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An Analysis of the Readiness and Challenges of Junior High School Mathematics Teachers in Implementing STEM Learning

Nurjihan Nabilah[1*], Endah Budi Rahaju[1]

[1]Mathematics Education Study Program, Universitas Negeri Surabaya, Surabaya

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***Corresponding author:**
nurjihan.23037@mhs.unesa.ac.id

Abstract: STEM learning is seen as a relevant approach to support contextual and problem-solving-oriented mathematics learning, but its implementation in the classroom still faces various challenges. This study aims to describe the readiness and challenges of junior high school mathematics teachers in implementing STEM learning after participating in STEM training. This study used a descriptive qualitative approach involving 30 junior high school mathematics teachers in Bangkalan Regency as participants. Data were collected through narrative questionnaires filled out by teachers after the presenters delivered the material at the STEM training activity, then analyzed qualitatively to obtain an overview of the readiness and challenges of implementing STEM learning. The results show that teachers already have a basic understanding of the concept of STEM learning and demonstrate readiness at the conceptual stage and in initial planning. However, their readiness for implementation in the classroom is still limited and faces various challenges, such as difficulties in integrating STEM components into mathematics learning, limited time and infrastructure, readiness of supporting competencies, and student motivation. These findings indicate that participation in initial STEM training provides a context for the development of conceptual understanding, whereas the ongoing implementation of STEM in the classroom requires continuous guidance and institutional support so that STEM can be applied effectively and contextually in mathematics instruction.

INTRODUCTION

Education today increasingly emphasizes the development of critical thinking, creativity, collaboration, and problem-solving skills needed in the 21st century. To achieve these goals, a learning approach that integrates science, technology, engineering, and mathematics is highly relevant because it can create meaningful and contextual learning experiences for students. In mathematics education, STEM integration connects mathematical concepts with science, technology, and engineering through interdisciplinary and real-world contexts to help students apply mathematical concepts in investigating, modeling, and solving problems (Goos et al., 2023; Just & Siller, 2022). In this context, the involvement of teachers as drivers of learning change is crucial because teachers have a strategic role in realizing innovative and future-oriented learning. Various studies show that teacher readiness in facing the demands of 21st-century learning is a key requirement for effectively implementing this approach, so that education can produce competent students who are

adaptable to the changing times (Holmlund et al., 2018; Margot & Kettler, 2019; Papagiannopoulou et al., 2023).

Nevertheless, various studies show that the reality in the field often differs from these educational expectations. Many teachers, especially at the junior high school level, still face limitations in their understanding of basic concepts and practical experience related to innovative learning such as STEM. For example, most teachers find it difficult to understand STEM in depth, so they face challenges when asked to independently develop STEM-based learning modules (Diana & Turmudi, 2021). In mathematics instruction, teachers may face challenges in integrating mathematical concepts with other STEM disciplines and in designing STEM activities that still give mathematics a meaningful role, especially when faced with limitations in STEM training, technological resources, and time (Ben-Motreb, 2026; Goos et al., 2023). In addition, several other challenges such as limited resources, intense learning schedules, and a lack of professional support have exacerbated the difficulties teachers face in implementing this learning approach. This highlights the need for further study to understand teachers' readiness and challenges in effectively implementing STEM-based learning.

Teachers' readiness to implement innovative learning approaches such as STEM can be seen through various dimensions of professional competence. In the context of learning, teachers' cognitive readiness in understanding the philosophy and objectives of new learning approaches, affective readiness to accept and adapt to such learning, and practical readiness to implement it in the classroom. For math teachers, this readiness also includes the ability to integrate mathematical knowledge and concepts with other STEM disciplines in meaningful learning activities (Goos et al., 2023). Research using specific instruments, such as the TRi-STEM scale, shows that to be truly ready to implement STEM, teachers need to have adequate cognitive, affective, self-efficacy, and commitment conditions (Papagiannopoulou et al., 2023). Thus, teacher readiness is not merely theoretical knowledge, but a set of competencies that must be fully integrated into teaching practice.

