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Promoting Innovation in Mathematics Learning: An International Program for Strengthening Teacher Competence through STEAM

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Abstract: This community service activity aims to strengthen teachers' competencies in designing and implementing contextual STEAM learning that is aligned with local school conditions. The program was conducted at the Musa-Asia Integrated School (SEPAMA), Cambodia, involving junior high school teachers and school leaders. The implementation methods included a baseline needs analysis, workshop-based training, instructional design mentoring, the implementation of simple classroom projects, and pre-test and post-test evaluations of teacher competency. Data were analyzed descriptively and quantitatively by comparing the mean pre-test and post-test scores and calculating the gain. The findings indicate an improvement in teacher competency across all measured dimensions, particularly in interdisciplinary integration and project-based learning. The average score for STEAM understanding increased from 2.82 to 3.27, representing a 15.96% improvement, while the project-based learning score increased from 2.45 to 3.09, representing a 26.12% improvement. Teachers also began to perceive STEAM learning as a practical and feasible approach that could be implemented by utilizing the school environment and students' daily activities. The classroom project implementation demonstrated increased student engagement, although not all teachers applied the approach consistently due to time constraints and the need for further adaptation. Field findings suggest that the simplified contextual STEAM approach is relevant to local school settings and effective in enhancing teacher readiness. Overall, this activity had a positive impact on improving teacher capacity and learning quality, with strong potential for sustainability through continuous mentoring and institutional support from partner schools.

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Introduction

21st-century education demands a major transformation in the way teachers teach, especially in subjects like mathematics, which students often find abstract and difficult. The STEAM (Science, Technology, Engineering, Arts, Mathematics) approach is one innovation that can address this challenge by integrating various disciplines to create contextual, creative, and technology-based learning (Adhy Putri Rilianti et al., 2023; Naela Khusna Faela Shufa & Tito Pangesti Adji, 2024; Zahlimar et al., 2024). Recent research shows that implementing project-based STEAM significantly improves students' critical thinking, creativity, communication, and collaboration skills (Djam'an et al., 2025; Ellianawati et al., 2024; Putri et al., 2023; Suryaningsih et al., 2022). Furthermore, STEAM facilitates real-life

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learning, which, according to S'anchez Milara & Cort'es Orduña (2024) is key to increasing student motivation and engagement in the classroom.

This global context also aligns with the education agenda in the Southeast Asian region, which increasingly emphasizes 21st-century skills and technology integration. A systematic study (Amanova & others, 2025) confirms that ASEAN countries face a similar challenge: a gap between progressive education policies and on-the-ground learning practices. Within this framework, the STEAM approach is seen as effective in bridging this gap because it can be flexibly adapted to various educational levels (Skowronek & others, 2025; Talafian et al., 2023).

The target partner for this program is the Musa-Asia Integrated School (SEPAMA) in Cambodia, an Islamic educational institution founded in 2012 and led by Muhammad Zain Musa. This school implements a dual curriculum that combines the Cambodian National Curriculum and religious education, offering unique potential for integrating interdisciplinary approaches. At SEPAMA, teacher-centered lecture methods are still the dominant method, limiting student active participation in learning. Most teachers have a background in teacher education, but few have received training in innovative learning methods like STEAM. Furthermore, learning practices generally haven't fully adopted a contextual approach, so the integration of technology, local context, and cross-disciplinary approaches hasn't been systematically implemented in the classroom. Initial observations indicate that the mathematics teachers at SEPAMA are highly dedicated, but most have not been systematically trained in designing STEAM learning that incorporates digital technology, local context, and cross-disciplinary integration. This challenge is exacerbated by limited access to interactive learning media such as GeoGebra or Desmos, which have been shown to be effective in enhancing understanding of mathematical concepts (Asyri & Asyri, 2024; Choirunnisa et al., 2023).

From a socio-cultural perspective, the SEPAMA community is located within the Khmer Muslim minority, which values mutual cooperation and strong religious traditions. This potential can be a valuable asset for developing STEAM projects based on local phenomena, such as calculating rice field irrigation, analyzing traditional building structures, or exploring geometric patterns in local carving and batik. Using cultural context in mathematics learning not only makes the material more meaningful but also fosters students' sense of identity and pride in their own culture.

