

Mapping the Trends of Inquiry-Based Learning Research in Elementary Science Education: A Bibliometric Analysis

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ARTICLE INFO

Article history:

Received July 21, 2024

Accepted October 14, 2024

Available online October 25, 2024

Kata Kunci:

Pendekatan Berbasis Inkuiri,
Pembelajaran IPA, Sekolah Dasar,
Analisis Bibliometrik

Keywords:

Inquiry-Based Approach, Science
Learning, Elementary School,
Bibliometric Analysis



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ABSTRAK

Penelitian berbasis inkuiri dalam pembelajaran Ilmu Pengetahuan Alam (IPA) di sekolah dasar memiliki potensi besar untuk meningkatkan kualitas pembelajaran, namun tren perkembangannya belum sepenuhnya terpetakan. Artikel ini bertujuan untuk menganalisis tren penelitian berbasis inkuiri dalam pembelajaran IPA di sekolah dasar menggunakan pendekatan bibliometrik. Penelitian ini dilakukan melalui empat tahap analisis: identifikasi, penyaringan, kelayakan, dan inklusi. Data diperoleh dari basis data Scopus dengan kata kunci "inquiry-based learning," "science," dan "elementary school," menghasilkan 43 dokumen terpilih dari tahun 2014 hingga 2023 yang berbahasa Inggris. Hasil analisis menunjukkan bahwa tiga istilah utama yang paling sering muncul adalah "inquiry-based learning" (22 kali, kekuatan tautan 76), "students" (14 kali, kekuatan tautan 76, tautan 35), dan "elementary school" (7 kali, kekuatan tautan 37). Publikasi terbanyak terjadi pada tahun 2023 dengan delapan dokumen, sedangkan publikasi terendah terjadi pada tahun 2017 dan 2021, masing-masing hanya satu dokumen. Penelitian ini menyimpulkan bahwa pendekatan berbasis inkuiri dalam pembelajaran IPA di sekolah dasar masih kurang mendapat perhatian dari para peneliti internasional. Oleh karena itu, diperlukan penelitian lebih lanjut untuk memperluas cakupan topik sehingga meningkatkan kontribusi pendekatan ini dalam pendidikan dasar.

ABSTRACT

Inquiry-based learning in science education at the elementary level holds significant potential to enhance teaching quality, yet its developmental trends remain insufficiently mapped. This article aims to analyze the research trends of inquiry-based learning in elementary science education using a bibliometric approach. The study was conducted through four stages of analysis: identification, screening, eligibility, and inclusion. Data were retrieved from the Scopus database using the keywords "inquiry-based learning," "science," and "elementary school," yielding 43 selected documents from 2014 to 2023, all in English. The analysis reveals three key terms that frequently appear in these studies: "inquiry-based learning" (22 occurrences, link strength 76), "students" (14 occurrences, link strength 76, links 35), and "elementary school" (7 occurrences, link strength 37). The highest number of publications was recorded in 2023 with eight documents, while the lowest numbers occurred in 2017 and 2021, with only one document each. The study concludes that inquiry-based learning approaches in elementary science education have received limited attention from international researchers. Thus, further studies are needed to expand the scope of this topic and enhance its contributions to primary education.

1. INTRODUCTION

Education is an effort that is systematically designed to help individuals grow and develop optimally through active interaction with teachers and the learning environment. In this context, learning Natural Sciences (IPA) in elementary schools plays an important role in forming the basis of students' scientific understanding (Zakirman et al., 2022). Science learning does not only aim to provide theoretical knowledge, but also to develop critical, analytical and creative thinking skills that are very necessary in everyday life (Fanny & Rahim, 2022; Miftahul et al., 2022). Science learning in Elementary School is expected to foster curiosity in students, foster problem-solving skills and build interest in science and technology. However, in reality, many students have difficulty in understanding abstract science concepts

so that science learning tends to be boring, and the use of learning methods is less varied (Sardulo, 2023). Therefore, effective and innovative learning methods are very necessary to improve the quality of science education (Nazirah et al., 2020). One approach that has received a lot of attention is the inquiry-based approach (Lilla & Erzsébet, 2021; Mária et al., 2023).

