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Game-Based STEM Learning for Enhanced Engagement: A Collaborative Program Involving Teachers, Students, and Parents

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ABSTRACT

Background: Limited access to educational technology at Sekolah Indonesia Yangon (SIY), Myanmar, created challenges in implementing engaging STEM learning. This community service program addressed these issues by supporting teachers, students, and parents in adopting creative, low-cost STEM activities.

Purpose of the Study: The program aimed to enhance teachers' competence in game-based STEM learning, improve students' STEM concept mastery, and strengthen parental involvement in home-based learning within three months.

Methods: A participatory mentoring model was used, integrating game-based learning, collaborative workshops, and hands-on experimentation through the activity "Ice Cream without a Freezer." Pre- and post-evaluations assessed changes in teacher skills, student understanding, and parental engagement.

Results: The program increased students' STEM understanding by 33%, improved teachers' creativity in designing learning games, and encouraged stronger parental support. The activity effectively fostered collaboration, communication, creativity, and problem-solving skills using simple, low-cost materials.

Keywords

STEM Education; Game-Based Learning; Teacher Training; Student Engagement; Indonesian Culture

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Introduction

The state of education in Myanmar faces complex challenges due to political, social, and economic instability. Since the military coup in February 2021, many educational institutions have experienced resource freezes and strict restrictions, leading to a loss of confidence in the national education system (Galloway, 2023; Salem-Gervais et al., 2024). School closures and a shift to emergency education have been attempted in response to this crisis (Htet, 2023). Inequality in access to education is also a major problem, especially for ethnic minorities such as the Karen and Mon, who face barriers to obtaining government-recognised formal education (South & Lall, 2016; Zaw, 2023). Many schools in areas controlled by ethnic groups do not follow the state curriculum, making it difficult for students to transfer to the government education system to continue to higher levels (South & Lall, 2016).

Not only that, but political tensions accompanied by violence worsen the psychosocial conditions of students and teachers (Htut et al., 2022). Studies on post-coup education recovery show that teachers and students feel unsafe continuing their work and studies, which has an impact on the quality of teaching, motivation, and students' mental health (Htet, 2023). This situation has led to a loss of talent and knowledge, further worsening the already weak education system (Naing et al., 2022). Myanmar's education system is fragmented and under pressure due to political instability.

The impact of the educational situation in Myanmar is also felt by the Indonesian School in Yangon (SIY), which faces similar challenges in providing quality education for students amid existing limitations. Based on interviews with teachers and analysis of the situation in the field, it was found that limited resources, lack of professional training for teachers, and low parental involvement are the main obstacles. In addition, students have difficulty adapting to Myanmar's social and cultural environment, which affects their emotional well-being and motivation to learn. In this situation, it is important not only to improve academic competence but also to instil Indonesian cultural values, such as cooperation, independence, and national spirit, so that students maintain a strong national identity even while abroad. This situation also requires a solution because it results in a widening gap in the quality of education, causing students to lose the opportunity to obtain learning experiences that are equivalent to national standards.

The main challenge also lies in the field implementation, where students often struggle to understand the material, and there is a lack of productive interaction among teachers, students, and parents (Sari et al., 2024). Effective communication between teachers and parents is essential in creating a supportive learning environment for students (Ramandhini et al., 2023). Parental involvement can strengthen the emotional support students need to adapt to a new environment and face learning challenges in a foreign country (Rahman & Sari, 2024). In this context, parents play a role not only as academic supervisors but also as active motivators in the learning process, helping students overcome cultural and language differences they may encounter (Puccioni, 2015).

Parents have a role to remain involved in academic development by actively discussing learning progress and providing necessary feedback to teachers (Lambert et al., 2021). Teachers can synergise with parents to share effective strategies for building discipline and responsibility in students (Saman et al., 2025). The synergy between teachers and students can help students achieve academic success and positive behaviour (Darmiany et al., 2023). This collaboration also strengthens the bonds within the educational community among students, parents, and teachers, thereby forming a broader support network.

