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Problems and Challenges of Science Learning Curriculum in Indonesia: A Systematic Literature Review and Bibliometric Analysis

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Abstract

Curriculum changes that adapt to current developments often create new obstacles in the implementation of learning. This study aims to analyze the problems and challenges in the implementation of the Natural Sciences (IPA) curriculum in Indonesia through the Systematic Literature Review (SLR) method and bibliometric analysis. Twenty-three scientific articles published between 2021 and 2025 were analyzed using the Publish or Perish (PoP) tool for bibliographic data collection and VOSviewer for research network map visualization. The analysis results show a significant increase in publications from 2024 to 2025, indicating that the Independent Curriculum topic is currently a primary focus of science education research. Keyword mapping resulted in three main clusters: difficulties for teachers and students in understanding and implementing Independent Curriculum-based science learning, challenges in implementing the Independent Curriculum and the role of science teachers, and contextual issues such as limited facilities, low scientific literacy, and the integration of local wisdom. The study also identified a research gap regarding the effectiveness of the Independent Curriculum in improving science literacy and student character. Therefore, improving teacher curriculum literacy, cross-institutional research collaboration, and strengthening science learning based on technology and local wisdom are needed to achieve contextual and modern learning.

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INTRODUCTION

The curriculum is a fundamental component of the education system, determining the direction, objectives, and quality of learning, including in the field of science, including Natural Sciences (IPA). Curricula change with the times, such as in the digital era and the 21st century, where learning is not solely focused on mastering concepts but also on developing critical, collaborative, and creative thinking skills (Halawa et al., 2024). In the context of science learning, this curriculum is expected to foster critical thinking skills, scientific literacy, and ecological awareness through a contextual, project-based approach (Hunaepi & Suharta, 2024; Fatimatuz Zahro & Maulida, 2023). However, various studies indicate that the

implementation of the science curriculum still faces many challenges, including teacher preparedness, learning resources, limited resources, low student scientific literacy, and a lack of relevance of the material to real-life contexts (Ramadhani & Amelia, 2025; Ulfa & Kuswanto, 2025).

Research conducted by Thomas & Boon (2023) explains that an overly dense and non-contextualized curriculum can hinder teachers from developing meaningful, student-centered learning. Surveys of teachers in various countries indicate that a science curriculum that is too dense and lacking relevance to students' contexts is a major obstacle in the teaching process. This is based on an international survey that found that 72% of teachers cited an overloaded curriculum as a factor inhibiting student learning outcomes (Rsc, 2024). The impact of rapid curriculum changes without a corresponding increase in teacher competency has led to a gap between policy and practice (Septiyani & Sukartono, 2023).

Research by Amrin et al. (2025) and Ruliandari et al. (2025) indicates that teachers still face difficulties in designing active learning, using technology-based media, and conducting authentic assessments in accordance with the demands of the Independent Curriculum. Similar challenges are also encountered in integrating science learning with the STEM/STEAM approach, where teachers do not yet fully understand how to connect science concepts with technology, engineering, and mathematics within a cohesive learning environment (Aprilista, 2022; Nuragnia & Usman, 2021).

Research conducted by Viqri et al. (2024) and Amelia et al. (2025) shows that many schools still struggle to develop lesson plans and assessments aligned with the Independent Curriculum, particularly in the context of integrated science in elementary schools. Rochman et al. (2018) demonstrated that the challenge of authentic assessment in science learning lies in the gap between curriculum design and classroom teaching practices. Malik et al. (2020) added that science learning in Indonesia is still dominated by traditional models oriented toward memorization, resulting in students' critical thinking and problem-solving skills not being optimally developed. Meanwhile, Agustina (2023) revealed that prospective science teachers encountered obstacles in implementing the STEM-R (Science, Technology, Engineering, Mathematics plus Religion)-based learning model due to a lack of practical experience and limited digital training. These conditions demonstrate that the problems with the science curriculum are not only technical, but also conceptual and systemic.

