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Bibliometric Analysis of Electronic Student Worksheets Research Trends in Physics Learning in Indonesia

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ABSTRACT

The rapid development of technology in education encourages the use of digital learning materials such as the Electronic Student Worksheets to improve the effectiveness of physics learning. However, comprehensive mapping of Electronic Student Worksheets research trends in Indonesia remains limited. This study aims to analyze publication trends, research characteristics, topic relationships, and identify research gaps related to Electronic Student Worksheets in physics learning in Indonesia. This research employs a bibliometric analysis approach by integrating the PRISMA method as a guideline for the identification, screening, and eligibility assessment of articles. Data were collected from Google Scholar and Scopus databases using the keyword. "Electronic Student Worksheets" and "Physics Learning," covering the period 2020–202. Through the PRISMA flow, 506 eligible articles were obtained after screening and removing duplicates. Data analysis was conducted using Publish or Perish (PoP) and VOSviewer software through three visualization types: network visualization, *overlay visualization, and density visualization to explore keyword relationships, topic trends, and research density. The results show that Electronic Student Worksheets publications have increased significantly since 2022, dominated by studies at the senior high school level and using applications such as Augmented Reality, Flip PDF, Wizer, Phet, and Liveworksheet, meanwhile the learning models that are often integrated are Problem Based Learning and Project Based Learning. Seventeen topic clusters and seventy-nine keywords were identified, with emerging themes including differentiated learning, socio scientific issues, and renewable energy material. The study concludes that Electronic Student Worksheets research trends are growing rapidly but remain limited to specific education levels and general topics. Future researchers are advised to expand the scope to vocational and higher education levels and explore teacher involvement in the development and implementation of Electronic Student Worksheets in Indonesia.*

INTRODUCTION

Education in the 21st century demands continuous innovation to meet the challenges of a rapidly changing world. One of the central elements of this transformation is the integration of digital technology into learning processes, which has created opportunities for

more interactive and adaptive educational experiences (Hikmah et al., 2023;Novitra et al., 2021). In this context, teaching materials are an important component of learning tools that function as learning resources that support the learning process (Permata et al., 2024), so they also need to transform to follow developments in digital technology so that learning becomes more effective and relevant to the needs of the 21st century. The digitalization of education is no longer an option but a necessity. Among the various technological integrations in education, the Electronic Student Worksheets has emerged as a significant innovation that aligns with the principles of the Independent Learning Curriculum, emphasizing flexibility, creativity, and independent learning (Martiani & Subali, 2024); (Basuki & Ramadhan, 2023; Suratmi et al., 2023).

Electronic Student Worksheets provides a platform where students can access materials, submit assignments, and receive feedback electronically, thus fostering more efficient and engaging learning experiences (Ariska & Aini, 2022). In the context of physics education, which involves abstract and complex concepts, Electronic Student Worksheets plays an essential role in helping students visualize phenomena and enhance conceptual understanding (Wahyuniyati et al., 2025). In addition, for example, Electronic Student Worksheets provides students with the opportunity to learn independently at their own pace, while still supporting collaborative learning through group discussions (Suryaningsih & Nurlita, 2021). Research shows that Electronic Student Worksheets based learning improves student motivation, critical thinking, and achievement through integration with innovative models such as Project Based Learning, Problem Based Learning, and Inquiry Learning (Annifah et al., 2024; Armanda & Putra, 2023; Jati et al., 2024). However, despite its increasing popularity, most studies on Electronic Student Worksheets remain fragmented and limited to product development or small-scale classroom implementations, without providing a holistic picture of the overall research landscape.

Several studies have addressed the use of digital media in physics learning, but few have systematically mapped how Electronic Student Worksheets research in Indonesia has evolved over time. For instance, Dawana et al. (2022) conducted a bibliometric study on e-books in physics learning, revealing a significant increase in publications over five years, yet their analysis was limited to general digital media without focusing on Electronic Student Worksheets. Similarly, Martiani & Subali. (2024) examined Electronic Student Worksheets research in the context of STEM learning but only reviewed 13 journal articles, leaving many aspects of Electronic Student Worksheets development in physics unexplored. Jaya et al. (2024) also employed bibliometric analysis to map research trends on students' science process skills, identifying 203 related publications but not addressing the integration of Electronic Student Worksheets as a learning innovation. These limitations indicate that while Electronic Student Worksheets has been studied in various contexts, there is still a lack of systematic mapping that identifies dominant themes, key contributors, and research gaps in the field.