Previous research has examined teachers' perspectives, experiences, readiness, and challenges in implementing STEM through various qualitative approaches. Bal & Bedir, (2021) used qualitative case studies and semi-structured interviews to explore teachers' views, the implementation of STEM in the classroom, and challenges such as classroom management and limitations in infrastructure and learning materials. Dare et al. (2018) employed a phenomenological multiple-case study, combining classroom observations and reflective interviews to examine teachers' experiences, including difficulties in integrating STEM disciplines and developing meaningful learning contexts. More recently, Paunova-Hubenova et al. (2025) examined teacher readiness through semi-structured interviews, focusing on institutional support, infrastructure, resources, and teacher competencies. In the context of mathematics education, Goos et al. (2023) highlight the role of mathematics in interdisciplinary STEM education and discuss the challenges of integrating mathematical knowledge with other STEM disciplines. Similarly, Ben-Motreb (2026) examines the

integration of STEM in mathematics learning and identifies various challenges related to teacher preparation, technological resources, curriculum demands, and time constraints. However, these studies differ in terms of participants, educational contexts, methodological approaches, as well as the aspects of teacher readiness and implementation challenges examined. In particular, further research is needed to understand how junior high school mathematics teachers perceive their own readiness and the challenges they face when implementing STEM learning in their classroom contexts.

Based on the research gap identified in previous studies, this study examines the readiness and challenges of junior high school mathematics teachers in implementing STEM learning through a narrative questionnaire. This aims to explore teachers' perspectives in depth and provide space for teachers' voices to be clearly explored. This study is expected to provide empirical contributions that can be used as a basis for practical recommendations for teacher training development, education policy formulation, and learning strategies that are more responsive to the needs of teachers in the field. Thus, this study not only fills a gap in academic literature but also has real implications for the world of education, particularly in advancing the quality of innovative and meaningful learning in schools.

METHOD

This study employs a qualitative descriptive approach aimed at describing teachers' experiences, perspectives, readiness, and challenges in implementing STEM education based on narrative data collected directly from the field (Creswell, 2012). The qualitative descriptive approach was chosen because it allows the researcher to provide a contextual overview of participants' experiences and perspectives based on their responses. The data were analyzed and presented in the form of descriptions and narratives to provide an in-depth understanding of teachers' experiences in the context of STEM learning.

The participants in this study were junior high school mathematics teachers in Bangkalan Regency who attended a STEM training program facilitated by the researcher. Of the 230 teachers who attended the training, 30 responded to the narrative questionnaire and were used as the data source for this study. Participants were selected based on their involvement in the training and their willingness to respond to the questionnaire. The inclusion criteria for this study were teachers who were actively teaching mathematics at the junior high school level and who responded to the narrative questionnaire. Data was collected after all STEM training materials had been presented. A questionnaire was administered following the training to give teachers an opportunity to reflect on their understanding, readiness, experiences, and the challenges they faced regarding STEM learning. This procedure ensured that the responses obtained reflected the teachers' perceptions and experiences after participating in the training.

The research instrument consisted of a narrative questionnaire comprising nine open-ended questions. The narrative questionnaire used in this study did not undergo a formal validation process by experts or peer review prior to its use. Therefore, the lack of

instrument validation is acknowledged as one of the study's limitations that must be considered when interpreting the findings. The open-ended questions in the narrative questionnaire were designed to explore aspects related to teachers' readiness and challenges in implementing STEM education, including teachers' understanding of STEM, their experiences in implementing STEM, their competency readiness, school resources and support, challenges in implementation, limitations in facilities and instructional time, competencies that still need to be developed, as well as teachers' suggestions and expectations. The aspects explored through the questionnaire are summarized in Table 1.