Therefore, examining the problems and challenges of the science curriculum is crucial to ensure that curriculum planning and implementation truly support meaningful, contextual, and adaptive learning. Various studies on science curriculum implementation and analysis of the challenges faced exist. However, the results have not been comprehensively integrated to illustrate the problem map and research direction regarding the problems and challenges of the science curriculum. Therefore, a Systematic Literature Review (SLR) approach is an effective method for exploring and in-depth analyzing previous research findings related to the problems and challenges of the science curriculum. Through this approach, researchers can identify key themes, research trends, and research gaps that require further exploration (Rojas-Sánchez et al., 2022). In addition, the use of bibliometric analysis strengthens SLR by

mapping the network of authors, keywords, and developing topic trends, thus producing a more objective and measurable knowledge map.

This study analyzed 23 scientific articles published between 2021 and 2025 using Publish or Perish (PoP) software for bibliographic data collection and VOSviewer for bibliometric network visualization. Through this combination of methods, the study aims to analyze the problems and challenges of the science curriculum by analyzing publication trends, mapping the relationships between keywords and authors, and identifying the most dominant themes from the 23 articles analyzed, thus generating an overview of future research gaps.

RESEARCH METHODS

This study employed a Systematic Literature Review (SLR) method with a bibliometric analysis approach. This approach was chosen to comprehensively review the latest research findings on the problems and challenges of the science curriculum in Indonesia. SLR allows researchers to identify research trends, dominant topics, and gaps that require further exploration (Rojas-Sánchez et al., 2022).

Data collection was conducted using the Publish or Perish (PoP) tool to search for scientific articles from Google Scholar, considered to have broader coverage. Keywords used included English-language keywords, including: "*science curriculum,*" "*problem,*" "*challenge,*" "*implementation,*" *dan* "*Indonesia,*", and Indonesian keywords, namely; "*masalah,*" "*tantangan,*" "*pembelajaran IPA,*" dan "*Indonesia.*". The use of keywords in both languages was used to identify international articles for review.

The search results were selected based on inclusion criteria, including articles published between 2021 and 2025, in Indonesian or English, discussing the implementation of the science curriculum in the Indonesian context, including an analysis of the obstacles/challenges and problems faced by researchers, available in full text, published in nationally accredited scientific journals or proceedings. Exclusion criteria, articles without full text and articles discussing non-curriculum/learning aspects

This process resulted in 23 relevant scientific articles from a total of 60 articles for further analysis. Bibliographic data from the 23 selected articles were exported in RIS format and processed using VOSviewer 1.6.20 software. The analysis was carried out through three main stages. The first stage, publication trend analysis (frequency per year and author's institution of origin), the second stage, keyword analysis (co-occurrence) to identify dominant research themes, the third stage, network analysis (co-authorship & co-citation) to map the relationship between authors and topics. The results of the analysis were visualized in the form of a bibliometric map showing the main topic clusters related to science curriculum issues and challenges.

In addition to using bibliometric analysis, researchers also use content analysis with a manual coding approach to understand the contents of articles in depth as a result of SLR (Lungu, 2022). Content analysis was conducted by reading the abstract, results, and discussion sections of each article to identify key issues regarding the problems and challenges of the science curriculum in Indonesia. Relevant text fragments were manually coded using

Microsoft Excel, then grouped into broad themes and linked to co-occurrence results from VOSviewer.

RESULTS AND DISCUSSION

Article Data Analyzed

A total of 60 articles were searched in the PoP and selected based on the inclusion criteria. Only 23 articles were selected and met the authors' intended topic. The following table displays the 23 articles used as sources for this systematic review.