The next challenge is the low level of students' problem-solving skills. The implementation of STEM at the elementary school level is a strategic step to equip students with 21st-century skills, such as critical thinking, creativity, collaboration, and communication. STEM is a learning approach that integrates different disciplines to improve students' skills in solving real-world

problems and strengthen collaboration (Usman et al., 2020). Research shows that STEM learning methods can improve understanding of science and mathematics concepts in more engaging, relevant ways (Hayati, 2023). In the context of elementary school education, STEM can be implemented through interactive learning activities, such as group projects in which students are invited to design and build solutions to everyday problems (Firdaus et al., 2021).

The use of STEM game platforms is expected to increase student engagement and hone their critical thinking skills (Julianty et al., 2024). Parental support through collaborative education programs also plays an important role in building student motivation and achievement (Evans-Whipp et al., 2017; Kahveci & Serin, 2017). Referring to the conditions in Yangoan, there is a need to build parental awareness of the importance of STEM education, which is a collaboration with teachers in achieving student learning well-being.

There are several crucial gaps in the implementation of STEM games in Indonesian schools in Yangoan, Myanmar, particularly in the role of parents, the use of games in education, and access to technology. Parental involvement greatly influences children's academic achievement, but many do not yet understand how to support STEM education through technology and games (Prayogo & Sholikhati, 2021). This condition underscores the urgent need for education on the importance of collaborative learning that actively involves students, parents, and teachers in the learning process (Wiseka et al., 2018).

Many teachers still need additional training to develop effective learning, while the lack of productive interaction between teachers, students, and parents hinders understanding of the material (Sari et al., 2024; Setiawan et al., 2020). The involvement of STEM games is expected to increase student engagement through interactive methods that hone critical and creative thinking skills. In addition, training in Indonesian cultural values such as cooperation, independence, and national spirit can help students cope with academic pressure and create a more positive learning environment (Deng et al., 2020). Parental support is crucial in collaborative education programs, as local culture influences parents' involvement in their children's education (Møller & Kaup, 2023; Saran, 2018).

Previous studies have widely examined the integration of game-based learning (GBL) and STEM education in various contexts, demonstrating positive impacts on student engagement, creativity, and conceptual understanding. However, most of these studies have focused on well-resourced schools or domestic settings, with limited attention to the challenges faced by overseas Indonesian schools (Sekolah Indonesia Luar Negeri) that operate with constrained facilities and cultural adaptation needs. Moreover, little research has examined how collaborative GBL-STEM models can be effectively implemented in crisis contexts, such as during post-pandemic recovery or in regions with limited technological access. This study, therefore, fills that gap by examining the implementation of a collaborative, culturally grounded GBL-STEM approach at Sekolah Indonesia Yangon, Myanmar, to strengthen learning quality and national identity among Indonesian students abroad.

In response to the identified learning challenges at Sekolah Indonesia Yangon (SIY), there is an urgent need for targeted, needs-based training and mentoring programs. These programs should incorporate innovative teaching approaches that accommodate diverse student learning styles and strengthen parental involvement, which has been shown to improve student learning outcomes (Lestari, 2023; Sinaga & Sitorus, 2022). This community service initiative was designed to provide meaningful support for SIY teachers and students, Indonesian citizens who deserve access to quality education even while living abroad. While the program was initiated based on the specific needs identified within the school (bottom-up), the implementation of Game-Based Learning (GBL) in STEM education was facilitated by expert guidance (top-down), forming a balanced, practical hybrid model. In addition to enhancing students' critical and creative thinking skills, the program also reinforced Indonesian cultural values of cooperation and collaboration,

fostering a strong sense of national identity overseas.

The needs assessment phase was conducted collaboratively through focus group discussions and informal interviews with teachers, students, and parents to identify learning challenges and contextual limitations. Building on these findings, the GBL-STEM solution was developed through a co-design process involving joint planning sessions between facilitators and school stakeholders. Teachers contributed local classroom insights and adapted game materials to align with students' cultural backgrounds and available resources, while students provided feedback on game prototypes to ensure engagement and accessibility. Parents also participated by suggesting home-based extensions of the learning activities. Although the GBL-STEM framework was initially introduced by the facilitators, its contextualization and implementation were collaboratively shaped through iterative discussion and reflection, ensuring that the final design reflected both expert input and community ownership.

