ESENSI: Jurnal Riset Pendidikan
Vol. 1, No. 2, Juni 2025, pp. 41-49
eISSN 3089-3615 | https://ejournal.gemacendekia.org/index.php/esensi

Systematic Literature Review: E-Module Development with PBL Approach to Enhance Students' Critical Thinking and Creativity in Science Education

Adisan[1*], Agus Ramadan[2], Abdul Syukur[3], Aris Doyan[4]

[1-4] Postgraduate, University of Mataram, Mataram, Indonesia
*Email: rafifrafan552288gmail.com

ABSTRACT

Critical thinking skills are one of the core competencies in 21st-century education, especially in science learning that emphasizes analysis, evaluation, and problem solving. This study aims to identify trends and research focuses on critical thinking in the context of science education through a bibliometric approach. Data were collected from the Dimensions database using the keywords "critical thinking" and related terms in the period 2010–2024. Bibliometric analysis was conducted using VOSviewer software to map the main keywords, the network of relationships between terms, and the temporal dynamics of publications. The results show that the keywords "critical thinking", "local wisdom", "module", "STEM", and "elementary school" emerged as dominant themes. The problem-based learning (PBL) approach, integration of local wisdom values, and the use of contextual modules are the most frequently studied strategies in an effort to improve students' critical thinking skills. Temporal analysis shows a spike in publications since 2020, indicating increasing attention to the importance of developing critical thinking in the science curriculum. These findings provide strategic directions for curriculum development, learning innovation, and educational research in the future.

Article History
Received 2025-06-04
Revised 2025-06-18
Accepted 2025-06-24

Keywords
Module,
Local Wisdom,
Critical Thinking

INTRODUCTION

Critical thinking skills are one of the main competencies in 21st century education and are the focus of attention in curriculum development in various countries, including Indonesia. These skills enable students to analyze information logically, evaluate arguments, and make evidence-based decisions (Facione, 2011; Ennis, 2015). In the context of science education, critical thinking is very essential because science requires not only conceptual understanding but also reflective thinking about scientific phenomena (Zubaidah, 2016; Nuryani et al., 2020; Qarareh, 2016). Therefore, the integration of critical thinking skills in science learning needs to be carried out systematically and based on the right approach.

Several studies have shown that the application of innovative approaches such as Problem-Based Learning (PBL), STEM (Science, Technology, Engineering, and Mathematics), and other constructivist approaches contribute significantly to improving students' critical thinking skills (Savery, 2006; Çevik, 2017; Semerci, 2000; Çınar et al., 2022; Dwyer et al., 2022; Mahanal et al., 2019; Irfannuddin et al., 2020; Sahyar et al., 2017). Contextually designed STEM-based learning has also been shown to be able to develop students' scientific skills and reflective thinking (Astalini et al., 2021; Hidayat et al., 2020). In addition to the approach, the use of relevant learning media, such as contextual modules based on local wisdom, has been proven effective in stimulating high-level thinking processes (Saputro et al., 2022; Rizal et al., 2021;

How to cite: Adisan, A., Ramadan, A., Syukur, A, & Doyan, A. (2025). Systematic Literature Review: E-Module Development with PBL Approach to Enhance Students' Critical Thinking and Creativity in Science Education. *ESENSI: Jurnal Riset Pendidikan, 1*(1), 1-5. https://doi.org/10.71094/esensi.v1i1.118

Nuswowati et al., 2020). This type of module helps students relate science material to their experiences and their local culture, thereby increasing engagement and understanding (Assefa & Rorissa, 2013; Qarareh, 2016). The combination of problem-based approaches, STEM integration, and local content is a potential strategy in developing critical and meaningful science learning.

On the other hand, the development of critical thinking studies in science education can be seen through bibliometric studies. Recent analysis shows an increase in interest in this topic in the last two decades, but with a distribution that is still scattered and unfocused (Farooq & Shah, 2023; Shahin et al., 2024). Further research reveals that the dominant keywords in scientific publications include "critical thinking", "STEM education", "local wisdom", and "module" (Samsudin et al., 2022; Yıldız & Yıldız, 2024; Tas & Bolat, 2022), but the relationship between these concepts is still not strong conceptually or practically.

