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Learning Media and Problem Based Learning Integration in Biology: Systematic Literature Review and Bibliometric Analysis

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ABSTRACT

This study is a systematic literature review and bibliometric analysis of the integration of learning media with the problem-based learning model in biology education. The research problem arises from students' low understanding of complex biological concepts and the lack of learning media capable of developing higher-order thinking skills. The purpose of this study is to identify publication trends, dominant biology materials, types of media, development models, and research gaps that can serve as directions for future research. Data were collected from 30 articles published between 2019 and 2025 through national and international databases. Bibliometric analysis was conducted using network, overlay, and density visualizations to trace conceptual relationships, thematic dynamics over time, and the density of scientific contributions. The results show that the most studied biology topics were ecosystems, excretory systems, biodiversity, and environmental pollution. The most frequently developed learning media were e-modules and E-LKPD, with the ADDIE and 4D models as the dominant development frameworks. Bibliometric visualization also revealed that research focus is still concentrated on general terms such as problem, medium, and development, while the integration of complex, abstract, and multilevel Biology content remains low. These findings indicate the need to develop media that supports in-depth scientific understanding as well as critical and creative thinking skills. This study provides an empirical basis for more adaptive, interactive, and relevant PBL media innovation for Biology education in the future.

A. INTRODUCTION

Biology is the study of life and living things and serves as an important foundation for understanding health, environmental sustainability, and various biological phenomena in everyday life (Gul & Yalinkilic, 2025). A deep understanding of biology requires students not only to master factual knowledge but also to be able to connect concepts, explain biological mechanisms, and apply scientific knowledge to solve real-world problems (Adams et al., 2023; Koć-Januchta et al., 2022). However, learning biology faces challenges because many concepts involve abstract, dynamic, and directly unobservable processes, ranging from molecular and cellular mechanisms to physiological processes and macroscopic phenomena (Gilissen et al., 2021). This requires students to integrate various levels of representation coherently to build a causal understanding of biological processes. When these relationships are not adequately established, students may rely on memorizing isolated facts rather than developing integrated conceptual understanding, which can hinder meaningful biology learning (Gilissen et al., 2021; Gul & Yalinkilic, 2025).

Problem-Based Learning (PBL) offers a relevant pedagogical approach to addressing these challenges by engaging students in authentic problem-solving processes that promote critical thinking, collaboration, and meaningful knowledge construction. PBL places authentic and contextual problems at the starting point of learning, enabling

students to identify problems, seek information, analyze evidence, and develop solutions through individual and collaborative inquiry (Nugraha et al., 2023; Susetyarini et al., 2022). These processes can foster higher-order thinking skills, including critical thinking, problem-solving, and collaborative reasoning. PBL can also enhance student motivation and engagement by connecting learning with real-life situations (Gusman et al., 2023; Mengyao & Ismail, 2025). Applying knowledge to authentic problems further supports knowledge transfer and deeper conceptual understanding (Laksmi et al., 2021).

The effectiveness of PBL in biology learning can be strengthened through the use of learning media that support the process of inquiry and visualization of abstract concepts. Various media, such as e-modules, e-LKPD, learning videos, interactive multimedia, and virtual laboratories, have been integrated with PBL to help students understand biological processes that are difficult to observe directly and to increase engagement and independence in learning (Carroll & Najafi, 2025; Lacey et al., 2024; Navarro et al., 2024). Research by Rahmawati & Cintamulya (2025), for example, developed a game-based e-module integrated with PBL to support 21st-century skills, while Hamidah et al (2025) examined PBL-integrated worksheets to enhance critical thinking. These findings demonstrate the growing research on media integration and PBL in biology education.

Research on media integration and PBL has developed across different media types, learning outcomes, and educational contexts. Previous research has mapped the types and characteristics of biology learning media at the secondary school level but did not specifically examine the development of media integration with PBL (Dewi & Saifuddin, 2022) Research on biology e-modules has employed SLR and bibliometric analysis to identify publication trends, themes, keywords, collaboration patterns, and research directions, but its scope was limited to e-modules (Riawan et al., 2025). Research on PBL supported by audiovisual media has also mapped research trends and characteristics, but focused on primary science education (Damayanti et al., 2026). These studies provide valuable evidence about particular aspects of media, PBL, and their application; however, they do not yet explain how research on the integration of diverse learning media and PBL has developed as a broader field within biology education.