Method

The community service was conducted at Sekolah Indonesia Yangon (SIY), Myanmar, involving teachers, students, and parents as the assisted subjects. The program was organised through a community-organising approach, in which stakeholders collaboratively identified issues, planned actions, and implemented strategies. The joint action planning process began with problem identification through observations, curriculum analysis, interviews, and surveys with teachers and students.

The assisted community actively participated in the planning process. Teachers contributed by identifying classroom challenges and providing input on learning media needs. Students were engaged in expressing their learning difficulties and expectations regarding STEM education. Parents were involved in discussions to align school-based innovations with home learning support.

Participants in this community service program were selected based on clear demographic criteria to ensure the intervention's suitability. The target group consisted of families residing in Myanmar who have children enrolled in primary school at Sekolah Indonesia Yangon (SIY). In total, 34 families met these criteria and were organised into five teams, each representing all grade levels. This structure was designed not only to facilitate collaboration among families but also to provide balanced representation across grades, enabling more effective coordination, peer support, and comprehensive monitoring of the program's implementation.

The strategies applied in this community service program included integrating Game-Based Learning (GBL), conducting teacher workshops, hosting parental engagement sessions, and providing student mentoring. These approaches were designed not only to strengthen students' STEM conceptual understanding but also to integrate Indonesian cultural values such as *gotong royong* and character education. The program was carried out in three stages: (1) workshops on the implementation of STEM games that provided capacity building for teachers and parents, (2) strengthening parental involvement through training and mentoring to support home-based GBL, and (3) utilisation of STEM game platforms by students in classroom practices guided by teachers with continuous monitoring and evaluation. One example of a STEM game developed was the "making ice without a freezer" project, which required collaboration among students, parents, and teachers. This activity challenged students to struggle and solve problems together while experiencing the connection between STEM concepts, game-based learning, and collaborative practice, ultimately producing a meaningful outcome that could be applied in daily life.

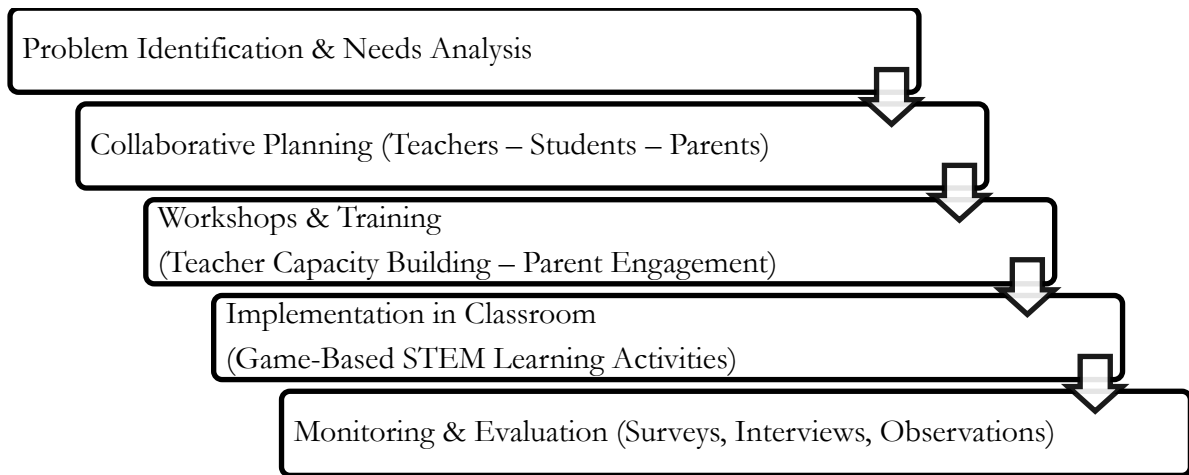


Figure 1. Flowchart of the implementation of the community service

The participatory process in this program involved teachers, students, and parents in a series of collaborative steps, including needs identification, co-design of learning activities, implementation, and reflection. Each stage followed a structured protocol: (1) preliminary interviews to identify learning challenges; (2) joint workshops to develop game-based STEM lesson plans; (3) classroom implementation of the “Ice Cream without a Freezer” activity; and (4) evaluation sessions using interviews and surveys. To enhance replicability, detailed procedural guidelines and visual diagrams have been added to illustrate the workflow, participant roles, and feedback loops throughout the program. These additions clarify how the participatory model can be adapted to similar educational contexts.

