Available online at the website :
http://e-journal.adpgmiindonesia.com/index.php/jmie
JMIE: Journal of Madrasah Ibtidaiyah Education, 9(1), 2025, 71-86

PRELIMINARY STUDY OF ELEMENTARY SCHOOL STUDENTS' LEARNING NEEDS IN STEM EDUCATION: A CONSTRUCTIVISM AND MULTICULTURALISM PERSPECTIVE

Nastitisari Dewi [1)] , Arita Marini [2)], Arifin Maksum [3)],
Nina Nurhasanah[4)], Linda Zakiah[5)]
Jakarta State University, Indonesia
E-mail: [1*]nastitisari.dewi@mhs.unj.ac.id ; [2]aritamarini@unj.ac.id; [3]amaksum@unj.ac.id ;
[4]nnurhasanah@unj.ac.id; [5]lindazakiah@unj.ac.id

Submit: 10 November 2024**, Revision:** 5 Mei 2025**, Approve:** 31 Mei 2025

Abstract

This preliminary study investigates the learning needs of elementary school students and teacher perceptions regarding the implementation of STEM education in schools where it has not yet been formally adopted, specifically in Sukabumi City. Data were collected from 127 students and 15 teachers through questionnaires and semi-structured interviews. The findings reveal that a significant number of students show a strong preference for project-based learning (35,43% strongly agree, 48,82% agree) experiment-based learning (41.73% strongly agree, 40.16% agree), with additional support for the integration of technology (38.58% strongly agree, 42.52% agree)and collaborative group work (33,86% strongly agree, 44,09% agree). From the teachers' perspective, major challenges to implementing STEM include limited access to essential tools and technology, inadequate infrastructure (60.00% strongly agree), and insufficient training opportunities (46.67% strongly agree). Guided by constructivist principles, this study emphasizes students' active engagement in hands-on and inquiry-based learning experiences. Additionally, the multicultural approach highlights the diverse backgrounds and learning styles of students, reinforcing the importance of inclusive and adaptable instructional strategies. The results suggest that while student interest in STEM learning is high, effective implementation requires improved infrastructure, greater resource allocation, and ongoing professional development for teachers. This study underscores the need for further research and targeted initiatives to support the sustainable integration of STEM education in elementary schools.

Keywords: Learning needs of Students; STEM learning; Constructivism; Multicultural approach; Elementary school

Quotation: Dewi, Nastitisari, et.al. (2025). Preliminary Study of Elementary School Students' Learning Needs in STEM Education: A Constructivism and Multiculturalism Perspective. *JMIE: Journal of Madrasah Ibtidaiyah Education*, 9(1), 2025, 71-86. jmie.v9i1.689.

Permalink/DOI: http://dx.doi.org/10.32934/jmie.v9i1.689

p-ISSN: 2580-0868, e-ISSN: 2580-2739

INTRODUCTION

In today's dynamic landscape of globalization, education is undergoing a profound transformation. Globalization affects the education sector in multifaceted ways, presenting both opportunities and challenges. On one hand, it acts as a catalyst for improving educational quality through the integration of advanced technologies and more adaptive teaching methodologies. On the other hand, it intensifies global competition and demands that students be well-prepared to meet the complex and ever-evolving requirements of the international job market (Jalal, 2009). Furthermore, educational disparities between developed and developing countries remain a critical issue, particularly regarding equitable access to quality education (Muttaqin et al., 2020). As we enter the era of the Fifth Industrial Revolution (Industry 5.0), the foundation of advancement and quality of life increasingly depends not merely on natural resources but on the strength of human capital (AlAli et al., 2023; Jiaxin et al., 2024; Tobin & Roth, 2007). Education must be capable of producing graduates equipped with 21st-century skills such as critical thinking, collaboration, digital literacy, effective communication, and innovative creativity (Kruse et al., 2025) . The demands of modern education extend beyond theoretical knowledge, requiring practical, real-world skills aligned with the current landscape. Investment in human capital is thus essential for improving living standards, enhancing social welfare, and promoting sustainable development. Consequently, it is imperative to establish a high-quality education system that produces graduates capable of thriving in a competitive global environment and contributing meaningfully to society.

In this context, STEM education (Science, Technology, Engineering, and Mathematics) has emerged as a globally relevant and transformative educational approach. Its primary objective is to equip students with the essential 21st-century competencies through problem-based learning, exploration, and real-life application (Kelley & Knowles, 2016) . In Indonesia, efforts to implement STEM in elementary schools have gained traction as part of a broader initiative to raise science and technology literacy from an early age. However, its implementation remains limited in certain regions, such as Sukabumi City, where awareness and practical application of STEM education are still in the early stages (Muttaqiin et al., 2020). In elementary education, the success of STEM implementation must be supported by pedagogical approaches that suit the developmental needs of young learners. A constructivist approach serves as a foundational pillar of STEM learning, emphasizing students' active engagement in building knowledge through hands-on experiences, experimentation, and social interaction. Constructivist learning encourages critical thinking, creative problem-solving, and meaningful reflection, with teachers acting as facilitators rather than mere transmitters of knowledge.

