ISEJ Indonesian Science Education Journal

ISSN Online: 2716-3350
Vol. 5 No. 1 January 2024 Pages 1-8
https://siducat.org/index.php/isej/
Published by Yayasan Darussalam Bengkulu

The Role of Scientific Approaches in Enhancing Natural Science Learning Outcomes in Indonesian Primary Schools

Noor Akhlis[1], Moh Sukri[2], A. Yunus[3]
Institut Agama Islama Negeri Salatiga[1,2,3]
E-mail: noorakhlis.na76@gmail.com

Abstract
Improving the quality of science education in primary schools has become a central concern in Indonesia, where international assessments continue to indicate lower achievement levels compared to neighboring countries, thus underscoring the importance of adopting pedagogical approaches that foster inquiry and scientific reasoning from an early age. This study aimed to analyze the urgency of implementing the scientific approach in natural science learning at the elementary school level by situating it within the framework of the 2013 Curriculum. Employing a qualitative descriptive design, data were collected from policy documents, peer-reviewed journals, and scholarly books and analyzed through thematic analysis to identify key patterns, challenges, and opportunities related to the integration of inquiry-oriented instruction. The results reveal that while the scientific approach is conceptually aligned with international standards of inquiry-based learning and has the potential to enhance student engagement and critical thinking, its implementation in Indonesian classrooms remains constrained by systemic barriers such as limited teacher preparation, insufficient resources, and exam-driven teaching practices. The discussion highlights that bridging the gap between curricular policy and classroom practice requires sustained professional development, contextual adaptation of teaching strategies, and supportive educational policies that prioritize inquiry processes over rote memorization. This study contributes to the literature by offering novel insights into the conceptual and practical urgency of the scientific approach in developing country contexts and implies that successful integration could not only improve student learning outcomes but also strengthen the foundations of scientific literacy essential for twenty-first century competencies.

Keywords: Curriculum 2013, Elementary Education, Inquiry-Based Learning, Scientific Approach, Science Learning.

INTRODUCTION

Education has long been recognized as a fundamental driver of human development and national progress, particularly in an era of rapid globalization and technological transformation. Quality education is essential for preparing students to actively participate in the knowledge society, where scientific literacy and problem-solving skills are paramount (Kumar & Choudhary, 2024; Samala et al., 2024; Zalli, 2024). In developing countries such as Indonesia, however, the quality of education still lags behind that of neighboring nations, as reflected in comparative international assessments that consistently report lower performance in science and mathematics. Such disparities highlight the urgency of rethinking pedagogical approaches that not only transmit knowledge but also foster critical thinking, creativity, and scientific reasoning from an early age (Eloranta et al., 2024; Gómez-Talal et al., 2024; Karim, 2021).

The implementation of the 2013 Curriculum in Indonesia was designed to address these challenges by emphasizing a scientific approach to teaching and learning. A scientific approach encourages students to engage in processes such as observing, questioning, experimenting, reasoning, and communicating, thereby fostering inquiry-based learning and active construction of knowledge (Karim, 2021; Lestari et al., 2024; Muhammad et al., 2022). This approach is aligned with international perspectives that view inquiry and experiential learning as central to developing students' scientific

understanding and twenty-first century skills (Antonio & Prudente, 2023; Chu et al., 2017; Qablan et al., 2024). Particularly at the elementary school level, where students are in their formative cognitive stages, the integration of scientific approaches is considered crucial to ensure that abstract concepts are made concrete through structured inquiry and contextual experiences (Granberg et al., 2021; Oktaviani et al., 2023; Wang et al., 2022).

Despite the theoretical advantages of scientific approaches in education, their implementation in Indonesian elementary schools remains inconsistent and often superficial. Previous studies have reported that teachers face significant barriers, including limited pedagogical knowledge, lack of resources, and rigid classroom practices that hinder the effective adoption of inquiry-based learning . In practice, many science lessons continue to rely heavily on rote memorization and textbook-based teaching, which reduce opportunities for students to develop higher-order thinking skills (Fitzgerald et al., 2019; Imaduddin et al., 2021; Zaiful Shah & Zakaria, 2024). Furthermore, cultural and systemic factors such as large class sizes, standardized examinations, and insufficient professional development exacerbate these challenges, making it difficult for teachers to shift toward more student-centered practices (de Jong et al., 2023; Revina et al., 2023; Shalikhah & Nugroho, 2023).

Internationally, a large body of research has affirmed the effectiveness of scientific approaches in improving student engagement, conceptual understanding, and problem-solving abilities (De Bruijn-Smolders & Prinsen, 2024; Mebert et al., 2020; Salim et al., 2024). Studies in diverse contexts have shown that when teachers effectively implement inquiry-oriented instruction, students not only achieve higher academic outcomes but also develop scientific attitudes and collaborative skills that are essential for lifelong learning (Herranen et al., 2019; Kwangmuang et al., 2021; Sam, 2024). However, evidence also indicates that successful implementation requires substantial teacher preparation, contextual adaptation, and continuous support, without which the approach may not yield its intended benefits (Eriksen et al., 2021; Valenta et al., 2023; Van den Broeck et al., 2024) .

