Trends in Practicum Tool Development with PjBL to Improve Digital Literacy, Process Skills, and Learning Outcomes: A Systematic Review

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Abstract: In the context of the rapidly evolving digital era, educational systems worldwide are facing significant challenges in fostering digital literacy, enhancing scientific process skills, and improving overall learning outcomes among students. This article presents a systematic review of the trends in the development of practicum tools utilizing the Project-Based Learning (PjBL) model from 2015 to 2024. The review aims to identify research patterns and provide insights into how these innovative tools can contribute to digital literacy and science process skills. Through the analysis of 1,000 documents indexed by Google Scholar, it is found that research interest surged notably between 2020 and 2023, reflecting a growing emphasis on integrating technology into education. The findings indicate that practicum tools developed under the PjBL model have effectively enhanced students' engagement with scientific concepts and real-world applications. Moreover, the review highlights the predominant types of publications in this field and the most frequently cited sources, shedding light on significant contributions to the ongoing discourse in science education. This research underscores the need for continued exploration and development of technology-based practicum tools to equip students with essential skills for the future.

Keywords: Digital Literacy; Learning Outcomes; Practicum Tools; Pjbl Models; Science Process Skills

Introduction

In the rapidly evolving digital era, education worldwide faces new challenges. One of these challenges is preparing students to develop strong digital literacy, scientific process skills, and optimal learning outcomes (Darmaji et al, 2023). In this context, the use of innovative and technology-based practicum tools has become a major focus in the development of science education (Kamarudin et al, 2024). Project-Based Learning (PjBL) models have proven to be an effective approach in enhancing these skills (Diana & Sukma, 2021).

The development of practicum tools based on the PjBL model not only facilitates more interactive learning but also provides students with the opportunity to experience the scientific process first-hand (Syawaludin et al, 2022). Well-designed practicum tools allow students to apply scientific concepts in real-world situations, develop critical thinking skills, and improve their understanding of the taught concepts (Zulyusri et al, 2023). Therefore, the development of technology-based practicum tools has become a significant trend in education, especially over the past decade (Zhang, 2022).

Digital literacy is increasingly becoming a crucial skill in science education, especially amid the rapid advancements in technology (Hussain & Phulpoto, 2024). Students are expected to not only use technology as an aid but also as a medium to independently explore scientific phenomena (Sahin & Yilmaz, 2020). Additionally, science process skills, which include

observing, analyzing, and drawing conclusions, are a key focus of the project-based learning model (Nasir et al, 2019). The combination of digital literacy and science process skills is essential in preparing students for future challenges (Rizaldi et al, 2020).

Various studies conducted between 2015 and 2024 have shown a growing interest in the development of technology-based practicum tools using the PjBL model (Gani, 2024). These studies not only focus on the effectiveness of the tools in improving learning outcomes but also on how these tools enhance students' skills in effectively utilizing technology (Delgado et al, 2015). A systematic review of this research is important to identify development trends and their potential contributions to digital literacy and science process skills (Spante et al, 2018).

Although numerous studies have been conducted, systematic reviews on the development of practicum tools with the PjBL model are still limited (Yusri at al, 2024). This research is crucial to provide a clearer picture of the trends and patterns in the development of practicum tools during the 2015-2024 period. Such a review allows researchers and educational developers to easily identify existing gaps and offer recommendations for further development (Huang et al, 2015).

This article aims to conduct a systematic review of studies related to the development of practicum tools with the PjBL model from 2015 to 2024. The findings from this review are expected to offer new insights into development trends, the challenges faced, and the potential contribution of these developments in improving digital literacy, science process skills, and student learning outcomes. Additionally, this research is expected to serve as a foundation for future studies.

Method

This study employed a descriptive and analytical research method with the aim of systematically exploring and mapping trends in research related to the development of practicum tools integrated with Project-Based Learning (PjBL) models to improve digital literacy, science process skills, and learning outcomes. The method was framed within the structure of a Systematic Literature Review (SLR), enabling the researchers to gather, filter, and analyze relevant studies in a transparent and replicable manner.

