

Enhancing Middle School Teachers' Understanding of Locally Context-Based STEM Learning

Jamaludin^{1*}, Marleny Leasa², Gazali Rachman¹, Efilina Kissiya³, Herman Samuel Wattimena¹, John Rafafy Batlolona¹

¹Physics Education Study Program, Faculty of Teacher Training and Education, Pattimura University, Ambon, Indonesia.

²Elementary School Teacher Education Study Program, Faculty of Teacher Training and Education, Pattimura University, Ambon, Indonesia.

³History Education Study Program, Faculty of Teacher Training and Education, Pattimura University, Ambon, Indonesia.

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Corresponding Author:

Jamaludin

kacianjamal@gmail.com

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Abstract: This community service activity aims to improve junior high school teachers' understanding of implementing local context-based STEM learning in Makariki District, Central Maluku Regency. The activity was carried out using a participatory approach through the stages of needs analysis, training, implementation assistance, and evaluation. The training materials included STEM concepts, STEM integration, local context, and implementation, as well as the application of Project Based Learning (PjBL) and Engineering Design Process (EDP) in project-based learning. The results of the activity showed an increase in teachers' understanding of the STEM aspects provided. Teachers also demonstrated increased ability in designing project-based learning tools and utilizing local culture and environment as contextual and meaningful learning resources for students. In addition, interview results showed a change in teachers' mindsets towards more active, creative, collaborative learning, and relevant to students' daily lives. Thus, local context-based STEM training has proven effective in improving teachers' professional competence and supporting the development of innovative, contextual, and problem-solving-oriented 21st-century learning.

Keywords: STEM; Local Context; Teacher Training; Contextual Learning; Teacher Professional Development

Introduction

21st-century education demands that teachers and educators develop learning that is not only oriented toward mastering concepts but also toward strengthening critical thinking, creativity, collaboration, and communication skills. One approach considered effective in achieving these goals is Science, Technology, Engineering, and Mathematics (STEM) learning, which integrates various disciplines or interdisciplinary approaches within the context of solving real-world, contextual problems (Zhang & Zhu, 2023). This approach has been widely recommended in global education policies in the context of high technology because it is able to increase STEM literacy collectively

or partially and the readiness of students to face future challenges (Hudha et al., 2019; Li et al., 2020; Buabeng & Amo-darko, 2026). In a number of countries, STEM education is seen as important for encouraging career interest, national development, economic growth, and increasing international competitiveness (Kelley & Knowles, 2016; Kocabas & Ozfidan, 2020; Pugliese & Santos, 2022). In addition to preparing students to face the demands of future careers, STEM education also contributes to improving learning outcomes in STEM disciplines (Lian et al., 2021; Thompson et al., 2023). On the other hand, the existence of STEM graduates is very much needed to meet the need for competent workers and strengthen a country's capacity (Newell & Ulrich, 2022). Therefore, many countries, both developed and

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developing, are carrying out educational reforms and allocating large investments in developing STEM programs so that students have greater opportunities to pursue careers in these fields (Elgrably et al., 2022; Jiang et al., 2021). Several studies also confirm that the integration of STEM education at various levels of education, from secondary school to university, plays a significant role in improving the quality of learning and developing students' potential (Mikhaylovsky et al., 2021).

STEM education was originally called Science, Mathematics, Engineering, and Technology (SMET) and is a STEM initiative introduced by the National Science Foundation of the United States in 1986, the concept of STEM (science, technology, engineering, and mathematics) is seen as an effective approach in preparing superior human resources in the field of technology. STEM education is designed to connect various disciplines in an integrated manner with an emphasis on practical activities, so as to improve problem-solving abilities and encourage innovative thinking patterns in students (Sanders, 2009; Khalil & Osman, 2017). The interdisciplinary and practice-based nature of STEM education demands that universities maintain high standards in preparing qualified STEM teacher candidates. Therefore, various countries have implemented specific policies and programs to ensure both the quality and quantity of STEM educators (Fouilloux et al., 2025). For example, in the United States, structured and targeted STEM education policies and strategies have been used as a model by many other countries. More specifically, in 2012, this project took a decisive step into the education sector when President Obama decided to increase teacher recruitment in these fields and thereby address the shortage of students in these fields (Perales & Aróstegui, 2024). Meanwhile, in the UK, STEM education is also developing rapidly with the establishment of the National STEM Strategy Group by the government, which focuses on developing the workforce through comprehensive STEM skills (Kovács & Hanjra, 2025). Australia has also experienced development from implementing STEM at the state level to a national strategy that supports STEM education through four main aspects, namely national policy, community involvement, resource integration, and strengthening teacher competency (Bentley et al., 2022). In China, the implementation of STEM education is more focused on the K-12 level, with an integrative, interdisciplinary approach and adaptation to the local context (Liu et al., 2026).

