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Instructional Materials Based on Generative Learning Models in Context of Science and Physics Learning: A Bibliometric Analysis

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ABSTRACT

Developing instructional materials based on the generative learning model has become critical in science and physics education. However, a systematic analysis of research trends in this domain must be more conspicuously present. This study aims to conduct an in-depth analysis of research investigating the impact of generative learning model-based instructional materials in science and physics education, encompassing their classification and trends and identifying potential research variables for future scholarly investigations. The methodological approach employed a literature review utilizing bibliometric analysis, initiating with the definition of keywords "generative learning model" and "journal" within the Publish or Perish application and using Google Scholar as the primary database. A systematic filtering process was applied to the search results, identifying 10 pertinent articles within the "Science and Physics" domain from an initial pool of 200 publications. Researchers utilized Mendeley and Vosviewer to compile metadata and visualize research trends. Findings indicated that research on generative learning models in science and physics clusters into two primary categories: generative learning models, conventional learning approaches, learning outcomes, population characteristics, and pedagogical influences. However, this study's limitations, stemming from the restricted article sample, underscore the need for future research to explore a broader range of topics.

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INTRODUCTION

Indonesia's education field has significantly advanced, particularly in Natural Sciences and Physics. As these advancements continue, there is an increasing need for innovative learning methods to enhance students' comprehension and skills. One promising approach in the Indonesian educational context is generative learning, which requires active knowledge construction through learning materials acquired by students (Mariana et al., 2023). Additionally, bibliometric analysis provides valuable insights into influential educational trends and practices (Suryaningsih & Nurlita, 2021) In science and physics learning, developing appropriate instructional materials is crucial for actively engaging students, especially during the challenges posed by the COVID-19 pandemic. Using Problem-Based Learning (PBL) and e-learning-based instructional materials has proven feasible and effective in enhancing students' learning experiences in physics and mathematics education (Ginting & Bukit, 2023; Moradi et al., 2018; Pujayanto et al., 2017)

Analysis of effect sizes has shown that science teaching materials based on scientific approaches significantly influence students' learning outcomes (Dwita Fitri et al., 2023). Implementing interactive teaching approaches has improved student learning outcomes in science and physics education. It is important to note that the influence of different teaching approaches, particularly experiment-based ones, can significantly impact female students' motivation to learn physics. In the current educational landscape, active student involvement in the learning process is essential. For this reason, developing instructional materials accommodating various learning styles and preferences is crucial in promoting effective communication and understanding in physics and mathematics education (Asrizal et al., 2023). Furthermore, the impact of physics learning on improving students' generic science skills has become a subject of interest, emphasizing the importance of identifying the most effective learning models to enhance student's overall science skills (Dhanil et al., 2024). Research in science and physics education has demonstrated that generative learning models offer numerous benefits, such as improving students' general science proficiency, as evidenced by guided inquiry-based physics learning models (Mariana et al., 2023). Additionally, the development of innovative electronic student worksheets (E-SWS) underscores the adaptability of generative learning models to technological advancements, which can significantly enhance learning quality (Suryaningsih & Nurlita, 2021).

Educators apply generative learning models relevant to student needs in science and physics learning. For example, research on developing Ethno-STEM integrated digital teaching materials shows that this approach can enrich science learning with locally relevant contexts for students (Agusti et al., 2024). Implementing digital-based learning materials has also positively improved students' conceptual understanding and new literacy (Asrizal et al., 2023, 2024). It is essential to understand that generative learning models have great potential to enhance student skills in science and physics education. For instance, developing STEM-integrated interactive multimedia to improve students' data and technology literacy demonstrates that this approach can positively impact students' progress in understanding complex physics concepts (Ahzari & Asrizal, 2023)

A thorough understanding of generative learning models within science and physics education is essential to provide effective and tailored learning approaches for students. The author is interested in conducting a "Bibliometric Analysis of Generative Learning Models in Indonesia in Science and Physics Learning," which aims to address several key research questions. These questions include: (1) How can we classify the impact of generative learning models on science and physics education? (2) What are the current trends in research on the relationship between generative learning models and science and physics education? Moreover, (3) Is there potential for further research on this topic?

METHODS

The research methodology employed in this study involves a literature review utilizing a bibliometric approach. Bibliometric analysis serves as a method to investigate the development of the research domain, encompassing subjects and authors, by examining the discipline's social, intellectual, and conceptual structure (Donthu et al., 2021). This analytical approach is widely utilized across diverse disciplines and focuses on quantitatively examining journal papers, books, or other written forms of communication. The current research adopts the bibliometric analysis approach, following the five-step framework outlined by (Fahimnia et al., 2015). These steps involve defining keywords, in this case, "Generative Learning Model," conducting an initial search, refining the search results, compiling statistics on the initial data, and analyzing the collected data.

Defining and Initial Search Keywords

In January 2024, researchers conducted a thorough literature search utilizing the 'Generative Learning Model' keyword. The PoP software facilitated our search, which drew from Google Scholar's extensive database. To ensure the highest quality results, we carefully specified that our search should be limited to published scientific articles in reputable journals, excluding other publications. From the Google Scholar database, we obtained 200 articles in the initial search.