In addition, a multicultural approach in STEM education is essential to ensure that the learning process is inclusive and responsive to the diverse cultural backgrounds, languages, and learning styles of students. Elementary schools, as multicultural social spaces, must adopt fair and adaptive strategies that honor each student's identity. This approach supports not only

technical skill development but also nurtures empathy, tolerance, and collaboration, values that are crucial in a pluralistic global society. Therefore, examining the learning needs of students and teachers' perceptions of STEM implementation at the elementary level, particularly in areas where it has not yet been formally adopted, such as Sukabumi City, is highly relevant. This study aims to explore students' preferences for STEM-based learning approaches and identify the challenges teachers face in implementation. Guided by constructivist and multicultural frameworks, the findings of this research are expected to contribute to the development of STEM learning strategies that are effective, inclusive, and contextually appropriate for elementary education.

To effectively address the challenges in STEM Education, the constructivist approach offers a compelling learning experience, suggesting that students build their understanding and knowledge through immersive experiences and meaningful interaction with their environment (Piaget, 2015; Vygotsky, 1978). Within the framework of STEM education, this learner-centric approach encourages students to explore, ask questions, and collaborate with their peers to devise solutions to real-world problems (Fosnot, 2013). This method not only enhances their comprehension of STEM concepts but also helps them connect these concepts to their everyday experiences, making learning more relevant and engaging. As a result, constructivism plays a crucial role in overcoming the relevant difficulties in STEM education, ensuring that the learning process is both informative and profoundly meaningful for students (Rahman. M et al., 2021).

In increasingly culturally diverse elementary school environments, it is essential to incorporate multicultural education into curriculum planning and classroom practices. Multicultural education seeks to create an inclusive learning atmosphere where all students, regardless of cultural, ethnic, or linguistic background, feel recognized, respected, and valued (Banks, 1993; Gay, 2018). This diversity-oriented approach not only ensures equal access to quality education but also enriches learning by fostering broader worldviews and multiple perspectives (Sleeter & Grant, 2008). In the context of STEM education, integrating multicultural perspectives enables students to approach problems from different cultural and cognitive angles, ultimately enhancing their critical thinking, creativity, and collaborative problem-solving skills (Dare, 2020; Sujarwanto, 2023).

In Indonesia, particularly in cities like Sukabumi, implementing STEM education in elementary schools presents unique challenges. These include not only limited access to infrastructure and technology but also the need to address the diverse academic, socio-cultural, and linguistic backgrounds of students (Muttaqiin et al., 2020; Nuragnia et al., 2021)). While existing studies have discussed the importance of STEM in improving scientific literacy and 21st-century competencies (Kelley & Knowles, 2016; H. Kwon et al., 2021), few have examined how STEM education can be adapted to meet the culturally diverse learning needs of students in non-metropolitan or underrepresented regions in Indonesia. This constitutes a significant research gap, particularly at the elementary school level, where foundational learning habits are

formed. Moreover, current STEM education practices often adopt a one-size-fits-all approach, with minimal consideration of how constructivist or multicultural frameworks can enhance student engagement and learning outcomes (Tam et al., 2020; Tobin & Roth, 2007). A constructivist approach encourages learners to actively construct knowledge through experience and social interaction (Fosnot, 2013), while a multicultural framework ensures that diverse perspectives are integrated into the learning process.

By combining constructivist and multicultural principles, STEM learning can become more responsive, inclusive, and engaging. Students are not only encouraged to participate actively in inquiry-based tasks but are also empowered to appreciate diversity as an asset in collaborative problem-solving. In diverse elementary classrooms, this dual approach helps bridge both academic and cultural gaps in STEM learning environments. The main purpose of this study is to analyze the learning needs of elementary school students in Sukabumi City with regard to STEM education, using both constructivist and multicultural perspectives. This study is important because it lays the groundwork for designing a localized STEM curriculum that not only builds students' technical skills but also fosters cultural responsiveness, inclusion, and relevance. By responding to the actual learning contexts in Sukabumi, the resulting recommendations are expected to be more applicable across various educational settings in Indonesia, especially in other culturally diverse classrooms.

This study employs a descriptive mixed-methods approach, integrating both quantitative (surveys) and qualitative (semi-structured interviews) data collection in several public elementary schools in Sukabumi City. Data will be analyzed to identify patterns in student learning preferences, perceptions of STEM-related activities, and teacher challenges in implementation. The findings are expected to contribute both theoretically and practically to STEM education literature, offering fresh insights for educational policymakers, curriculum developers, and school practitioners. In particular, this study aims to fill a notable gap in STEM research in Indonesia by focusing on culturally responsive and constructivist-based STEM instruction at the elementary level—an area that remains underexplored in current national and international literature (Saavedra & Opfer, 2012; Santos et al., 2023; Sargiotis, 2025).

METHODS

This preliminary study employs a mixed-methods approach, combining descriptive quantitative and qualitative methods to identify the learning needs of elementary school students and the perceptions of teachers in Sukabumi City regarding the implementation of STEM education. Although STEM education has not yet been formally adopted in these schools, the study aims to explore students' preferences for STEM-based learning methods and the challenges teachers face in preparing and applying such approaches (Bybee, 2010; Sujarwanto, 2023). The participants consist of 127 students and 15 teachers from selected public elementary schools in Sukabumi City, chosen through purposive sampling. Students

in grades 4 to 6 were selected based on their developmental readiness to engage in STEM-based learning activities (Kelley & Knowles, 2016). The participating teachers were those responsible for subjects relevant to STEM content areas, such as science, mathematics, and technology.