Table 1. Narrative Questionnaire Framework

No.	Aspects Explored	Focus of Questions
1	Understanding of STEM	Teachers' understanding of STEM learning concepts
2	Implementation Experience	Teachers' experience in implementing STEM learning
3	Competency Readiness	Teachers' perceptions of their competency readiness to implement STEM
4	School Facilities and Support	Availability of school facilities, resources, and support
5	Implementation Challenges	Difficulties teachers face in implementing STEM
6	Facilities and Time	Constraints related to facilities, equipment, and instructional time
7	Competencies to Be Developed	Competencies that still need to be improved
8	Development Needs	Training or support needs for STEM implementation
9	Suggestions and Expectations	Teachers' suggestions and expectations regarding STEM implementation

The questionnaire responses were analyzed using thematic analysis. The analysis aimed to identify recurring patterns of meaning in the teachers' responses and organize them into themes that describe teachers' readiness and challenges in implementing STEM education. The analysis was conducted in several stages: data familiarization, initial coding, grouping of related codes, theme development, and theme review and refinement (Ahmed et al., 2025).

First, the researchers familiarized themselves with the data by repeatedly reading through all the questionnaire responses to understand the context and nuances of the teachers' answers. Second, portions of the responses that were meaningful and relevant to the research focus were identified and assigned initial codes. These codes were descriptive in nature and represented the content of the teachers' responses. For example, a teacher's response describing difficulties in integrating mathematics with technology and design was initially coded as "difficulties in cross-disciplinary integration." Codes related to difficulties in connecting mathematics with other STEM disciplines were then grouped into the category "integration difficulties" and developed into a broader theme, namely "STEM integration." Responses regarding limitations in instructional time, facilities, teacher competencies, and student motivation were also coded and grouped based on their common meanings. Examples of the coding process are presented in Table 2.

Table 2. Examples of Coding and Theme Development

Participant	Response Excerpt	Initial Code	Theme
T2	"Collaboration across subjects"	Challenges in cross-subject collaboration	STEM integration
T3	"Lack of student motivation"	Low student motivation	Student readiness

Participant	Response Excerpt	Initial Code	Theme
T5	"As for project equipment, I don't think the school is ready yet"	Limitations in project equipment	Infrastructure
T10	"The technology component"	The need to improve technological competencies	Teacher competencies
T15	"The lack of engineering development opportunities I can pursue"	Limitations in engineering competencies	Teacher competencies
T28	"Existing facilities and the quality of student input"	Limitations in facilities and student-related factors	Infrastructure and student readiness
T30	"Collaboration on content with the fields of technology and design"	Difficulties integrating mathematics with technology and design	STEM integration

Once the initial codes were identified, related codes were grouped based on shared meanings and developed into broader themes. For example, codes related to difficulties in connecting mathematical concepts with other STEM disciplines, such as challenges in cross-subject collaboration and integrating mathematics with technology and design, were developed into the theme "STEM integration." Meanwhile, codes related to limitations in project facilities and equipment were developed into the theme "infrastructure." Next, all codes with similar patterns and meanings were reviewed to determine the themes that best aligned with the teachers' responses.

The initial themes were then reviewed and refined by comparing them again with the original responses in the questionnaire. This process was conducted to ensure that each theme truly represented the meanings conveyed by the participants and that the resulting themes could be distinguished from one another. When calculating the frequency of themes, each teacher is counted once for a given theme if their response contains evidence relevant to that theme, even if the same teacher mentions that theme more than once in their response. The final themes were then used to organize the presentation of findings regarding teachers' readiness and challenges in implementing STEM education.

To illustrate how often each theme emerged, the researchers also recorded the number of teachers whose responses contained evidence related to each theme. Frequency is used to indicate the number of participants who mentioned or demonstrated a particular theme, not to suggest that that theme is more important than others. In addition to frequency, the depth and richness of the teachers' responses were also taken into account when interpreting the findings. Before data collection began, informed consent was obtained from all participants. All participant responses were anonymized to protect their identities.