This gap demonstrates the need for a more comprehensive analysis to understand the trajectory of Electronic Student Worksheets research in physics learning. Bibliometric analysis offers a robust and quantitative approach to achieving this goal. As defined by Donthu et al. (2021), bibliometric analysis examines patterns in scientific publications based on metadata such as keywords, authorship, citations, and institutional affiliations. It allows researchers to identify thematic clusters, collaboration networks, and temporal trends in a given research area. Recent advancements in bibliometric software, such as Publish or Perish (PoP) and VOSviewer, have made it possible to visualize complex relationships among research topics through network, overlay, and density visualizations (Van Eck & Waltman, 2009).

By using these tools, the present study seeks to fill the knowledge gap regarding the evolution of Electronic Student Worksheets research in Indonesia. Through bibliometric mapping, it becomes possible to identify which topics are most frequently studied, how they interconnect, and which areas remain underexplored. This approach not only quantifies publication trends but also helps reveal the intellectual structure and emerging frontiers within the domain of Electronic Student Worksheets based physics education. In line with the principles of scientific mapping, such findings can serve as a foundation for formulating new research directions that are data-driven and evidence-based (Abdullah et al., 2023; Zatrahadi et al., 2025). Furthermore, the novelty of this study lies in its integration of multiple databases—Google Scholar and Scopus—to provide a broader and more representative overview of Electronic Student Worksheets research. Previous studies typically relied on a single source, resulting in limited data coverage. By combining these two databases and analyzing over 500 articles from 2020–2025, this research offers an unprecedented overview of Electronic Student Worksheets development in physics learning. It also incorporates visual network analyses to display keyword co-occurrences, thematic clusters, and density maps, thereby presenting both quantitative and qualitative insights.

Compared to earlier studies, this research offers an innovative contribution by not only identifying trends but also exploring the relationships among topics such as "augmented reality," "critical thinking," "differentiated learning," and "renewable energy materials." Such an approach helps reveal how emerging educational themes intersect with Electronic Student Worksheets research in the Indonesian context. This integration of topic modeling and trend mapping represents a step forward in understanding the evolution of digital learning research in physics education. Therefore, the present study aims to: (a) analyze publication trends and research characteristics of Electronic Student Worksheets in physics learning in Indonesia from 2020 to 2025; (b) map keyword relationships and topic clusters through network, overlay, and density visualizations; and (c) identify research gaps and opportunities for future exploration. These objectives are framed within the larger goal of strengthening the empirical foundation for digital learning innovations in science education.

The expected contribution of this research is twofold. Theoretically, it enriches the existing body of knowledge on bibliometric analysis in educational technology, offering a systematic understanding of how Electronic Student Worksheets research has evolved in Indonesia. Practically, it provides valuable insights for educators, curriculum developers, and policymakers to design more adaptive, interactive, and evidence-based learning strategies in physics education. In this way, the study supports the advancement of 21st-century learning and the creation of digital learning ecosystems that are both innovative and pedagogically sound.

METHODS

This research employed a quantitative descriptive approach using the bibliometric analysis method, which aims to systematically describe the trends and characteristics of scientific publications regarding Electronic Student Worksheets in physics learning in Indonesia. Bibliometrics is a scientific field that applies research to bibliographies, literature, and other information media that can be used as tools to evaluate and observe the development of a scientific discipline (Ninkov et al., 2022). Bibliometric analysis is a quantitative technique used to examine and analyze scientific publications based on statistical data from publication metadata, such as the number of articles, frequency of keywords, authors, institutions, publication years, and others (Li et al., 2024). The effective use a bibliometric analysis in compiling a scientific map (Al Husaeni & Munir, 2023).

Bibliometric analysis was chosen because it allows a systematic exploration of various pieces of literature by using publication metadata such as titles, authors, years, keywords, and citation frequencies (Donthu et al., 2021). This approach combines quantitative analysis of publications with visualization of relationships among research elements using supporting software, namely VOSviewer. This type of descriptive bibliometric research is exploratory in nature, as it not only describes the data but also traces potential research gaps that can serve as the basis for future studies. Data collection was conducted online through two academic databases Google Scholar and Scopus via Google Scholar. The selection of these two databases was based on the availability of relevant scientific publication metadata, broad accessibility, and their ability to represent the development of both national research. The research was conducted for one month, analyzing publications from 2020 to 2025, since this period reflects a significant increase in the development of digital learning media following the COVID-19 pandemic and the implementation of the Independent Curriculum in Indonesia.