The implementation of the community service program at Sekolah Indonesia Yangon (SIY) followed a structured process to ensure systematic outcomes. The program began with problem identification and needs analysis through observations, interviews, and curriculum review to capture the main challenges in STEM learning. After that, a collaborative planning stage was conducted with teachers, students, and parents to allow all stakeholders to contribute ideas and build shared ownership of the program.

The results indicated that most teachers were not yet familiar with the Game-Based Learning (GBL) model in STEM. At the same time, students needed more practical, engaging activities to grasp scientific concepts better. Based on these findings, the team developed a practical module and guideline for the activity “Ice Cream without a Freezer.” The module was designed not only to provide step-by-step instructions for making ice cream but also to highlight its integration with the four STEM pillars. The next step was workshops and training focused on strengthening teacher capacity in integrating Game-Based Learning (GBL) and engaging parents to support learning at home.

The program then moved into classroom implementation, where students applied STEM concepts through game-based activities. The project of making ice without a freezer not only encouraged collaboration among teachers, students, and parents but also connected STEM concepts to everyday life. Finally, the program conducted monitoring and evaluation through surveys, interviews, and observations to assess teacher competence, student engagement, and parental involvement, and to identify challenges and recommend measures to sustain the program.

Result

Activity Implementation Results

This stage laid the foundation for the program's success. Activities began with intensive coordination between the implementation team and the Indonesian School in Yangon (SIY). This coordination covered scheduling activities, determining the venue, the number of participants, and logistical needs. Next, the needs of teachers and students were identified through discussions and short questionnaires. The results of the identification showed that most teachers were unfamiliar with STEM-based game-based learning (GBL), while students needed more practical, enjoyable activities to understand science concepts.

After that, the team prepared the Ice Cream without a Freezer module and a practical guide. This guide not only explains the steps for making ice cream, but also outlines the connection between the activity and the four pillars of STEM:

1. Science: Explaining the concept of changes in the state of matter (liquid to solid), the role of salt in lowering the freezing point, and the mechanism of heat transfer.
2. Mathematics: Teaching weight and volume measurements, as well as ingredient proportions.
3. Engineering: Applying insulation techniques and adjusting shaking time to accelerate the freezing process.
4. Technology: Utilising simple technology such as ziplock bags, thermometers, and stopwatches.

The module is also adapted to local conditions in Myanmar, for example, replacing *whipping cream* with sweetened condensed milk and liquid milk available in local markets.

Implementation of Activities

The Collaborative was conducted in an interactive and participatory manner. The activity shows the atmosphere of togetherness among teachers, students, and parents in they participate in the training series. In the initial session, the resource persons presented STEM material using presentation media. Teachers, students, and parents listened enthusiastically to explanations of basic science concepts, particularly simple experiments on the freezing of liquids. The colourful classroom atmosphere made the activity even more engaging and suited to children's learning styles.



Figure 2. Workshops & Training

Next, the activity continued with collaborative practice between students and parents. Together, they conducted simple experiments, such as mixing liquid ingredients in plastic containers, adding supporting ingredients, and observing the changes. Teachers and resource people provided direct assistance to ensure that each participant understood the flow of activities and the STEM learning objectives. This can be seen in the following picture.



Figure 3. Implementation in the Classroom

They show the close synergy between teachers, students, and parents, where children are excited to try things for themselves, while parents support and help them. This collaborative approach not only teaches science concepts in a fun way but also strengthens the emotional bond between children and parents in the learning process. Teacher training was conducted in the form of a six-hour interactive workshop. The theory session explained the principles of GBL, its benefits in STEM learning, and strategies for creating learning that combines practice with concepts. The practical session invited teachers to make ice cream without a freezer. In this session, teachers practised measuring ingredients, mixing the batter, recording temperature data, and analysing the results. The training results showed significant improvement:

1. 100% of teachers understand the principles of GBL and STEM integration.
2. 80% of teachers can develop teaching modules that include these experiments.
3. 90% of teachers successfully adapted the method to various grade levels, from lower to upper grades.