An inquiry-based approach in science learning involves students actively in the learning process (Rosa & Chen, 2021). Students are encouraged to ask questions, conduct experiments, and seek answers through independent investigation (Xiao et al., 2022). This approach emphasizes the process of discovery and exploration, so that students not only receive information passively but are also involved in the search for knowledge (Bunyamin, 2023). Thus, this method not only improves understanding of scientific concepts, but also develops critical and creative thinking skills (Nurfardilla et al., 2023). Apart from that, the inquiry approach can also increase students' learning motivation because they feel more involved and have control over their learning process (Chilya et al., 2022; Machpud, 2022). In practice, this approach requires teachers who are able to facilitate and guide the inquiry process, as well as providing a learning environment that supports exploration and discovery (Ganesan et al., 2020). Teachers also need to design learning activities that are challenging and relevant to students' daily lives, so that learning becomes more meaningful and contextual. Therefore, an inquiry-based approach not only demands changes in teaching methods, but also in the roles of teachers and students in the learning process (Constantina et al., 2020).

As time goes by, research on inquiry approaches in science learning in elementary schools is increasing (Constance et al., 2022).

Various studies have explored the effectiveness and application of the inquiry approach in diverse educational contexts, reflecting growing interest from academics and practitioners worldwide (Fabiola, 2023; Hamka et al., 2022; Indah et al., 2023). This method has proven globally relevant, with research conducted in both developed and developing countries to improve the quality of science education. These studies encompass aspects such as curriculum design, teaching strategies, and the evaluation of student learning outcomes, while also addressing challenges like limited resources, insufficient teacher training, and resistance to changing traditional teaching methods (Walter et al., 2022). Despite extensive research, a gap remains in understanding the development of research trends in inquiry-based science learning in elementary schools (Fru et al., 2019). Previous research consistently demonstrates the benefits of the inquiry approach in science learning, highlighting its effectiveness in enhancing student involvement, understanding of scientific concepts, and learning outcomes (Ibrohim et al., 2020; Vidriana & Bano, 2023; Windhiana et al., 2022). Additionally, these studies reveal that inquiry-based learning not only improves critical and creative thinking skills but also fosters motivation, interest, and positive attitudes toward science. This aligns with findings indicating that active involvement in the learning process significantly enhances both learning outcomes and student satisfaction.

Previous research highlights the effectiveness of inquiry-based learning models in improving student learning outcomes and fostering active engagement. First researcher reported a 12.5% increase in student performance on solar system material using cooperative inquiry (Irsan, 2023), while another research found a rise from 72.11% to 81.11% in students mastering the digestive system through guided inquiry (Maryamah & Iis, 2023). Previous study also demonstrated a significant improvement in understanding photosynthesis, with scores increasing from 68.75% to 82.5%, emphasizing the benefits of project-based inquiry (Desta et al., 2023). Similarly, another study noted that inquiry learning not only enhances academic outcomes but also develops critical, creative, and responsible attitudes (Rahyu, 2023). Other researches revealed significant differences favoring project-based inquiry over conventional methods and highlighted its effectiveness in improving science learning outcomes and creative thinking in elementary students (Irma et al., 2023; Mawarni et al., 2023; Nurdiyanti et al., 2023). Despite these findings, there remains limited research on trends in inquiry-based learning development using bibliometric approaches.

The novelty of this research lies in its efforts to address existing gaps by providing a comprehensive overview of research trends and identifying areas requiring further exploration (Jian et al., 2022). This study not only contributes to understanding research development trends but also offers valuable insights into under-researched areas that demand further attention. Additionally, it aims to identify factors influencing the successful implementation of the inquiry approach and provide recommendations for enhancing its effectiveness in the context of elementary science education (Indah et al., 2023; Nurdin & Udan, 2023). This study aims to analyze the development trends of inquiry-based research in elementary science education using a bibliometric approach. This method offers a comprehensive perspective on research progress in inquiry-based learning while highlighting research gaps that require future investigation. Through this analysis, the study aims to provide deeper insights into the direction of research development, identify key topics, and recognize the contributions of authors

and institutions in this field. The findings are expected to serve as a valuable reference for researchers, educators, and policymakers in designing more effective science learning strategies.

2. METHOD

This research uses a bibliometric approach to analyze trends in the development of inquiry-based research in natural science (science) learning in elementary schools. The bibliometric approach was chosen because it allows researchers to identify and analyze patterns of scientific publications, including temporal trends, main topics, collaboration between authors and institutions, as well as the influence of various external factors (Dewi et al., 2023). This method also makes it possible to evaluate research developments over time and identify areas that have received insufficient attention.