Table 1. Analyzed Article Data

Article Title	Author	Year	Main Topic	Source
Peran dan tantangan guru IPA dalam pengimplementasian Kurikulum Merdeka untuk konservasi alam dan kearifan lokal	Zahro, F. & Fauziah, A.N.M.	2024	Independent Curriculum, Local Wisdom, Conservation, Challenges	Unesa Proceeding
Kendala dan Tantangan Pembelajaran IPA di UPT SD Negeri 064995 Kota Medan	Ramadhani, A. & Amelia, F.R.	2025	Implementation of the Independent Curriculum, Obstacles and Teachers Challenges	JPI
Analisis Tantangan Guru IPA SMP dalam Pelaksanaan Pembelajaran IPA Terintegrasi STEM	Aprilista, E.	2022	STEM Learning, Teacher Challenges	UNS Repository
Tantangan guru dalam pembelajaran IPA dengan pendekatan saintifik 5M	Rosida, S. & Erman, E.	2021	Scientific 5M, Science Approach, teacher challenges	Unesa Journal
Problematika pembelajaran IPA terpadu (kendala guru dalam pengajaran IPA terpadu)	Indrawati, E.S. & Nurpatri, Y.	2022	Integrated Science, Teacher Constraints	EDUCATIVO: Jurnal Pendidikan
Implementasi Kurikulum Merdeka dalam Pembelajaran IPA di SDN 069054	Amelia, F.R. et al.	2025	Effectiveness of independent curriculum, implementation, obstacles	JTPP Kopusindo
Problematika Pembelajaran IPAS dalam Kurikulum Merdeka	Viqri, D. et al.	2024	Social Sciences, Teacher Challenges	JIEPP
Analisis tantangan guru IPA SMP di Indonesia dalam menerapkan pembelajaran terintegrasi STEM	Candra, N.K. et al.	2022	STEM, Teacher Challenges	FKIP e-PROCEEDING
Tantangan guru dalam mengajar IPA: Studi kasus guru SD	Zuhaida, A. & Yustiana, Y.R.	2023	Elementary school teachers, science learning, teacher challenges	Paedagoria
Implementasi dan Tantangan Evaluasi Pembelajaran IPA di Sekolah	Amrin, A. et al.	2025	Learning evaluation, Assessment constraints	Moral Journal

Article Title	Author	Year	Main Topic	Source
Analisis Tantangan dan Strategi Guru dalam Implementasi Kurikulum Merdeka pada Pembelajaran IPA	Ruliandari, L. et al.	2025	Teacher strategies, Independent Curriculum, challenges	Innovative Journal
Pembelajaran STEAM di Sekolah Dasar: Implementasi dan Tantangan	Nuragnia, B. & Usman, H.	2021	STEAM, Elementary School, Learning Innovation, Challenges	JPNK
Analysis of Science Teachers' Difficulties in Implementing the Independent Curriculum	Irsyadi, I.F. et al.	2025	Independent Curriculum, Teacher Obstacles	Ar-Raniry Journal
Implementation of Kurikulum Merdeka in Science Learning: Case Study in Malaysia	Nurdiyanti, N. et al.	2024	Independent Curriculum, Overseas Schools, Challenges	Edelweiss Applied Science and Technology
Transforming Education in Indonesia: The Impact and Challenges of the Merdeka Belajar Curriculum	Hunaepi, H. & Suharta, I.	2024	Curriculum reform, National challenges	SSOAR
Implementation of the Merdeka Curriculum and Its Challenges	Ndari, W. & Mahmudah, F.N.	2023	Implementasi kurikulum, IPA, tantangan	EJ-EDU
Indonesian Curriculum Reform in Policy and Local Wisdom: Science Education Perspective	Suprapto, N. et al.	2021	Curriculum policy, local wisdom, challenges	Jurnal Pendidikan IPA Indonesia
Teachers' Challenges in Implementing Independent Learning Curriculum in Science and Social Studies	Septiyani, I.	2023	Elementary school teacher, social science, challenges	Jurnal Cakrawala Pendas
Analysis of 2013 Curriculum Problems So It Is Changed into Merdeka Curriculum	Lestari, N.A.P.	2023	Policy analysis, curriculum change, problems	Jurnal Pendidikan Dasar Nusantara
An Analysis of Student Learning Challenges in Elementary School Science	Syahputra, A. et al.	2022	Learning difficulties, elementary school science	Undikma Journal
Mengukur Efektivitas Model PBL dalam Pembelajaran IPA	Amiruddin, A. et al.	2024	PBL, Learning effectiveness, learning problems	TSB Journal
Model Discovery Learning Berbantu Google Meet untuk Meningkatkan Hasil Belajar IPA	Ma'mun, H.H. et al.	2022	Discovery learning, digital media, learning outcomes problems	Educatio
Tantangan Guru IPA dalam Pelaksanaan Kurikulum Terpadu	Rosida, S. & Erman, E.	2021	Integrated Science, Teacher Constraints	Unesa Journal