Furthermore, recent studies highlight the importance of scientific literacy and critical thinking skills as the foundation for 21st-century learning (Semerci, 2000; Çevik, 2017; Sahyar et al., 2017). Some studies even emphasize the need to develop learning designs that emphasize constructivism and critical reflection in contexts close to students' daily lives (Vallespin, 2024; Irfannuddin et al., 2020). However, there is still a gap in studies related to the simultaneous integration of critical thinking skills, local approaches, and learning technology, especially at the elementary and secondary education levels.

With this background, this study aims to evaluate the trend and direction of critical thinking research in science education through a bibliometric approach. This study will map the growth of publications, collaboration between authors, dominant keywords, and examine the influence of module-based approaches and integration of local wisdom on the development of critical thinking. The results of this study are expected to present a comprehensive scientific map while providing direction for policy making, curriculum development, and future teaching practices.

METHOD

This study uses a quantitative bibliometric approach to analyze research trends related to critical thinking in the context of science education. The bibliometric approach was chosen because it is able to provide a comprehensive picture of scientific publications, including the number of documents, dominant keywords, relationships between authors, temporal trends, and institutional collaborations systematically and objectively (Donthu et al., 2021; Aria & Cuccurullo, 2017). With this method, researchers can map the landscape of knowledge that has developed and the future direction of research in related fields.

The data in this study were sourced from *Dimensions.ai* , a multidisciplinary scientific database that includes journal articles indexed by Scopus, Web of Science, Crossref, and PubMed. The selection of Dimensions was based on the completeness of metadata, broad document coverage, and integration with relevant scientific metrics. Data collection was conducted in April 2025 using a combination of keywords such as "critical thinking", "science education", "STEM", "problem-based learning", "module", "local wisdom", and "elementary science". The search results were filtered based on the year of publication from 2010 to 2024, the type of document in the form of a scientific journal article, and the language of publication which includes English and Indonesian. Based on these filters, 298 relevant documents were obtained and further filtered using inclusion and exclusion criteria.

The data analysis process was carried out with the help of VOSviewer software version 1.6.19. This software is used to analyze keyword frequency through *co-occurrence analysis*

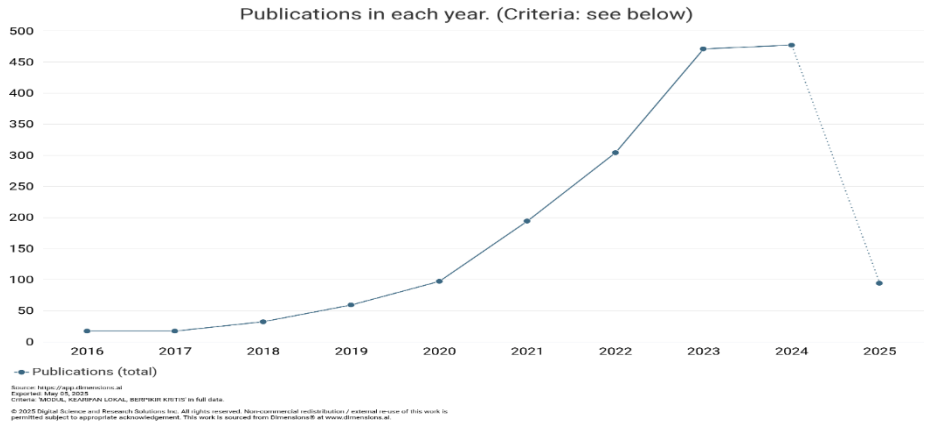
techniques, map collaboration networks between authors and institutions, and visualize relationships between topics and temporal developments. The steps taken include metadata extraction in CSV format, cleaning data from irrelevant and duplicate keywords, and importing data into VOSviewer to create network maps and clustering. Interpretation is done by paying attention to node size (indicating frequency), color (representing topic clusters), and connecting lines (indicating the strength of the relationship between elements).

To ensure the validity and reliability of the analysis results, triangulation was carried out by comparing the visualization results with data from the Scopus database and involving two bibliometric experts in reviewing the resulting visual map. If ambiguity was found in the meaning of keywords or cluster mapping, then a consensus re-arrangement was carried out to maintain the accuracy of data interpretation. With this approach, the analysis results are expected to provide a valid and representative picture of the development of critical thinking research in science education.