The data used in this research was obtained from a leading scientific database, namely, Scopus. The data collection process involved several stages, namely: literature search using relevant keywords such as "inquiry-based learning," "science education," "elementary school," and "bibliometric analysis"; filtering articles based on predetermined inclusion and exclusion criteria; and data extraction from articles that meet the criteria. Inclusion criteria include articles that focus on inquiry-based learning in science in elementary schools, published in accredited scientific journals, and available in English or Indonesian. Meanwhile, exclusion criteria include articles that are not relevant to the research topic, articles that are not peer-reviewed, and articles that are not available in full text. Stage of literature review using the bibliometric method with the Scopus database is visualized in Figure 1.

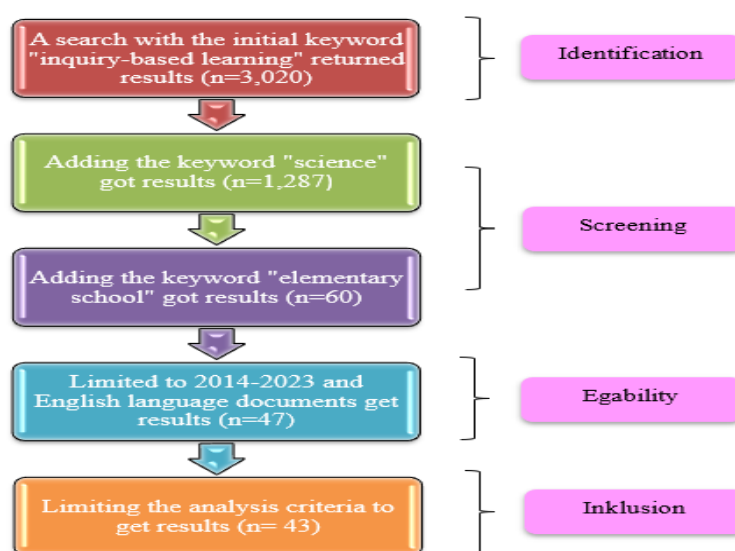


Figure 1. Stage of Literature Review Using the Bibliometric Method with the Scopus Database.

The stages of bibliometric analysis used by researchers include: Identify keywords relevant to the research title, such as "inquiry-based learning", "science in elementary schools", and "research trends", then conduct a literature search using online databases such as Scopus using the identified keywords, then analyze the results of the literature search to identify research development trends in inquiry-based learning in science in elementary schools. Then identify related studies that are relevant to the research topic to enrich understanding of the research trends. After that, make a summary of important findings in previous studies on inquiry-based learning in science in elementary schools. Then identify research gaps that still need to be further studied in this field. Finally, make recommendations for further research based on the research development trends that have been identified.

3. RESULT AND DISCUSSION

Result

Research Publication Trends

Researchers took document publication data related to inquiry-based approaches in science learning in elementary schools in the form of bar charts for the years 2014-2023, the data will be presented in Figure 2.