1) Data Collection Procedures

Quantitative data were collected through a closed-ended questionnaire using a 5-point Likert scale (strongly agree to strongly disagree) to assess students' preferences for various STEM-based instructional methods, including: a) Experiment-based learning; b) Project-based activities; c) Group collaboration; d) Use of digital technologies. The questionnaires were administered in person during school hours under the supervision of classroom teachers and the research team to ensure students' understanding of the items.

Qualitative data were obtained through semi-structured interviews conducted with the teachers in their respective schools. Each interview session lasted approximately 30–45 minutes and was audio-recorded with participants' consent. The interviews followed a flexible guide covering key themes such as teacher readiness, perceived barriers to STEM implementation, and professional development needs (Patel, 2020). Interviews were conducted individually to ensure in-depth responses and confidentiality.

2) Instrument Validation

Prior to administration, both the questionnaire and interview guide were subjected to content validation by three experts in elementary education and STEM curriculum. Revisions were made based on expert feedback to ensure that each item was aligned with the research objectives. Additionally, a pilot test of the questionnaire was conducted with 20 students outside the main sample to confirm item clarity and enhance reliability.

3) Data Analysis Techniques

The quantitative data were analyzed using descriptive statistics, primarily to calculate the percentage of students favoring each STEM learning method. This analysis provides insight into the most preferred instructional approaches among the target population. Qualitative data from teacher interviews were analyzed using a thematic analysis approach to identify recurring patterns and core challenges, including inadequate infrastructure, limited access to technology, and insufficient teacher training (Fosnot, 2013). These findings offer a grounded understanding of the barriers to implementing innovative and collaborative STEM learning strategies at the elementary level.

4) Triangulation and Credibility

To enhance the credibility of the findings, methodological triangulation was employed by comparing insights drawn from the student questionnaires and teacher interviews. This strategy helped identify consistencies and discrepancies between student preferences and teacher readiness, contributing to a more comprehensive picture of the current conditions

for STEM education in Sukabumi (Cresswell & Holloway, 2014). Additionally, data collection was supported by trained research assistants to ensure consistency and procedural integrity across all sites.

RESULTS AND DISCUSSION

Student Learning Needs in STEM Education

Based on the analysis of student questionnaires and teacher interviews, this study reveals that elementary students in Sukabumi City exhibit diverse and high levels of interest in STEM learning, particularly in project-based, experiment-based, and collaborative methods. As shown in Table 1, a majority of students expressed agreement or strong agreement with these active learning approaches, with 84.25% (35,43% strongly agree, 48,82% agree) of students favoring project-based learning and 81.89% (41.73% strongly agree, 40.16% agree) favoring experiment-based activities. These findings align with constructivist learning theory, which emphasizes the role of students as active participants in constructing their own understanding through meaningful experiences (Fosnot, 2013; Vygotsky, 1978).

Table 1. Students' Preferences for STEM learning methods (N=127)

Learning Method Responses	Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly disagree (%)
Project-based learning	35,43	48,82	12,60	2,36	0,79
Experiment-based learning	41,73	40,16	13,39	3,94	0,78
Use of technology	38,58	42,52	14,17	3,15	1,58
Group Collaboration	33,86	44,09	17,32	3,94	0,79

The results of the student questionnaire reveal that a significant majority of elementary school students in Sukabumi City expressed a strong preference for project-based learning. Specifically, 35.43% strongly agreed and 48.82% agreed that project-based approaches are more enjoyable and preferable compared to conventional methods. This indicates a clear tendency toward interactive and student-centered learning experiences. Such preferences reflect diverse learning needs and are consistent with the findings of (Dare, 2020), who emphasize that students are generally more motivated and engaged when involved in collaborative, experiential activities. Further support for this was found in student interviews, which revealed a high interest in classroom experiments—another hallmark of active, inquiry-based learning. However, students also reported limited access to tools and technology, which they felt hindered their ability to engage fully in STEM learning. This limitation underscores the necessity of integrating digital literacy and improving infrastructure within the educational system. According to (H. Kwon et al., 2024), technological access and competency are fundamental to successful STEM implementation, especially in elementary education contexts.

Table 1 provides a detailed visualization of student preferences for various STEM

learning strategies, based on the questionnaire results. The figure illustrates the percentage of agreement across four categories: project-based learning, experiment-based learning, use of technology, and group collaboration. These findings highlight the importance of aligning instructional practices with student preferences. For instance, 84.25% of students either agreed or strongly agreed that project- and experiment-based learning methods are more engaging than traditional lectures. This supports previous studies (Mizell & Brown, 2017) which show that project-based learning enhances student motivation and deepens understanding in STEM education.