However, in practice, the implementation of STEM learning in schools still faces various obstacles, particularly at the level of teacher understanding. Several studies show that many teachers still struggle to grasp the concept of STEM integration and apply it in

contextual and meaningful learning designs (Galanti & Holincheck, 2022; Rehman et al., 2025). Learning still tends to be carried out separately between disciplines, so that the integrative essence of STEM has not been optimally achieved (Baker & Galanti, 2017; Margot & Kettler, 2019). In addition, teachers demonstrated limited understanding of STEM integration, particularly through the use of models. However, the dominant approach observed was the traditional teacher-centered method, which hinders the promotion of critical thinking among students (Mafugu et al., 2024). This condition shows that systematic efforts are needed to improve teacher capacity through structured and ongoing training activities (Zhou et al., 2023; Simos et al., 2026). The various challenges faced by teachers in many countries show that many educators still do not have adequate experience in STEM education (Awad & Barak, 2018). Teachers need to gain STEM-based learning experiences and be encouraged to implement the STEM curriculum through the presentation of real-life problems. This approach can strengthen understanding of STEM concepts and pedagogical strategies that support learning, such as problem-solving skills, scientific inquiry skills, and critical thinking (Zollman, 2012). In addition, professional development programs play a vital role in helping teachers explore STEM learning more deeply, enriching and refining their initial understanding of STEM, and enhancing their understanding of the STEM curriculum (Huang et al., 2022). The implementation of STEM education in Indonesia is implemented through various learning models, including PjBL, the 6E model which includes engage, explore, explain, engineer, enrich, and evaluate, learning oriented towards assessing high-level thinking skills, inquiry learning, think pair share, Problem Based Learning (PBL), the use of Android-based games, as well as learning media in the form of digital books and student books (Mafugu et al., 2024). PjBL is a method widely used in the implementation of STEM education in Indonesia (Khotimah et al., 2021).

On the other hand, effective learning must also consider the local context as a relevant and meaningful learning resource. A culturally responsive pedagogy emphasizes the importance of linking learning materials to students' experiences and environments (Druker-ibáñez & Cáceres-jensen, 2022; Govender et al., 2026). In the context of Maluku as an archipelago, there are various local wisdoms such as *sasi*, traditional boat technology, and sago processing that contain scientific concepts that can be integrated into STEM learning (Zidny & Sjöström, 2021; Matindike & Ramdhany, 2025). This integration is known as the Ethno-STEM approach, which combines local knowledge with modern science to increase the relevance of learning (Asmaningrum et al., 2025). The study results show that the use of ethno-

STEM-based learning materials significantly increased students' perceived usefulness, cultural relevance, and engagement in learning, as supported by a high model fit index. Learning engagement was found to be the most dominant factor in skill development, while cultural relevance played a particular role in fostering student creativity (Asrizal et al., 2026).

Various results of community service and previous research show that teacher training that integrates the STEM approach with the local context has a significant contribution in improving conceptual understanding, teachers' ability to design innovative learning, and their motivation to implement STEM-based learning in the classroom (Sari et al., 2020; Rosyada et al., 2025). In addition to improving pedagogical competence, this type of training also helps teachers understand how to connect learning materials to real-life problems that are close to students' lives, making the learning process more contextual and meaningful. Furthermore, the participatory approach to training, designed through hands-on activities, collaboration between teachers, group discussions, and joint reflection, has proven to be more effective in building in-depth understanding than training that focuses solely on delivering theory (Thibaut et al., 2018; Ho, 2024). Through these active and collaborative learning experiences, teachers become more confident in developing creative, adaptive learning ideas that are tailored to the needs of students in their respective environments. Therefore, community service activities in the form of teacher training are a relevant and important strategy to support the improvement of teacher professional competence, particularly in areas with limited access to ongoing professional development programs, learning resources, and adequate educational support.