Student mentoring in the collaborative STEM game training and mentoring activity was carried out through two structured core meetings. The first meeting focused on introducing STEM concepts through simple educational games. At this stage, students are introduced to everyday scientific phenomena, such as the process of changing liquids into solids, using game-based experiments. Teachers and resource people provide basic guidance, and students are then guided to try it out for themselves with their parents' involvement. The learning atmosphere is fun, full of questions and answers, and exploration, making it easier for students to understand the concepts being studied.

The second meeting focused on collaborative learning and reflection. Students and parents were asked to complete challenges in the form of STEM games that emphasised cooperation, problem-solving, and creativity. Speakers and teachers served as facilitators, accompanying students, providing feedback, and ensuring that every child participated actively. At the end of the session, a reflective discussion was held to assess how well the students understood the material and to gauge the benefits of the STEM games they had played.

Through these two core meetings, student mentoring not only emphasised the understanding of science concepts in an applied manner but also built 21st-century skills such as collaboration, communication, creativity, and critical thinking. With the involvement of parents, the mentoring process became more meaningful because learning did not only stop at school but could be continued at home in the form of simple activities with the family.

From the observation of the students, the following results were obtained:

1. 75% of students can explain the concept of changes in the state of matter verbally.
2. 70% of students can read a thermometer correctly.
3. 80% of students demonstrated improved teamwork skills.

The "STEM with Parents" session was designed to involve parents in their children's learning. In this session, parents were introduced to the Ice Cream Without a Freezer experiment as an educational family activity. The activity concluded with a joint reflection session in which participants shared their experiences and impressions after the training. With a warm atmosphere, this activity successfully created a creative, applicable, and enjoyable STEM learning experience, while strengthening the involvement of the Indonesian school community in Myanmar.

Results of STEM Project

Evaluation was conducted using three main instruments: a) Pre-test and post-test for students to measure their understanding of STEM concepts. b) Teacher questionnaire to assess understanding and skills after the training. c) Parent feedback forms to measure their level of involvement at home. The evaluation results showed a significant increase in all indicators:

Table 1. Quantitative Improvements in STEM Understanding, Teacher Competence, and Parental Involvement

Indicator	Before	After	Improvement
Student STEM understanding	45	78	+33
Teachers can design GBL	35	100	+65
Parental involvement	25	60	+35

Complementing these figures, participants' qualitative reflections revealed notable changes in teaching and learning dynamics. Teachers expressed greater confidence and creativity in integrating GBL; students reported that learning became "more fun and easier to understand"; and parents noted increased enthusiasm for home-based STEM projects. To enhance the evidential richness of this report, visual documentation, including photos of the "Ice Cream without a Freezer" sessions, screenshots of game prototypes, and excerpts from reflection logs, has been included to illustrate the process and outcomes more vividly. Together, these quantitative and qualitative elements provide a more comprehensive and compelling portrayal of program impact.

Results with Qualitative Process

The implementation of the collaborative GBL-STEM program at Sekolah Indonesia Yangon produced significant improvements in learning outcomes, as reflected in a 33% increase in students' STEM understanding, a 65% improvement in teachers' ability to design GBL activities, and a 35% rise in parental involvement. Beyond these quantitative gains, qualitative observations revealed rich process dynamics throughout the program. During workshops, some teachers initially expressed uncertainty about adapting GBL to limited classroom facilities, but confidence grew after peer demonstrations and facilitator mentoring. Students showed increasing enthusiasm, often extending experiments beyond the assigned time and sharing their results with classmates. Parents, initially hesitant to participate, became actively involved after observing their children's excitement, with one parent noting, "Learning science through games makes our children talk about school again at home." Challenges such as inconsistent internet access and limited materials occasionally slowed activities. However, these were mitigated through collaborative problem-solving and improvisation, further reinforcing the spirit of *gotong royong* central to the program's design.

Discussion

Game-Based Learning for STEM

The results of the activity show that using *Ice Cream without a Freezer* as a *game-based learning* (GBL) medium successfully increased student enthusiasm and engagement. Theoretical studies indicate that educational games serve not only as entertainment but also as interactive tools that encourage collaboration and critical thinking (Avdiu, 2019). In practice, this experiment presented real challenges that students had to solve, such as measuring ingredients accurately, controlling time, and understanding the freezing process. This is in line with the opinion that educational games reduce boredom, increase social interaction, and provide learning experiences that are relevant to everyday life (Gui et al., 2023).