However, teacher preparedness is a key factor in the success of this innovation. Studies (Hama & Osam, 2021) and (Mursidah et al., 2021) show that microteaching-based training is effective in improving teaching skills and providing a safe space for teachers to experiment with new strategies. The training model combines curriculum co-design and direct mentoring. Therefore, the program's design is tailored to the Cambodian context so that teachers can develop realistic and relevant STEAM projects.

This Community service program has three main objectives. First, to improve the competency of SEPAMA mathematics teachers in designing integrative, contextual STEAM learning that utilizes digital technology. Second, to create a collaborative learning ecosystem among teachers that encourages innovation and the exchange of good practices. Third, to support the strengthening of international education relations between Indonesia and Cambodia as part of ASEAN education diplomacy.

Finally, through a collaborative, relevant, and research-based approach, this Community service program is expected to not only improve the quality of mathematics learning in SEPAMA but also serve as a model that can be implemented in other schools in

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the ASEAN region. This international collaboration will strengthen regional education networks and demonstrate that learning innovation can grow from respectful intercultural collaboration.

Method

This internationalization Community service program was implemented in Cambodia at the Musa Asiah Integrated School. The program involved 12 teachers from various disciplines, including mathematics, science, language arts, religion, art, and technology. All participants attended the outreach activities, and the majority actively participated in the discussions. This diversity of fields supports the implementation of an integrative STEAM approach. The program's implementation method was systematically structured through continuous stages, including socialization, training, mentoring, and evaluation. The stages were:

1) Socialization and Building Understanding (Awareness & Contextualization)
   The socialization stage was an important initial step to establish a common understanding of the program's objectives and processes.
2) Training and Co-Design Workshop
   The next stage was intensive training that encouraged teachers to actively participate in designing STEAM project-based learning materials. This workshop was held offline at SEPAMA Cambodia.
3) Implementation and Refinement
   Before the lesson plans were widely implemented, teachers participated in online microteaching sessions in small groups. They conducted teaching simulations using the plans they had created and received direct feedback from colleagues and facilitators.
4) Mentoring
   Mentoring is a crucial part of supporting the program's success and sustainability. This activity involves direct support to help teachers overcome challenges in designing and implementing STEAM-based learning. In addition to receiving input from facilitators, teachers also share experiences, creating a collaborative and reflective learning environment. Through this process, teachers are encouraged to refine their learning to make it more relevant, integrated, and tailored to student characteristics.
5) Evaluation
   In the evaluation phase, data was collected through a Likert-scale questionnaire assessing STEAM understanding, interdisciplinary integration, project-based learning, technology utilization, and local context. Data were also supplemented by observations and reflections to record teachers' experiences during the program. Next, the data were analyzed descriptively by comparing pre-test and post-test scores and calculating score increases (gains) to measure changes in teacher competency after the program concluded.

Result and Discussion

The program's implementation method is systematically structured through a series of stages, including socialization, training, mentoring, and evaluation.

Socialization and Building Understanding (Awareness & Contextualization)

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The socialization stage is a crucial initial step to establish a common understanding with the school principal and the proposal team regarding the program's objectives and processes. At this stage, the proposal team provides an overview of the STEAM learning concept, program objectives, and expected benefits for improving the quality of mathematics learning in schools. The explanation also covers the importance of integrating science, technology, engineering, arts, and mathematics in creating more contextual and meaningful learning experiences for students. Through this presentation, at least a preliminary understanding of how the STEAM approach can be integrated with the existing curriculum and adapted to the characteristics of students in each school is gained.

In addition to delivering material, the socialization stage also serves as a space for dialogue between the proposal team and the principal. This discussion aims to identify initial needs, learning challenges, and local potential that can be used as context for developing the learning project. With this two-way interaction, it is hoped that an understanding will be formed regarding the direction of the program and at the same time foster a joint commitment to actively participate in each stage of the activities to be implemented.

Co-Design Training and Workshop

Once teachers have a basic understanding and relevant learning themes, the next stage is intensive training that encourages them to actively participate in designing STEAM project-based learning materials. This workshop is held offline at SEPAMA Cambodia.

