Elementary School Teachers' Readiness in Integrating STEM into Science Learning

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Abstract. The integration of Science, Technology, Engineering, and Mathematics (STEM) into elementary science learning has gained increasing recognition as a promising approach for developing students' twenty-first-century competencies. However, successful STEM implementation depends largely on teachers' readiness to integrate interdisciplinary learning into classroom practices. This study aimed to examine the level of readiness among elementary school teachers in integrating STEM into science learning. A quantitative descriptive survey design was employed, involving 59 elementary school teachers. Data were collected using a validated questionnaire consisting of four dimensions: STEM knowledge, technological readiness, pedagogical readiness, and STEM implementation readiness. Data were analyzed using descriptive statistics, including mean scores and standard deviations. The findings revealed that teachers demonstrated a high level of readiness across all dimensions, with an overall mean score of 3.85. Technological readiness obtained the highest mean score (M = 3.98), followed by STEM knowledge (M = 3.86), while pedagogical readiness and STEM implementation readiness shared the lowest mean score (M = 3.79). Teachers showed strong interest in participating in STEM-related professional development and expressed readiness to implement STEM in science classrooms. Nevertheless, limited hands-on STEM experience and difficulties in designing STEM-based learning activities and assessments remain notable challenges. The findings indicate that while elementary school teachers possess positive perceptions and substantial readiness toward STEM integration, continuous professional development and institutional support are necessary to strengthen pedagogical competencies and practical implementation. These findings offer empirical evidence to inform teacher training program development and policy-making aimed at advancing STEM education at the elementary level.

Keywords: STEM education; teacher readiness; science learning; elementary school teachers

INTRODUCTION

The rapid advancement of science and technology in the twenty-first century has compelled educational systems to develop human resources equipped with critical thinking, creativity, collaboration, and complex problem-solving skills. According to the Organisation for Economic Co-operation and Development (OECD, 2019) these competencies are among the essential skills required to address future global challenges. Consequently, school learning is no longer focused solely on the acquisition of conceptual knowledge but also on the development of higher-order thinking skills and multidisciplinary literacy. One educational approach that has been widely recommended to achieve these goals is STEM (Science, Technology, Engineering, and Mathematics) education. STEM is an instructional approach that integrates science, technology, engineering, and mathematics within authentic, real-world problem contexts (Thibaut et al., 2018). As an interdisciplinary learning framework, STEM provides students with opportunities to explore ideas through technical design experiences and hands-on practices within problem-based learning environments (Trivena et al., 2025). Through STEM learning, students are encouraged to develop a range of higher-order competencies, including analytical reasoning and innovative problem-solving (Sugeng, 2025).

At the elementary school level, science education offers substantial potential for STEM integration. The characteristics of science learning, which emphasize scientific processes, observation, experimentation, and inquiry (Akbar et al., 2025), enable students to connect scientific concepts with technology, engineering, and mathematics in everyday life. Furthermore, integrating STEM from the elementary level has been shown to enhance students' ability to understand, analyze, and actively participate in solving real-life problems (Funa, 2026; Kartimi et al., 2021).

Despite its potential benefits, the implementation of STEM in elementary science education continues to face various challenges. Several studies have reported that teachers often experience difficulties in designing learning activities that meaningfully integrate multiple disciplines. In addition, limited STEM knowledge, insufficient professional development opportunities, and inadequate facilities and resources have been identified as major barriers to effective STEM implementation in schools (Margot & Kettler, 2019; Talib et al., 2024). Teachers play a pivotal role in the successful implementation of STEM education. Teacher readiness encompasses multiple dimensions, including content knowledge, attitudes, pedagogical skills, and the availability of instructional resources (Sulaeman et al., 2022). Therefore, assessing teacher readiness constitutes a critical preliminary step before STEM can be effectively implemented in classroom practice (Margot & Kettler, 2019).

In Indonesia, research on STEM education at the elementary level has grown considerably. However, most existing studies have primarily focused on the development of instructional models or the effects of STEM on students' learning outcomes (Purnamaningtyas et al., 2026) and conceptual understanding (Funa, 2026). Studies specifically investigating elementary school teachers' readiness to integrate STEM into science instruction remain relatively limited. Meanwhile, information regarding teachers' readiness levels is essential for designing professional development and training programs that address the practical needs of schools and educators (Amanova & Brynteson, 2025).