While the existing literature has examined the role of scientific approaches in science education, most research in Indonesia has concentrated on secondary schools or specific interventions, with relatively little attention given to their conceptual and practical urgency in elementary school contexts (Hill et al., 2025; Kurniahtunnisa et al., 2024; Nurwahyunani, 2021). Moreover, there is a lack of comprehensive analysis that integrates theoretical frameworks, empirical evidence, and curricular mandates to evaluate how scientific approaches can be systematically embedded in primary science learning. This gap suggests a pressing need to re-examine the significance of scientific approaches in Indonesian elementary schools and to articulate their potential role in shaping effective science education at the foundational level.

Therefore, the present study seeks to provide a conceptual and empirical overview of the urgency of implementing scientific approaches in natural science learning in Indonesian elementary schools. Specifically, it aims to analyze how the scientific approach aligns with the 2013 Curriculum, to identify challenges and opportunities in its application, and to highlight its implications for improving the quality of science learning at the basic education level. By doing so, this study contributes to the broader discourse on pedagogical innovation in developing countries and offers insights for policymakers, educators, and researchers committed to advancing science education in line with global standards.

METHODS

This study employed a qualitative descriptive design aimed at exploring and conceptualizing the urgency of applying a scientific approach in natural science learning at the elementary school level. A qualitative descriptive approach was chosen because it allows researchers to investigate educational phenomena in depth by integrating theoretical perspectives, documentary analysis, and empirical reflections, rather than testing hypotheses in a controlled setting (Akerson et al., 2019; Nur'ariyani et al., 2023; Nureva & Melinda, 2022). The data were collected from multiple sources, including national curriculum documents, previous empirical studies published in peer-reviewed journals, scholarly books, and relevant government regulations related to the implementation of the 2013 Curriculum in Indonesia. Such a strategy ensured a comprehensive understanding of the phenomenon under investigation while also allowing triangulation across different forms of evidence to strengthen validity.

The data collection process followed a systematic procedure of literature identification, selection,

and review. First, relevant documents were identified through academic databases such as Scopus, Web of Science, and Google Scholar, using keywords including "scientific approach," "science learning," "elementary education," and "curriculum 2013." Second, studies were selected based on inclusion criteria that prioritized peer-reviewed journal articles, official curriculum guidelines, and recent scholarly works published between 2010 and 2023 to ensure both relevance and currency (Hvalby et al., 2024; Oliveira & Bonito, 2023; Zhang et al., 2023). Third, the selected literature was critically reviewed to extract information related to the definition, scope, implementation, and challenges of the scientific approach in primary science learning.

The analysis was conducted using a thematic approach, which involved coding, categorizing, and synthesizing data into key themes. Thematic analysis was chosen because it is widely used in qualitative educational research to identify patterns across diverse sources and to generate insights that extend beyond individual studies (Ferk Savec & Mlinarec, 2021; Oliveira & Bonito, 2023). Themes were developed inductively from the data but guided by theoretical frameworks on student-centered learning and inquiry-based pedagogy. The analysis process was iterative, moving back and forth between the literature and emerging concepts until saturation was reached and coherent themes were established.

To enhance the trustworthiness of the study, several strategies were employed. Triangulation was achieved by comparing findings across multiple data sources, thereby reducing the risk of bias and ensuring the robustness of interpretations (Carter et al., 2014; Johnson et al., 2020; Riazi et al., 2023). Peer debriefing was also conducted with fellow researchers in the field of science education to validate the coding process and the thematic structure. Moreover, an audit trail was maintained to document analytical decisions and ensure transparency in the research process. Ethical considerations were carefully observed by relying solely on secondary data from publicly available documents and ensuring accurate attribution of all cited sources. Since the study did not involve human participants directly, issues such as informed consent and confidentiality were not applicable.

Overall, this methodological approach was designed to provide a rigorous and holistic understanding of the urgency of implementing scientific approaches in natural science learning at the elementary school level. By systematically reviewing, analyzing, and synthesizing relevant literature, the study contributes credible insights that may inform educational policy, curriculum design, and classroom practice.

RESULT and DISCUSSION

Conceptualization of the Scientific Approach in Primary Science Education

The analysis revealed that the scientific approach is perceived not merely as a pedagogical strategy but as a comprehensive framework for fostering inquiry, critical thinking, and active student participation in elementary science classrooms. The 2013 Indonesian Curriculum mandates the integration of inquiry-oriented processes, such as observing, questioning, experimenting, reasoning, and communicating, which are closely aligned with international standards of science pedagogy. Findings indicate that teachers and curriculum designers view the scientific approach as essential for enabling students to bridge abstract concepts with concrete experiences, thereby facilitating deeper conceptual understanding at the primary level.