At this stage, teachers not only act as training participants but also as learning designers, actively developing ideas and project designs based on the previously identified local context. Mentoring from a team of facilitators is provided to help teachers understand the steps of project-based learning design, from determining learning objectives and developing learning activities to planning assessments that align with the characteristics of the STEAM approach. Through this activity, teachers are expected to develop learning that is not only oriented towards mastering concepts but also fosters critical thinking skills, creativity, and student collaboration.

Furthermore, this workshop is designed as a collaborative space that allows for the exchange of ideas and experiences among teachers. Teachers are encouraged to provide feedback on the learning designs, making the design process more reflective and comprehensive. Group discussions, presentations of design results, and feedback from facilitators are crucial in ensuring that the resulting lesson plans align with STEAM integration principles and can be realistically applied in classroom learning contexts.

Figure 1. Workshop Activity

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Mentoring and Project Implementation in the Classroom

Mentoring is key to the program's success and sustainability. Mentoring is conducted regularly online to address technical and non-technical challenges faced by teachers during the learning process.

During the implementation phase, teachers begin implementing STEAM project-based lesson plans that have been refined through training and microteaching. At this stage, students are actively involved in learning activities that emphasize exploration, problem-solving, and collaboration in completing projects related to real-world contexts in their environment. The mentoring team provides guidance and support to teachers in managing project activities, ensuring interdisciplinary integration, assisting in adapting interdisciplinary integration, and adapting learning strategies to the classroom context.

In addition to providing technical assistance, the mentoring process also encourages teachers to reflect on their ongoing teaching experiences. Teachers are encouraged to document the learning process, note emerging challenges, and identify learning practices deemed effective in increasing student engagement and understanding. The results of these reflections are then discussed with the mentoring team as material for evaluating and refining the implementation of STEAM learning at the next meeting. Thus, the mentoring process not only helps resolve emerging obstacles but also strengthens teachers' capacity to develop more innovative and sustainable learning.

Figure 2. Class Activity

Evaluation

In the final stage, an evaluation is conducted. As part of the program's sustainability efforts, the results of the reflections and good practices obtained during the activities are then disseminated to the broader teacher community. Teachers are encouraged to share their experiences and results of implementing STEAM learning through discussion forums, educational seminars, and teacher learning communities. This dissemination activity aims to expand the program's impact and encourage the formation of collaborative networks among teachers in developing innovative STEAM-based learning sustainably.

Initial Teacher Competency as the Basis for Program Intervention

Before the training and mentoring program is implemented, an initial assessment is conducted to determine the condition of teacher competency related to STEAM-based learning. This measurement aims to obtain an initial overview of teachers' understanding of STEAM concepts, their ability to integrate across disciplines, and their use of technology in learning. This baseline data serves as an important basis for designing training materials and mentoring strategies to meet teachers' actual needs. By understanding teachers' initial

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competency profiles, intervention programs can be designed in a more targeted manner, thus optimally impacting the quality of learning.

Table 1. Descriptive Statistics of Teacher Competencies (Pre-Test)

Competency Aspects	Average
STEAM Understanding	2.82
Cross-disciplinary Integration	2.64
Problem-Based Learning	2.45
Digital Technology	2.91
Local Context	2.64

Based on the descriptive statistics from the pre-test, it appears that teacher competency in several aspects remains at a relatively moderate level. The understanding of STEAM concepts had an average score of 2.82, indicating that some teachers already possess basic knowledge of the approach, but still need strengthening, particularly in its application in learning. Meanwhile, teachers' ability to integrate various disciplines received an average score of 2.64, indicating that the integration of science, technology, engineering, arts, and mathematics concepts into teaching and learning activities has not been fully implemented systematically.

Furthermore, the Project-Based Learning (PjBL) aspect received the lowest average score of 2.45. This indicates that most teachers still need a deeper understanding of designing and implementing effective project-based learning. Meanwhile, the utilization of digital technology had an average score of 2.91, which is relatively higher than other aspects, although it still needs improvement to optimally support STEAM learning. Meanwhile, the ability to relate learning materials to the local context achieved an average score of 2.64, indicating that the potential of the surrounding environment as a learning resource is still not being optimally utilized in the learning process.