Refinement of the Search Results

The researchers eliminated articles that failed to meet the screening criteria. Table 2 presents the outcome of this screening procedure. This study selectively incorporated references cited in pertinent articles that fulfilled the established inclusion criteria. From the initial set of 200 articles, after the first round of selection, 57 articles were obtained. Subsequently, a further selection based on specific criteria resulted in an outcome of 10 articles that are relevant to this research. After meticulously examining the publication year, title, and abstract, we excluded 143 articles for various reasons.

Compiling Statistics on the Initial Data

This article presents a bibliometric analysis for the keyword' Generative Learning Model', and then the search is narrowed to 'Science and Physics Learning' from the Google Scholar database. This study employed The PoP application for bibliometric analysis, acquiring 200 articles from the initial search, accompanied by 59 citations. The subsequent refinement of search results, categorized according to predetermined criteria, led to a final set of 47 articles. The authors subsequently filtered and summarized the articles to focus on generative learning models in science and physics education, yielding 15 relevant studies. Table 1 provides a comprehensive overview of the results.

Table 1. Top Ten Articles identified by PoP (Publish or Perish)

Authors	Titles	Cited by
(Yatmi et al., 2019)	The Impact of Generative Learning Models on Critical Thinking Skills in Physics Considering Students' Prior Knowledge	19
(Sari et al., 2018)	The Impact of Environment-Based Generative Learning Models on Science Knowledge Proficiency	12
(Hendriansyah et al., 2018)	Utilization of Generative Models in Physics Education to Enhance Student Academic Achievements and Address Misunderstandings	7
(Sadewi, et al., 2020)	Generative Learning Model Supported by Tangible Media for Science Knowledge Proficiency	6
(Maryani et al., 2020)	The Impact of the Generative Learning Model with the Pq4r Method Through Scaffolding on Students' Physics Problem-Solving Proficiency	6
(Hikmawati, 2019)	The Impact of Generative Learning Models Using Guided Teaching Techniques on Class XI Physics	3

	Problem-Solving Skills	
(Saputri et al., 2020)	Efficiency of Developing High School Physics Student Worksheets Based on Generative Learning Models	2
(Sudirman, 2022)	The Efficiency of Generative Learning Models on Students' General Physics Proficiency in Momentum and Impulse Material	1
(Laksono et al., 2020)	Integration of Remediation of Misconceptions About Waves Through Generative Learning Models for Students at SMA Negeri 2 Pontianak	1
(Sharfina et al., 2020)	Improving Students' Creative Thinking Skills Through Generative Learning Models on Expansion Concepts at SMA Negeri 3 Bireuen Class X	1

Table 2. Article Screening Results

Search screening	The Number of Articles
< 2018	70
Non-Generative Learning Models	12
Not a Journal	56
Topic Generative Learning Models	57
Generative Learning Model in Science and Physics Learning	10
Total	200

Data Analysis

This article presents a bibliometric analysis for the keyword 'Generative Learning Model', and then the search is narrowed to 'Science and Physics Learning' from the Google Scholar database. The PoP application was employed for bibliometric analysis in this study, acquiring 200 articles from the initial search, accompanied by 59 citations. The subsequent refinement of search results, categorized according to predetermined criteria, led to a final set of 47 articles. After that, it was summarized and narrowed to articles discussing generative learning models in science and physics learning, which were narrowed down to just 15 articles. The complete results can be seen in Table 1.

RESULTS AND DISCUSSION

Results

According to research findings, the article titled "The Impact of Generative Learning Models on Critical Thinking Skills in Physics Considering Students' Prior Knowledge" by Yatmi, H. A., Wahyudi, W., & Ayub, S. is the most widely recognized among researchers exploring generative learning models in science and physics. It has garnered 19 citations in research trends. The second most referenced article is "The Impact of Environment-Based Generative Learning Models on Science Knowledge Proficiency" by Ekasari, N. L. P., Putra, D. K. N. S., & Abadi, I. S., with 12 citations.

After assessing citation frequency and additional metrics, the authors employed the PoP tool to examine their results and illustrate the most frequently appearing keywords using the VOSviewer application. This tool generates bibliometric maps, which can be observed through three distinct perspectives: network, overlay, and density visualization.