Nonetheless, significant challenges remain in implementing these methods, particularly in under-resourced settings like Sukabumi. As (Liburd & Jen, 2021) point out, successful STEM adoption is closely tied to the availability of infrastructure and teacher training. Without adequate tools, resources, and support systems, even the most promising teaching strategies may fall short of their intended outcomes. Additionally, STEM learning is not solely about content acquisition, it also aims to develop critical thinking, creativity, and collaboration skills (Fernandu et al., 2022; Kruse et al., 2025; K. Kwon et al., 2024). The current study affirms that these 21st-century skills are recognized by students as essential for meaningful learning experiences. However, the lack of targeted professional development and educational technology in elementary schools remains a significant barrier to achieving this vision.

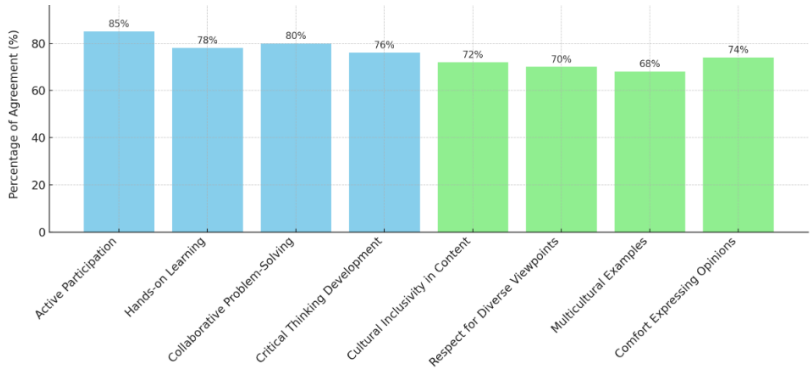

Figure 1. Student Perceptions of Constructivist and Multicultural Perspectives in STEM Learning

Source: Results from preliminary study research

The analysis of questionnaire and interview data reveals that elementary students in Sukabumi City exhibit a strong preference for student-centered, experiential, and inclusive approaches in STEM education. Although STEM has not been formally integrated across the surveyed schools, students expressed enthusiasm for project-based learning, hands-on experimentation, and group collaboration. These preferences reflect a broader trend in education that emphasizes constructivist and multicultural frameworks as effective paradigms for engaging diverse learners. Figure 2 provides a detailed breakdown of students' perceptions related to constructivist and multicultural elements in STEM learning. The diagram presents levels of agreement across eight indicators: four rooted in constructivist theory (active

participation, hands-on learning, collaborative problem-solving, critical thinking development) and four associated with multicultural pedagogy (cultural inclusivity in content, respect for diverse viewpoints, multicultural examples, and comfort in expressing opinions).

The highest level of agreement was reported for active participation (85%), followed by collaborative problem-solving (80%), hands-on learning (78%), and critical thinking development (76%). These findings strongly support constructivist theories of learning, which assert that knowledge is best constructed through meaningful experiences, social negotiation, and student agency (Fosnot, 2013; Piaget, 2015; Vygotsky, 1978). Similar findings are reported by (Dare, 2020), who argue that students in STEM settings show increased engagement and motivation when they actively participate in problem-solving and project-based activities.

Furthermore, multicultural indicators also received high levels of agreement. Cultural inclusivity in content (72%), respect for diverse viewpoints (70%), multicultural examples (68%), and comfort expressing opinions (74%) suggest that students value an inclusive learning environment where cultural identities are acknowledged and respected. These findings resonate with (Gay, 2018) framework of culturally responsive teaching, which emphasizes the importance of cultural relevance, validation, and student voice in curriculum design and delivery. According t(Banks, 1993), multicultural education fosters equity and engagement, particularly when instructional practices reflect students' lived experiences and diverse backgrounds. Despite the evident enthusiasm, several structural challenges persist. Interview responses highlight students' limited access to digital tools and scientific equipment necessary for effective STEM learning. While students expressed interest in technology and classroom experimentation, they noted barriers related to inadequate facilities. This aligns with the work of (H. Kwon et al., 2024), who identified digital access and technological literacy as prerequisites for successful STEM implementation, especially in under-resourced educational contexts. Similarly, (Liburd & Jen, 2021) underscore the critical role of infrastructure and teacher readiness in supporting sustained STEM integration in elementary schools.

Additionally, STEM education is expected to promote higher-order thinking skills such as creativity, problem-solving, and critical reasoning (Chan & Erduran, 2023; Chee Choy et al., 2020). The current study affirms that students recognize the relevance of these skills, yet the lack of pedagogical support and professional development for teachers in Sukabumi's elementary schools presents a significant limitation. Teachers require targeted training in STEM methods that embed both constructivist and multicultural strategies to cultivate these competencies effectively (Smith & García, 2018).

Teachers' perceptions and constructivism approaches of STEM Learning Implementation.

In a series of in-depth interviews, participating elementary school teachers shared their perspectives on the relevance of STEM (Science, Technology, Engineering, and Mathematics) education, particularly through a constructivist lens. Overall, they conveyed a strong belief that STEM

education equips students with essential 21st-century skills, such as critical thinking, creativity, collaboration, and problem-solving skills deemed crucial for navigating an increasingly complex and technology-driven world (Saavedra & Opfer, 2012). One teacher reflected this view by stating: *"STEM learning is not just about teaching science or technology—it's about how we help students think critically and solve problems together. This is the kind of learning that stays with them."* (Teacher A, Interview, 2024).