The resulting knowledge gap concerns the absence of a comprehensive research map that explains the structure and development of media-integrated PBL research in biology education. The dominant types of learning media, frequently investigated biology topics, methodological approaches, learning outcomes, emerging research themes, and scientific collaboration patterns have not been systematically identified. Existing empirical studies predominantly address the effectiveness or implementation of particular media and PBL within specific contexts, leaving limited evidence about broader research trajectories and underexplored areas. This gap is important because understanding the development and structure of the research field is necessary to distinguish established research themes from emerging topics and to identify priorities for future investigation.

A Systematic Literature Review (SLR) can synthesize the characteristics and findings of relevant studies, while bibliometric analysis can reveal publication trends, thematic development, keyword relationships, and scientific collaboration networks. The combination of these approaches has been used to examine particular areas of biology learning media research and provide systematic evidence of research development (Riawan et al., 2025). This study therefore employs SLR and bibliometric analysis to map research on the integration of learning media and Problem-Based Learning in biology education over the past five years. The analysis examines publication trends, media types, research themes and contexts, methodological approaches, learning outcomes, collaboration networks, and publication sources. The findings are expected to provide a

systematic overview of the research landscape, identify underexplored areas, and establish an evidence-based foundation for future research and innovation in biology education.

B. METHODS

This study uses a combination of Systematic Literature Review (SLR) and bibliometric analysis to examine the development of research on learning media based on Problem Based Learning(PBL) in biology education. SLR is used to systematically identify, select, and synthesize relevant literature (Triandini et al., 2019), while bibliometric analysis is used to map research trends and developments based on scientific publications (Putra et al., 2024). The process of identifying and selecting articles refers to the frameworkPreferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Dea et al., 2021). Literature search was conducted onFebruary 2026through databaseSemantic Scholar and Crossrefusing search string("Problem Based Learning" OR PBL) AND ("learning media" OR "e-module" OR "e-LKPD" OR multimedia OR worksheet) AND (biology OR "biology education"). The search is limited to journal articles published during the period 2019–2025 Search results from each database were exported in RIS format, then combined and managed using Mendeley to remove duplication. Remaining articles were screened based on title and abstract, then reviewed through full text against inclusion and exclusion criteria. The entire selection process was recorded using Microsoft Excel. The flow of article identification and selection is presented in Figure 1.Of the 178 articles identified in the initial stage, it was obtained 30 articles that meet the criteria for further analysis.