Bibliometric Analysis Results

a. Publication Trends (2021–2025)

Analysis shows a sharp increase in publications in 2024–2025, indicating that the topic of "Independent Curriculum in Science Learning" has become a new research focus in science education. 2025 recorded five publications, while 2021–2023 showed an initial focus on

integrating scientific approaches (PBL, discovery learning) and STEM/STEAM. This pattern illustrates the shift in national education policy direction from the 2013 Curriculum to the Independent Curriculum, which emphasizes learning autonomy, student-centered learning, and the integration of 21st-century competencies.

b. Keyword Mapping

The analysis of keyword mapping in the problems and challenges of the science learning curriculum using VOSviewer is shown in the following figure.

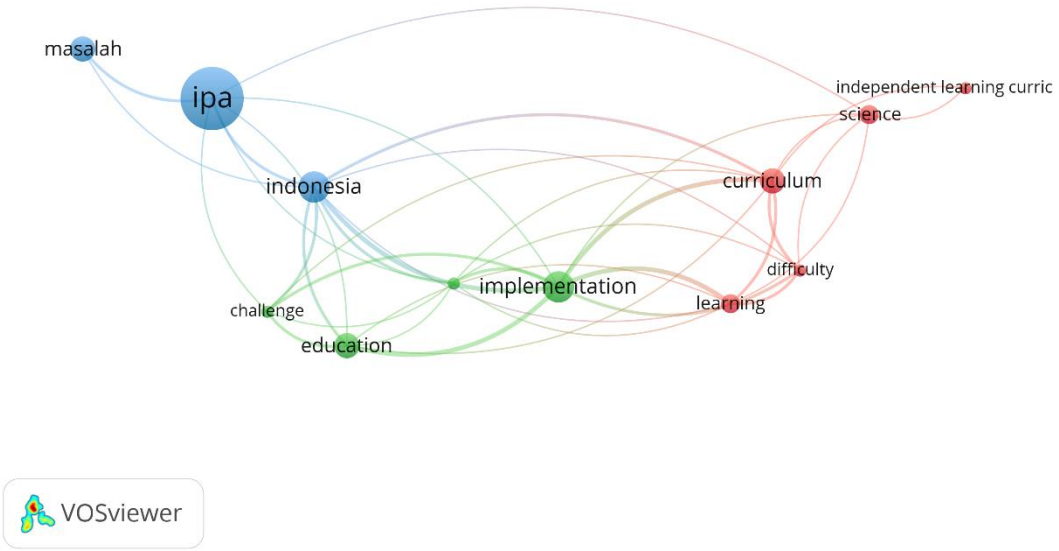

Figure 1. Keyword Mapping of Problems and Challenges in the Science Learning Curriculum

Based on the visualization of keyword co-occurrence analysis using VOSviewer (Figure 1), three main clusters were identified, illustrating the interrelationship between research themes in the field of science learning and the Independent Curriculum.