Teachers emphasized that the constructivist approach, where students learn through active inquiry, experimentation, and collaboration, is closely aligned with the core values of STEM education. Many mentioned that they frequently design classroom activities that require students to explore concepts hands-on and work in groups, even though these are not yet formally labeled as "STEM" in the school curriculum. Another teacher added: *Even though we don't have a STEM program officially, we always try to give students real problems to solve in groups, like creating simple machines or understanding how electricity works from household items."* (Teacher B, Interview, 2024). However, despite their enthusiasm, teachers consistently expressed concern over the lack of training and insufficient resources to implement STEM approaches effectively. Several respondents cited limited access to technological tools, science kits, and appropriate teaching materials. As one participant remarked : *"I believe in STEM. But to be honest, sometimes it's just an idea—because we don't have the tools. How can we do science experiments with no lab, or introduce technology with no computers?"* (Teacher C, Interview, 2024).

These sentiments reflect findings from previous studies which stress the importance of professional development and institutional support in enabling effective STEM instruction (Liburd & Jen, 2021; Smith & García, 2018). Teachers noted that they require structured training programs focused not only on content knowledge, but also on pedagogical strategies rooted in constructivism such as inquiry-based learning, problem-based learning, and the integration of real-world contexts. Moreover, one teacher articulated the pedagogical gap directly : *"I've attended workshops on curriculum or general teaching, but never anything specific to STEM or inquiry learning. We need training that shows us how to teach this way, not just what to teach."* (Teacher D, Interview, 2024). This qualitative insight reinforces the view that while educators are conceptually aligned with STEM and constructivist ideals, the realization of these in classrooms remains limited by systemic constraints. Without sufficient investment in teacher capacity-building, schools may struggle to meaningfully implement STEM learning.

These interview findings are consistent with literature emphasizing the need for robust teacher preparation and ongoing professional learning in STEM integration. As argued by (Smith & García, 2018), STEM education is most effective when teachers are well-versed in inquiry-oriented pedagogy and supported with adequate infrastructure. Similarly, (H. Kwon et al., 2021) highlight that teacher confidence and instructional innovation in STEM significantly increase when accompanied by sustained mentoring and access to instructional technologies. Additionally, in these insightful conversations, teachers highlight the profound impact students' cultural backgrounds have on their learning preferences. They observed that students from certain cultural contexts often gravitate toward collaborative learning environments, which emphasize teamwork and collective problem solving. This collaborative approach helps them thrive in a group environment. In contrast,

learners from different cultural backgrounds may feel more comfortable engaging in a solitary learning style, where they can work independently and at their own pace. This observation sheds light on the complex relationship between multicultural education and constructivist methodology within the STEM learning framework (Akran & Aşiroğlu, 2018; Chee Choy et al., 2020).

The elementary school teachers who participated in this study, in particular, were enthusiastic about integrating STEM into their teaching practices. They viewed it as a powerful tool for fostering analytical and creative thinking skills in their students, which are critical for future success. These enthusiastic sentiments align with research highlighting the transformative potential of STEM education in shaping young minds (Hinnant-Crawford, 2016). However, many teachers expressed feelings of inadequacy regarding their readiness to use effective pedagogical techniques and incorporate technology into STEM teaching. These concerns align with research showing that the specific pedagogical competencies required for successful delivery of STEM education are often lacking, particularly in elementary school settings (Akran & Aşiroğlu, 2018; AlAli et al., 2023). Additionally, teachers acknowledged the critical nature of ongoing professional teaching strategies to better meet the diverse needs of their students. In an era increasingly characterized by digital learning environments, teachers must acquire relevant skills that facilitate engaging and interactive learning experiences that enable students to actively construct their understanding of complex concepts (Bybee, 2010; Fosnot, 2013). However, a significant challenge that emerged during the discussions was the limited time and pressing administrative support for project-based learning initiatives. Many teachers voiced feelings of being overwhelmed by the extensive demands of their already dense curricula, making it difficult to allocate the necessary time for projects that require careful planning, collaboration, and sustained engagement. This dilemma mirrors research findings that highlight the significant obstacles teachers face when attempting to incorporate enriching, hands-on STEM projects into their teaching practices (Saavedra & Opfer, 2012). In addition, teachers also continue to struggle when attempting to construct students' thinking to gain deeper knowledge from project learning. The constructivist approach that underpins STEM learning becomes less effective when students tend to be passive and simply wait for instructions from the teacher. Teachers feel the need for more contextual training so that they can apply learning better and more meaningfully (Bybee, 2010).

The Influence of Cultural Background on STEM Learning

A more in-depth analysis has revealed the profound impact of students' cultural backgrounds on their preferred learning methods, particularly in STEM (Science, Technology, Engineering, and Mathematics) education. In environments characterized by collaborative cultural norms, students showed a strong inclination towards project-based learning and group activities. This trend underscores the idea that for STEM education to be effective, it must be tailored to the cultural contexts of diverse students. In particular, a comprehensive exploration of the intersection between STEM education and cultural diversity (Ogodo, 2024; Putri et al., 2023; Sargiotis, 2025) is needed.