Makariki District, Central Maluku Regency, is an area with significant potential for developing locally context-based learning, but still faces limitations in implementing STEM learning. Based on initial observations, most junior high and vocational high school teachers in this area lack an adequate understanding of STEM concepts, their integration into learning, and the utilization of local contexts as learning resources. This situation results in less than optimal innovative and contextual learning in the classroom. In response to this problem, this community service activity was designed in the form of locally context-based STEM learning training for junior high and vocational high school teachers in Makariki, Central Maluku. This training aims to build and strengthen teachers' understanding through a participatory approach, hands-on practice, and the integration of local wisdom into learning design. Thus, this activity is expected to increase teachers' capacity in designing and

implementing STEM learning that is contextual, innovative, and relevant to the students' environment.

Method

Community service activities carried out by the team are an annual routine agenda. This program aims to provide real contributions to the community, especially in the development of education. In 2025, the activity was held on October 21-23. The implementation of this community service involved five lecturers who have competence in their respective fields, namely Prof. Dr. Marleny Leasa, M.Pd., Efilina Kissiya, S.Pd., M.Hum., Ph.D., Jamaludin, S.Pd., M.Sc., and John Rafafy Batlolona, S.Pd., M.Pd and other Professional Staff namely Dr. Gazali Rachman, M.Si and Dr. Herman Samuel Wattimena, M.Si. The entire team worked together in carrying out activities centered at SMP Negeri 14 Central Maluku and 15 teachers were involved from various different subjects. In its implementation, two students participated, namely various Chairpersons of Student Associations along with one member. They helped deliver the material to the teachers. The distance from Pattimura University to the activity location is 97.57 km by sea transportation.

This community service activity was implemented using a participatory approach that actively involved teachers in every stage of the activity, from needs analysis to evaluation of training results. The initial stage was carried out through a needs analysis to identify teachers' initial understanding of local context-based STEM learning using pre-tests, questionnaires, and directed interviews. Questionnaire data was used as quantitative data, while interview results were used as qualitative data to obtain a more in-depth picture of teacher readiness in implementing local wisdom-based STEM learning. Next, the activity continued with local context-based STEM training that focused on strengthening teachers' understanding of STEM concepts, ethnoscience, ethnotechnology, and the importance of contextualizing learning through local Maluku culture. The training materials included the integration of STEM elements in various local cultural practices, such as sago processing, baileo traditional house construction, traditional textile motifs, and Maluku community planting patterns. In addition, participants were also equipped with the application of the Project Based Learning (PjBL) model and the Engineering Design Process (EDP) approach in designing project-based learning. An example of a project developed is the innovation of a sago filtering tool that is more hygienic and efficient as a form of integration of science, technology, engineering, and mathematics in a local context.

The next stage is a learning design workshop, where teachers collaboratively develop project-based learning tools utilizing the local potential of their respective regions. The tools developed include learning steps for the PjBL model, teaching modules or RPP, and LKPD based on local contexts. After that, implementation mentoring is provided to help teachers apply the developed learning tools into the classroom learning process with direct guidance from the community service team. This mentoring provides teachers with real-world experience in integrating STEM and local contexts into learning. The final stage is reflection and evaluation carried out through post-tests, reflective discussions, and the development of assessment rubrics to measure changes in teacher understanding and skills after participating in the entire series of activities. The evaluation results are used to determine the effectiveness of the training in improving teacher competency in designing and implementing STEM learning based on local contexts. The teachers hope that this activity will not only be carried out now but can continue for other scientific activities through special mentoring for teachers.

Then, to find out the level of understanding of the concept of all students, this can be found out through the assessment rubric from Kurniawan et al. (2017) By dividing the level of conceptual understanding, students are divided into three categories: low, medium, and high. This grouping is done based on the percentage of conceptual understanding students obtain from the assessment or learning evaluation process. Students are categorized as having low conceptual understanding if their comprehension percentage is in the range of 0% to less than 30%. This category indicates that students are still experiencing difficulties in understanding the material or concepts being studied and therefore require further guidance and reinforcement in the learning process. Furthermore, students are said to have a moderate level of conceptual understanding if the percentage obtained is in the range of more than 30% to less than 70%. In this category, students have been able to understand some of the concepts being studied, but this understanding is not yet fully optimal and still requires development so that students can master the material more thoroughly. Meanwhile, students who obtain a conceptual understanding percentage of more than 70% to 100% are included in the high category.