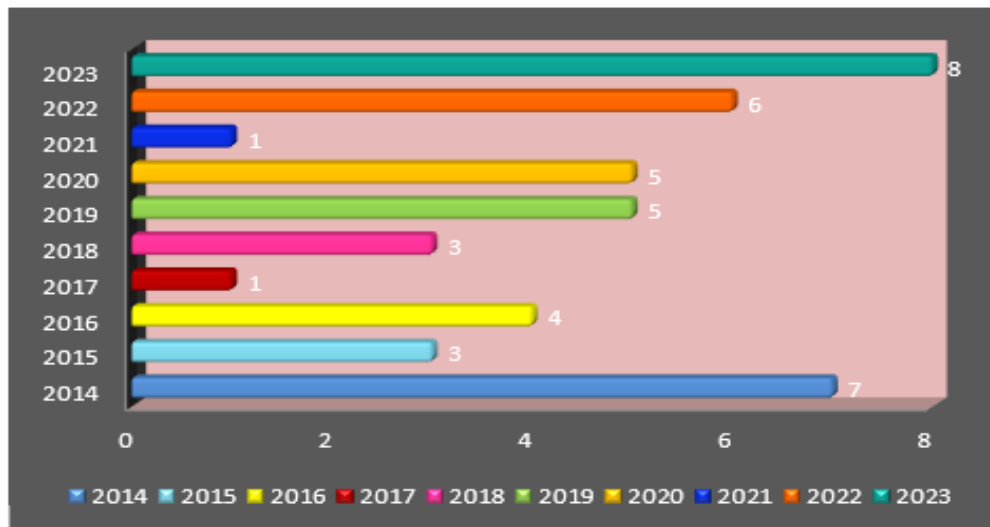


Figure 2. Trends in Research Publications on the Scopus Database

Based on [Figure 2](#), the number of publications in the 2014-2023 period regarding inquiry-based approaches in science learning in elementary school has a varying amount of data each year, the lowest document publication data was found in 2017 and 2021 with the number of document data being 1, then The highest number of document publication data was found in 2023, the number of document data was 8, then the second highest number of publication data occurred in 2014, namely with a total of 7 documents published on the Scopus database, while in 2019 and 2020 there was the same number of data publications. documents in Scopus, namely 5 documents that have been published.

Research Publication Trends by Country

In data searches using Scopus, researchers took document publication data based on countries or regions related to inquiry-based approaches in science learning in elementary schools in the form of bar charts for the years 2014-2023. The data will be presented in [Figure 3](#).

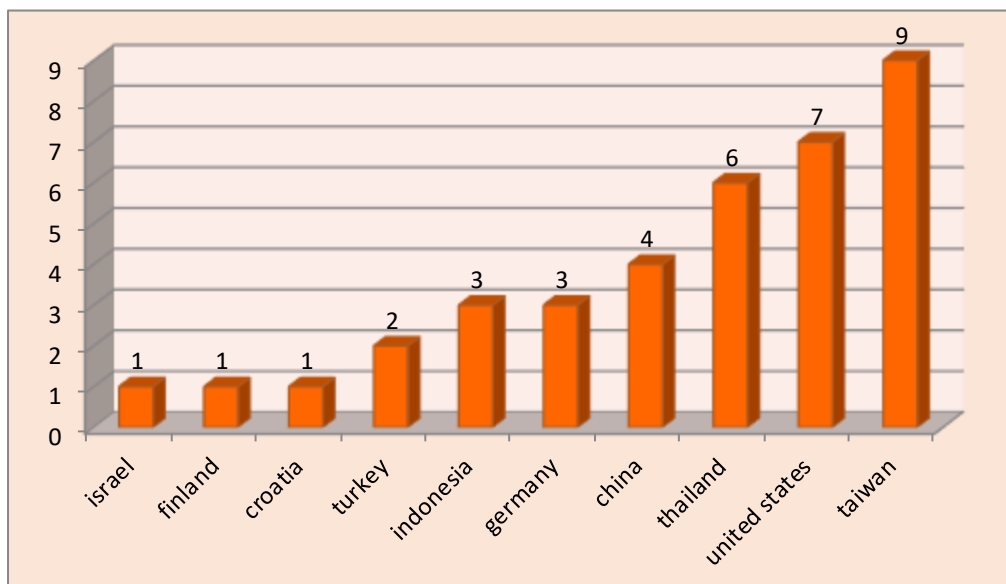


Figure 3. Trends in Research Publications by Country or Territory in the Scopus Database

Based on [Figure 3](#), the country with the highest number of publications related to the inquiry-based approach is Taiwan with 9 documents published on the Scopus database, the second most published with 7 document data published on Scopus is the United States, then the country with data publications The 3rd largest number of documents is Thailand with a total of 6 document data, Germany

and Indonesia have the same amount of data, namely 3 document data that have been published in the Scopus database. Israel, Finland, Croatia have the lowest number of document data published on the Scopus web with 1 document data.

Citation Count Trends

The trend in the number of quotes or citations regarding inquiry-based approaches in science learning in elementary school presented in [Table 1](#). This data was obtained using the publish or perish application.

Table 1. Citation Trends from 2014-2023 on the Scopus Database

Years	Total Publications	Total Citations	Number Citation Paper	H- Index	G- Index
2023	8	10	4	2	3
2022	6	19	4	2	4
2021	1	2	1	1	1
2020	5	33	4	3	5
2019	5	53	5	3	5
2018	3	3	2	1	1
2017	1	48	1	1	1
2016	4	19	3	2	4

Based on [Table 1](#), the highest number of citations was in 2014 with 622 citations and had 7 NCPs, the highest h-index and g-index were also found in 2014 where the number of h-index and g-index in 2014 was 4 and 7, respectively. Then the second highest number of citations was in 2019 with 53 citations and 5 NCP paper citations. The years 2018 and 2021 have the lowest citations and NCP or paper citation numbers with the number of citations being 3 and 2, while the NCP or paper citation number they have is 2 and 1. The number of citations in 2015, 2016 and 2022 has the same number, namely 19, whereas, for the number of NCPs for 2015 and 2016, the number of NCPs is the same, namely 3, the NCP or paper citation number in 2022 is 4. From this data, the year is the most influential and provides many references regarding inquiry-based approaches in science learning in elementary schools for the author. Another is 2014, scientific document data in 2014 is presented in the form of [Table 2](#).