RESULT AND DISCUSSION

Teacher Readiness in Implementing STEM Learning

Analysis of the mathematics teachers' responses showed that 26 out of 30 teachers (86.7%) understood STEM as a learning approach that integrates science, technology, engineering, and mathematics. This understanding was reflected in the teachers' responses, which linked STEM to the integration of multiple disciplines and the solving of real-world problems. For

example, T2 stated that "STEM is a tool for solving real-world problems involving science, technology, engineering, and mathematics," while T16 explained that "STEM is a learning approach that integrates science, technology, engineering, and mathematics to solve real-world problems." Both responses indicate that most teachers not only recognize STEM based on the acronym's meaning but are also beginning to understand its characteristics as an approach that integrates multiple disciplines to solve real-world problems. This understanding generally emerges after teachers participate in STEM training that provides an initial overview of the use of mathematics in an interdisciplinary context. However, teachers' understanding still tends to be conceptual and does not yet fully demonstrate their readiness to design and implement integrated STEM learning in the classroom. This condition is in line with international research findings which show that mathematics teachers generally already have an initial perception of STEM, but still need further study to effectively integrate this approach into mathematics learning in the classroom (Margot & Kettler, 2019).

In addition, teachers' readiness to plan STEM lessons varies. Teachers generally feel more prepared to design lessons related to mathematics and problem-solving, but still face difficulties in systematically integrating technology and engineering elements into their lesson plans. This is reflected in T16 response, who stated, "I feel sufficiently prepared in terms of understanding basic STEM concepts, designing simple project activities, and linking lesson content to real-world problems. However, I still need to improve my ability to manage more complex projects and ensure that all students are actively engaged." Meanwhile, T30 stated that they are "prepared in terms of mathematics content," but the area that still needs improvement is "collaborating content with related subjects such as technology and design." This response indicates that the teacher is prepared in terms of mathematics content and planning simple activities but still needs to develop the ability to integrate other disciplines more comprehensively. Thus, STEM instructional planning requires a shift from procedure-focused mathematics instruction toward learning that involves projects, real-world contexts, and interdisciplinary collaboration. This situation illustrates the challenges faced by mathematics teachers during the STEM lesson planning phase, particularly in integrating interdisciplinary elements and developing collaborative learning strategies (Tytler et al., 2023).

In the context of classroom implementation, teachers' readiness to conduct STEM instruction still reveals a gap between conceptual understanding and practical readiness. Although some teachers have grasped the basic concepts of STEM and feel prepared to design simple activities, implementing them requires additional skills related to the direct management of the learning process. This is evident from T6 response, who stated, "I feel that my conceptual and planning competencies are sufficiently developed, but I still need to improve my competencies in practical implementation and authentic assessment in the classroom." Similarly, T12 stated that he was sufficiently prepared to "understand basic STEM concepts, design simple project activities, and relate lesson content to real-world

problems," but still needed to improve his ability to "manage time, create STEM assessment rubrics, and prepare more comprehensive instructional materials." These responses indicate that an understanding of concepts and the ability to plan instruction do not automatically translate into readiness to implement STEM effectively. This occurs because the implementation of STEM requires more complex practical competencies, such as managing time, organizing student activities, conducting authentic assessments, preparing learning materials, and managing project-based activities that actively engage students. Thus, even though teachers already possess conceptual readiness and initial planning, the implementation of STEM in the classroom still requires adaptation to more open, collaborative, and project-based learning practices. This finding aligns with Wu et al. (2022), who showed that teachers' readiness to implement STEM in teaching practices, particularly in interdisciplinary and project-based activities, can face obstacles even when teachers already possess a basic understanding of STEM.