Changes in Teacher Competence After Training and Mentoring

After the entire series of training and mentoring sessions were completed, a reassessment was conducted to determine changes in teacher competency in implementing STEAM-based learning. This assessment aimed to determine the extent to which the program had improved teachers' understanding and skills in designing and implementing integrated learning. The results of this assessment also serve as an important indicator for assessing the effectiveness of the training and mentoring activities provided. By comparing conditions before and after the program, we can identify the development of teacher competency in various aspects focused on in these activities.

Table 2. Descriptive Statistics of Teacher Competence (Post-Test)

Competency Aspects	Average
STEAM Understanding	3,27
Cross-disciplinary Integration	3,36
Problem-Based Learning	3,09
Digital Technology	3,27
Local Context	3,18

Based on the descriptive statistics results from the post-test, there was an increase in average scores across all aspects of teacher competency after participating in the training and mentoring. The STEAM understanding aspect increased to 3.27, indicating that teachers have a better grasp of the concepts and basic principles of the STEAM approach to learning. This improvement was also evident in the cross-disciplinary integration aspect, with an average score of 3.36, indicating that teachers are beginning to be able to link various disciplines in learning activities more systematically.

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Furthermore, teachers' ability to implement project-based learning (PjBL) also improved, with an average score of 3.09. This indicates that the training provided helped teachers understand the steps for designing and implementing learning projects that involve active student participation. In the utilization of digital technology aspect, the average score increased to 3.27, indicating that teachers are becoming more accustomed to using technology to support the learning process. Meanwhile, the ability to integrate local contexts into learning also increased to 3.18, indicating that teachers are beginning to utilize the potential of the surrounding environment as a relevant learning resource for students.

Program Impact on Achieving Primary Objectives

To assess the extent to which the program achieved its objectives, a direct comparison was conducted between pre-test and post-test scores. This comparison aimed to provide a clearer picture of changes in teacher competency following a series of training activities, workshops, microteaching, and classroom implementation assistance. This comparative analysis also helped identify competency aspects that experienced the most significant improvement as a result of the program's implementation. Therefore, the results of this analysis can be used as an indicator of the program's success in improving teacher capacity in implementing STEAM-based learning.

Table 3. Comparison of Average Teacher Competency (Pre–Post)

Competency Aspects	Pre-Test	Post-Test
STEAM Understanding	2,82	3,27
Cross-disciplinary Integration	2,64	3,36
Problem-Based Learning	2,45	3,09
Digital Technology	2,91	3,27
Local Context	2,64	3,18

Based on the comparison of pre-test and post-test scores in Table 3, improvements are evident in all aspects of teacher competency focused on in this program. A significant increase was seen in the cross-disciplinary integration aspect, which rose from 2.64 to 3.36. This indicates that after participating in the training and mentoring program, teachers are better able to connect various disciplines in learning activities, thus making the learning process more integrated and contextual. Furthermore, understanding of STEAM concepts also increased from 2.28 to 3.27, indicating a development in teachers' understanding of this learning approach.

The project-based learning (PjBL) aspect also showed a significant increase, from 2.45 to 3.09. This indicates that the design workshops and microteaching sessions conducted in this program play a crucial role in helping teachers understand how to design and implement learning projects more effectively. Furthermore, the use of digital technology in learning also increased from 2.91 to 3.27, indicating that teachers are increasingly confident in using various digital media to support learning. Meanwhile, the ability to integrate local contexts into learning increased from 2.64 to 3.18, indicating that teachers are beginning to utilize the potential of the surrounding environment as a relevant learning resource to support STEAM project activities in the classroom.

STEAM Project Implementation as a Tangible Indicator of Success

Program success is measured not only by increased competency scores but also by actual implementation in the classroom. To more concretely assess the program's impact, monitoring was conducted to determine the extent to which teachers implemented STEAM learning projects after participating in training and mentoring. This implementation is an important indicator that the knowledge and skills acquired during the program can be applied

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in learning practices. Furthermore, implementing projects in the classroom also provides insight into teachers' readiness to manage more innovative and student-centered learning activities.