The first cluster (red) links the words "curriculum," "science," "learning," "difficulty," and "independent learning curriculum." This cluster highlights the difficulties teachers and students face in understanding and implementing science learning based on the Independent Curriculum (Irsyadi et al., 2025; Ndari et al., 2023). The second cluster (green) focuses on the keywords "education," "challenge," "implementation," and "Merdeka curriculum." This cluster demonstrates the focus of research related to educational challenges in implementing the Independent Curriculum, particularly on aspects of teacher roles and changes in learning approaches (Ramadhani & Amelia, 2025; F Zahro & Fauziah, 2024). The third cluster (blue) centers on the words "science," "Indonesia," and "problems," emphasizing contextual issues in Indonesia, such as limited resources, teacher preparedness, and adaptation to curriculum changes (Hunaepi & Suharta, 2024; Indrawati & Nurpatri, 2022).

These results indicate that the main research themes on the Independent Curriculum and science learning in Indonesia are still focused on implementation and practical challenges in the field, rather than on the development of new learning models or technology-based pedagogical innovations.

c. Writers Collaboration Network

The analysis of keyword mapping in the problems and challenges of the science learning curriculum using VOSviewer is shown in the following figure.

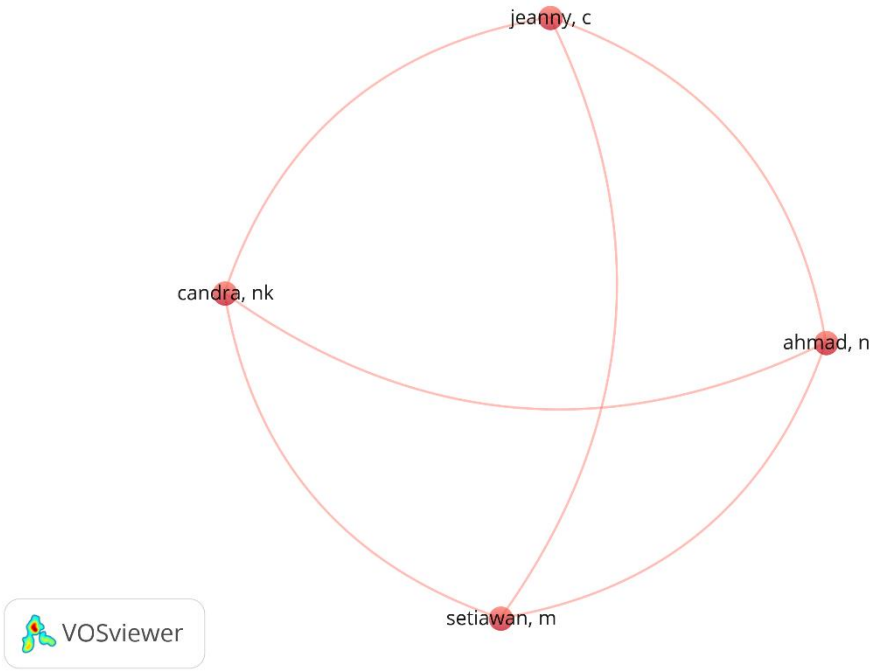

Figure 2. Author Mapping in the Analysis of Problems and Challenges in the Science Learning Curriculum

The author mapping results (Figure 2) show four networked authors: Candra, Jeanny, Setiawan, and Ahmad (2022), who researched science teachers' challenges in STEM learning. The overall author mapping is shown in Figure 3 below.