This study analyzes publication trends from 2016 to 2025 related to the development of learning modules that integrate local wisdom and critical thinking. Based on Figure 1, research activities in this field show a consistent increase from year to year, especially from 2020 to 2023, reflecting the increasing academic attention to the topic. The sharpest increase occurred between 2021 and 2022, where the number of publications more than doubled. However, in 2025, there was a significant decline in the number of publications recorded at less than 100. This decline was likely due to incomplete data, considering that the data was extracted in early May 2025 so that the publications for that year were not yet fully inputted. Overall, this trend suggests a peak in research interest in 2022 to 2024, followed by a decline that appears to be temporary.

RESULTS AND DISCUSSION

This study uses research documents from the research trend of integrated e-module development of local wisdom with the PBL model in science learning to improve student creativity in 2016-2025 . Figure 1 related to research trends shows that research increases occurred in 2016 and 2020. There has been an increase in the last 10 years in the frequency of studies, from 25 studies.



Picture 1 Research Trends in the Every Year

Picture 1 presenting types of research related to the development of ethnoscience-based e-modules integrated with the help of Google Sites and using project-based learning models in science learning at the junior high school level to improve student creativity.

Table 1 Number of Research Publications on the development of ethnoscience-based e-modules

Types of article publications	Publication
Article	1,663
Edited book	75
Proceeding	15
Chapter	14
Monograph	8

Based on the results presented in Table 1 related to the types of research publications from the development of ethnoscience-based e-modules integrated with the help of Google Sites and using project-based learning models in science learning at the junior high school level to improve student creativity, there are five types of publications. These types of publications include articles, edited books, proceedings, chapters in books, and monographs. The largest number of publications was articles with a total of 1,663 publications, while the smallest number of publications was monographs, namely 8 publications.

Table 2 Trends in the top 5 research source titles

Name	**Publication**	**Quote**	**Meaningful Quotes**
Advances in social science, education and humanities research	80	130	1.63
Science Education Research Journal	66	269	4.08
Bacedu journal	48	633	13.19
Educational journal of educational science	38	101	2.66
Journal of early childhood education obsession	27	141	5.22

This table presents the top five sources used in education research based on the number of publications, citations, and average citations per publication. The source with the largest number of publications is *Advances in Social Science, Education and Humanities Research* which recorded 80 publications and 130 citations, with an average citation rate of 1.63. This source is known as part of Atlantis Press, an international open access publisher that publishes proceedings, journals, and scholarly books in the social sciences, education, and humanities. In second place, *Jurnal Penelitian Pendidikan IPA* recorded 66 publications with 269 citations and an average of 4.08 citations per publication, indicating that the publications from this journal are quite influential in the field of science education.

Interestingly, *Jurnal Bacedu* has the greatest influence individually with 48 publications that collect a total of 633 citations, resulting in the highest average citation of 13.19. This shows that although the number of articles is smaller than other sources, each article from this journal is very often referred to in other studies. Meanwhile, *Edukatif: Jurnal Ilmu Pendidikan* with 38

publications and 101 citations has an average of 2.66 citations per publication, indicating its contribution to the dissemination of educational theory and practice studies. Meanwhile, *Jurnal Obsesi: Pendidikan Anak Usia Dini* recorded 27 publications with 141 citations, and an average citation of 5.22, indicating a fairly strong influence especially in early childhood education research.

Table 3 Top 5 research citation

Citations/ year	Year	Writer	Title
926	2022	You are the prophet	Development of teaching modules based on the independent curriculum
79	2023	Nurhayati, E, Andayani, Y	Character Education Through Learning Hybrid Based on Local Wisdom to Develop Student Potential.
70	2022	JREM NO	Problem-based learning model as efforts to improve critical thinking skills in biology learning.
46	2021	Agnesa, OS, Rahmadana, A	Development of STEM-based chemistry e-modules with an ethnoscience approach
44	2022	Widiya, M, Lokaria, E, Sepriyaningsih, S.	The role of local wisdom-based modules to support independent learning education. Elementary Education Proceedings.