Based on these considerations, the present study aims to analyze elementary school teachers' readiness to integrate STEM into science learning by examining four key dimensions: STEM Knowledge, technological readiness, pedagogical readiness, and STEM Implementation readiness. The findings are expected to provide empirical insights into the current state of teacher readiness. In turn, these insights may serve as a foundation for policymakers and educational stakeholders in developing effective programs to strengthen teacher competencies related to STEM implementation in elementary schools.

METHODS

Research Design

This study employed a quantitative approach using a descriptive survey method. This approach was considered appropriate for obtaining a systematic, factual, and measurable overview of elementary school teachers' readiness to integrate STEM into science instruction. Data were collected through a self-administered online questionnaire distributed to participants during the 2025/2026 academic year.

Participants

The participants consisted of 59 elementary school teachers actively teaching in public and private elementary schools located in Bekasi Regency and Bekasi City, Indonesia. Participants were selected using a purposive sampling technique based on the inclusion criterion that they were directly involved in teaching science subjects at the classroom level. Of the 59 participants, 49 were female and 10 were male. In terms of teaching experience, 16 participants had fewer than 5 years of experience, 19 had between 5 and 10 years, 18 had between 11 and 20 years, and 6 had more than 20 years of teaching experience. This distribution indicates that the sample represented a broad range of teaching experience levels, from novice to highly experienced teachers.

Research Instrument

The research instrument was a questionnaire designed to assess teachers' readiness to integrate STEM into science learning. The questionnaire was developed based on an extensive review of relevant literature and previous studies. The instrument comprised four measurement dimensions with a total of 20 items: (1) STEM knowledge (5 items), (2) technological readiness (5 items), (3) pedagogical readiness (5 items), and (4) STEM implementation readiness (5 items). Each item was rated on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Prior to data collection, the instrument was subjected to validity testing. Content validity was established through expert review conducted by [number] specialists in STEM education and educational measurement, who evaluated the relevance and clarity of each item. Based on expert feedback, minor revisions were made to improve item wording. Item validity was then assessed using Pearson product-moment correlation, with all 20 items yielding correlation coefficients exceeding the critical value ($r > 0.30$), confirming that all items were valid measures of the intended constructs. Instrument reliability was subsequently assessed using Cronbach's alpha coefficient, yielding satisfactory to excellent values across all dimensions: STEM knowledge ($\alpha = 0.899$), technological readiness ($\alpha = 0.888$), pedagogical readiness ($\alpha = 0.888$), and STEM implementation readiness ($\alpha = 0.790$). The overall Cronbach's alpha for the instrument was 0.945, indicating excellent internal consistency (Gliem & Gliem, 2003) and confirming that the instrument was highly reliable for measuring teachers' readiness to integrate STEM into science instruction.

Data Analysis

The collected data were analyzed using descriptive statistics, including mean scores, standard deviations, frequencies, and percentages. Teachers' readiness levels were categorized into three levels based on mean score ranges adapted from Riduwan (2015).

Table 1. Score Range Categories

Score Range	Category
1.00 – 2.33	Low
2.34 – 3.66	Moderate
3.67 – 5.00	High

RESULTS AND DISCUSSION

This study aimed to analyze elementary school teachers' readiness to integrate STEM (Science, Technology, Engineering, and Mathematics) into science instruction. Data were collected from 59 elementary school teachers teaching in various public and private schools. Teachers' readiness was assessed across four key dimensions: STEM knowledge, technological readiness, pedagogical readiness, and STEM implementation readiness.

STEM Knowledge Readiness

The results of the analysis revealed that the STEM knowledge dimension achieved a mean score of 3.86, which falls within the high readiness category. The highest mean score was found for the indicator concerning the importance of implementing STEM in elementary schools (M = 4.19), while the lowest mean score was observed for the indicator related to understanding the instructional procedures and stages of STEM learning (M = 3.59).

These findings indicate that teachers generally recognize the importance of STEM integration in science education. However, they still require further professional development to strengthen their understanding of the systematic procedures and implementation stages of STEM-based instruction.