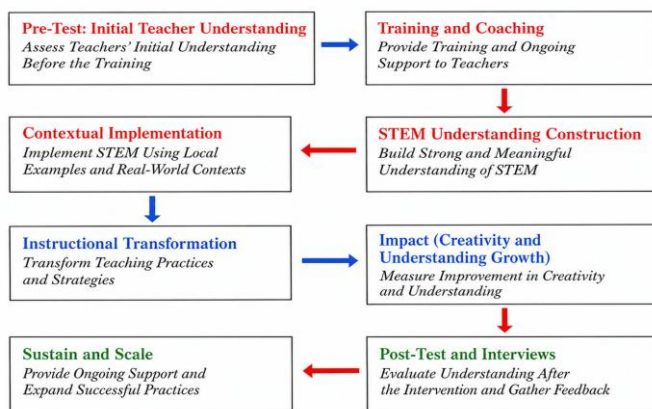


Figure 1. Community Service Implementation Scheme

Results and Discussion

The pre-test and post-test results in Figure 2 show the evaluation of teachers' abilities before and after participating in STEM-based learning training integrated with the local context. The assessment was conducted on four main aspects. The data is presented as a comparison of pre-test and post-test scores from 15 teachers. Overall, the data indicate an increase in scores across all aspects after the training.

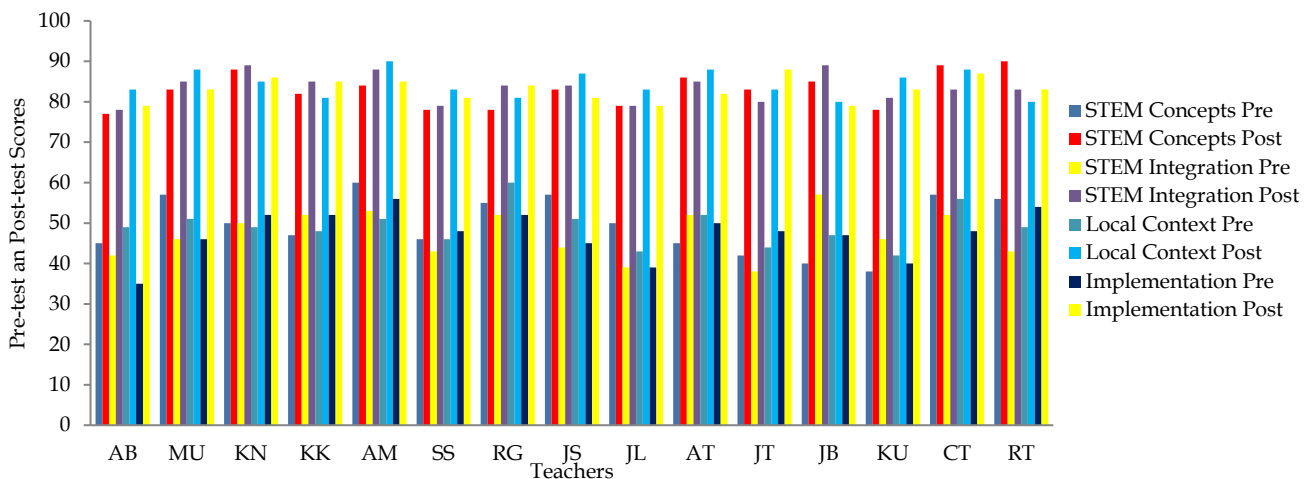


Figure 2. Pre-test and Post-test Results of High Junior School Teachers

In the pre-test phase, most teachers still scored in the moderate range, around 35–60. This indicates that before the training, teachers' understanding of STEM concepts and their application in learning was still suboptimal. Several teachers appeared to have quite low scores, especially in the aspects of STEM integration and learning implementation. This condition indicates that teachers still experience difficulties in connecting elements of science, technology, engineering, and mathematics into an integrated learning design and are not yet accustomed to implementing project-based learning or contextual problem-solving in the classroom. In the aspect of STEM concepts, teachers' pre-test scores generally ranged from 40–58. After the training, post-test scores increased significantly to around 78–90.