Table 3 presents information related to the top 5 citations on research trends on the development of integrated ethnoscience e-modules assisted by Google sites with project-based learning models in science learning for enhance students' creativity.

Table 4 Research trend keywords

provision	Incident	Relevance
Engineering	3	4.95
Technology	4	3.95
Local wisdom based inquiry module	3	2.50
Science	5	1.79
draft	7	1.65

The results of the research landscape map visualization represent the visual of scientific research subjects. The results of bibliometric mapping on the shared word network in articles related to the topic of developing integrated e-modules of local wisdom assisted by the Google site with a project-based learning model in science learning to improve student creativity are illustrated in Figure 2.

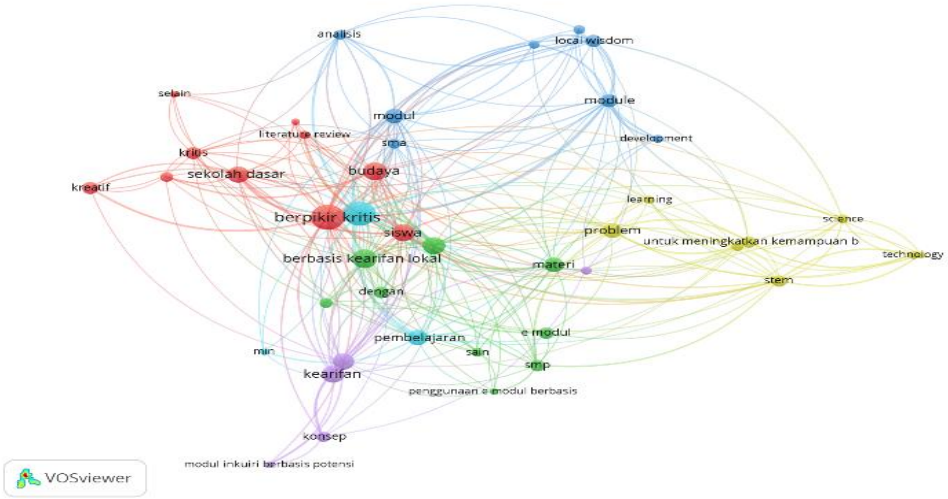


Figure 2 Visualization of the research network

Based on the visualization results presented in Figure 2, the results of the bibliometric keyword mapping of research trends from the development of integrated e-modules of local wisdom assisted by the Google site with a project-based learning model in science learning to improve students' critical thinking creativity, there are 40 keywords that are often used in the research from 2020 to 2025. The figure also produces a research network visualization that shows the network between the visualized terms.

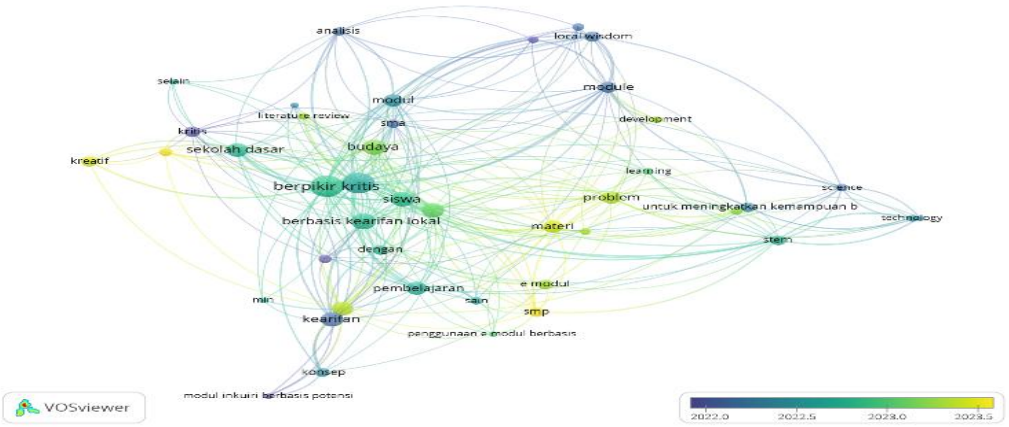


Figure 3. Overlay Visualization

The visualization presented in Figure 3 is an overlay visualization. This visualization is an overlay service visualization to show the historical trance of research. The darker the bibliometric trace produced, the longer the research was completed (Habibi et al, 2022). This research trend was completed from 2016 to 2025. The research trend that has the darkest color here is local wisdom, school, student, science, model, integrated, location wisdom project,. This research is popular in 2022. Meanwhile, it is rarely done or has a light color in investigation and research.