Table 2. Trend of the Highest Number of Citations in 2014 on the Scopus

Author	Title	Journal	Citations
(Chiang et al., 2014)	An augmented reality-based mobile learning system to improve students' learning achievements and motivations in natural science inquiry activities	Educational Technology and Society	394 citations
(Varma, 2014)	Supporting scientific experimentation and reasoning in young elementary school students	Educational Technology and Society	19 citations
(Lai et al., 2014)	Using collaborative teaching and inquiry-based learning to help elementary school students develop information literacy and information technology skills	Educational Technology and Society	8 citations

Based on [Table 2](#), the manuscript written by Chiang, Tosti HC, Yang, Stephen JH, Hwang, Gwo-Jen in 2014 had the most citations, namely 394 citations, they stated that students who learn with augmented reality-based mobile learning approaches and inquiry-based learning approaches demonstrated significantly higher motivation on the dimensions of attention, confidence, and relevance. Then, research conducted by Varma, Keisha, which had 19 citations, said that learning using an inquiry-based approach helped first and third grade students participate in three series of experimental science learning activities at the school. Furthermore, the manuscript written by Lai, yuang-ling, Tsai, chung-hsien, Guo, shy-jen with a total of 8 citations states that students' science learning scores increased significantly after implementing IBL. Students reported the positive impact of collaborative teaching and IBL on their science learning.

Research Focus

The focus of the research regarding the use of multimedia in science learning in elementary schools can be seen from [Figure 4](#). The researcher used the VosViewer application to present images.