During the interviews, teachers revealed valuable insights, noting that students from more individualistic cultures often face challenges when navigating collaborative STEM learning environments. Despite these obstacles, these students showed a strong interest in technology-based learning experiences, finding them relevant and applicable to their everyday lives. This observation is in line with findings investigating the significance of digital literacy in contemporary education (Patel, 2020). By adopting a multicultural perspective, this study further reveals that students' cultural backgrounds intricately shape their interactions with STEM learning. Students from collectivist backgrounds are naturally drawn to collaborative learning opportunities, thriving in group settings where they can share ideas and work together on projects. In contrast, those from individualistic cultures often prefer technology-driven lessons and hands-on experiments that allow for more independence. The argument for STEM education, when designed with and enhance student engagement. Furthermore, the idea is that cultural factors greatly influence students' perceptions of STEM education and their interactions with various technologies (Nuragnia et al., 2021). Thus, teachers need to foster an understanding of this cultural diversity to create STEM learning experiences that are appropriate for students' diverse backgrounds. In the realm of multicultural education, this research suggests the need to adapt STEM teaching approaches to appreciate and address students' cultural differences (Tam et al., 2020). STEM education not only hones students' technical skills but also fosters the development of important social and communication skills within a multicultural framework.

Challenges in Implementing STEM Learning

Despite its importance, the implementation of STEM education in elementary schools is very meaningful, but it is full of challenges. One of the most significant obstacles is the lack of adequate infrastructure, including well-equipped science laboratories and essential technological equipment, which are essential for effective learning experiences. Furthermore, teachers often express concerns about the limited time available to manage project-based learning initiatives, especially in educational contexts that demand a constructivist approach to learning (Fosnot, 2013; Johnson et al., 2021). These challenges highlight the critical need for strong support from school administration, in addition to comprehensive and ongoing professional development for teachers. Such initiatives are essential to improving the quality of STEM education in elementary grades, ultimately ensuring that students receive the enriching and engaging learning experiences they deserve. The following is a graph showing the perceptions of elementary school teachers in Sukabumi City regarding the challenges faced when implementing STEM. learning in the classroom.

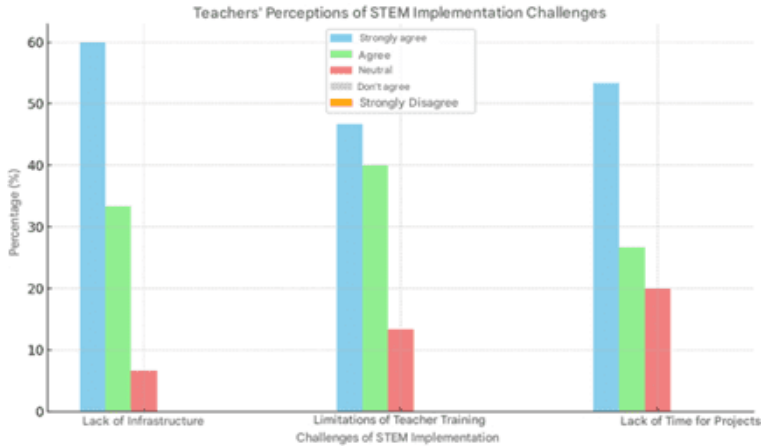

Figure 2. Challenges in STEM Implementation from Teachers' Perspectives

Source: Results from preliminary study research

From the analysis presented in Table 2, it is clear that the most significant barriers to the implementation of STEM (Science, Technology, Engineering, and Mathematics) education in primary schools are inadequate infrastructure and lack of comprehensive teacher training. A total of 93.33% of the teachers surveyed acknowledged that inadequate facilities and resources were a major barrier to effectively integrating STEM into their classrooms. In addition, 86.67% of the teachers stated the need for further professional development to improve their ability to teach STEM subjects. These findings are consistent with research highlighting the critical role of pedagogical competence in providing high-quality STEM education, particularly for younger students at the elementary level (Ertmer & Simons, 2006; Ho, 2023; Liburd & Jen, 2021; Smith & García, 2018).

The insights gained from this study reveal that there is a crucial demand for the implementation of STEM education in elementary schools. However, it is important to note that challenges related to infrastructure and teacher expertise remain major barriers to progress. Students in these environments show a strong interest in engaging, interactive, and collaborative learning experiences, as illustrated in Table 1. the value of collaborative learning environments in fostering essential skills such as critical thinking and problem solving among students (Fernandu et al., 2022; Rahman. M et al., 2021). To effectively address the challenges that lie in the path of STEM implementation, educational institutions must prioritize the establishment of appropriate infrastructure and the provision of quality training programs for their teachers. In addition, this study also shows that students' cultural backgrounds significantly shape their preferences for different STEM learning approaches. Those from collectivist cultures are often more likely to embrace collaborative learning experiences, while students from individualistic cultures may gravitate toward technology-driven learning methods. This observation is in line with the perspective that STEM education must be carefully tailored to reflect and meet the diverse

cultural contexts of students in order to increase their relevance and engagement in the learning process (Santos et al., 2023; Sleeter & Grant, 2008). STEM education also through a constructivist approach emphasizes meaningful learning for students. so that the learning presented by teachers is able to build stronger knowledge concepts in their basic knowledge. students not only understand the concepts learned but are able to apply them in everyday life.