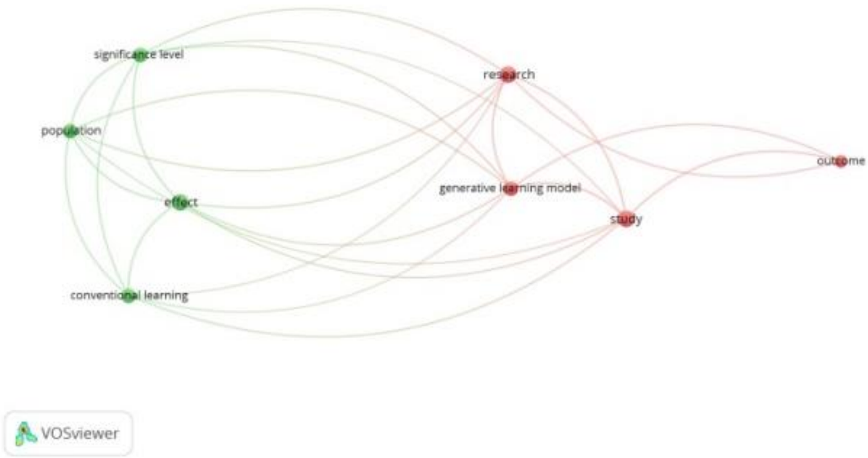

Figure 1. Research Trend Map Visualization

The PoP application analysis reveals two main clusters in research on teaching materials based on generative learning models. The first cluster emphasizes aspects of the generative learning model itself, encompassing its implementation and effectiveness in learning. The second cluster compares conventional learning, demonstrating how these two approaches interconnect in research. Both clusters exhibit an identical occurrence value of 3, demonstrating researchers' balanced attention to both aspects. The interconnection between clusters illustrates how researchers frequently compare generative learning models with conventional methods to measure effectiveness. This visualization also identifies research gaps in developing teaching materials based on generative learning models that require further exploration.

We conducted a density analysis using VOSviewer to gain deeper insights into the research intensity across various aspects of generative learning models. The density visualization in Figure 2 highlights the most extensively researched areas in the context of teaching materials based on generative learning models. Brighter colours indicate topics that appear more frequently in the research.

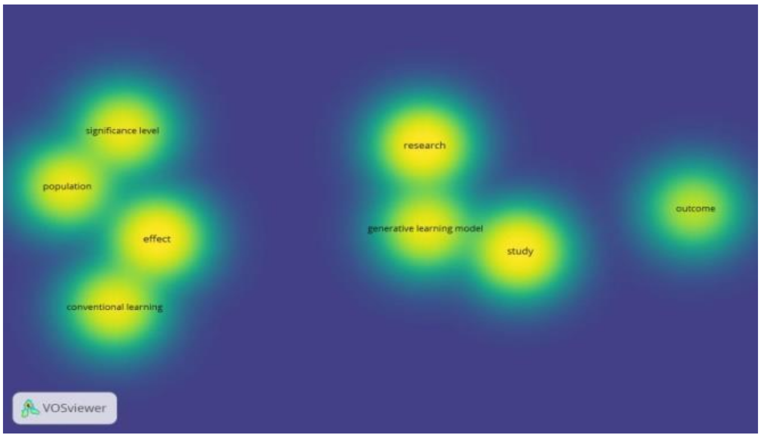

Figure 2. Visualization of Research Trend Density

The density visualization in Figure 2 reveals several important findings in the research development of teaching materials based on generative learning models. The highest density areas appear in zones related to learning outcomes and critical thinking skills, indicating these aspects receive the most research attention. The second zone with medium density encompasses aspects of teaching material development and its implementation in science and physics learning. The density distribution also identifies research gaps in long-term evaluation and technology integration in teaching materials. This density pattern provides clear insights into current research focus areas and domains that require further exploration. These findings offer valuable guidance for future research directions.

Discussion

The generative learning model is an instructional approach that demands students actively explore their prior knowledge and connect it with the new knowledge they are learning (Rizaldi & Amri, 2022). Anggriani et al., (2022) found that implementing the generative learning model impacts students' process skills and learning outcomes. Halmuniati et al., (2022) demonstrated that the generative learning model positively influences learning outcomes in physics. In another context, the generative learning model has enhanced students' mathematical communication skills (Jusniani & Nurmasidah, 2021).

The research findings revealed several important insights into developing instructional materials based on the generative learning model. First, researchers identified two primary research clusters, focusing on model effectiveness and comparisons with conventional learning approaches. Second, density analysis uncovered that learning outcomes and critical thinking skills were the primary research focus. Third, the analysis revealed a critical research gap in generative learning models' long-term evaluation and technology integration aspects. Fourth, citation patterns indicated increasing research interest in developing instructional materials based on the generative learning model. Fifth, research trends are moving towards technology integration and local context in instructional material development. These findings provide valuable implications for educators, instructional designers, and researchers seeking to enhance student learning outcomes through effective instructional materials.

The researchers limited the analysis to articles on Google Scholar, acknowledging the potential exclusion of relevant research from other databases. Second, the limited research timeframe might only capture some recent developments in the field. Third, the focus on science and physics instructional materials limits the generalizability of findings to other study domains. Fourth, the number of analyzed articles could have been higher due to strict selection criteria. Fifth, restricted access to complete articles may have influenced the depth of analysis.

CONCLUSION

This study, 57 articles were examined to explore the generative learning model. The researchers employed Publish or Perish (PoP) software to search the Google Scholar database, identifying ten articles on applying generative learning models in science and physics education. After filtering the initial pool of 200 articles, the refined search based on predefined categories resulted in ten articles ultimately included in the review. The study revealed potential areas for future research on generative learning model instructional materials and their impact on science and physics education. As this topic gains momentum, fostering research collaboration across sub-topics such as learning outcomes, processes, populations, media, and learning model influences becomes crucial. By exploring these domains, we can develop a more comprehensive understanding of instructional materials and generative learning models and enhance our knowledge of effective educational practices.

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