Table 2. STEM Knowledge Readiness

Indikator	Mean	SD	Category
Understanding STEM concepts	3.79	0.76	High
Understanding STEM integration in science instruction	3.66	0.8	High
Recognizing the importance of STEM implementation in elementary schools	4.19	0.65	High
Understanding the benefits of STEM for Students	4.06	0.63	High
Understanding STEM instructional procedures	3.59	0.87	High
Average	**3.86**	**0.74**	High

Based on Table 2, the STEM Knowledge Readiness dimension demonstrated a high level of readiness, with an overall mean score of 3.86 (SD = 0.74). All indicators within this dimension were classified as high, indicating that the teachers possessed a relatively strong understanding of STEM concepts and recognized the importance of STEM integration in elementary science education.

Technology Readiness

The technology readiness dimension achieved a mean score of 3.98, making it the second-highest scoring dimension. The findings indicate that teachers demonstrated a strong ability to utilize digital media and online learning platforms in their instructional practices. The highest mean score was observed for the indicator using digital media (M = 4.16), whereas the lowest mean score was found for the adequacy of school technology facilities (M = 3.72).

Tabel 3. Technology Readiness

Indicator	Mean	SD	Category
Using digital media	4.16	0.85	High
Using online learning platforms	4.06	0.82	High
Utilizing technology in science instruction	4.10	0.80	High
Adequate school technology facilities	3.72	0.88	High
Familirity with using technology	3.83	0.98	High
Average	**3.98**	**0.87**	**High**

These findings suggest that teachers possess a relatively high level of competence in utilizing technology to support STEM instruction. Nevertheless, the availability and adequacy of technological facilities in schools remain an area requiring further improvement to facilitate the optimal implementation of STEM education.

Pedagogical Readiness

The pedagogical readiness dimension obtained an overall mean score of 3.79, which falls within the high readiness category. However, this dimension recorded the lowest average score among the four readiness dimensions assessed in this study. The highest mean score was observed for the indicator guiding students in problem-solving activities (M = 4.10), while the lowest mean score was found for conducting STEM-based assessment (M = 3.56).

Table 4. Pedagogical Readiness

Indicator	Mean	SD	Category
Developing STEM-based instructional materials and lesson plans	3.57	0.79	High
Implementing Project-Based Learning (PjBL)	4.05	0.75	High
Guiding students in problem-solving activities	4.10	0.66	High
Integrating STEM into science instruction	3.66	0.82	High
Conducting STEM-based assessment	3.56	0.77	High
Average	**3.79**	**3.80**	**High**

These findings indicate that teachers are relatively well prepared to manage problem-oriented learning environments and facilitate students' problem-solving processes. Nevertheless, they still require further professional development to strengthen their competencies in designing STEM-based instructional materials and implementing appropriate assessment practices for STEM learning.

STEM Implementation Readiness

The STEM implementation readiness dimension was designed to assess elementary school teachers' preparedness to implement STEM-based learning in the classroom. The analysis revealed that this dimension achieved an overall mean score of 3.79 with a standard deviation of 0.74, indicating a high level of readiness. These findings suggest that, in general, teachers possess adequate readiness to integrate STEM into science instruction.

Table 5. STEM Implementation Readiness

Indicator	Mean	SD	Category
Confidence in implementing STEM	3.59	0.83	High
Interest in participating in STEM training	4.05	0.67	High
Readiness to implement STEM in the classroom	4.10	0.61	High
Experience in implementing STEM	3.66	0.87	High
Need for additional STEM training	3.55	0.71	High
Average	**3.79**	**0.74**	High

Based on Table 5, the indicator readiness to implement STEM in the classroom achieved the highest mean score (M = 4.10; SD = 0.61), indicating that most teachers perceive themselves as prepared to integrate STEM into their teaching practices. Similarly, the indicator interest in participating in STEM training received a high score (M = 4.05; SD = 0.67), reflecting teachers' strong motivation to enhance their competencies and understanding of STEM implementation. The indicator confidence in implementing STEM obtained a mean score of 3.59 (SD = 0.83), which also falls within the high category. However, this result suggests that some teachers are still not fully confident in their ability to independently conduct STEM-based instruction. This lack of confidence may be associated with limited experience and insufficient professional training. Meanwhile, experience in implementing STEM recorded a mean score of 3.66 (SD = 0.87) and was the only indicator classified within the moderate category. This finding indicates that although teachers demonstrate high levels of readiness and interest in STEM, their practical experience in implementing STEM-based learning remains relatively limited. This suggests that STEM practices have not yet been implemented consistently and sustainably across elementary schools. Furthermore, the indicator need for additional STEM training achieved a mean score of 3.55 (SD = 0.71), indicating that teachers continue to perceive professional development opportunities as essential for strengthening their capacity to implement STEM effectively in classroom settings.