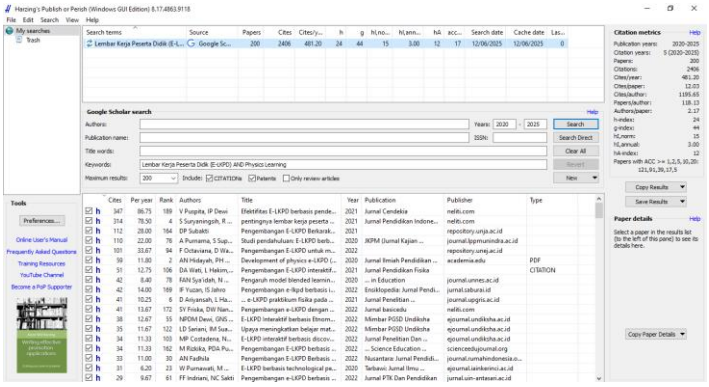

Figure 1. Data Collection Through Publish or Perish

The target or research object of this study is not individuals or respondents, but rather scientific documents discussing the topic of Electronic Student Worksheets in physics learning. The research subjects consisted of 506 scientific articles collected after a screening process from an initial total of 510 publications identified in both databases. The selection process followed the principles of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA**)**, which include four stages: identification, screening, eligibility, and inclusion (Page et al., 2021). This method is designed to assist researchers in compiling, reporting and synthesizing findings from various studies relevant to a particular research topic (Moher et al., 2009). The research procedure is presented in Figure 2 below.