This study provides a clear picture of the importance of constructivist and multicultural approaches in STEM learning so that it becomes the basis for conducting further research so that the application of STEM learning is more inclusive and meaningful for students

CONCLUSION

This study shows that elementary school students in Sukabumi City have a high interest in STEM learning, even though its implementation in schools is still limited. Many students favor project-based learning and the use of technology, supporting active and engaging learning approaches. However, several obstacles hinder implementation. Students reported limited access to technology, while teachers pointed to inadequate infrastructure (60%) and a lack of professional training (46.67%) as major challenges. These findings are consistent with previous studies emphasizing the need for systemic support in STEM education. Furthermore, most students support constructivist and multicultural learning approaches, such as active participation, group work, and culturally inclusive materials—reflecting the principles of meaningful learning (Fosnot, 2013, Banks, 1993) assertion that culturally responsive education enhances student engagement by validating diverse backgrounds and identities.

To improve the quality of STEM education at the elementary level, concrete steps are needed, such as providing adequate facilities and technology, offering teacher training focused on STEM methods and educational technology, and developing inclusive and collaborative curricula. Partnerships between schools, parents, universities, and industry are also essential to support project-based learning and real-world experiences. Future research should further explore the long-term impact of early STEM exposure, compare regional differences (urban vs. rural), evaluate the effectiveness of teacher training programs, and examine how constructivist and multicultural principles can be integrated into STEM curricula. These efforts are expected to strengthen an inclusive, relevant, and sustainable foundation for STEM education at the elementary school level.

REFERENCES

Akran, S. K., & Aşiroğlu, S. (2018). Perceptions of teachers towards the stem education and the constructivist education approach: Is the constructivist education approach preparatory to the STEM education? *Universal Journal of Educational Research*, *6*(10), 2175–2186. https://doi.org/10.13189/ujer.2018.061016

AlAli, R., Alsoud, K., & Athamneh, F. (2023). Towards a Sustainable Future: Evaluating the Ability of STEM-Based Teaching in Achieving Sustainable Development Goals in Learning. *Sustainability (Switzerland)*, *15*(16). https://doi.org/10.3390/su151612542

Banks, J. A. (1993). Chapter 1: Multicultural Education: Historical Development, Dimensions, and Practice. *Review of Research in Education*, *19*(1), 3–49. https://doi.org/10.3102/0091732X019001003

Bybee, R. W. (2010). Advancing STEM Education: A 2020 Vision. *International Technology and Engineering Educators Association*.

Chan, J., & Erduran, S. (2023). The Impact of Collaboration Between Science and Religious Education Teachers on Their Understanding and Views of Argumentation. *Research in Science Education*, *53*(1), 121–137. https://doi.org/10.1007/s11165-022-10041-1

Chee Choy, S., Sau-Ching Yim, J., & Leong Tan, P. (2020). A METACOGNITIVE KNOWLEDGE, METACOGNITIVE EXPERIENCE, AND ITS EFFECTS ON LEARNING OUTCOMES FOR STEM AND NON-STEM MALAYSIAN STUDENTS. In *International Journal of Advanced Research in Education and Society* (Vol. 2, Issue 1). http://myjms.moe.gov.my/index.php/ijares

Cresswell, T., & Holloway, R. (2014). *Place What Is Place?*

Dare. (2020). Pedagogy and Information Technology Integration, As Strategies for Improving Academic Performance in Stem Subjects: A Critical Literature Review. *Journal of Education and Practice*. https://doi.org/10.7176/jep/11-21-21

Ertmer, P. A., & Simons, K. D. (2006). Jumping the PBL Implementation Hurdle: Supporting the Efforts of K–12 Teachers. *Interdisciplinary Journal of Problem-Based Learning*, *1*(1). https://doi.org/10.7771/1541-5015.1005

Fernandu, D. E., Abdurrahman, A., & Lengkana, D. (2022). Design and Validation of STEM Integrated e-Modules on Environmental Pollution to Improve Problem-Solving Skills. *Jurnal Pendidikan MIPA*, *23*(2), 754–765. https://doi.org/10.23960/jpmipa/v23i2.pp754-765

Fosnot, C. T. (2013). *Constructivism: Theory, perspectives, and practice.* . Teachers College Press.

Gay, G. (2018). *Culturally responsive teaching: Theory, research, and practice.* . teachers college press.

Hinnant-Crawford, B. N. (2016). Increasing access: the application of multicultural education to STEM. In *Journal for Multicultural Education* (Vol. 10, Issue 3, pp. 250–256). Emerald Group Publishing Ltd. https://doi.org/10.1108/JME-06-2016-0035

Ho, W. C. (2023). *Culture, Creativity, and Music Education in China: Developments and Challenges*. Routledge.

Jalal, F. (2009). Teacher certification in Indonesia: A strategy for teacher quality improvement.

: *: Jurnal Departemen Pendidikan Nasional RI*.

Jiaxin, G., Huijuan, Z., & Md Hasan, H. (2024). Global competence in higher education: a ten-year systematic literature review. *Frontiers in Education*, *9*. https://doi.org/10.3389/feduc.2024.1404782

Johnson, C. C., Moore, T. J., Peters-Burton, E. E., & Guzey, S. S. (2021). *The need for a STEM road map. In STEM Road Map 2.0*. Routledge.