Overall Readiness of Elementary School Teachers to Integrate STEM into Science Instruction

The results of the analysis indicate that, overall, elementary school teachers demonstrated a high level of readiness to integrate STEM into science instruction. This is reflected in the overall mean score of 3.85, which falls within the high category. These findings suggest that teachers possess the necessary knowledge, skills, and readiness to support the implementation of STEM-based learning in elementary schools.

Table 6. Overall Teachers' Readiness to Integrate STEM into Science Instruction

Dimension	Mean	Category
STEM Knowledge Readiness	3.86	High
Technology Readiness	3.98	High
Pedagogical Readiness	3.79	High
STEM Implementation Readiness	3.79	High
Overall Average	**3.85**	**High**

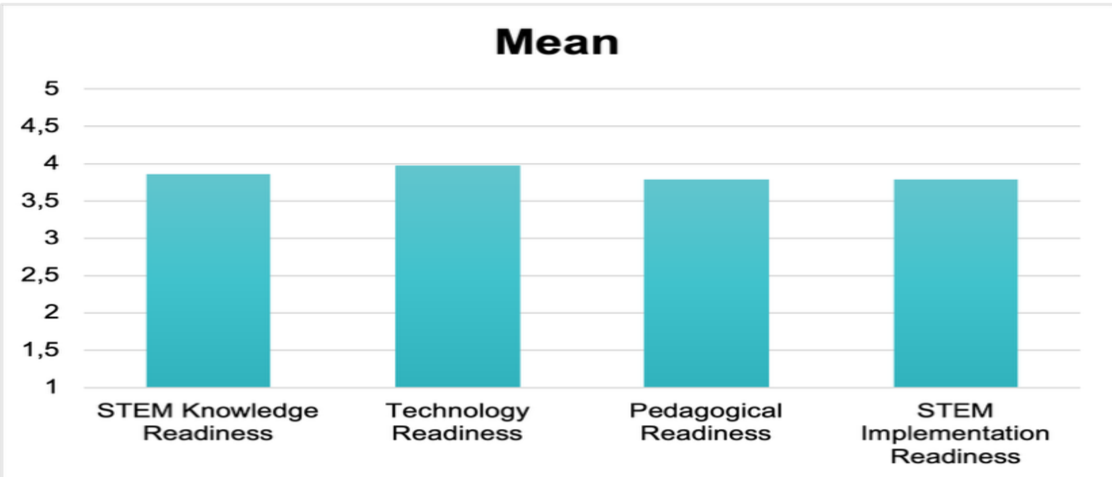

Figure 1. Mean Scores of Teachers' Readiness to Integrate STEM into Science Instruction.

Based on Table 6 and Figure 1, the Technology Readiness dimension obtained the highest mean score (M = 3.98), which falls within the high category. This finding indicates that most teachers are familiar with utilizing technology in the learning process, including the use of digital media, online learning platforms, and various technology-based learning resources. A high level of technological readiness represents an important asset for STEM implementation, as technology is one of the core components of the STEM approach.

The STEM Knowledge Readiness dimension achieved a mean score of 3.86, which also falls within the high category. This result suggests that teachers possess a relatively strong understanding of STEM concepts, the educational benefits of STEM, and the importance of integrating STEM into science instruction. Adequate STEM knowledge serves as a critical foundation for teachers in designing and implementing effective STEM-based learning experiences.

Furthermore, the STEM Implementation Readiness dimension obtained a mean score of 3.79, indicating a high level of readiness. This finding demonstrates that teachers have strong motivation and willingness to implement STEM in their classrooms. The high levels of interest in participating in STEM-related professional development and readiness to apply STEM-based instruction reflect positive attitudes toward educational innovation. Nevertheless, teachers' practical experience in implementing STEM remains limited and requires further enhancement to translate this readiness into more effective classroom practice.