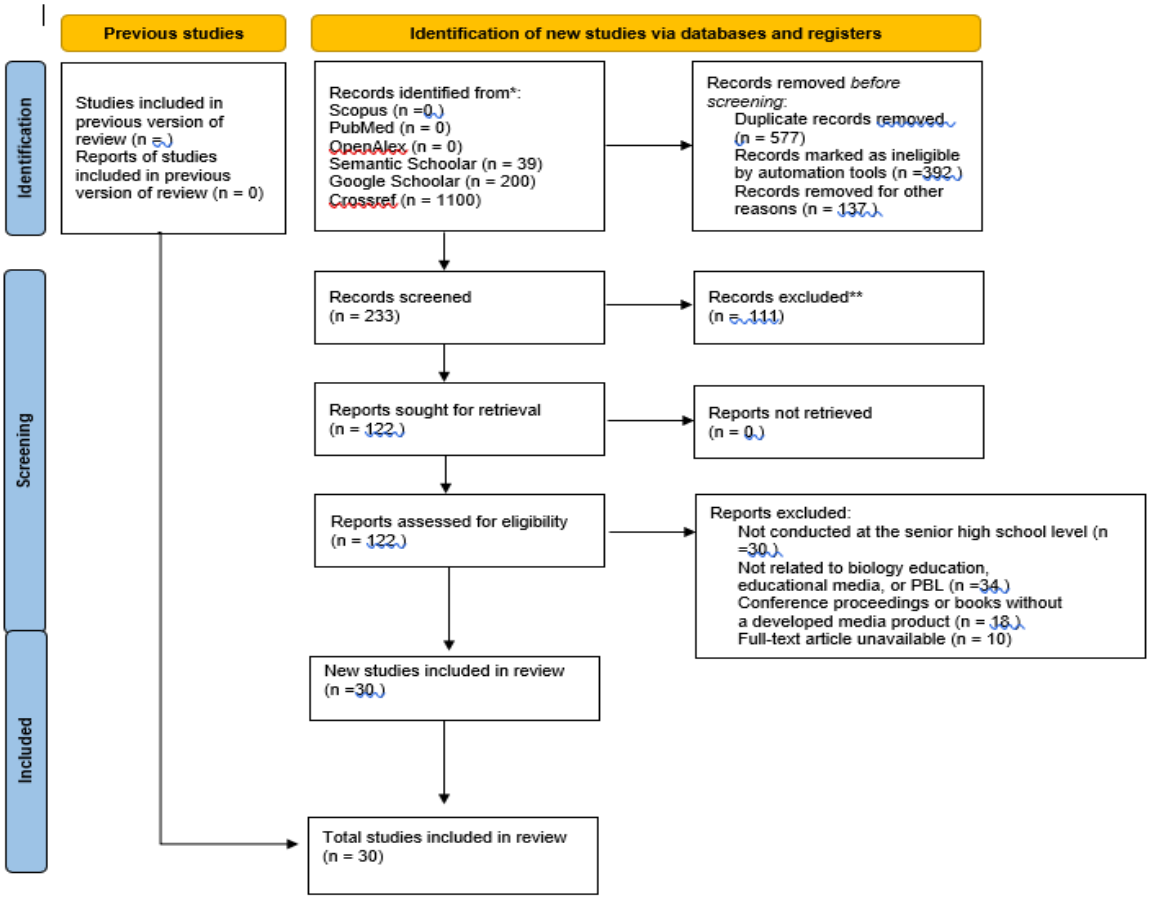

Figure 1. PRISMA Matrix

Articles that have passed the screening stage are then assessed based on inclusion and exclusion criteria. Articles are included if they focus on biology or biology education, integrate PBL, use a developmental research design, produce PBL-based learning media, and are published in the journal during the 2019–2025 period.peer-reviewedindexedFEEL 1–4, and available in full text in Indonesian or English. Articles that did not meet these criteria were excluded from the analysis.Details of the inclusion and exclusion criteria are presented in Table 1.

Table 1. Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
The study is a Developmental Research (Research & Development or Design-Based Research) producing PBL-based learning media.	Conceptual studies, literature reviews, opinions, or non-empirical reports.
The research focuses on biology or science relevant to biology education.	Research in non-biology fields (e.g., chemistry, physics, mathematics).
Learning media include e-Modules, e-LKPD, instructional videos, digital simulations, virtual laboratories, or technology-based interactive media.	PBL studies without learning media or using non-instructional media**.**
Articles published in the period2019–2025.	Articles published before 2019 or after 2025.
Articles written in English or Indonesian.	Articles written in languages other than English or Indonesian.
Articles published in journals indexed in SINTA 1–4, or other reputable international journals.	Articles that are non-peer-reviewed, in repositories, or blog posts.
Articles available in full-text format	Articles not accessible in full-text or available only as abstracts.

Data from 30 selected articles were extracted using Microsoft Excel. The collected data included article title, author, year of publication, journal name, type of learning media, development model, educational level, biology material, keywords, and citation information. Publish or Perish was used to check citation information, while VOSviewer was used for bibliometric analysis and visualization. The bibliometric analysis included:annual publication trends, citation patterns, andkeyword co-occurrence. Keywords with minimal frequency of occurrencetwiceused as threshold in VOSviewer mapping. Analysis keyword co-occurrence used to identify the relationship between keywords and research theme groups, while the development of research focus was analyzed based on the emergence and changes in keywords during the 2019–2025 period.The SLR results were analyzed descriptively based on the type of learning media, development model, educational level, biology material, and research trends. Furthermore, the bibliometric analysis and SLR results were integrated to identify trends, dominant themes, and research opportunities for PBL-based learning media in biology education.