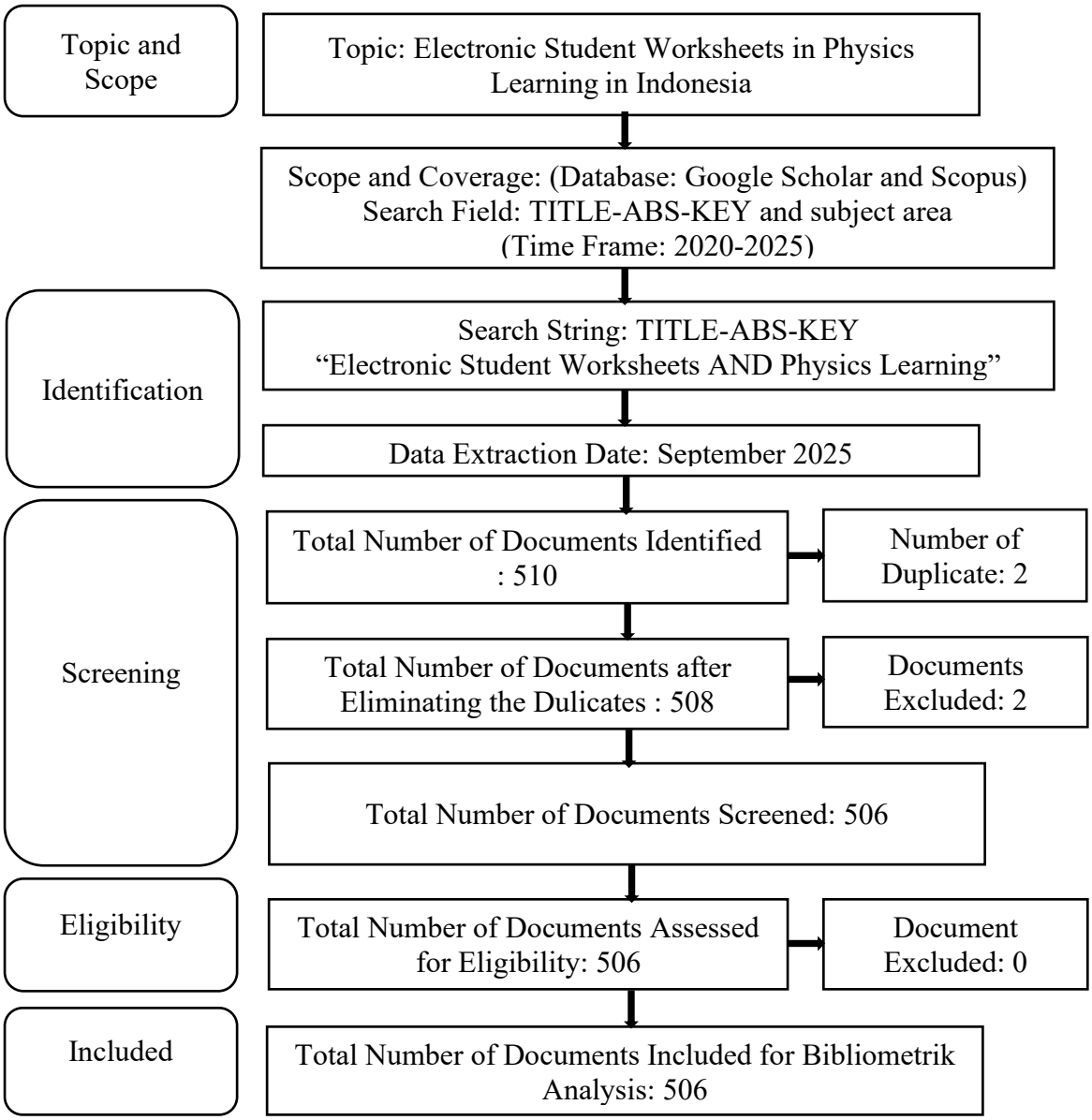

Figure 2. Prisma Diagram
(Page et al., 2021)

In the identification stage, articles were searched using the keywords "Electronic Student Worksheets AND Physics Learning." The screening stage was carried out to remove duplicates and irrelevant publications, while the eligibility stage ensured that the articles met the inclusion criteria—written in Indonesian or English, discussing Electronic Student Worksheets in the context of physics learning, and published within the determined period. The research procedure began with the data collection process using Publish or Perish (PoP) software, which functions to extract publication metadata from the selected databases. The metadata collected included article titles, author names, publication years, journal names, citation counts, and keywords. All data were then exported in two formats, namely CSV (Comma Separated Values) for processing in Microsoft Excel and RIS (Research Information System) for bibliometric analysis using VOSviewer. The exported data from Google Scholar and Scopus were then combined, filtered from duplicates, and normalized through a data cleaning process to ensure consistency and validity of the metadata.

The research instruments used in this study consisted of four main tools, namely Publish or Perish (PoP), Microsoft Excel**,** Mendeley, and VOSviewer. Publish or Perish was used to extract publication metadata such as article title, author, year of publication, journal, dan citations (Vidiasratri et al., 2024), from Google Scholar and Scopus databases. Microsoft Excel was used to categorize, filter, and clean data from duplicate entries. Mendeley was used to manage references and verify article metadata. Meanwhile, VOSviewer served as the main analytical tool to produce bibliometric maps. Graphical representation also facilitates rapid, data-driven decision-making (Puspitaningtyas et al., 2021). This application was used to visualize relationships among keywords *(*co-occurrence*)*, collaborative relationships among authors *(*co-authorship*)*, and the temporal distribution of research topics *(*overlay visualization*)*. The use of these four instruments allowed the researcher to obtain an accurate and comprehensive picture of the development of Electronic Student Worksheets research in physics learning in Indonesia.

The data analysis technique in this study followed bibliometric stages as described by (Hudha et al., 2020), consisting of descriptive analysis and visual analysis. Descriptive analysis was conducted to calculate the number of publications per year, the distribution of document types, the educational levels studied, and the digital platforms used in developing Electronic Student Worksheets. Meanwhile, visual analysis was carried out using network visualization, overlay visualization, and density visualization to map the relationships among research topics and thematic clusters. The results of the analysis were then interpreted to identify relationship patterns, dominant themes, and research gaps that remain unexplored. The interpretation was conducted deductively to draw conclusions relevant to the research objectives.

Overall, this research method was designed to produce a valid and representative bibliometric map of research trends on Electronic Student Worksheets in physics learning in Indonesia. Each procedural stage was conducted systematically and in a measurable manner to ensure that the obtained data could be scientifically justified. The results of this process are expected to contribute to the development of scientific databases on technology-based learning and assist researchers and educators in understanding the direction and focus of research currently developing in the field of physics education.