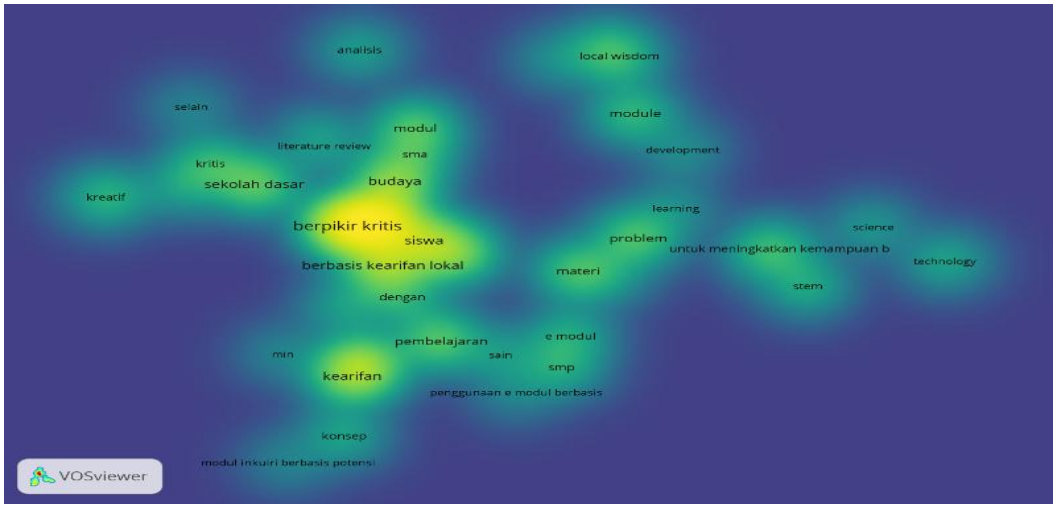


Figure 4 Density visualization

Density visualization is done to help identify the level of connectedness between terms or topics that appear in the studies analyzed (Fauddin et al., 2023). Terms that appear larger and clearer in the visualization indicate a higher level of dominance or frequency of occurrence. In the context of this study, some of the most prominent main topics include *publication*, *citation* , *journal*, and *education*. Meanwhile, a number of other terms that appear but are not too dominant include *early childhood*, *science learning*, *influence*, *impact*, *open access*, *average citation*, and *pedagogy.* In general, research that reviews the contribution of various scientific journals in the field of education, especially those that highlight the effectiveness of publications and citations, is important to show the direction and quality of the development of educational science in Indonesia. This is also relevant to efforts to improve the quality of research and scientific publications as part of the implementation of the Independent Curriculum, which emphasizes strengthening critical, collaborative, and reflective thinking competencies (Anggelia et al., 2022). Through mapping influential journals, educational researchers and practitioners can be more selective in choosing strategic references and publication targets to strengthen their scientific contributions.

CONCLUSION

The results of the study indicate that research on the development of local wisdom-based e-modules that integrate *Google Sites* with the *Project-Based Learning approach* in science learning is still relatively minimal in recent years. The number of relevant study findings is relatively limited, reflecting a decline in interest or lack of exploration of this topic. This tendency indicates a gap in the development of scientific studies that combine local context, technological innovation, and efforts to increase student creativity in science education.

The low frequency and density of occurrence of important keywords such as “local wisdom”, “Google Site”, and “student creativity” in the data analysis strengthens the indication that this topic has not received adequate attention and is still scattered without strong integration. This situation is actually an opportunity for future research to develop a more comprehensive and contextual learning approach. Strategic efforts are needed in designing digital teaching tools that not only reflect local cultural values but are also able to stimulate student creativity through authentic project-based learning activities, by utilizing easily accessible technology such as *Google Sites* . This initiative is also in line with the spirit of curriculum development that emphasizes the importance of 21st century skills.

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