The responses from math teachers also indicate that readiness to implement STEM education is influenced by the availability of infrastructure and school support. Some teachers stated that basic facilities are available, but the utilization of these facilities to support STEM activities is still not optimal. This is reflected in T5 response, who stated, "As for project equipment, I don't think the school is ready yet." This response indicates that the limited availability of project equipment at the school can be an obstacle for teachers in transforming their understanding and planning of STEM into concrete learning activities. Thus, teachers' readiness is determined not only by individual understanding and competence but also by the availability of facilities and institutional support that enable teachers to carry out STEM activities in a more structured manner. Although the STEM training teachers have attended has provided an initial understanding of STEM implementation, further support is still needed to facilitate a more structured and sustainable implementation. This reinforces the fact that the readiness of math teachers to implement STEM learning depends not only on individual competencies but also on school support and the sustainability of professional development programs (Bakytkazy et al., 2025).

Challenges for Teachers in Implementing STEM Learning

Analysis of the 30 teacher responses revealed five recurring themes of challenges in implementing STEM education: teacher competence, infrastructure and resources, time constraints, STEM integration, and student readiness and motivation. Teacher competence was mentioned by all 30 teachers (100%), followed by infrastructure and resources, cited by 23 teachers (76.7%); time constraints, cited by 22 teachers (73.3%); STEM integration, cited by 20 teachers (66.7%); and student readiness and motivation, cited by 11 teachers (36.7%). These frequencies indicate the number of participants whose responses contained evidence related to a particular theme and do not imply that themes with higher frequencies are more important than others. A single teacher may have cited more than one theme in their response. The distribution of themes based on teachers' responses is presented in Table 3.

Table 3. Distribution of Themes Based on Teachers' Responses

Theme	Number of Teachers (n)	Percentage (%)
Teacher Competence	30	100,0
Infrastructure and Resources	23	76,7
Time Constraints	22	73,3
STEM Integration	20	66,7
Student Readiness and Motivation	11	36,7

In addition to frequency, the depth and richness of teachers' responses were also considered in interpreting the findings. STEM integration has emerged as one of the challenges in implementing STEM-based learning in mathematics education. Teachers reported difficulties in connecting elements of science, technology, and engineering to mathematics instruction. Some teachers noted that mathematics instruction has traditionally focused more on procedures and problem-solving, so implementing an integrated approach like STEM requires significant adjustments. Teachers also expressed confusion about defining the role of each STEM component to ensure it remains relevant to mathematics learning objectives. This situation aligns with the findings of Tytler et al. (2023), who explain that STEM integration presents challenges in establishing meaningful connections between mathematical concepts and various scientific disciplines. Therefore, the integration of STEM into mathematics education requires conceptual and pedagogical support so that teachers can meaningfully connect mathematical concepts to interdisciplinary contexts.

Time constraints are also a frequently reported challenge in the implementation of STEM education, this was mentioned by 22 out of 30 teachers (73.3%). Mathematics teachers also revealed that limited learning time poses a significant challenge in implementing STEM learning. Project-based learning, which is characteristic of STEM, is considered to require more time than conventional learning, while the allocation of mathematics class hours is relatively limited. In addition, teachers face difficulties in managing the classroom and ensuring the active involvement of all students during the STEM learning process, especially when time management and instructional dynamics are not in line with the demands of interdisciplinary activities. Along with that, teachers often experience instructional challenges in STEM practice due to limited time to plan and implement comprehensive learning and difficulties in adjusting their learning approaches to the more complex pedagogical demands of STEM (Dong et al., 2020).

In addition to pedagogical aspects, limitations in infrastructure and resources are also frequently cited as challenges in the implementation of STEM education, as mentioned by 23 out of 30 teachers (76.7%). Although some schools already have basic technological facilities, teachers said that the availability of tools to support STEM projects is still limited and uneven, so that learning activities based on experiments and technology are often constrained. This situation is exacerbated by the lack of ongoing support in the form of advanced training and guidance on STEM implementation in schools, which makes many teachers feel unsupported in improving their capacity to design and manage interdisciplinary learning. The relationship between resource constraints and the need for professional support is explained in international research showing that STEM teachers

often face various practical obstacles in the classroom, such as difficulties in classroom management, curriculum development, and recognition of practical constraints, all of which are exacerbated by a lack of adequate training, facilities, and professional support for teachers. Therefore, the successful implementation of STEM learning depends not only on the readiness of individual teachers, but also on school support systems and sustainable teacher professional development policies so that these obstacles can be overcome more effectively (Aslam et al., 2023).