Table 4. STEAM Project Implementation by Teachers

Category	Total	Percentage
Implementing the project	7	63,64%
Not yet implemented	4	36,36%

According to Table 4, the majority of teachers have implemented STEAM-based learning in their classrooms. This indicates that the program not only deepens understanding but also encourages the application of knowledge in learning practices. This success demonstrates that training accompanied by mentoring can build teachers' confidence in adopting new, more contextual and student-focused approaches. However, 36.36% of teachers have not yet implemented STEAM projects. Reflection reveals that this is not solely due to a lack of understanding, but rather a phase of adaptation to changes in learning methods. Some teachers still experience difficulties transforming project designs into actual classroom implementation, particularly in managing time, combining multiple subjects simultaneously, and adapting activities to students' conditions. In addition, limitations in the use of learning technology and variations in language in understanding training materials also slow the implementation process. This confirms that the transition to STEAM-based learning involves more than just knowledge (Oanh & Dang, 2025); it requires teachers' pedagogical and contextual readiness to manage more complex learning (Spyropoulou & Mathiopoulos, 2025). Therefore, these findings support research conducted by Zamrudah & Subekti (2024) that reinforce the need for implementation of learning innovations to be carried out gradually with the support of ongoing mentoring. Teachers need not only initial training, but also opportunities to practice, reflect, and receive feedback in order to optimally internalize the STEAM approach in daily teaching and learning activities. Nevertheless, through ongoing mentoring and reflection, these teachers still have the opportunity to implement STEAM-based learning in the future (Fitriani et al., 2025; Meliza et al., 2024). These findings demonstrate that the sustainability of the mentoring program is crucial to ensure that more teachers can consistently implement innovative learning in their classrooms.

Participant Reflections and Potential Program Sustainability

Teacher reflections are an important indicator for assessing the program's acceptability and sustainability. Through the reflection process, teachers can share their experiences, impressions, and assessments of the training and mentoring activities they have participated in. This reflection data also provides an overview of the program's ability to meet teachers' needs in developing STEAM-based learning. Furthermore, the reflection results are used as a basis for assessing the program's potential for sustainability and opportunities for developing collaborations in future activities.

Table 5. Reflections and Program Sustainability

Aspect	Average
Satisfaction with the program	4,27
Intention to continue STEAM	4,00
Willingness for further collaboration	100%

Based on the reflection results shown in Table 5, the average teacher satisfaction rating with the program was 4.27, indicating a very positive response from participants. This score indicates that the majority of teachers felt the training and mentoring activities provided were beneficial in improving their understanding and skills in designing and implementing

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STEAM-based learning. Furthermore, teachers also assessed that the activities carried out during the program provided new learning experiences and opened up insights into more innovative and contextual learning approaches.

Regarding the intention to continue implementing STEAM learning, the average score was 4.00, indicating that teachers have a strong motivation to continue developing this approach in classroom learning activities. This is further supported by the finding that all participants (100%) expressed their willingness to engage in further collaboration, whether through discussions, sharing good practices, or developing joint learning projects, such as research conducted by Videla et al. (2026) and (Ferna, 2025). These findings demonstrate that the program not only has a short-term impact on improving teacher competency but also has the potential to build a learning community that can support the sustainability of STEAM-based learning innovations in schools (Yawisah et al., 2019; Zulfikasari et al., 2025).

Conclusion

Based on the activity results, it can be concluded that implementing STEAM-based training has a positive impact on improving teachers' competencies, especially in integrating across subjects and designing project-based learning. The teacher started to realize that the STEAM approach could be applied in a simple and relevant way by using the surroundings. In addition, implementing projects in class has been shown to increase student engagement, although the consistency of implementation still needs to be improved further. A simplified contextual STEAM approach has been found to be relevant for use in local schools and effective in building teachers' readiness. This activity not only improves teachers' skills and learning quality but also has the potential for long-term success through ongoing support and assistance from partner schools.

Recommendation

This program demonstrates that schools should not only provide policy support but also create opportunities for teachers to gradually experiment with and develop STEAM-based learning. Teachers must continually practice connecting material to real-world situations and build confidence in implementing learning methods that differ from previous practices. Furthermore, similar activities in the future need to be accompanied by more intensive and ongoing mentoring, so that teachers' adaptation process doesn't stop at understanding but extends to practical application in the classroom.

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