This improvement demonstrates that the training strengthened teachers' understanding of basic STEM concepts, the characteristics of STEM learning, and the importance of implementing an interdisciplinary approach in the learning process. Teachers gained a better understanding of how elements of science, technology, engineering, and mathematics can be integrated to support more active, creative, and problem-oriented learning. In terms of STEM integration, scores also showed significant improvement. Before the training, some teachers still struggled to design lessons that integrated multiple disciplines simultaneously. This was evident in their relatively low pre-test scores. However, after the training, their post-test scores increased to around 80–89. This increase indicates that teachers are beginning to understand strategies for developing STEM-based learning tools, including developing learning activities, developing simple projects, and integrating various cross-disciplinary concepts into a structured learning activity. In terms of local context, the results showed a significant improvement compared to before the training. Before the training, some teachers were unfamiliar with utilizing their surroundings as a learning resource. After the training, scores increased to a high range of 80–88.

This indicates that teachers are beginning to understand the importance of linking learning to local conditions, culture, regional potential, and real-world problems in the students' environments. A local context-based approach is considered capable of making learning more meaningful because students can understand the material through experiences close to their daily lives. Furthermore, the implementation aspect of learning also experienced significant improvement. In the initial stage, implementation scores were still in the moderate category, indicating that teachers were not yet fully confident in implementing STEM learning in the classroom. After the training, scores consistently increased for all participants. This

indicates that the training activities not only improved teachers' theoretical understanding but also helped them develop practical skills for implementing STEM-based learning. Teachers became better prepared to design learning activities, manage group discussions, implement project-based learning, and guide students to explore and solve problems independently. Overall, the improved scores seen in almost all teachers indicate that the training program was effective and had a positive impact on improving the professional competence of junior high school teachers. The results of this training align with a study in Malaysia that found teachers' attitudes toward STEM were in the moderate category. This is because the current Malaysian education curriculum still does not meet the goals of STEM education. These four disciplines are still taught separately, and teachers are trained to master only one discipline (Wei & Maat, 2020).

The relatively even score increase across all participants also indicates that the training materials and methods were well understood by teachers from various skill levels. This success was likely influenced by the participatory training approach, which involved hands-on practice, discussion, reflection, and collaborative development of learning materials. This approach enabled teachers to gain more concrete and meaningful learning experiences than simply receiving theoretical material. Thus, the STEM-based learning training integrated with local contexts successfully improved junior high school teachers' understanding of STEM concepts, learning integration skills, utilization of local contexts, and implementation skills. This finding aligns with the constructivist approach, which emphasizes that knowledge is built through active learning experiences during the training process (Bicer et al., 2017; Zhou et al., 2020).

The STEM integration indicator showed a relatively higher increase compared to the basic concept indicator. This indicates that teachers not only understand STEM concepts theoretically but are also beginning to be able to connect various disciplines in the learning process. A paradigm shift has occurred from isolated learning to interdisciplinary learning. This is crucial in 21st-century learning because STEM integration plays a role in developing higher-order thinking skills (Palinussa et al., 2025) and student motivation (Leasa et al., 2024). In the local context indicator, improvements are also quite clear, although some teachers are still in the moderate category. This finding indicates that teachers are beginning to be able to connect learning materials to the local environment and culture in Central Maluku. In the context of an archipelagic region like Maluku, utilizing local wisdom is crucial for creating relevant and meaningful learning for students. One recommended lesson is IBL-STEWeb to improve students' academic

quality. The use of IBL-STEWeb can consider the involvement of student prejudices, provide in-depth foundational knowledge, help students make connections within the context of conceptual frameworks, and can map students' knowledge in a way that facilitates information retrieval and application (Batlolona & Jamaludin, 2022).

Coastal environments, maritime culture, natural resources, and local community life can serve as contextual learning resources while strengthening students' local identities. For example, strengthening STEM education with a focus on renewable energy can be a strategic step in preparing students to face increasingly complex environmental challenges. The Allang region is known for its significant wind and ocean wave potential. This natural potential can be utilized as a source of clean electrical energy. Areas with these characteristics are also highly relevant as STEM learning media, as they can equip students with the ability to utilize the potential of their surrounding environment as a strength to support the region's future development (Batlolona et al., 2025). More broadly, Indonesia has enormous renewable energy potential, reaching 419 GW, consisting of 75 GW of hydropower, 23.7 GW of geothermal energy, 32.6 GW of bioenergy,

207.8 GW of solar energy, 60.6 GW of wind energy, and 19.3 GW of microhydro (Pambudi et al., 2023). In Maluku Province, the greatest potential comes from solar energy, followed by biomass, wind, and hydropower. With optimal management, Maluku has the potential to become an energy-independent region based on renewable resources (Tumiran et al., 2022). However, electricity distribution in this region remains uneven, leaving many small and remote islands without adequate access to electricity.