Challenges related to teacher competence were a theme that emerged in all of the teachers' responses; specifically, they were identified in the responses of 30 out of 30 teachers (100%). Based on teachers' responses, many of them feel that they are not confident enough in making optimal use of technology or designing engineering activities that are relevant to mathematics material. These challenges are also evident in teachers' difficulties in developing assessments that are capable of assessing students' thinking processes, collaborative work, and problem-solving skills, which are characteristics of STEM learning. These conditions indicate that teachers face various obstacles when developing integrated STEM activities, including constraints in combining technology and engineering in learning practices and limited pedagogical knowledge to assess learning authentically, which encourages the need for continuous professional development support so that they can improve their technology, engineering, and assessment competencies in the context of STEM (Lin et al., 2025).

Mathematics teachers also highlighted that student motivation and readiness pose particular challenges in implementing STEM education, as reported by 11 out of 30 teachers (36.7%). Teachers stated that students are not yet accustomed to learning that requires group work, independent exploration, and open-ended problem-solving, as called for by the STEM approach. These challenges are even more pronounced in schools with diverse student backgrounds, including limited access to technology and learning habits that are still oriented towards conventional learning. This shows that teachers often feel that students are not fully prepared to meet the demands of STEM learning (such as critical thinking, collaboration, and problem solving) due to their limited experience in inquiry-based and real-world learning. Therefore, adjusting the context of students and the school environment is important so that STEM learning objectives can be achieved gradually and sustainably (Margot & Kettler, 2019).

CONCLUSION AND SUGGESTIONS

Based on the research findings, junior high school mathematics teachers have generally demonstrated a basic understanding of STEM education as well as readiness at the conceptual and initial planning stages. However, this readiness has not yet been fully reflected in classroom instruction, particularly in integrating STEM components into mathematics instruction. Teachers reported various challenges related to interdisciplinary integration, limited instructional time, infrastructure and resources, as well as teacher

competencies. Additionally, student motivation and readiness emerged as significant challenges in implementing STEM education. These findings indicate that an understanding of STEM concepts and initial readiness in planning do not automatically translate into readiness to implement them in the classroom. This relates to the need for additional practical competencies, such as the ability to manage time, organize student activities, conduct assessments, utilize technology, and manage interdisciplinary and project-based learning. These findings suggest that participation in initial STEM training provides a context for the development of conceptual understanding, whereas the ongoing implementation of learning in the classroom requires continuous guidance and institutional support.

This study also reveals that mathematics teachers face various challenges in implementing STEM learning, both in terms of learning integration, time management, availability of infrastructure, and readiness of supporting competencies. In addition, student motivation and school context also influence the success of STEM learning implementation in mathematics classrooms. Therefore, the implementation of STEM learning requires systemic support in the form of continuous training, implementation assistance, and school policies that support innovative learning. The findings of this study are expected to serve as a starting point for the development of STEM learning programs that are more contextual and in line with the actual conditions of schools. One limitation of this study is that the narrative questionnaire used did not undergo a formal validation process by experts or peer review. Therefore, the study's findings should be interpreted with these limitations in mind.

Based on the results of this study, further research is needed to explore in greater depth effective STEM learning mentoring strategies and implementation models in mathematics classrooms. Therefore, further research can be conducted by involving direct observation of learning or case studies of STEM implementation in schools. Thus, further research is expected to provide a more comprehensive picture of contextual and sustainable STEM learning practices.

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