C. RESULT AND DISCUSSION

The PRISMA-based screening identified 30 relevant studies on the development of PBL-based biology learning media from 2019 to 2025 (Table 3). The findings reveal diverse media innovations, including print modules, e-modules, LKPD, e-LKPD, interactive multimedia, and augmented reality, reflecting ongoing efforts to enhance PBL implementation through more adaptive and engaging learning tools. These media are primarily applied to complex biological topics, such as the excretory system, ecosystems,

respiratory systems, and environmental issues, underscoring the need for deeper conceptual understanding. Most studies are concentrated at the secondary school level, highlighting its strategic importance in fostering higher-order thinking skills. In addition, the predominance of ADDIE and 4D models indicates a strong preference for systematic and practical instructional design approaches in developing PBL-based learning media.

Tabel 3. Mapping of Research on the Development of Biology Learning Media Based on Problem-Based Learning (2019–2025)

No	Author	Learning Media	Lesson Material	Level Of Education	Development Model
1	(Selviani et al., 2019)	Module	Biology (General)	Senior High School	4-D
2	(Hidayati & Prayitno, 2023)	Multimedia Digital Quiz	Circulatory System	Bachelor's Degree	4D
3	(Rahmawati & Cintamulya, 2025b)	e-Module	Biology (General)	Junior High School	ADDIE
4	(Amanda & Wulandari, 2025)	Food Chain Magic Box Media	Ecosystem	Elementary School	Borg and Gall
5	(Sholikha et al., 2024)	Augmented Reality	Virus	Senior High School	ADDIE
6	(Lathifah et al., 2025)	Interactive Multimedia	Ecosystem	Senior High School	4D
7	(Kori et al., 2025)	Audio-Visual Learning	Respiratory System	Elementary School	ADDIE
8	(Syamsi & Fitrihidajati, 2021)	LKPD	Environmental Pollution	Senior High School	4D
9	(Sartika et al., 2024)	E-modul	Digestive System	Senior High School	ADDIE
10	(Hamidah et al., 2025a)	e-worksheets	Excretory System	Senior High School	ADDIE
11	(A. B. Saputra et al., 2024)	E-LKPD	Excretory System	Senior High School	ADDIE
12	(Aisyah et al., 2025)	E-LKPD	Circulatory System	Junior High School	4D
13	(Yulanda et al., 2023)	E-LKPD	Respiratory System	Junior High School	ADDIE
14	(Destiansari et al., 2024)	E-LKPD	Environmental Change	Senior High School	ADDIE
15	(Firdani et al., 2024)	e-Module	Reproductive System	Bachelor's Degree	ADDIE
16	(Halhaji & Suhartini, 2024)	E-LKPD	Environmental Change	Senior High School	ADDIE
17	(Hassan et al., 2025)	module	Respiratory System	Senior High School	ADDIE
18	(R. Dewi & Mercuriani, 2024)	E-module	Biotechnology	Senior High School	ADDIE
19	(Pitorini et al., 2024)		Environmental Change	Senior High School	Borg and Gall

No	Author	Learning Media	Lesson Material	Level Of Education	Development Model
20	(Triswidiyanto et al., 2024)	KIT "EGCA"	Global Warming	Senior High School	4D
21	(Darmawan & Sudarma, 2025)	Interactive Learning Video	Biodiversity	Sd	ADDIE
22	(Alhusein & Pratama, 2025)	E-LKPD	Ecosystem	Senior High School	ADDIE
23	(Putri & Manalu, 2024)	Module	Biodiversity	Senior High School	ADDIE
24	(Pramana et al., 2020)	E-module	Biology (General)	Senior High School	ADDIE
25	(Najib et al., 2023)	e-module	Biodiversity	Bachelor's Degree	ADDIE
26	(Mardiani et al., 2020)	Modul	Excretory System	Junior High School	Research and Development (R&D) according to Sugiyono's development model
27	(Rahmi et al., 2024)	LKPD	Immune System	Senior High School	4D
28	(Nasution & Rasyidah, 2022a)	LKPD	Digestive System	Senior High School	ADDIE
29	(Elci et al., 2021)	media pembelajaran biologi berbasis android	Excretory System	Junior High School	model Borg & Gall
30	(Anggraini & Trimulyono, 2025)	e-module	Virus	Senior High School	4D

1. Trends in Research Publication and Distribution (2019-2025)

Based on the results in Table 1, research publications regarding the development of biology learning media based on*Problem Based Learning*(PBL) shows an increasing trend during the 2019–2025 period. The development trend of these publications is presented in Figure 2.