The primary data for this review were collected from Google Scholar, selected due to its broad scope, accessibility, and consistent indexing standards in the field of education. A total of 1,000 documents published between 2015 and 2024 were retrieved using the Publish or Perish (PoP) application, which facilitated the extraction of bibliographic data such as titles, abstracts, authorship, and citation metrics. Additionally,

Dimensions.ai was used to cross-validate the relevance and citation impact of the documents.

The search process was conducted using a combination of keywords, specifically targeting phrases such as "practicum tool development," "project-based learning," "digital literacy," "science process skills," and "learning outcomes." These keywords were systematically entered into the Google Scholar search engine, both individually and in combination, to ensure comprehensive coverage of related literature. The inclusion criteria focused on peer-reviewed journal articles, conference papers, and open-access academic publications relevant to science education and practicum innovation.

To ensure the validity and reliability of the review process, the study followed the guidelines of PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). This included stages of identification, screening, eligibility, and inclusion of documents. Duplicates and irrelevant studies were excluded after an initial screening of titles and abstracts, followed by a full-text assessment of the remaining articles.

The final set of relevant literature was then analyzed descriptively to identify emerging themes, dominant research focuses, publication trends, and existing gaps in the field. This approach allowed the researchers to develop a synthesized understanding of how the development of practicum tools using PjBL models contributes to key educational outcomes in science learning environments.

Result and Discussion

The purpose of this research is to describe trends in studies on the development of practicum tools using PjBL models to enhance digital literacy, science process skills, and learning outcomes from 2015 to 2024. Research documents focusing on these trends in the development of practicum tools with PjBL models aimed at improving digital literacy, science process skills, and learning outcomes in science education were collected from documents spanning 2015 to 2024. Figure 1, presented below, illustrates the trends in this research area.

Figure 1 illustrates that research trends on the development of practicum tools with PjBL models to enhance digital literacy, science process skills, and learning outcomes in science education saw a significant rise in 2020 and 2023. However, in 2024, there was a decline in the research focus on using these practicum tools with PjBL models for improving these competencies. The surge in research interest from 2020 to 2023 can be attributed to the growing focus on 21st-

century education, which places a strong emphasis on integrating digital technology into educational practices.

In 2015, there was only one publication related to the development of practicum tools with PjBL models aimed at improving digital literacy, science process skills, and learning outcomes. This number steadily increased, reaching 90 publications by 2023. This growing research trend reflects a deeper understanding of the issue of inadequate integration of technology with the PjBL model in science learning and explores solutions to address this challenge. Through various approaches, including the project-based learning model, research has demonstrated its potential to enhance digital literacy, science process skills, and learning outcomes. Table 1, presented below, summarizes the research on the development of practicum tools with PjBL models to improve these competencies, categorized by the type of publication.
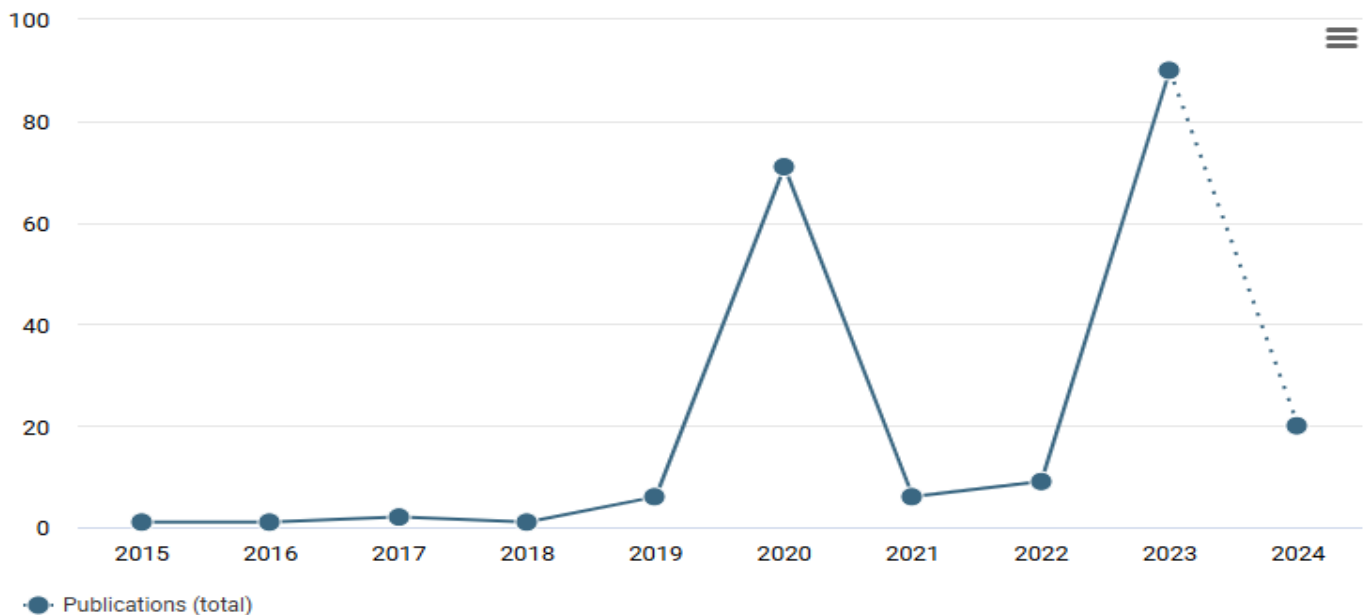