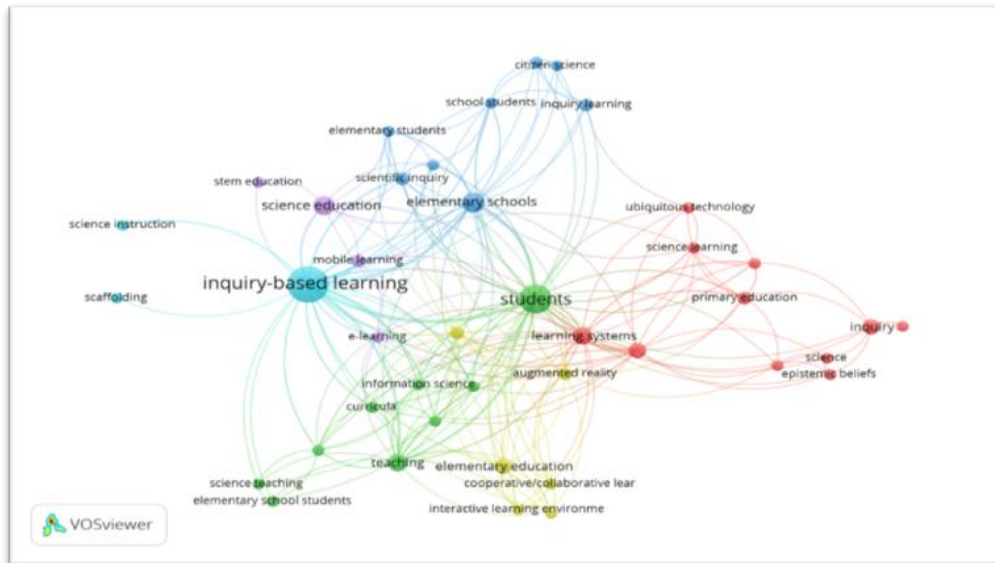


Figure 4. Network Visualization based on Co-occurrence on the Scopus Database

Based Figure 4 there are 6 clusters with 41 items based on network visualization, each cluster consists of a different color starting from cluster 1 with 11 items in red, these items consist of "education", "elementary school". Epistemic beliefs, "inquiry", "learning system", "primary education", "science", "science learning", "simulation", "student", "ubiquitous technology", cluster 2 with 9 items in green, items in cluster 2, namely "curricula", "elementary school student", "engineering education", "information literacy", "information science", "learning performance", "science teaching", "students", "teaching", then cluster 3 with 8 items having a dark blue color, the items consist of "citizen science", "digital device", "elementary school", "elementary students", "inquiry learning", "school students", "scientific inquiry", "scientific knowledge", then cluster 4 with 6 yellow items, these items consist of "augmented reality", "computer aided instruction", "cooperative/collaborative", "elementary education", "interactive learning environment", "teaching/learning strategies", cluster 5 with 4 items has a purple color, these items consist of "e-learning", "mobile learning", "science education", "stem education", finally in cluster 6 with item 3 light blue, the items consist of "inquiry-based learning", "scaffolding", "science instruction".

Figure 1 shows the network on research topics with the theme of inquiry-based approaches in science learning in elementary schools. There are 3 research topics that often appear in network visualizations based on co-occurrences, namely the first term "inquiry-based learning" which appears 22 times with a link strength of 76 and a total of 32 links which are included in cluster 6 which is colored light blue. The second term "students" appears 14 times, link strength is 76 and has 35 links, the second term is in cluster 2 which is green. The three terms "elementary school" appear 7 times, have a link strength of 37 and a link strength of 27, the term elementary school has a dark blue color in class 3.

Novelty of Research

Range of years on research topics regarding inquiry-based approaches in science learning in elementary schools is visualized in Figure 5. The colors in the visualization overlay vary because of the topics or keywords used from oldest to newest. Purple means the topic used is old and yellow means the topic used is new. The following year range regarding the topic of inquiry-based approaches in science learning can be seen in Figure 5.

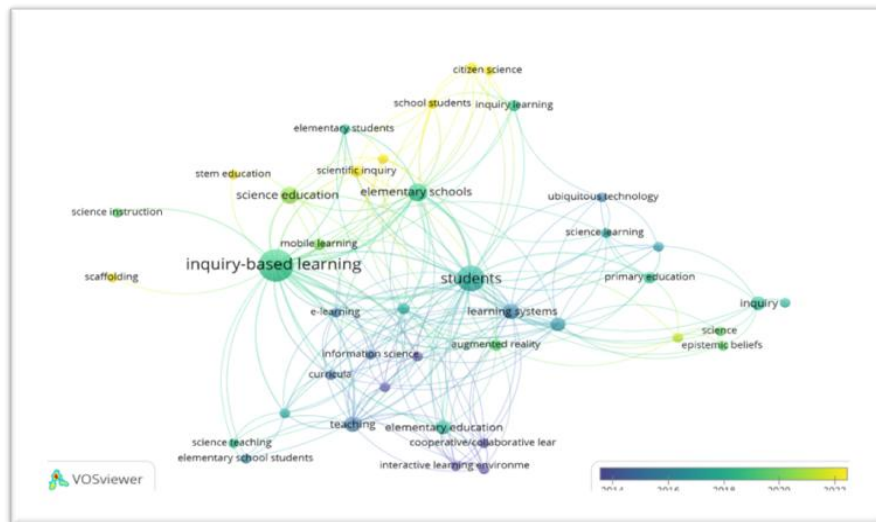


Figure 5. Overlay Visualization based on Co-occurrence

Based on [Figure 5](#), research topics that are frequently used or recently used are the topics "scientific inquiry", "scientific knowledge", "school students", "citizen science", "stem education", "scaffolding" which are used around 2022 to 2023. Then around 2020 to 2021 the topics often used in research are "student", "science education" and "mobile learning". Topics that have long been used in research around 2014 are the topics of "teaching learning strategies" and "cooperative/collaborative learning". The research topics in this title were used around 2018, namely "inquiry-based learning", "elementary school", "inquiry learning", "science instruction", and "augmented reality".

Research Density

[Figure 6](#) shows the density of inquiry-based approach topics in science learning in elementary schools. The colors in the picture show the density of topics used in research. The brighter the color, the more frequently it is used. If the color is not bright, the topic is rarely used.



Figure 6. Density Visualization in the VosViewer Application.

Based on [Figure 6](#), it can be seen that the keyword "inquiry-based learning" has a bright yellow color, which means the keyword has been widely used in research, then research topics with the word "student" are yellow but not bright, meaning the topic is often used or appear frequently in research, while the keywords "science education" and "elementary school" are yellowish green, meaning these topics also frequently appear in research. Then topics with a dark green color such as "learning performance", "scaffolding", "science instruction" and others mean that they rarely appear in research related to inquiry-based approaches in science learning in elementary school.

