Developing Teachers' Skills in Designing STEAM-Based Learning Through Group Mentoring

Dewi Ayu Krisharyanti
BPK PENABUR Jakarta
dewiayu.hope@gmail.com

ABSTRACT

The STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach is a learning method for equipping students with 21st-century skills, encompassing critical thinking, creativity, collaboration, and communication. However, its implementation is frequently hindered by teachers' low theoretical understanding and competencies, as well as a lack of sustained support following basic training. This study aims to examine the implementation of strategies for developing teachers' understanding and competencies through the integration of training, workshops, and group mentoring. This study employs a descriptive qualitative approach with descriptive analysis methods. Data were collected through training and workshop evaluation results, an open-ended questionnaire via Google Forms exploring teachers' narrative experiences and reflections, and a document analysis of the teaching modules designed by the teachers. All data were analyzed thematically to identify patterns in understanding and competency development. The results showed that prior to group mentoring, the majority of teachers experienced significant difficulties in integrating engineering and arts components into regular subjects and were trapped in the myth that STEAM requires high costs. However, when training was combined with an intensive and sustainable group mentoring strategy, teachers were able to reconstruct their understanding, overcome technical barriers, and design lesson plans that adhere to the principles of the Engineering Design Process (EDP). This synergy proved to create a supportive learning community, providing space for teachers to reflect, collaborate, and cross-validate their pedagogical work. In conclusion, the integrated training and group mentoring model is an essential key to real, adaptive, and sustainable transformation of teacher competencies.

Keywords: STEAM Approach, Teacher Competence, Group Mentoring.

INTRODUCTION

The world of education in the 21st century faces very complex and dynamic challenges. Education is required not only to transfer factual knowledge but also to equip students with the 4C skills: Critical Thinking, Creativity, Collaboration, and Communication (Syarifuddin et al., 2025). To meet these demands, the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach has emerged as a promising pedagogical innovation. The STEAM approach is not merely a combination of five disciplines, but rather an interdisciplinary framework that integrates science, technology, engineering, arts, and mathematics into a cohesive inquiry (Conradty & Bogner, 2020; In'am et al., 2026). Through this approach, students are encouraged to solve real world and are able to connect abstract academic concepts with practical applications. In Indonesia, the urgency of implementing STEAM is becoming increasingly evident in line with the need to produce digital talents and problem solvers who are adaptive to global changes (Pusat Kurikulum dan Pembelajaran, 2025).

Although the literature consistently highlights the benefits of the STEAM approach, the reality on the ground shows a significant gap between policy regulations and classroom practices. The implementation of STEAM, particularly in elementary schools, still faces serious obstacles, especially related to the low competence of teachers in designing integrated teaching modules (Sari et al., 2025). Many teachers are still trapped in a conventional monodisciplinary approach that focuses on mastery of factual material (Syarifuddin et al., 2025). This issue is worsened by the fact that most professional development programs for teachers have traditionally been short-term and focused on final products, without continuous mentoring (Aklis, 2026).

Furthermore, widespread myths continue to hinder teacher creativity. STEAM is often perceived as something that requires expensive equipment, even though its core principles can be brought to life using simple tools and materials found around the school environment (Pusat Kurikulum dan Pembelajaran, 2025). The state of the art from previous studies shows that the main obstacle to this implementation is not a lack of physical infrastructure, but rather the capacity, competence, and confidence of the teachers themselves (Segarra-Morales & Rodríguez-Miranda, 2026). This reality is supported by research data showing that while 78% of teachers are familiar with the term STEAM, only about 34% have actually participated in specialized training and designed their own activities independently (Septiadevana et al., 2026).

In response to these competency gaps, governments and education departments have made various efforts to improve teacher capacity through mass training, webinars, or workshops. However, this "one-size-fits-all" approach has proven ineffective. It generally offers only a one-way transfer of knowledge isolated from actual classroom contexts, focusing on final products without long-term support (Aklis, 2026). Studies show that roughly 80% of teachers receive STEAM training only once. Without ongoing systemic support, 75% of them tend to default back to traditional teaching methods within six months after the training ends (Sari et al., 2025). Once training is over and teachers face administrative burdens, curriculum demands, and student dynamics, their initial enthusiasm often fades, and they return to lecturing (Hasanah, 2023). It is common for teachers to struggle with module design in the early phases. Research indicates that around 72% of elementary school teachers initially lack confidence in integrating engineering and technology components into their teaching due to having unrelated educational backgrounds (Sari et al., 2025). This is exactly what previous researchers have often overlooked: the need for a post-training support ecosystem that can bridge the transition from theoretical understanding to long-term practical competence in the classroom.