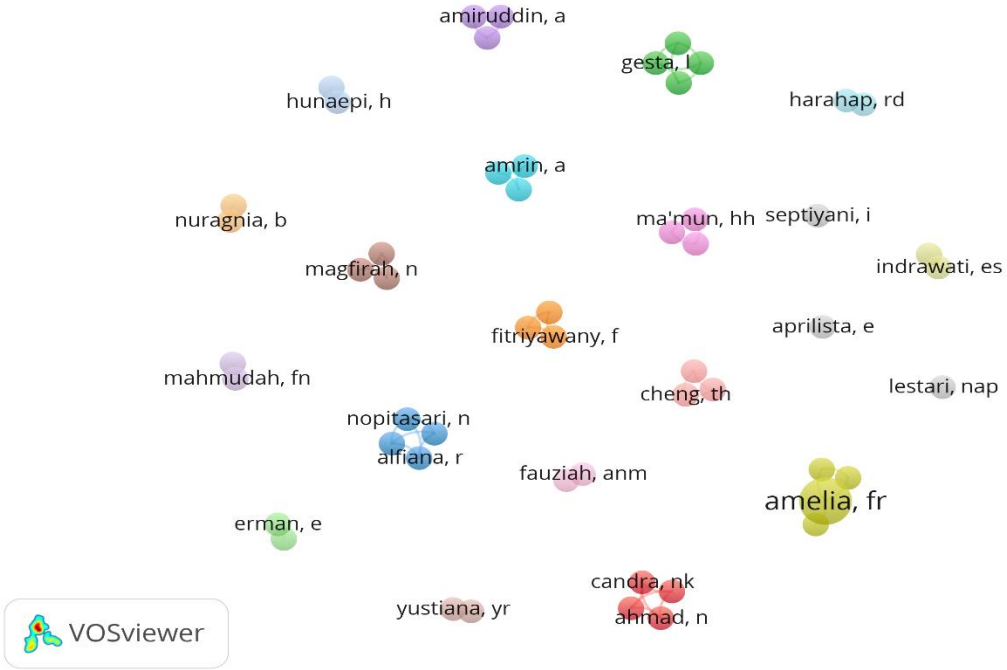

Figure 3. Overall Mapping of Authors in the Analysis of Problems and Challenges in the Science Learning Curriculum.

In general, research collaboration networks remain weak, characterized by few inter-author relationships and minimal cross-institutional collaboration. This aligns with the

findings of Suprapto et al. (2021) which states that science education research in Indonesia tends to be individualistic and has not yet formed a strong collaborative research ecosystem.

Systematic Literature Review Results

The most dominant themes emerging from keyword co-occurrence (from VOSviewer) include, independent curriculum (23 occurrences), science teachers (18 occurrences), STEM/STEAM (9 occurrences), learning evaluation (6 occurrences), and local wisdom (5 occurrences). From the VOSviewer mapping, the five main topic clusters are as follows:

a. Challenges for Science Teachers in Implementing the Independent Curriculum

According to Ramadhani & Amelia (2025), and Ruliandari et al., (2025) stated that science teachers face major obstacles in the pedagogical aspect and readiness to adapt to new teaching tools, especially in the implementation of Project-Based Learning (P5) and competency-based learning. (Ruliandari et al., 2025; F Zahro & Fauziah, 2024). Many teachers still do not fully understand learning outcomes (CP), the learning objectives (ATP), and how to conduct diagnostic assessments in accordance with the principles of the Independent Curriculum. Aprilista Research (2022) revealed that science teachers in junior high schools face challenges in several aspects, for example, explaining abstract science content, time management, and preparing learning tools.

According to Ramadhani & Amelia (2025) and Amrin et al., (2025), explained the continued lack of science learning media and resources relevant to the Independent Curriculum approach, particularly in elementary schools. Technical challenges such as inadequate laboratories, limited access to technology, and limited teacher training remain major obstacles.

b. Integrated Science Learning and Innovation of STEM/STEAM Approaches

Science learning integrated with the STEM (Science, Technology, Engineering, Mathematics) approach is increasingly considered an important strategy in preparing students to face 21st century competencies. (Widiyatmoko, 2023). Research of Nuragnia & Usman (2021) and Zuhaida & Yustiana (2023) shows that STEM and STEAM approaches are starting to be widely applied to increase the relevance of science learning to real life. However, their implementation is often hampered by limited laboratory facilities, technological support, and project implementation time. These results are reinforced by Hunaepi & Suharta (2024) which emphasizes that the transformation of science education in Indonesia requires synergy between curriculum policy, teacher preparedness, and school culture. Furthermore, STEM integration requires adequate facilities and infrastructure, as well as a deep understanding of the engineering design process, which many teachers in the field have not yet mastered. (Candra et al., 2022).