Figure 1. Research trends in development of practicum tools with PjBL models to improve digital literacy, science process skills, and learning outcomes`

Table 1. Trends in development of practicum tools with PjBL models to improve digital literacy, science process skills, and learning outcomes Research Based on Publication Types

Publication Type	Publications
Chapter	120
Edited Book	78
Article	8
Monograph	3
Proceeding	1

According to Table 1, research on the development of practicum tools with PjBL models to enhance digital literacy, science process skills, and learning outcomes from 2015 to 2024 is spread across five types of publications. These include 120 documents in chapters, 39 documents in edited books, 8 documents in articles, 3 documents in monographs, and 1 document in proceedings. The majority of the research is found in chapter form, making it the most common type of publication for studies on this topic. Conversely, proceedings contain the fewest research outputs related to the development of practicum tools with PjBL models to improve these skills.

The chapter-type documents have more publications because the chapter format usually provides more flexibility to elaborate on concepts and research findings in greater depth within a book or a collection of chapters (Funck & Karlsson, 2023). Additionally, books containing multiple chapters are often used as references in education, making this format more popular for publishing research to reach a wider audience (Denscombe, 2017).

Table 2 below presents the top ten sources frequently cited by other researchers, showcasing trends in research on the development of practicum tools with PjBL models aimed at improving digital literacy, science process skills, and learning outcomes.

Table 2 reveals that the most frequently published source on research trends concerning the development of practicum tools with PjBL models aimed at improving digital literacy, science process skills, and learning outcomes is the *Advances in Social Science, Education and Humanities Research*, with 46 publications, 48 citations, and an average citation rate of 1.04. This proceedings series focuses on publishing research from conferences related to social sciences, education, and

humanities, emphasizing theories and methodologies in these fields. All proceedings in this series are open access, allowing articles to be freely accessed, downloaded, copied, and distributed. Each volume is published under the CC BY-NC 4.0 license, which governs third-party reuse of the articles. The online publication of these proceedings is funded by conference organizers, meaning no additional publication fees are required. Table 3 below also presents the top ten most cited articles on research trends related to the development of practicum tools with PjBL models to enhance digital literacy, science process skills, and learning outcomes.