Kelley, T. R., & Knowles, J. G. (2016). A conceptual framework for integrated STEM education. In *International Journal of STEM Education* (Vol. 3, Issue 1). Springer. https://doi.org/10.1186/s40594-016-0046-z

Kruse, J., Voss, S., Easter, J., Kent-Schneider, I., Menke, L., Owens, D., Roberts, K., & Woodward, L. (2025). Preparing students for the modern information landscape and navigating science–technology–society issues. *Journal of Research in Science Teaching*, *62*(3), 792–824. https://doi.org/10.1002/tea.21972

Kwon, H., Capraro, R. M., & Capraro, M. M. (2021). When I Believe, I Can: Success STEMs from My Perceptions. *Canadian Journal of Science, Mathematics and Technology Education*, *21*(1), 67–85. https://doi.org/10.1007/s42330-020-00132-4

Kwon, H., Capraro, R. M., Lee, Y., & Williams, A. (2024). Fostering growth: The impact of STEM PBL on students' self-regulation and motivation. *J. Korean Soc. Math. Ed. Ser. D*, *1*, 111–127. https://doi.org/10.7468/jksmed.2024.27.1.111

Kwon, K., Jeon, M., Zhou, C., Kim, K., & Brush, T. A. (2024). Embodied learning for computational thinking in early primary education. *Journal of Research on Technology in Education*, *56*(4), 410–430. https://doi.org/10.1080/15391523.2022.2158146

Liburd, K. K. D., & Jen, H. Y. (2021). Investigating the effectiveness of using a technological approach on students' achievement in mathematics–case study of a high school in a Caribbean country. *Sustainability (Switzerland)*, *13*(10). https://doi.org/10.3390/su13105586

Mizell, S., & Brown, S. (2017). *The Current Status of STEM Education Research 2013-2015*.

Muttaqiin, A., Putri, R. E., Sari, M. P., Lufri, L., & Rahim, F. R. (2020). Supporting STEM and critical thinking on energy transformation topic: Pre-study of digital reality book. *Journal of Physics: Conference Series*, *1481*(1). https://doi.org/10.1088/1742-6596/1481/1/012118

Nuragnia, B., Nadiroh, & Usman, H. (2021). PEMBELAJARAN STEAM DI SEKOLAH DASAR : IMPLEMENTASI DAN TANTANGAN. *Jurnal Pendidikan Dan Kebudayaan*, *6*(2), 187–197. https://doi.org/10.24832/jpnk.v6i2.2388

Ogodo, J. A. (2024). Culturally Responsive Pedagogical Knowledge: An Integrative Teacher Knowledge Base for Diversified STEM Classrooms. *Education Sciences*, *14*(2). https://doi.org/10.3390/educsci14020124

Patel, J. (2020). *The Constructivist Approach to Curriculum Integration of STEM Education*.

Putri, T. D. Z., Irwandi, I., & Mursal, M. (2023). Constructivism theory in the ISLE-based STEM approach model for wave topics in middle and high school students. . *Journal of Aceh Physics Society*, *12*(2), 19–24.

Rahman. M, A., Arsyad, M., & Arafah, K. (2021). The Development of Teaching Material

Based on Science, Technology, Engineering, and Mathematics (STEM). *Jurnal Pendidikan Fisika*, *9*(1). https://doi.org/10.26618/jpf.v9i1.4499

Saavedra, A. R., & Opfer, V. D. (2012). Learning 21st-Century Skills Requires 21st-Century Teaching. *Phi Delta Kappan*, *94*(2), 8–13. https://doi.org/10.1177/003172171209400203

Santos, R., Anderson, D., & Milner-Bolotin, M. (2023). Research trends in international science, technology, engineering, and mathematics education conference series: An analysis of a decade of proceedings. *Frontiers in Education*, *7*. https://doi.org/10.3389/feduc.2022.1099658

Sargiotis, D. (2025). *Redesigning Education: A Transformative Approach*. https://doi.org/10.20944/preprints202406.1891.v2

Sleeter, C. E., & Grant, C. A. (2008). *Making choices for multicultural education: Five approaches to race, class and gender*. John Wiley & Sons.

Smith, A., & García, H. A. (2018). Increasing the trickle: A proposed critical multiculturalist conceptual model to increase the pipeline to a more diverse STEM doctorate population. *Journal for Multicultural Education*, *12*(3), 206–220. https://doi.org/10.1108/JME-09-2016-0052

Sujarwanto, E. (2023). Prinsip Pendidikan STEM dalam Pembelajaran Sains. *BRILIANT: Jurnal Riset Dan Konseptual*, *8*(2), 2023. https://doi.org/10.28926/briliant.v8i2

Tam, H., Chan, A. Y., & Lai, O. L. (2020). Gender stereotyping and STEM education: Girls' empowerment through effective ICT training in Hong Kong. *Children and Youth Services Review*, *119*, 105624. https://doi.org/10.1016/j.childyouth.2020.105624

Piaget. (2015). *The Construction of Reality in the Child*.

Tobin, K., & Roth, W. M. (2007). *The culture of science education: Its history in person : Vol. Vol. 3*. BRILL.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes* (Vol. 86). Harvard university press.