The data from the activity show that 75% of students were able to verbally explain the concept of changes in the form of matter, and 80% showed an improvement in teamwork. This activity not only trains cognitive skills, but also affective and social aspects, in line with the view that educational games play a role in shaping real-world skills. The study confirms that STEM learning integrates science, technology, engineering, and mathematics to solve real-world problems. The results show that the *Ice Cream without a Freezer* activity combines all four aspects: 1) Science that students learn about changes in the form of matter and the principles of heat; 2) Technology that using simple tools such as thermometers and stopwatches; 3) Engineering that finding the most efficient method to freeze ice cream; 4) Mathematics that measuring and calculating the ratio of ingredients. This method is in line with research that emphasises the importance of *project-based learning* to develop 21st-century skills.

The increase in students' understanding of STEM from 45% to 78% proves the effectiveness of this approach. In addition, active involvement in experiments allows students to practice communication, collaboration, creativity, and problem-solving. This is in line with previous studies, which highlight that STEM understanding can be significantly enhanced through project-based activities (Fernández-Limón et al., 2018). Research has shown that hands-on projects not only strengthen conceptual knowledge but also foster creativity, collaboration, and problem-solving skills among students. By engaging in practical tasks such as the *Ice Cream without a Freezer* project, students are encouraged to connect theory with real-life applications, making abstract scientific and mathematical concepts easier to grasp. Such project-based approaches have been proven effective in promoting deeper learning, as they allow learners to experience the integration of science, mathematics, engineering, and technology in meaningful ways while working together to achieve common goals.

The results of the activities show that involving teachers, parents, and students leads to more sustainable learning. The "STEM with Parents" sessions allow parents to accompany their children in experiments, in line with the theory that emphasises the importance of parental involvement in providing emotional and academic support. This approach not only strengthened the children's understanding of STEM concepts but also reinforced family bonds through collaborative learning. These findings align with educational theories that emphasise the critical role of parental involvement in supporting students' emotional well-being and academic achievement (Johnston-Wilder et al., 2020). As parents are partners in the learning process, the program successfully created a supportive ecosystem where students felt motivated, guided, and encouraged to explore STEM in enjoyable, practical ways.

The fact that 60% of parents tried experiments with their children and 85% reported an increase in positive interactions with their children proves that there is synergy. Teachers act as learning facilitators, while parents serve as motivators and enforcers of discipline, creating a support network that enhances the success of elementary school students.

Supporting and Hindering Factors of the Activity

The results of the STEM project, as presented in Table 1, show significant improvement across all key indicators. Student STEM understanding increased from 45 to 78, reflecting a gain of 33 points. This indicates that students not only became more engaged but also developed a deeper comprehension of STEM concepts through hands-on, game-based activities. Teachers' ability to design GBL improved most dramatically, rising from 35 to 100, an 65-point increase. This suggests that the training and workshops were highly effective in equipping teachers with the skills and confidence to create and implement game-based learning models in their classrooms. Parental involvement increased from 25 to 60, showing an improvement of 35 points. This highlights the success of the "*STEM with Parents*" sessions in encouraging parents to take a more active role in supporting their children's learning both at school and at home. These results demonstrate that the collaborative approach involving teachers, students, and parents not only enhanced STEM learning outcomes but also strengthened the program's sustainability.

Students showed significant improvement in their understanding of the concepts of changes in the physical state of matter, heat, measurement, and team collaboration. This is in line with *game-based learning* theory, which states that interactive activities increase engagement and learning outcomes (Evans-Whipp et al., 2017). Teachers became more confident and skilled in designing experiment-based learning, in line with the STEM approach that requires cross-disciplinary integration. Parents became more involved in their children's learning process, strengthening the synergy between home and school. This activity created a fun and applicable learning experience, thereby increasing students' motivation to learn.