Table 2. Top 10 Sources Title Trend of development of practicum tools with PjBL models to improve digital literacy, science process skills, and learning outcomes Research in 2015-2024

Name	Publications	Citations	Citations Mean
Advances in Social Science, Education and Humanities Research	46	48	1.04
Jurnal Penelitian Pendidikan IPA	42	131	3.12
Journal of Physics Conference Series	6	63	10.50
AIP Conference Proceedings	5	2	0.40
International Journal of Instruction	5	107	21.40
Jurnal Pendidikan IPA Indonesia	5	79	15.80
JPBI (Jurnal Pendidikan Biologi Indonesia)	4	10	2.50
JPI (Jurnal Pendidikan Indonesia)	3	38	12.67
Jurnal Pendidikan dan Pengajaran	3	0	-
Jurnal Pendidikan Sains Indonesia	3	23	7.67

Table 3 shows that the most widely cited research on the development of practicum tools with PjBL models to improve digital literacy, science process skills, and learning outcomes is titled "A Study of Critical Thinking Skills, Science Process Skills, and Digital Literacy: Reviewed Based on Gender," with an average of 22.75 citations per year (Kurniawan et al., 2023). Following this is the study titled "The Effect of E-Module in Improving the Learning Outcomes of Secondary School Students in Science Learning: A Meta-Analysis," cited 2.75 times per year (Asrizal et al., 2024). Another highly cited study, "Analysis of Integrating Local Potential in Science Learning and Its Effect on 21st Century Skills and Student Cultural Awareness: Literature Review," conducted by Wilujeng et al. (2024), receives 1.00 citation per year. Lastly, Herlina et al. (2023), in their research

"Development of Learning Program Based on Multiple Representations Integrated with PjBL-STEM to Foster Students' Sustainability Literacy," has been cited 0.33 times per year.

The research data aligns with the increasing trend in studies on the development of practicum tools with PjBL models aimed at enhancing digital literacy, science process skills, and learning outcomes from 2015 to 2024. This indicates that during these years, such research was consistently cited by other scholars. Many of the articles written by these researchers frequently use terms related to the development of practicum tools with PjBL models to improve digital literacy, science process skills, and learning outcomes. Below are the ten most popular keywords associated with this area of study.

Table 3. Top 10 Citations on Trend of development of practicum tools with PjBL models to improve digital literacy, science process skills, and learning outcomes in 2015-2024

Author	Citations/year	year	Tittle
Dwi Agus Kurniawan	22.75	2023	A Study of Critical Thinking Skills, Science Process Skills and Digital Literacy: Reviewed Based on the Gender
Asrizal Asrizal	2.75	2024	The Effect of E-Module in Improving The Learning Outcomes of Secondary School Students in Science Learning : A- Meta Analysis
Insih Wilujeng	1.00	2024	Analysis of Integrating Local Potential in Science Learning and its Effect on 21st Century Skills and Student Cultural Awareness: Literature Review
Kartini Herlina Herlina	0.33	2023	Development of Learning Program Based on Multiple Representations Integrated with PjBL-STEM to Foster Students' Sustainability Literacy
Yuli Rahmawati	10.33	2023	The integration of mobile learning in STEM-PjBL for Physics learning: a systematic literature review
Tomi Apra Santosa Santosa	23.67	2023	Literature Study: Utilization of the PjBL Model in Science Education to Improve Creativity and Critical Thinking Skills
Darmaji Darmaji	17.67	2023	A Study of Critical Thinking Skills, Science Process Skills and Digital Literacy: Reviewed Based on the Gender

Author	Citations/year	year	Tittle
Astalini Astalini	17.67	2023	A Study of Critical Thinking Skills, Science Process Skills and Digital Literacy: Reviewed Based on the Gender
Riandi Riandi Riandi	1.00	2023	Learning strategies on ecosystem concepts and environmental change: A pedagogical study analysis
Lufri Lufri	20.00	2023	Literature Study: Utilization of the PjBL Model in Science Education to Improve Creativity and Critical Thinking Skills

Table 4 shows that the keyword project frequently appears in research on the development of practicum tools with PjBL models to enhance digital literacy, science process skills, and learning outcomes, with 57 occurrences and a relevance level of 2.40. Practicum activities combined with the PjBL model are among the instructional approaches recommended by the Kurikulum Merdeka (Rasmani et al, 2023). Additionally, learning is another commonly appearing keyword, showing up 30 times with a relevance score of 2.07 in studies on this topic. Numerous articles explore the development of practicum tools with PjBL models aimed at improving digital literacy, science process skills, and learning outcomes (Ilma et al., 2023).