RESULTS AND DISCUSSION

Results

Research Topic Trends

Search result for articles with keywoards: Electronic Student Worksheet and Physics Learning related to specific keywords in the time span 2020 to 2025. This report provides a very useful overview of the impact and distribution of citations to these publications. The bibliometric analysis revealed a total of 506 articles.

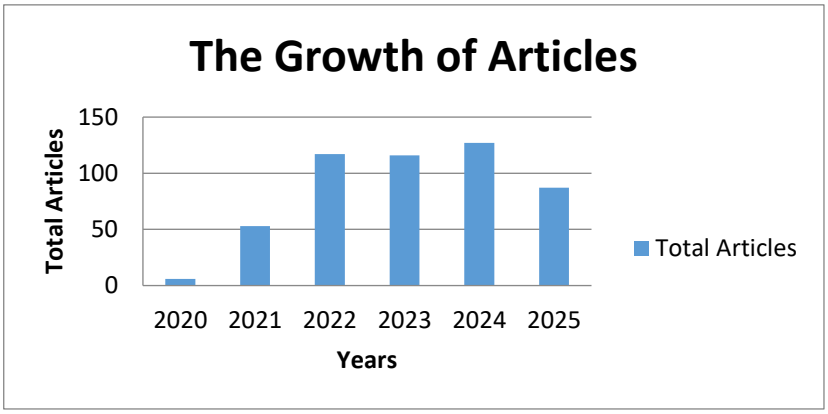

Figure 3: The Growth of Articles

The data in Figure 1 show a significant increase in publication output beginning in 2022. This upward trend indicates a growing scholarly interest in the integration of digital learning materials, especially Electronic Student Worksheets, following the widespread adoption of online and hybrid learning during the COVID-19 pandemic. The sharp growth from 2021 to 2022 (almost 120% increase) aligns with the global digital education shift reported by Donthu et al. (2021). This also reflects how the Indonesian education community began prioritizing the development of interactive and technology-based learning media in response to national education reforms under the Independent Learning framework. Electronic Student Worksheets research was also categorized according to the level of education targeted. Table 1 summarizes the findings

Table 1. Distribution of Electronic Student Worksheets Research by Educational Level

Educational Level	Number of Articles	Percentage (%)
Junior High School (SMP)	28	5.5
Senior High School (SMA)	71	14.0
Vocational School (SMK)	3	0.6
University	2	0.4
General (unspecified)	402	79.5
Total	506	100

Most of the studies (79.5%) did not specify a clear educational level, suggesting that the Electronic Student Worksheets concept has been applied in a generalized context without tailoring to specific learner characteristics. However, among the specified levels, the senior high school group dominates. This can be explained by the nature of physics content taught at this level, which often involves abstract concepts requiring high visualization and simulation, making Electronic Student Worksheets an effective tool. Conversely, the limited research in vocational and university settings shows that implementation of Electronic Student Worksheets remains underdeveloped beyond secondary education — a research gap worth exploring further. Subsequently, present the software and applications used in Electronic Student Worksheets development. Table 2 show the software tools most commonly.

Table 2. Software Used in Electronic Student Worksheets Development

Application/Software	Number of Articles
Flip PDF	6
Liveworksheet	5
Phet	4
Wizer.me	3
Canva	2
Others (Google Form, Wordwall, Quizziz, etc.)	7

The dominance of Flip PDF and Liveworksheet illustrates the popularity of platforms that allow user-friendly design and interactive features. These tools are widely preferred by educators because they require minimal programming knowledge yet provide engaging learning experiences (Armanda & Putra, 2023). Meanwhile, the use of PhET simulations suggests a focus on visualization and conceptual understanding in physics, consistent with findings by Asrizal et al. (2018). However, the limited diversity of software tools highlights a technological dependency on a few platforms, indicating a potential need for exploring open-source or adaptive learning technologies in future Electronic Student Worksheets research.

Research Trend Visualization

The visualization of research trends provides a comprehensive overview of how keywords and research themes related Electronic Student Worksheets in physics learning have evolved over time. Through bibliometric mapping, clusters of keyword can be identified, revealing dominant research focuses and the relationship among emerging topics. A total of 79 keywords were identified across the database. The *co-occurance* analysis generated 17 keyword clusters, each representing a thematic focus area in Electronic Student Worksheets research. Table 3 summarizes selected clusters.