Meanwhile, the Pedagogical Readiness dimension recorded a mean score of 3.79, making it the lowest-scoring dimension, although it still falls within the high category. This finding suggests that teachers continue to face challenges in developing STEM-based instructional materials, integrating multiple disciplines into coherent learning experiences, and designing assessment strategies that align with the characteristics of STEM education. Therefore, strengthening pedagogical competencies through targeted professional development and mentoring programs should be prioritized to improve the quality of STEM implementation in elementary schools.

Overall, the findings indicate that elementary school teachers demonstrate a high level of readiness to integrate STEM into science instruction. Although all dimensions were categorized as high, pedagogical readiness and practical STEM implementation experience require further improvement to ensure that STEM integration can be carried out more effectively and sustainably. These findings highlight the importance of institutional support, continuous professional development, and the provision of adequate learning resources to optimize STEM implementation in elementary science education.

The findings of this study indicate that elementary school teachers demonstrate a high level of readiness to integrate STEM into science instruction. The high score achieved in the "STEM knowledge" dimension suggests that teachers recognize the importance of STEM as an instructional approach capable of fostering students' twenty-first-century skills (Laksmiwati et al., 2020). This finding is consistent with previous studies reporting that teachers perceive STEM as a relevant approach for enhancing students' critical thinking, creativity, collaboration, and problem-solving abilities (Dan & Gary, 2018). The "technology readiness" dimension also achieved a relatively high score, indicating that teachers are accustomed to utilizing digital technologies in the teaching and learning process. This condition may be attributed to the increased adoption of educational technologies during the period of online learning prompted by the COVID-19 pandemic(Abdulatif, 2021; Putra et al., 2022). Nevertheless, challenges remain regarding the availability of technological infrastructure in schools, which may hinder the effective implementation of STEM education.

The lack of supporting facilities, such as laboratories, technological devices, science equipment, and reliable internet access particularly in rural areascontinues to be a major obstacle to providing meaningful STEM learning experiences (Nguyen et al., 2025). Regarding "pedagogical readiness", teachers demonstrated strong capabilities in implementing project-based learning and facilitating students' problem-solving processes. However, their competencies in designing STEM-based instructional materials and conducting STEM-oriented assessments still require further development. This finding suggests that although teachers possess a conceptual understanding of STEM, they may not yet have sufficient experience in developing integrated and sustainable STEM learning environments. An important finding of this study is the high level of teachers' interest in participating in STEM-related professional development and their expressed need for additional training. Previous studies have emphasized the importance of practical training programs and integrated instructional guidance to enhance teachers' STEM teaching competencies and strengthen their confidence in designing STEM learning experiences (Delahunty et al., 2021; Widyatiningtyas, 2025).

Therefore, professional development initiatives focusing on STEM instructional design, the integration of the engineering design process, and the development of STEM-based assessment practices should be prioritized to improve the quality and sustainability of STEM implementation in elementary schools. Overall, the findings suggest that elementary school teachers possess a solid foundation for STEM integration. However, strengthening pedagogical competencies, expanding opportunities for practical STEM implementation, and improving access to technological resources remain essential to ensuring the successful and sustainable integration of STEM in elementary science education.

CONCLUSION

This study aimed to analyze elementary school teachers' readiness to integrate STEM into science instruction. The findings revealed that, overall, teachers demonstrated a high level of readiness, with an overall mean score of 3.85. All dimensions assessed namely STEM knowledge, technology readiness, pedagogical readiness, and STEM implementation readiness-were categorized as high. Among the four dimensions, technology readiness obtained the highest mean score, indicating that teachers are generally familiar with utilizing technology to support the teaching and learning process. In contrast, pedagogical readiness received the lowest score, although it remained within the high category. This finding suggests that teachers' competencies in designing STEM-based instruction and developing appropriate STEM assessment practices still require further improvement. In addition, teachers expressed a strong interest in participating in STEM-related professional development and demonstrated readiness to implement STEM in science classrooms; however, their practical experience with STEM implementation remains relatively limited. These findings indicate that elementary school teachers possess a solid foundation for integrating STEM into science education. Nevertheless, the successful and sustainable implementation of STEM requires structured professional development programs, practice-oriented training opportunities, and adequate learning resources and technological facilities. Therefore, educational institutions, schools, and policymakers should collaborate to strengthen teachers' competencies and provide the necessary support systems to ensure the effective implementation of STEM education and its contribution to the development of students' twenty-first-century skills.

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