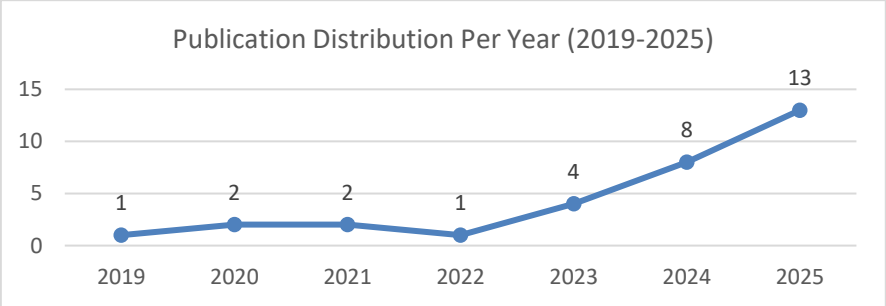

Figure 2. Publication Distribution Per Year (2019-2025)

Figure 2 shows the fluctuation of research publications regarding the development of biology-based learning media. PBL during the 2019–2025 period. In the 2019–2022 period, publication development was still relatively limited and did not show consistent improvement. Research during this period included the development of modules and

student worksheets (LKPD) as PBL-based learning media (Nasution & Rasyidah, 2022; Selviani, 2019; Syamsi & Fitrihidajati, 2021; Wisnu Pramana et al., 2020). The increase in publications began to be seen in 2023 and became more pronounced in 2024–2025, along with the emergence of research on more diverse biological media and materials, such as e-LKPD, digital multimedia, the respiratory system, the excretory system, ecosystems, and biodiversity (Hidayati & Prayitno, 2023; Yulanda et al., 2023). This pattern indicates that research on the development of PBL-based learning media is receiving increasing attention in biology education in the final period of the study.

2. Types of PBL-Learning Media

An analysis of PBL-based learning media types reveals a wide variety of forms and orientations developed to support biology learning. This diversity reflects efforts to meet the pedagogical demands of PBL, which emphasizes problem-oriented, interactive, and contextual learning experiences that foster student autonomy. As shown in Figure 3, the distribution of media types highlights prevailing trends in recent studies and indicates a clear preference for specific media forms that align with these teaching requirements.

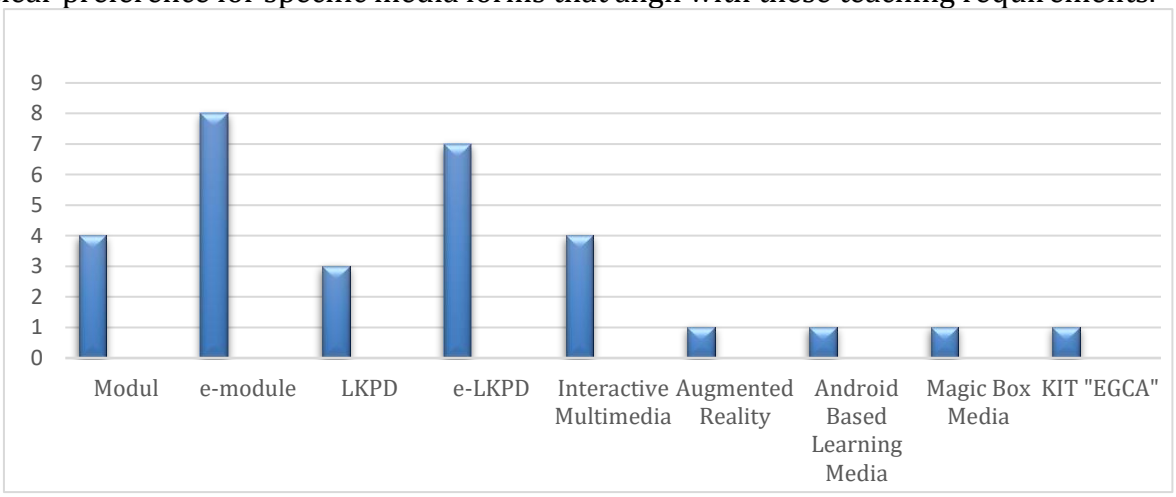

Figure 3. Distribution of PBL-Based Learning Media Types in Recent Studies (2019-2025)