c. Local Wisdom as a Context for Science Learning

Research by Zahro & Fauziah (2024), and Suprapto et al., (2021) emphasizes the importance of integrating local wisdom and environmental conservation into science learning to enhance students' environmental awareness and problem-solving skills. This approach not only supports the achievement of science competencies but also instills character values and

ecological awareness in students. This aligns with the objectives of the Independent Curriculum, which prioritizes the Pancasila-based student profile.

Other research indicates that teachers experience difficulties adapting teaching materials and integrating local wisdom values into science learning. (Nurdiyanti et al., 2024).

d. Learning Evaluation and Authentic Assessment

Analysis of the article by Amrin et al.. (2025) and Ndari & Mahmudah (2023) Studies show that implementing authentic assessment remains a serious challenge. Many teachers struggle to develop project- and portfolio-based assessment instruments that align with the characteristics of science. Learning evaluations also do not adequately reflect students' actual competencies. (Amrin et al., 2025). This problem is related to the lack of technical training and differences in understanding among teachers regarding the concepts of formative and summative assessment in the context of the Independent Curriculum.

e. Research Direction and Study Gaps

Mapping using VOSviewer shows that current research has focused on implementation and teacher challenges, while studies on the curriculum's impact on student science learning outcomes and the development of innovative, locally context-based learning models remain very limited. This means that future research opportunities are wide open regarding the effectiveness of the Independent Curriculum in improving science literacy and student character at various levels of education. This finding strengthens the results of previous research which shows that curriculum transformation in Indonesia always presents implementation challenges in the field. (Hunaepi & Suharta, 2024; Lestari et al., 2023). The main problem isn't curriculum design, but rather teacher capacity and the supporting ecosystem.

Furthermore, research by Irsyadi et al. (2025) and Ndari et al. (2023) also emphasized that science teachers still lack a full understanding of the Independent Curriculum, particularly in its implementation of project-based learning and formative assessment. In this context, the role of training and institutional support is crucial.

Thus, the bibliometric and SLR results indicate that to optimize science learning within the Independent Curriculum, the following is needed improving teachers' curriculum and pedagogical literacy through ongoing training, cross-institutional research collaboration to strengthen evidence-based teaching practices, and integrating local wisdom and digital technology into science learning to make it more contextual and adaptive to global change.

CONCLUSION

Based on bibliometric and SLR analysis of 23 scientific articles, it can be concluded that research trends have increased significantly since 2024–2025, indicating that the Independent Curriculum topic has become a primary focus of current science education research, following the national implementation of the Independent Curriculum. Keyword mapping identified three clusters: the first highlights the difficulties faced by teachers and students in understanding and implementing Independent Curriculum-based science learning; the second cluster highlights research focused on educational challenges in implementing the

Independent Curriculum; and the third cluster emphasizes contextual issues in Indonesia. The authors' mapping findings indicate very weak results due to limited interconnectedness.

The dominant research topics focused on the implementation of the Independent Curriculum, teacher challenges, and STEM-based learning innovations and local wisdom. The main obstacles faced by science teachers include understanding curriculum documents, limited laboratory facilities, and difficulties implementing authentic assessments. The research map shows five major clusters: curriculum implementation, teacher challenges, STEM integration, local wisdom, and learning evaluation. The research gap lies in measuring the effectiveness of science learning in improving scientific literacy, creativity, and student character.

So that future research recommendations can examine the theme regarding the effectiveness of the Independent Curriculum theme in improving scientific literacy and student character at various levels of education.

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