Table 4. Keywords on Trend of development of practicum tools with PjBL models to improve digital literacy, science process skills, and learning outcomes Research in 2015-2024

Terms	Occurrences	Relevance
Project	57	2.40
Learning	30	2.07
Sensor	41	1.04
Arduino	27	1.00
Outcome	19	0.85
Tool	35	0.64
Education	37	0.45
Student	25	0.45
Development	17	0.10

The landscape map below provides a visual summary of topics associated with scientific studies in this area. Figure 2 displays the bibliometric mapping results for the co-word network in articles focused on the development of practicum tools with PjBL models to enhance digital literacy, science process skills, and learning outcomes. This map offers insights into frequently occurring keywords and their relationships, helping to reveal patterns and trends in the research from 2015 to 2024.

Figure 2 presents the results of bibliometric keyword mapping, highlighting research trends in the development of practicum tools with PjBL models aimed at enhancing digital literacy, science process skills, and learning outcomes. From 2015 to 2024, nine primary keywords frequently appeared in studies on this topic. These keywords are divided into two clusters: the first cluster, shown in red, includes five keywords

namely tool, sensor, student, outcome, and development. The second cluster, in green, consists of project, Arduino, education, and learning. These clusters illustrate key thematic areas within the research and highlight the interrelationships among topics central to advancements in science education.
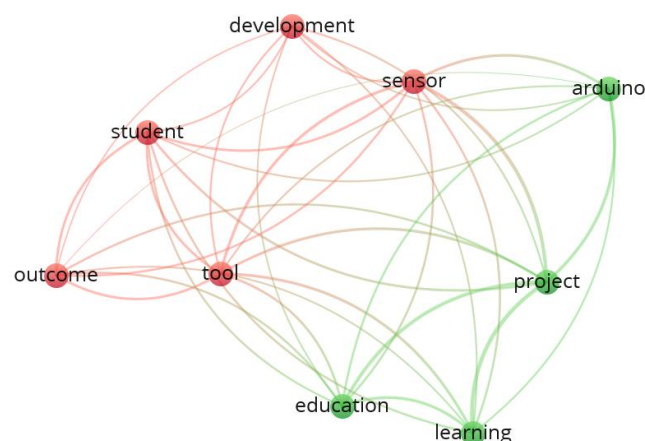

Figure 2. Network visualization on trend development of practicum tools with PjBL models to improve digital literacy, science process skills, and learning outcomes` research

Figure 2 additionally illustrates the network visualization, which displays connections between terms in a structured, color-coded format. Keywords divided into two clusters are shown in distinct colors, indicating their interconnections. This analysis provides insight into recent keyword trends in research related to the development of practicum tools with PjBL models aimed at improving digital literacy, science process skills, and learning outcomes. The greater the frequency of a keyword, the broader its representation within the visualization. An overlay visualization of these keywords is also presented, further highlighting recent trends in this research area.

Figure 3 illustrates the trends in keywords related to research on the development of practicum tools with PjBL models to enhance digital literacy, science process skills, and learning outcomes, as indexed in Google Scholar from 2015 to 2024. In this visualization, trends in article themes related to these practicum tools are color-coded from oldest to most recent: blue for the earliest years, followed by turquoise, dark green, light green, and yellow for the most recent years. The keywords

project, tool, and Arduino were frequently used by researchers in 2020, while sensor, outcome, and student were popular in 2021, reflecting evolving research focus areas over time.