Figure 3 demonstrates that e-modules and e-LKPD are the most dominant forms of learning media, indicating a shift toward technology-based approaches that facilitate flexible access, problem-oriented learning, and enhanced visualization, in line with the principles of PBL (D. G. Saputra et al., 2024; Yulanda et al., 2023). Empirical evidence further confirms their effectiveness in improving students' analytical and critical thinking skills across various biology topics (Alhusein & Pratama, 2025; Destiansari et al., 2024). At the same time, print modules and interactive multimedia remain relevant, with print media offering practicality and adaptability, while interactive multimedia enhances engagement through dynamic visualization and simulation (Darmawan & Sudarma, 2025; Hassan et al., 2025; Lathifah et al., 2025). Other media, including worksheets, augmented reality, Android-based applications, and learning kits, are less frequently used, likely due to early adoption stages and technological constraints, although they show strong potential in supporting inquiry processes and higher-order thinking skills (Elci et al., 2021; Sholikha et al., 2024; Triswidiyanto et al., 2024).

3. Prevalent Development Models Across the Reviewed Literature

The analysis of development models in PBL-based learning media research demonstrates a clear preference for systematic and structured instructional design approaches, reflecting efforts to ensure the validity, effectiveness, and relevance of the developed media.

Table 4. Development Model Research R&D

Development Model	Article Quantity
ADDIE	18
4D	8
Borg & Gall	3
R&D Sugiyono	1

As shown in Table 4, the ADDIE model dominates with 18 studies, highlighting its flexibility and alignment with instructional goals, learner needs, and content characteristics (Abuhassna et al., 2024; Halhaji & Suhartini, 2024; Yulanda et al., 2023). The 4D model follows with eight studies, maintaining its relevance in producing structured and validated media while supporting higher-order thinking skills (Aisyah et al., 2025; Lathifah et al., 2025; Rahmi et al., 2024; Triswidiyanto et al., 2024). In contrast, the Borg & Gall model appears less frequently due to its time-intensive procedures despite its strong empirical rigor (Amanda & Wulandari, 2025; Elci et al., 2021; Pitorini et al., 2024), while Sugiyono's R&D model is minimally used, indicating limited suitability for technically detailed PBL-based media design. Overall, these findings reflect a strong inclination toward development frameworks that are systematic, efficient, and practical, in line with the demands of PBL-oriented learning media development.

4. Distribution of articles by biology topic

The distribution of research topics in PBL-based biology learning media, which covers areas such as organ systems, biodiversity, biotechnology, and environmental issues. This diversity demonstrates the broad application of PBL across various conceptual and contextual domains, while supporting higher-order thinking skills.