The above are practical examples that must be followed up. Therefore, teachers' ability to integrate local contexts still requires further strengthening and mentoring for optimal implementation. Meanwhile, implementation indicators show significant improvement, with some teachers even achieving near-maximum scores. This indicates that teachers are able to apply the training findings in practical activities, simple projects, and problem-based learning that utilizes the local context. This improvement demonstrates a real shift from simply understanding concepts to being able to implement them in learning practices (from knowing to doing). Thus, the training is not only theoretical but also provides practical experience that directly impacts teachers' teaching abilities (Zhang & Zhu, 2023).

Table 1. Interview Results with 5 Teachers

Main Theme	Narrative in the Context of Maluku
Learning Transformation	The learning process has shifted from conventional methods to active, project-based learning, which is more suited to school conditions in Maluku. Teachers have begun to involve students in environmental exploration activities, such as observing coastal ecosystems, utilizing marine products, and processing local resources as part of the learning process.
STEM Integration	The STEM approach is understood as integrated learning that connects science, technology, engineering, and mathematics with the lives of the Maluku people. For example, students are encouraged to understand scientific concepts through marine phenomena, simple fisheries technology, and the application of mathematics to local economic activities.
Local Contextualization	Maluku's natural and cultural environment is utilized as a contextual learning resource. Its rich culture, maritime traditions, spices, and coastal resources are used as learning resources, making it easier for students to understand the material because it directly relates to their daily lives.



Figure 3. Documentation of Community Service Activities at SMP Negeri 14 Maluku Tengah

Conclusion

The results of the community service activities that have been implemented, it can be concluded that the

local context-based STEM learning training has a positive impact on improving the understanding and competence of junior high school teachers in designing and implementing innovative, contextual, and

integrated learning. The pre-test and post-test results showed an improvement in all aspects, namely STEM concepts, STEM integration, local context, and learning implementation. Before the training, most teachers still had difficulty understanding STEM concepts in an integrated manner and connecting them to project-based learning and real-world problems in the surrounding environment. However, after participating in the training, teachers became more understanding of the application of STEM in learning and were better able to integrate elements of science, technology, engineering, and mathematics in active and meaningful learning activities. In addition to improving conceptual understanding, this training also helped teachers in utilizing the local context as a learning resource relevant to students' lives. Teachers began to be able to link learning to culture, the environment, and regional potential such as maritime culture, natural resources, and the lives of local communities in Maluku. The participatory training approach through direct practice, discussion, reflection, and collaborative work proved effective in increasing teachers' confidence and readiness to implement STEM learning in the classroom. Thus, this training activity not only improves teachers' theoretical abilities, but also provides practical experience that supports the development of 21st-century learning that emphasizes creativity, collaboration, critical thinking, and problem-solving skills.

Based on the results of the implementation of the activities, it is recommended that subsequent training be conducted on an ongoing basis and accompanied by implementation mentoring in the classroom so that teachers can apply locally context-based STEM learning more optimally and consistently. This mentoring is important to assist teachers in developing learning tools, developing real-world problem-based projects, and evaluating student learning processes and outcomes. Furthermore, subsequent training activities should provide a greater portion of practice than theory so that teachers gain direct experience in designing and implementing STEM-based learning. It is also recommended that subsequent training further expand the use of local potential and regional cultural wisdom as learning resources. The coastal environment, maritime culture, natural resource management, and various local traditions in Maluku can be developed into more innovative and relevant learning projects to students' lives. Thus, learning not only improves students' academic abilities but also strengthens their cultural identity and concern for the surrounding environment. Furthermore, greater involvement of teachers across subjects and educational levels is needed so that STEM integration can be implemented more collaboratively. Support from schools, local

governments, and universities is also essential in providing facilities, learning resources, and ongoing teacher professional development programs. Therefore, collaboration between various parties is expected to strengthen the sustainability of local context-based STEM training programs and improve the quality of learning in schools.

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