Teachers, students, and parents showed high interest and motivation to participate in the activities. This made the training and practice process run smoothly. The Indonesian School in Yangon provides full support in terms of facilities, scheduling, and participant coordination, ensuring that activities can be carried out as planned. Parents play an active role both during the "STEM with Parents" sessions and in providing feedback, thereby strengthening the continuity of learning outside of school. The *Ice Cream Without a Freezer* activity combines *game-based learning* and STEM experiments, making learning fun and relevant. The availability of structured practical guidelines makes it easier for teachers, students, and parents to understand the steps of activities and related scientific concepts. These findings are in line with previous studies that emphasise the importance of strong collaboration and high motivation from all stakeholders as key factors in the success of STEM-based educational innovations (Rajasekaran, 2024; Ready & Chu, 2015).

The implementation of the STEM project also encountered several hindering factors that influenced the overall process and outcomes. The limited availability of ingredients in Myanmar posed a challenge, particularly with items such as whipping cream, which required recipe adjustments using substitutes like sweetened condensed milk and liquid milk. Another challenge was the differences in students' levels of understanding, as varying academic abilities required additional time and more intensive guidance for students who struggled with STEM concepts. Local language and cultural factors also presented difficulties. Although the students belong to the Indonesian community, adapting learning activities within the Myanmar context, particularly when involving external stakeholders, required sensitivity to cross-cultural communication. These hindering factors highlight the need for flexibility, contextual adaptation, and continuous support in ensuring the success and sustainability of similar programs.

This study effectively demonstrates how game-based learning (GBL) in STEM education can enhance teacher competence, student engagement, and parental involvement, aligning with constructivist and socio-cultural learning theories that emphasise collaboration and experiential learning. However, several limitations should be acknowledged. The implementation took place in a single overseas Indonesian school with a relatively small number of participants, which may limit the generalizability of the findings. Additionally, because the facilitators introduced the GBL-STEM

framework, teachers' local adaptation may have been influenced by external guidance, potentially creating a dependency on external guidance. Minor inconsistencies between quantitative and qualitative data also suggest that improvements in motivation did not always translate into long-term behavioural change. Future programs should therefore include longitudinal follow-up and wider school participation to test sustainability and adaptability across different contexts. Addressing these aspects would provide a more balanced and comprehensive understanding of the program's impact.

Conclusion

The implementation of the *Collaborative STEM Game Training and Mentoring* program for teachers, students, and parents at the Indonesian School in Yangon, Myanmar, through the Ice Cream without a Freezer activity, has proven effective in improving learning quality. This activity not only succeeded in increasing students' understanding of science, technology, engineering, and mathematics (STEM) concepts by 33%, but also equipped teachers with the skills to creatively and practically design *game-based learning*. The active participation of parents through the "STEM with Parents" activity further strengthened the synergy between the school and families, positively impacting student motivation and engagement in learning. This simple experimental approach, packaged in a fun way, created an interactive learning atmosphere, reduced boredom, and fostered curiosity, making it one of the relevant learning innovations to be implemented in overseas schools.

This study reinforces the theoretical premise that game-based learning (GBL) integrated with STEM education can strengthen conceptual understanding through experiential and collaborative engagement. It extends existing theory by demonstrating how GBL-STEM approaches can be effectively adapted in resource-limited, cross-cultural contexts such as overseas Indonesian schools, thereby contributing to the discourse on inclusive and culturally responsive pedagogy.

In practice, the study recommends institutionalising teacher capacity-building programs focused on the design and evaluation of GBL-STEM activities, supported by school-level mentoring systems. Policy-wise, the Indonesian government and overseas education units (SILN) could incorporate structured GBL-STEM modules into professional development frameworks and provide digital resource kits to facilitate replication. Future initiatives should also include periodic monitoring and impact assessment to ensure sustainability and policy alignment with the Ministry of Education's global education strategies.

This activity also proves that learning does not always require sophisticated equipment or high costs to provide a meaningful learning experience. The use of simple materials and household tools, when packaged with the right methods, can provide a deep understanding of scientific concepts. This provides a great opportunity for schools with limited facilities to continue implementing effective, innovative learning. With an adaptive activity design, this method can be replicated in various contexts, both domestically and in Indonesian schools abroad. The successful implementation of *the Ice Cream without a Freezer* activity shows that simple, experiment-based learning innovations, combined with a game-based learning approach and STEM principles, can serve as a model worth further development. This activity not only improves academic results but also builds student character through fun, collaborative, and applicable learning.

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