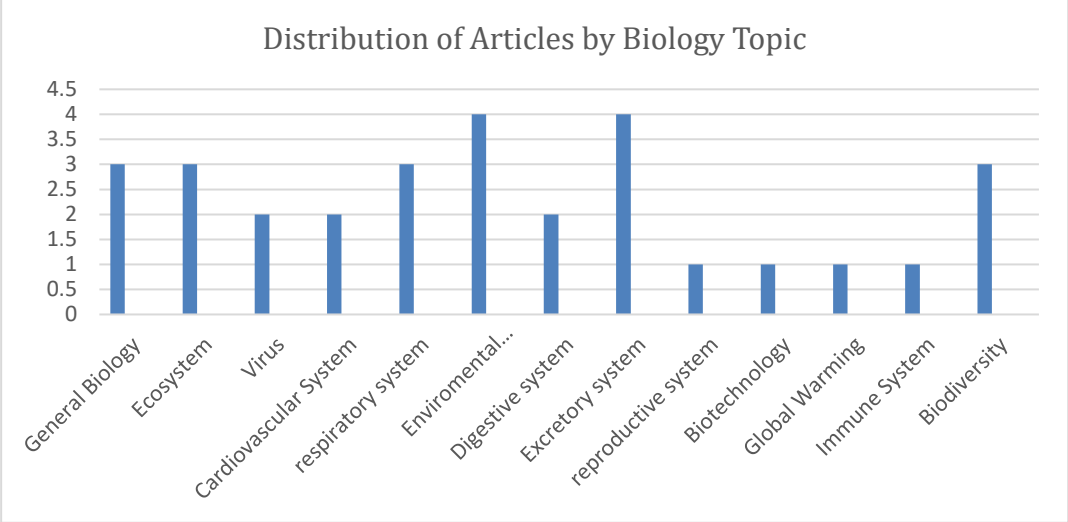

Figure 4. Distribution of Articles by Biology Topic

The distribution of research topics in Figure 4 highlights a clear pattern in PBL-based biology learning media studies, with environmental change and the excretory system emerging as the most prominent areas due to their conceptual complexity and strong real-world relevance (Destiansari et al., 2024; Halhaji & Suhartini, 2024; A. B. Saputra et al., 2024). Moderately represented topics, such as general biology, ecosystems, biodiversity, and respiratory systems, remain consistently explored as foundational concepts that are well-suited for PBL integration (Alhusein & Pratama, 2025; Darmawan & Sudarma, 2025). In contrast, topics including viruses, circulatory and digestive systems are less frequently studied, likely due to their abstract nature and visualization challenges (Anggraini & Trimulyono, 2025; Hidayati & Prayitno, 2023; Nasution & Rasyidah, 2022a). The least represented areas biotechnology, global warming, immune

systems, and reproductive systems indicate significant research gaps despite their high relevance and potential within PBL contexts (R. Dewi & Mercuriani, 2024; Rahmi et al., 2024; Triswidiyanto et al., 2024). Overall, this imbalance underscores the need to expand research toward underexplored yet complex and contextually meaningful topics to advance pedagogical innovation and higher-order thinking skills.

5. Research GAP and Future Research Direction

Bibliometric mapping offers a systematic framework for identifying research gaps and future directions in the integration of learning media and PBL in biology education through network, overlay, and density visualizations. These analyses reveal relationships among key concepts, temporal research trends, and the distribution of scholarly contributions.

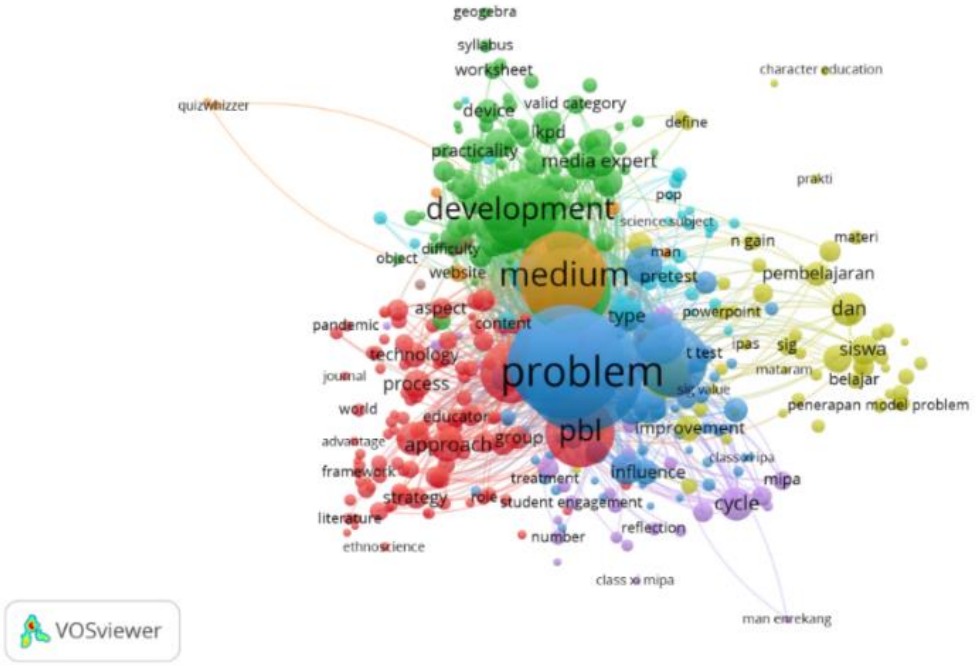

Figure 5. Visualization of the Keyword Co-Occurrence Network in Research on Media Learning-PBL Integration

As shown in Figure 5, the dominant cluster centered on terms such as problem, PBL, media, and development indicates a strong emphasis on technical aspects, where media primarily function as tools for problem presentation rather than as cognitive supports for deep conceptual understanding. This tendency is further reflected in the frequent use of terms such as *pretest, posttest*, and *N-gain*, highlighting the prevalence of short-term, quasi-experimental designs. Although additional clusters point to validation processes and emerging pedagogical and technological perspectives, their relative separation from the core cluster suggests that the integration of learning theory and the development of students' scientific thinking skills remain limited, underscoring important directions for future research.