To fill that gap, this research offers an integration concept in the form of a combination of initial training, workshops, and group mentoring. Through group mentoring, technical barriers are overcome by familiarizing teachers with the Engineering Design Process (EDP) stages, which includes five key phases: ask, imagine, plan, create, and improve (Krisma et al., 2026). Unlike regular training, group mentoring emphasizes a culture of collaboration, mutual reflection, and collective knowledge construction (Elyashiv, 2026). Through group mentoring, teachers are given a safe space to reflect, share best practices, cross-validate pedagogical work, and discuss technical challenges with both facilitators and peers (Aklis, 2026; Elyashiv, 2026; In'am et al., 2026). Mentoring not only serves as a mechanism for technical skill transfer but also provides emotional and psychological support for novice teachers who might feel isolated or anxious when trying new methods (Avidov-Ungar, 2024).

The concept of group mentoring aligns with the dual-structured mentoring approach, which combines traditional one-on-one mentoring with collaborative mentoring to create a comprehensive support system for teacher career development (Elyashiv, 2026). This approach transforms training into a Professional Learning Community, enabling collective reflection and the regular exchange of best practices (Aklis, 2026). Through group interactions facilitated by expert mentors, teachers have a safe environment to dissect the specific challenges they face when designing lesson modules, receive constructive feedback, and validate learning ideas before implementing them in the classroom.

Therefore, the urgency of this research arises from the still limited implementation of STEAM education in elementary schools despite various training sessions having been conducted. Many teachers are still unable to translate conceptual understanding into consistent learning practices in the classroom, so educational innovations often stop at the training stage and do not continue into changes in teaching practices. The novelty of the research lies in the development and evaluation of a sustainable teacher professional development model through the integration of training, workshops, and group mentoring, thereby bridging the gap between conceptual understanding of STEAM and its implementation in classroom teaching practices. Through this mentoring model, teachers are expected to overcome both technical and psychological barriers, reconstruct their understanding, and ultimately design student-centered STEAM modules aligned with the principles of the Engineering Design Process (EDP) (Pusat Kurikulum dan Pembelajaran, 2025). This proper implementation will not only improve academic achievement but also prove to develop the creative character and independence of students from the elementary education level (Hadi et al., 2025). This study demonstrates that a structured competency transformation model can ensure the sustainability of STEAM innovations in elementary schools.

METHOD

This research uses a descriptive qualitative approach. This method was selected to deeply, holistically, and contextually explore the development of teachers' understanding, pedagogical competencies, and psychological dynamics as they participated in the STEAM capacity strengthening program. Using a descriptive approach allows the researcher to systematically describe the facts and characteristics of the research subjects without manipulating variables or utilizing statistical control groups. The subjects of this study were teachers involved in a series of STEAM competency-building activities, which included stages of conceptual training, module design workshops, and group mentoring. The total number of participants in this study was 20 teachers.

The research activities were designed to be cyclical and continuous, divided into two main phases as outlined below:

1. Training and Workshop Phase: Teachers received theoretical training on the core essence of STEAM, followed by a hands-on workshop to create the initial drafts of their learning modules. At the end of the session, teachers presented their initial drafts and received feedback and suggestions from the speakers.
2. Group Mentoring Phase: Teachers were grouped according to their respective schools to discuss their module drafts, unpack challenges faced during classroom application, and receive constructive feedback.

The data collection procedure was carried out through three main instruments:

1. Training and Workshop Evaluation Results: Used to determine the development of teachers' knowledge related to the STEAM concept after participating in the training and workshop.
2. Open-Ended Questionnaire: The open questionnaire was distributed via Google Forms to explore teachers' reflective experiences regarding STEAM myths, the challenges faced, and the role of group mentoring in the process of teachers designing modules.
3. Document Analysis: An analysis of the module drafts designed by the teachers. The analysis rubric focused on evaluating how well the

modules aligned with STEAM integration standards and the implementation of the Engineering Design Process (EDP) stages (ask, imagine, plan, create, and improve).