Table 3. Example of Keyword Clusters in Electronic Student Worksheets Research

Cluster	Dominant Keywords	Description
1	Electronic Student Worksheets, Learning Media, Physics	Development of digital worksheets in science education
2	Problem Based Learning, Motivation, Learning Outcomes	Integration of PBL models with Electronic Student Worksheets
3	Critical Thinking, HOTS, Augmented Reality	Digital learning emphasizing higher-order thinking
4	STEM, Differentiated Learning, Creativity	Innovative approaches for modern curriculum
5	Renewable Energy, Environment, Project Based Learning	Electronic Student Worksheets used in contextual science themes

Network Visualization (NV)

The results of the bibliometric analysis using VOSviewer illustrate clustering of topic and the linkages between the key words identified (Ahmad et al., 2022). In Figure 2, different colors are used to visualize different clusters, which represent groups of articles that have similar research focus and topics. This analysis helps in identifying patterns of relationships between different concepts and themes related to research-based science learning and reveals dominant trends and research centers in the existing literature.

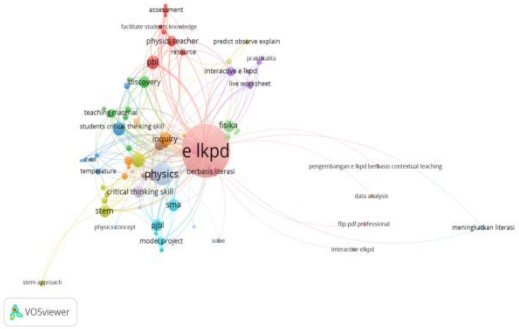

Figure 4. Network Visualization

The network visualization produced by VOSviewer illustrates how keywords are interconnected. Keywords such as Electronic Student Worksheets, motivation, and physics learning are positioned in the core network, forming the backbone of Electronic Student Worksheets research. Peripheral clusters such as Augmented Reality, STEM, and Differentiated Learning represent new intersections between educational technology and pedagogy. The visualization reveals that most research remains practice-oriented, focusing on classroom implementation rather than theoretical model development.

Overlay Visualization (OV)

An overlay visualization was used as a second analysis to map the development of research on Electronic Physics Sudent Worksheets over the years. Figure 3 displays the evolution of changing research themes and focus over time, with timelines highlighting significant periods in the literature. Using this technique, it is possible to observe how research interest in and emphasis on Electronic Physics Sudent Worksheets has evolved from particular aspects of the natural sciences, as well as identify trends and changes in the approaches and methodologies used in this research. This analysis provides an in-depth view of the dynamics of this field of study and how research interests have changed over time.

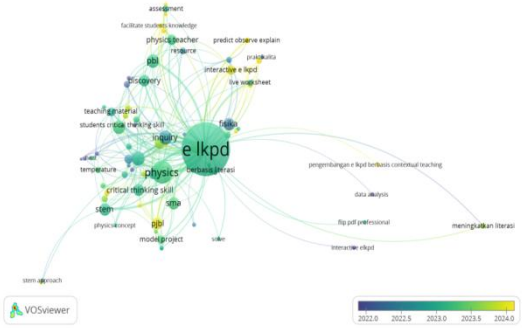

Figure 5. Overlay Visualization

The visualization depicts a spectrum of colors that reflect the level of research use of a topic, from long-standing to relatively new. The difference in color from dark to light indicates the duration of the research, where dark colors indicate research that has been conducted over a considerable period of time, while light colors indicate topics that are still new to research. Clusters with dark colors tend to be older studies compared to brighter clusters, such as yellow and green, which indicate more recent studies. The network visualization produced by VOSviewer illustrates how keywords are interconnected.

Keywords such as Electronic Student Worksheets, motivation, and physics learning are positioned in the core network, forming the backbone of Electronic Student Worksheets research. Peripheral clusters such as Augmented Reality, STEM, and Differentiated Learning represent new intersections between educational technology and pedagogy. The visualization reveals that most research remains practice-oriented, focusing on classroom implementation rather than theoretical model development.

Density Visualization (DV)

The visualization illustrates the intensity of the relationship between these keywords in the analyzed literature, with the size and thickness of the lines indicating how strongly they are related. This density analysis gives an idea of how often and how closely these concepts co-occur in the context of studies on research-based science learning and the development of critical thinking skills in students. This visual data helps to clarify patterns a nd relationships between key concepts in this research domain, and can provide an in-depth view of the focus and shifts in related research over a period of time. he density visualization in the VOSviewer reveals the level of research on various topics, where bright colors such as yellow indicate topics that have been widely researched.