Discussion

This research explores trends in inquiry-based learning (IBL) within science education at the elementary school level, using bibliometric analysis sourced from the Scopus database. Tools such as VOS Viewer and Publish or Perish were employed to analyze and visualize publication trends, citations, co-occurrences, and research density. The findings provide insights into the evolution of IBL research and its application in educational contexts. The analysis revealed varying publication trends from 2014 to 2023, with the lowest output in 2017 and 2021, each recording only one publication, while 2023 saw the highest number with eight publications. Taiwan emerged as the leading contributor with nine publications, followed by countries like Israel, Finland, and Croatia with only one publication each. Citation trends peaked in 2014, which examined the integration of augmented reality (AR) with IBL and demonstrated its significant impact on improving students' learning outcomes (Chiang et al., 2014).

Network visualization highlighted key terms frequently appearing in the research. "Inquiry-based learning" was the most prominent, appearing 22 times with a link strength of 76, followed by "students" and "elementary school," which also showed substantial connectivity. Novelty visualization indicated emerging topics like "scientific inquiry," "STEM education," and "citizen science," particularly prevalent in studies from 2022 and 2023. Additionally, density visualization underscored the widespread use of terms such as "inquiry-based learning" and "students," indicating their centrality to the research field.

The findings align with prior research emphasizing the pedagogical benefits of IBL. Prior study highlighted how integrating AR with IBL enhanced students' understanding of abstract scientific concepts, critical thinking, and problem-solving skills (Chiang et al., 2014). Similarly, other relevant studies found that combining IBL with collaborative teaching improved student engagement, self-confidence, motivation, scientific concepts, process skills, and attitudes (Lai et al., 2014; Varma, 2014). Furthermore, other studies also confirmed that IBL contributes to better student learning outcomes and fosters a positive attitude toward science learning (Fabiola, 2023; Windhiana et al., 2022). Compared to earlier studies, this research extends understanding by identifying global trends and gaps in IBL research. While earlier studies focused primarily on pedagogical benefits, such as improved engagement (Indah et al., 2023), learning outcomes (Ibrohim et al., 2020), and critical thinking (Walter et al., 2022), the present study highlights geographic disparities in IBL research and underscores the potential for integrating innovative methods like AR (Hamka et al., 2022) and citizen science (Fru et al., 2019).

The findings of this study contribute significantly to the field of education, particularly in the context of science learning in elementary schools. The bibliometric analysis highlights global trends in the implementation of inquiry-based learning (IBL) and its association with improved learning outcomes, student engagement, and mastery of scientific concepts. These findings underscore the importance of pedagogical innovation that integrates IBL with technologies such as augmented reality and collaborative approaches to create more meaningful and immersive learning experiences. The implications of this research emphasize the necessity of curriculum development and teacher training programs focused on fostering students' critical, creative, and collaborative skills. Consequently, this study recommends further cross-regional investigations to address geographical gaps in IBL research and the development of methods combining technology with scaffolding strategies to optimize the effectiveness of this approach in diverse educational contexts.

4. CONCLUSION

Inquiry-based learning (IBL) represents a transformative approach to education, particularly in science learning, by fostering active student engagement, critical thinking, and meaningful understanding of concepts. This study underscores the global relevance and adaptability of IBL, revealing its potential to bridge traditional teaching practices with innovative strategies such as technology integration and collaborative learning. The bibliometric findings illuminate not only the prevalence of IBL in contemporary educational research but also the emerging focus on enhancing its application through contextual and technological advancements. Conceptually, IBL aligns with the constructivist paradigm, emphasizing the learner's role in constructing knowledge through exploration and inquiry, thereby cultivating lifelong learning skills. As education evolves to meet the demands of the 21st century, IBL serves as a foundational strategy to prepare students for complex problem-solving and adaptability in an ever-changing world.

5. ACKNOWLEDGE

First, I would like to thank Allah SWT who has given me the blessings of physical and spiritual health so that I can write this manuscript well. secondly, I would like to thank my parents and my family for giving me encouragement and support, thirdly I would like to thank Mr. Rohmani as my guide so that

this article can be completed well, then I thank my parents and friends who have supported and motivated me in completing this article.

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