All qualitative data gathered from the questionnaires, evaluation forms, and document analyses were analyzed thematically using an interactive analysis model (Miles, Huberman, & Saldana, 2014). This data analysis process involved three distinct stages:

1. Data Reduction: The process of selecting, focusing, simplifying, and sorting data from the training evaluations results, Google Forms, and project module analyses. Data that were not relevant to the focus on teacher skill development were eliminated, while relevant data were coded based on specific themes. (e.g., identification of initial myths, transformation of competencies through group mentoring, and implementation readiness).
2. Data Presentation: The reduced data is presented systematically in the form of descriptive narratives, tables, and diagrams so that the patterns of relationships between themes become clearer and easier to understand.
3. Conclusion Drawing: As the final stage of data analysis, the researcher draws conclusions by identifying the meaning, patterns, and consistency of the presented data to formulate a strong conclusion regarding the development of teachers' skills in preparing STEAM-based learning through group mentoring. The conclusions obtained are then reverified by referring to field notes and supporting theories. The validity of the data is ensured through triangulation techniques by comparing training evaluation results, open-ended questionnaire results, and document analysis to confirm the consistency of the research findings.

FINDINGS AND DISCUSSION

The results of the field data analysis collected from training evaluations, open questionnaires, and project module document analysis show a significant transformation in the aspects of conceptual understanding, pedagogical competence, and teacher readiness. In general, the flow of change and the achievement of teacher competencies in preparing STEAM learning can be visualized in the following flowchart:

Figure 1:
Activity Flowchart

1. Initial Training and Workshops
- Understanding STEAM concepts
- Obstacle: The module is still rigid

2. Group Mentoring
- Group discussion and reflection
- Technical support

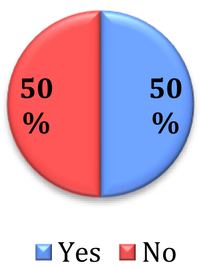
3. Final Outcome
- Integrative and contextual STEAM modules
- High and adaptive teacher readiness

The flowchart illustrates that conventional training alone is insufficient to produce an adaptive project module design. Further guidance in the form of group mentoring is required to achieve mature competence. The research findings highlight four primary thematic phases: identification of initial myths, teachers' responses to training and workshops, transformation of competencies through group mentoring, and implementation readiness.

1. Initial Competence Profile and Myths Regarding STEAM

The initial data analysis revealed a significant gap in experience and competence among teachers before they received training, workshops, and group mentoring. Based on the questionnaire results, the responding teachers came from diverse and evenly balanced backgrounds of experience.

Pie Chart 1:
Proportion of Teachers' Experience in Implementing STEAM



The data shows that 50% of teachers have implemented STEAM projects in the form of simple projects, while the other 50% have not yet applied the STEAM approach. Furthermore, qualitative analysis from the open-ended questionnaire showed that before the structured intervention, the majority of teachers (including those with basic experience) still face several fundamental misconceptions about STEAM. Teacher anxiety was centered around four primary inhibiting factors:

a. The Myth of High Costs and Advanced Technology: Teachers assume that STEAM learning must always use expensive equipment, advanced technology, or robotics devices.
b. The Complexity of Subject Integration: There was major concern regarding how difficult it would be to combine all five elements (Science, Technology, Engineering, Arts, and Mathematics) into a single project without sacrificing the curriculum targets of each individual subject.
c. Idea Confusion: Teachers feel burdened by the assumption that project ideas must come purely from the teacher's creativity, rather than from stimulating problem initiatives around the students.
d. The Abstraction of the Engineering Design Process (EDP): The engineering approach and the EDP workflow were still viewed as highly unfamiliar and abstract concepts by most teachers.

This condition is also reflected in the initial understanding score of teachers toward STEAM before the program was implemented, which only reached 8.63 (out of a maximum score of 10).

2. Teacher Responses to Training and Workshops

The first phase consists of training and workshops that serve to strengthen the STEAM concept for teachers. Through conceptual exposure, a radical paradigm shift occurred, with teachers beginning to realize that the essence of technology and engineering in STEAM is a systematic problem-solving process, which can even utilize recycled materials or locally based cultural materials. Quantitatively, teachers' responses to the quality of the training and workshop implementation were rated very positively, as summarized in the following table:

Table 1:
Summary of Average Scores for Each Training Evaluation Aspect

Key Evaluation Aspect	Score	Evaluation Rating
Facilitator	9.48	Excellent
Training Materials	9.23	Excellent
Training Execution	9.05	Good

Based on Table 1, the Facilitator and Training Materials aspects received the highest ratings. Participants' positive responses in this phase were driven by several outstanding aspects identified through the analysis of the instrument items:

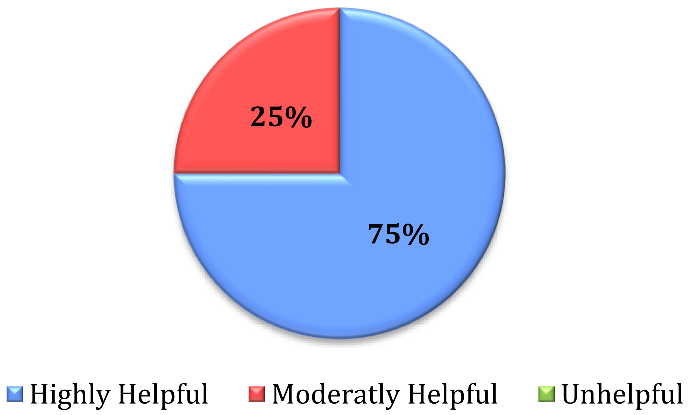
a. Facilitator Interaction and Feedback (Score: 9.63): Facilitators were rated as highly successful in building two-way discussions, providing concrete examples, being responsive to participants' confusion, and giving constructive feedback. Facilitators were also highly rated (9.50) for contextually linking STEAM concepts to student projects.
b. Material Absorption (Scores: 9.38 & 9.25): The STEAM execution workflow (9.38), guidelines for preparing student work (9.25), and best-practice presentation examples (9.25) were all deemed to have a high level of real-world applicability for elementary schools.
c. Facilities and Simulation (Score: 9.38): The project mentoring simulation space ran very smoothly and was fully supported by excellent physical facilities (rooms, LCD projectors, sound systems).

Although the evaluation scores were high, the research uncovered a critical reality on the ground: cognitive understanding does not automatically translate into practical skill. In the immediate post-training phase, the majority of teachers still experienced methodological confusion. The initial drafts of the lesson modules they submitted tended to be rigid, and the five elements of STEAM felt forced into a single session without a logical, driving purpose.

3. Competence Transformation Through Group Mentoring

The true shift in the quality of lesson design only occurred when the intervention was combined with ongoing group mentoring. Small group discussions acted as essential scaffolding, bridging the gap between theory and practical execution.

Pie Chart 2:
Teachers' Perception of the Impact of Group Mentoring



This positive impact was confirmed by the open-ended questionnaire results, where 75% (15 teachers) stated that group mentoring was "Highly Helpful" and 25% (5 teachers) found it "Moderately Helpful." Notably, not a single teacher felt that the mentoring was useless. Qualitatively, group mentoring within small groups successfully fulfilled several vital functions:

a. Ideation Facilitation: It provided a safe space to break through creative blocks through group discussion, while serving as a collaborative platform to find solutions when teachers encounter confusion and other technical obstacles.
b. Workflow Guardrails: It ensured that the module designs stayed on track and systematically aligned with EDP guidelines.
c. Expanding Perspectives: Providing critical feedback so that teachers can identify gaps for improvement in their initial designs.
d. Validation Space: It acted as a confirmation tool for teachers to ensure their project ideas were realistic to execute, effectively reducing the fear of failure.

This aligns with findings by Avidov-Ungar (2024), that mentors act as brainstorming partners, allowing the module to be evaluated, critiqued, and cross-validated by fellow peers within a caring community. This is also stated by Hasanah (2023) that group mentoring not only focuses on content but also on mutual care and collaboration among teachers.

The real-world impact of this group mentoring process was clearly documented in the quality improvements seen in the final module documents produced by the teachers, as compared in Table 2.

Table 2:
Comparison of Module Document Quality
Before and After Group Mentoring

Analytical Aspect	Condition Before Group Mentoring	Condition After Group Mentoring
Learning Focus	*Teacher-centered; focused heavily on completing factual content.*	*Student-centered; built around solving real-world, contextual problems.*
Workflow & Structure	Project activity syntax lacked a clear chronological structure.	Systematic and orderly; naturally follows the stages of the Engineering Design Process (EDP).