Research on the development of practicum tools using PjBL models to enhance digital literacy, science process skills, and learning outcomes has seen significant growth in recent years. The following section presents keywords related to this area of research based on density visualization. Figure 4 illustrates this density visualization, where research themes are represented in bright yellow. A brighter color indicates a higher volume of research activity, while a fainter color signifies that a theme is less frequently studied (Kaur et al., 2022; Liao et al., 2018). Yellow highlights keywords that are currently prevalent in research, such as project,sensor, tool, etc.
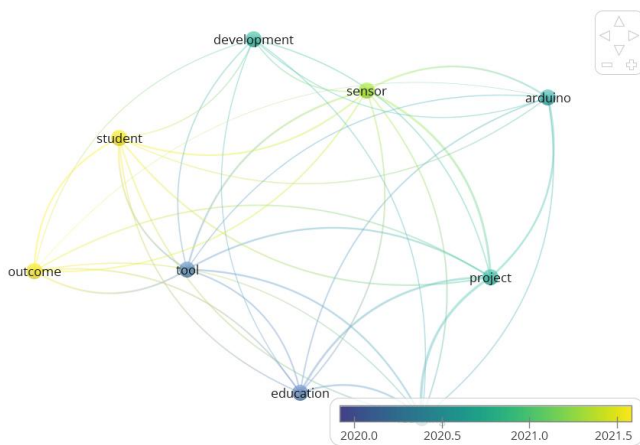

Figure 3. Overlay visualization on trend development of practicum tools with PjBL models to improve digital literacy, science process skills, and learning outcomes` research.
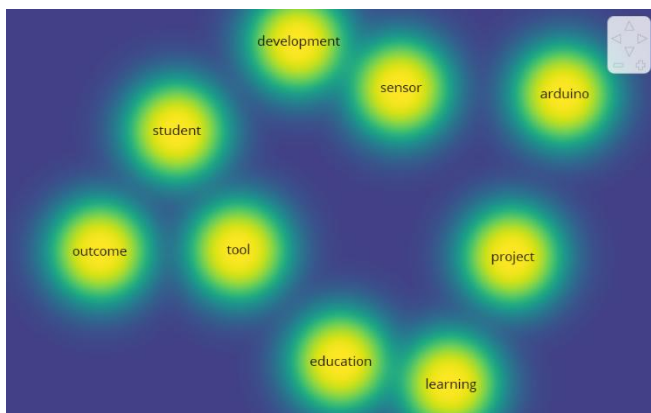

Figure 4. Density visualization on trenddevelopment of practicum tools with PjBL models to improve digital literacy, science process skills, and learning outcomes` research.

Overall, research on the development of practicum tools utilizing PjBL models to enhance digital literacy, science process skills, and learning outcomes is crucial as it makes significant contributions to the digital era. The PjBL model effectively facilitates this process (Apriadi et al., 2020; Roemintoyo & Budiarto, 2023; Stehle & Peters-Burton, 2019). It is essential for students to possess digital literacy and science process skills to improve their learning outcomes. The trend of researching practicum tools with PjBL models aimed at enhancing digital literacy, science process skills, and learning outcomes is anticipated to continue evolving in the coming years (Markula & Aksela, 2022; Darling-Hammond et al., 2020; Parker et al., 2022; Zhang et al., 2024). This advancement can be achieved by exploring new combinations of the PjBL model with technology or integrating it with other approaches, such as STEM, particularly in science subjects.

Conclusion

Research on trends in the development of practicum tools using PjBL models to enhance digital literacy, science process skills, and learning outcomes is highly urgent due to its potential benefits for education. From 2015 to 2024, the research trend on this topic indexed by Google Scholar has shown a fluctuating increase. However, a decline is projected for 2024 regarding the development of practicum tools utilizing PjBL models to enhance these skills and outcomes. Numerous documents, including chapters, edited books, articles, monographs, and proceedings, discuss this research area. Frequently used keywords in this research include project, learning, sensor, and others.

Conflicts of Interest
The author declares no conflict of interest.

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