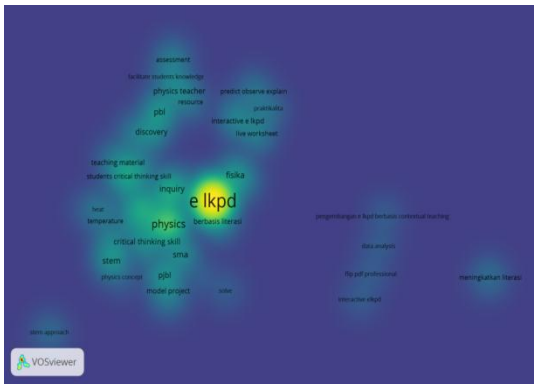

Figure 6. Density Visualization

The density visualization highlights areas of research intensity. The densest regions appear around Electronic Student Worksheets, motivation, and learning outcomes, showing these remain the most extensively studied themes. Meanwhile, low-density areas such as STEM integration and Augmented Reality suggest opportunities for further exploration. These findings imply that while the core objectives of Electronic Student Worksheets research have been well established, innovation in technological integration and learning analytics remains underdeveloped.

Discussion

The findings of this bibliometric analysis indicate that research on Electronic Student Worksheets in physics learning has grown rapidly between 2020 and 2025, with a notable surge beginning in 2022. This increase reflects the growing integration of digital learning media following the acceleration of educational technology adoption during and after the COVID-19 pandemic (Donthu et al., 2021). The dominance of studies at the secondary school level and the frequent use of tools such as Flip PDF, Liveworksheet, and PhET demonstrate that Electronic Student Worksheets has primarily been applied to support conceptual understanding and motivation in learning physics. Similar patterns were also reported by Annifah et al. (2024), who found that digital worksheets based on Problem Based Learning

and Project Based Learning effectively improved students' engagement and achievement. However, this study reveals a gap in research at the vocational and higher education levels, indicating limited exploration of Electronic Student Worksheets implementation in more advanced learning contexts. This gap highlights the need for broader and more diversified research to extend the benefits of Electronic Student Worksheets across all educational stages.

Furthermore, the keyword network and visualization analysis identified 17 thematic clusters and 79 keywords, with central themes focused on learning outcomes, motivation, and critical thinking, while emerging topics such as STEM, socio-scientific issues, and renewable energy materials suggest an ongoing paradigm shift toward contextual and sustainability-oriented learning (Zatrahadi et al., 2025). Compared to previous bibliometric studies, such as Dawana et al. (2022) and Martiani & Subali (2024), which examined digital learning more broadly, this research offers a more focused and comprehensive mapping of Electronic Student Worksheets within physics education, integrating data from both Google Scholar and Scopus. This methodological contribution strengthens the reliability of the findings while revealing new research directions related to interdisciplinary learning and digital pedagogy. Therefore, the present study contributes to the advancement of educational technology by providing a data-driven overview of how Electronic Student Worksheets has evolved and identifying potential areas for future innovation in digital-based physics learning.

CONCLUSION

This study concludes that research on Electronic Student Worksheets (E-LKPD) in physics learning in Indonesia has experienced significant growth, reflecting a broader shift toward digital and student-centered education. Through the PRISMA-guided selection process, 506 relevant publications were systematically identified and mapped, providing a comprehensive overview of the research landscape. The bibliometric visualization revealed that most studies were concentrated at the secondary education level and frequently integrated digital tools such as Augmented Reality, Flip PDF, Wizer.me, PhET, and Liveworksheet. Additionally, the analysis identified seventeen thematic clusters and seventy-nine dominant keywords, indicating a diverse intellectual structure that includes themes such as learning motivation, conceptual understanding, differentiated learning, socio-scientific issues, and renewable energy topics. These patterns show that E-LKPD has evolved from a simple digital worksheet into an innovative pedagogical medium that supports higher-order thinking, contextual learning, and interdisciplinary exploration. The findings also highlight existing research gaps, particularly the limited focus on vocational education, higher education, and teacher involvement in E-LKPD development. Therefore, future research is encouraged to expand into these underrepresented areas and to design more adaptive, relevant, and future-oriented digital learning strategies for physics education.

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