(2), 171-190.
- Iswahyudi, M. S., Irianto, I., Salong, A., Nurhasanah, N., Leuwol, F. S., Januaripin, M., & Harefa, E. (2023). Kebijakan dan inovasi pendidikan: arah pendidikan di masa depan. PT. Sonpedia Publishing Indonesia.
- Jawad, D. F., Farida, I., & Sukmawardani, Y. (2021). Pembuatan kit eksperimen spektrofotometer led sederhana untuk analisis ion logam besi dalam air. *Gunung Djati Conference Series*, 2(1), 1–14.
- Khandelwal, A., Leong, T. K., Yang, Y., Wee, L. K., García Clemente, F. J., Venkatesan, T., & Jani, H. (2022). Modern physics demonstrations with diy smartphone spectrometers. *The Physics Educator*, 4(1). <https://doi.org/10.1142/S2661339522500032>
- Kolesnichenko, P. V., Eriksson, A., Lindh, L., Zigmantas, D., & Uhlig, J. (2023). Viking spectrophotometer: A home-built, simple, and cost-efficient absorption and fluorescence spectrophotometer for education in chemistry. *Journal of Chemical Education*, 100(3), 1128–1137. <https://doi.org/10.1021/acs.jchemed.2c00679>
- Majied, A. A. (2023). Analisis bibliometrik perkembangan penelitian kajian akhlak mulia pada dimensions. *Gunung Djati Conference Series*, 23, 452–464.
- Maspul, K. A. (2024). Exploring STEM education for real-world climate change concerns to empower students as change agents. *Journal of Physics Education and Science*, 1(2), 12. <https://doi.org/10.47134/physics.v1i2.249>
- Novianti, B. A., Nitiasih, P. K., & Riastini, P. N. (2023). Study of stem-based learning against 4c skills (critical, creative, communication, and collaboration) in science. *Jurnal Ilmiah Profesi Pendidikan*, 8(3), 1917–1921. <https://doi.org/10.29303/jipp.v8i3.1455>
- Nurocktavianti, T. (2022). Pengembangan lembar kerja peserta didik (lkpd) praktikum berbasis pendekatan saintifik pada pokok bahasan koloid melalui proses penjernihan air menggunakan kitosan dari cangkang kepiting (*Scylla serrata*). (Bachelor's thesis, Jakarta: FITK UIN Syarif Hidayatullah Jakarta).

- Osterheider, M., Bourdin, B., Boettcher, R., Beeken, M., & Imlau, M. (2022). A do-it-yourself Czerny – Turner spectrometer : Atomic emission, absorption, reflection and fluorescence spectroscopy in natural sciences. *Physics Education*, 57(6), 065012.
- Pertiwi, M. G. I., & Poluakan, C. (2022). Pengaruh model pembelajaran science technology society berbasis multiple representation-semiotic resources materi pencemaran lingkungan di smp. *SCIENING : Science Learning Journal*, 3(1), 64–70.
- Pramono, S. M., Raharja, S., & Nur, A. E. (2022). Analisis bibliometrik: sustainability in higher education institutions (heis). *Bookchapter Ekonomi Universitas Negeri Semarang*, (1), 1-22.
- Rizqi, I., & Rahmah, N. (2023). Peningkatan keterampilan geografis peserta didik di pembelajaran abad 21. *Geography Science Education Journal (GEOSEE)*, 4, 2754–391.
- Saputri, D. F., Wahyudi, W., Nurhayati, N., Nurussaniah, N., & Misbah, M. (2023). Development of electronic modules based on science, technology, engineering and mathematical (stem) approaches in vibration and wave courses. *Jurnal Pendidikan Fisika dan Keilmuan*.
- Shidiq, A. S., Permanasari, A., Hernani, H., & Hendayana, S. (2021). The use of simple spectrophotometer in STEM education: A bibliometric analysis. *Moroccan Journal of Chemistry*, 9(2), 290–300. <https://doi.org/10.48317/IMIST.PRSM/morjchem-v9i2.27581>
- Shofiyah, N., Mauliana, M. I., Istiqomah, I., & Wulandari, R. (2021). STEM approach: The development of optical instruments module to foster scientific literacy skill. *Jurnal Penelitian Dan Pengkajian Ilmu Pendidikan: E-Saintika*, 5(2), 92–103. <https://doi.org/10.36312/esaintika.v5i2.388>
- Suryana, I., Nurhaliza, S., Nisa, S., Helvira, H., Andriani, H., & Fajarwati, S. (2024). Laboratorium Sebagai Pusat Sumber Belajar. *Journal of Law, Administration, and Social Science*, 4(5), 719–727. <https://doi.org/10.54957/jolas.v4i5.878>
- Ummah, E. S., Narjis, K., & Latifatun Niswah, T. (2023). Analisis bibliometrik metode montessori berbasis data scopus. *Murhum : Jurnal Pendidikan Anak Usia Dini*, 4(2), 464–475. <https://doi.org/10.37985/murhum.v4i2.189>
- Wibowo, F. C., Prahani, B. K., Kurniawan, B. R., Brata, W. W. W., Budhi, H. S., Noor, F. M., Fawaida, U., Jamaludin, D. N., Jalil, M., Ahmad, N. J., Costu, B., & Karlin, K. A. A. (2024). Challenges of STEM approach in physics learning: A bibliometric analysis. *AIP Conference Proceedings*, 3116(1). <https://doi.org/10.1063/5.0210180>
- Yudhoyono, A. H., Sukoco, B. M., Maharani, I. A. K., Putra, I. K., & Suhariadi, F. (2025). Bridging the gap: Indonesia’s research trajectory and national development through a scientometric analysis using SciVal. *Journal of Open Innovation: Technology, Market, and Complexity*, 11(1), 100505. <https://doi.org/10.1016/j.joitmc.2025.100505>

AUTHOR PROFILES



Fakhira Nursabrina

Fakhiranursabrina0517@gmail.com

Master’s Program in Physics Education, Faculty of Mathematics and Natural Sciences, Universitas Negeri Jakarta

https://scholar.google.com/citations?view_op=list_works&hl=id&user=lAKeWEUAAAAJ

<https://orcid.org/0009-0005-5654-2479>



Bambang Heru Iswanto

bhi@unj.ac.id

Master's Program in Physics Education, Faculty of Mathematics and Natural Sciences, Universitas Negeri Jakarta

https://scholar.google.ca/citations?view_op=list_works&hl=en&hl=en&user=UVifepQAAAAJ

<https://sinta.kemdikbud.go.id/authors/profile/6166289>

<https://orcid.org/0000-0002-6545-5036>

<https://www.scopus.com/authid/detail.uri?authorId=35795703200>



Hadi Nasbey

hadinasbey@unj.ac.id

Master's Program in Physics Education, Faculty of Mathematics and Natural Sciences, Universitas Negeri Jakarta

<https://scholar.google.com/citations?user=0FBdSd8AAAAJ&hl=en>

<https://sinta.kemdikbud.go.id/authors/profile/6688243>

<https://orcid.org/0000-0003-2883-9943>

<https://www.scopus.com/authid/detail.uri?authorId=56458880500>



Firmanul Catur Wibowo

fcwibowo@unj.ac.id

Master's Program in Physics Education, Faculty of Mathematics and Natural Sciences, Universitas Negeri Jakarta

https://scholar.google.co.id/citations?hl=id&user=9K5q_-kAAAAJ

<https://sinta.kemdikbud.go.id/authors/profile/5979798>

<https://orcid.org/0000-0003-2883-9943>

<https://www.scopus.com/authid/detail.uri?authorId=57191545325>