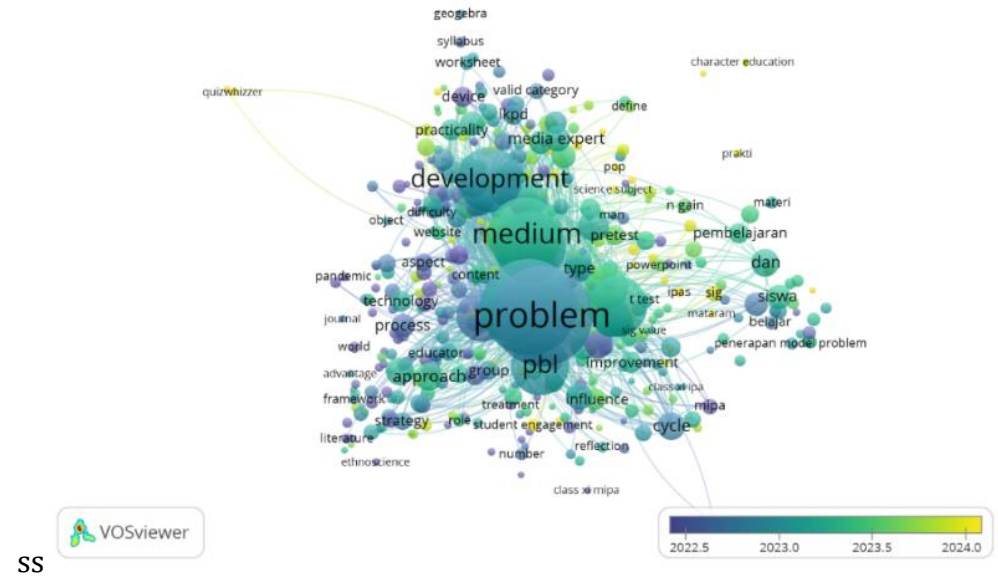

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Figure 6. Visualization of Research Focus Trends on the Integration of Digital Media and Problem-Based Learning in Biology Education (2019–2025).

The overlay visualization (Figure 6) shows that recent research increasingly emphasizes digital media and quantitative evaluation, as indicated by the prominence of terms such as quizwhizzer, n-gain, t-test, and sig value, while pedagogical elements such as strategy, framework, and process receive comparatively less attention. This pattern suggests that PBL-based media research in biology education remains largely product-oriented, with media primarily functioning as tools for problem presentation rather than as cognitive supports for deep conceptual understanding and scientific inquiry. Accordingly, future research should focus on developing media that integrate the epistemological nature of biology, utilize technology as a cognitive tool, and incorporate authentic, contextual problem design, while also emphasizing the assessment of higher-order thinking skills such as scientific literacy, argumentation, and collaboration through a more integrated alignment of technology, pedagogy, and content.

D. CONCLUSION AND SUGGESTIONS

Systematic and bibliometric review of 30 articles showssss that the development of PBL learning media in biology education is still concentrated on e-modules and Electronic Student Worksheets (E-LKPD), with the ADDIE and 4D models dominating media development practices. The bibliometric visualization reveals a significant research gap: current studies remain focused on general terms such as problem, medium, and development, while the integration of complex, abstract, and multilevel biology content, along with learning strategies that promote higher-order thinking skills, remains limited. Based on these findings, future research should emphasize developing interactive media that (1) integrate abstract and multilevel biological concepts, (2) incorporate technology-based visual or interactive simulations, and (3) support adaptive PBL strategies aligned with learner characteristics. The development of such media is expected to enhance students' deep conceptual understanding as well as their critical and creative thinking skills, thereby addressing the need for more effective and innovative learning media.

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