This result is consistent with earlier studies demonstrating that inquiry-based strategies positively affect students' ability to construct knowledge and develop scientific reasoning (Chan & Lee, 2021; Chirove & Ogbonnaya, 2021; Mohammad et al., 2023). However, the present study extends these findings by situating the discussion within the Indonesian educational context, where structural, cultural, and policy-related challenges significantly shape classroom practices.

Challenges in the Implementation of the Scientific Approach

Despite the recognized importance of the scientific approach, the study found substantial barriers to its effective implementation in Indonesian elementary schools. Teachers frequently reported limitations in pedagogical knowledge, insufficient training, and a lack of appropriate teaching resources. Moreover, systemic factors such as large class sizes, exam-oriented teaching practices, and rigid time allocation hinder the sustained use of inquiry-based learning strategies.

These challenges resonate with previous findings that emphasize the gap between curriculum design and classroom enactment (Kang & Keinonen, 2016; Ulferts, 2021; Wulandari & Setiawan, 2023).

Similarly, Asmayawati et al. (2024) and Kotsis (2024) have shown internationally that successful adoption of inquiry pedagogy requires sustained professional development and contextual adaptation. The novelty of the present study lies in highlighting how these challenges manifest uniquely in Indonesian primary schools, where curricular mandates often conflict with resource limitations and systemic pressures.

Comparative Insights from International Practices

A comparative review of international practices suggests that the scientific approach, when implemented effectively, leads to improved student engagement and achievement. For example, Suyono et al. (2024) found that problem-based learning enhanced both content mastery and collaborative skills, while Guo et al, (2020) emphasized the role of teachers as facilitators in cultivating authentic inquiry experiences. In Finland, inquiry-oriented science education has been successfully integrated into national curricula, supported by extensive teacher training and assessment reforms (Akpen et al., 2024). In contrast, the present study demonstrates that Indonesia still struggles to align policy with classroom realities, creating a mismatch between curricular expectations and actual pedagogical practices. This divergence highlights the need for stronger institutional support, particularly in professional development and resource allocation, to ensure the scientific approach is not reduced to a rhetorical requirement but becomes an actionable classroom practice.

Implications for Curriculum and Pedagogy

The findings suggest several critical implications. First, the scientific approach should not be treated as an isolated methodology but as an integral component of curriculum design, teacher preparation, and classroom culture. Second, policymakers must address systemic constraints by providing sustained professional development, reducing class sizes, and introducing formative assessments that reward inquiry processes rather than rote memorization. Third, teachers need access to contextually relevant instructional resources that make inquiry feasible in diverse classroom environments. The novelty of this study lies in articulating the urgency of the scientific approach as both a curricular mandate and a pedagogical necessity in Indonesian primary education. While international research has extensively documented the benefits of inquiry-based learning, few studies have examined its systemic urgency and implementation challenges within the Indonesian elementary context. This research, therefore, adds a new layer of analysis by connecting policy-level directives with classroom-level realities.

Limitations of the Study

Although this study provides valuable insights, certain limitations must be acknowledged. First, the research is primarily based on secondary data and literature review, which may not fully capture the dynamic practices and challenges experienced by teachers in real classroom settings. Second, the reliance on published studies and policy documents may introduce publication bias, as unpublished practices and informal innovations remain undocumented. Third, the study does not include empirical classroom observations or direct teacher interviews, which could have provided richer, context-specific data. Future research should therefore employ mixed-methods approaches, combining classroom ethnographies, teacher interviews, and student learning assessments to provide a more comprehensive understanding of the scientific approach in practice. Such studies would allow for deeper exploration of how systemic, cultural, and institutional factors interact in shaping the effectiveness of inquiry-based science learning in Indonesian primary schools.

CONCLUSION

This study concludes that the scientific approach is not only a pedagogical option but an essential framework for enhancing natural science learning in Indonesian elementary schools, as it fosters inquiry, critical thinking, and active knowledge construction aligned with the competencies required by the 2013 Curriculum and global educational standards. The findings demonstrate that while the scientific approach conceptually aligns with international best practices in inquiry-based learning, its

implementation in Indonesia faces systemic challenges, including limited teacher preparation, insufficient resources, and exam-driven instruction, which often constrain the realization of student-centered learning. By synthesizing theoretical perspectives and empirical evidence, this study provides novel insights into the urgency of embedding the scientific approach within primary education, highlighting its potential to improve student engagement and learning outcomes if supported by sustained professional development, contextualized instructional resources, and policy adjustments. Although limited by its reliance on secondary data, the study contributes to the literature by articulating the gap between curriculum policy and classroom practice in developing country contexts, offering both theoretical implications for advancing inquiry-based pedagogy and practical recommendations for strengthening teacher capacity and educational reform.

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