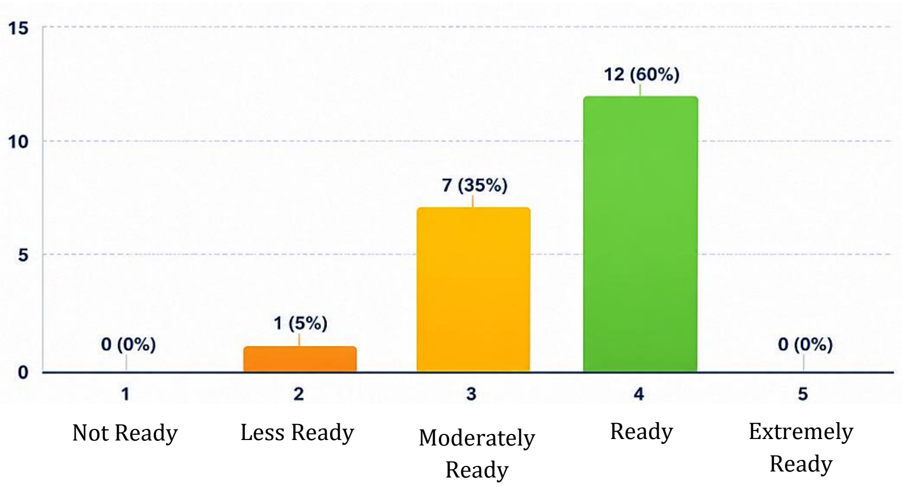
STEAM Integration	Rigid; disciplines felt forced and overlapped awkwardly within sessions.	Elements are integrated logically, flowing naturally into the core classroom activities.
Resource Utilization	Hindered by assumptions of lacking advanced facilities; plans stalled if tools were unavailable.	Creative material substitution; actively uses recycled items and local community resources.

The final module produced by the teacher proves that the teacher is capable of designing a systematic flow following the EDP syntax and guiding students to ask, imagine, plan, create prototypes, and finally test and improve their work.

4. Implementation Readiness

As a final outcome of this integrated professional development model, teachers' confidence levels and readiness to implement their STEAM modules in the classroom jumped significantly.

Graph 1:
Distribution of Teacher Readiness Levels



Based on the graph data, teacher confidence levels are in a very promising position. Document analysis and readiness questionnaires show that the majority of teachers feel highly optimistic: 60% (12 teachers) declared they are "Ready" (Score 4), 35% (7 teachers) feel "Moderately Ready" (Score 3), and only 5% (1 teacher) feels "Less Ready" (Score 2). This evidence proves that a community of practice approach offers far greater leverage and success retention in changing instructional behavior compared to traditional, one-way lectures.

The results of this study provide empirical contributions regarding the group mentoring model as part of continuous professional development that helps teachers translate the STEAM concept into classroom learning practices. The primary benefit of these findings proves that teacher skill development cannot be optimally achieved through "one-shot" lecture-style training programs. The characteristics of group mentoring, which prioritize collaborative dialog and interactive guidance in small groups, have proven capable of mitigating conceptual constraints while also reducing teachers' personal psychological anxiety.

When compared to traditional teacher training methods explored in past research, the conventional training model without mentoring often fails at the classroom implementation stage because teachers lose direction when facing technical difficulties in the field. Conversely, this study shows that having a mentor serve as a sounding board and feedback provider keeps teachers securely aligned with the structural path of the EDP. The validation space and peer collaboration offered by group mentoring serve as the primary differentiators, where teachers do not just passively absorb technical knowledge, but actively build self-confidence and restructure their instructional mindsets.

Nevertheless, feedback from teachers requesting "complete module examples" and proposing a "follow-up workshop specifically for the Engineering Design Process (EDP)" highlights a critical perspective: this intervention must be designed as a continuous program. The synergy between training and group mentoring is merely the first step toward building a robust STEAM education ecosystem, which ultimately requires collaboration between schools, academic institutions, and the wider community (Talaue et al., 2022). To ensure long-term innovation sustainability, it is highly recommended that this mentoring program does not stop at module design, but extends into regular, periodic evaluations of classroom impact (Ramadhani et al., 2025).

CONCLUSION

Developing teacher skills to prepare for STEAM learning cannot rely solely on one-way training programs. Research findings indicate that the integration of training, workshops, and group mentoring plays a crucial role in supporting the development of teachers' competencies and confidence in designing STEAM learning. Training provides the foundational knowledge, workshops sharpen the skills needed to draft modules, and group mentoring offers emotional and intellectual support to overcome technical challenges in module design and to adaptively apply the Engineering Design Process (EDP) principles within the modules.

The research results show a significant shift in teacher mindsets, from initially viewing STEAM as something expensive and complicated, to an approach that is creative, more student-centered, and can be implemented with simple materials. Group mentoring ultimately proved to be a "safe space" for teachers to reflect, collaborate, master systematic

Engineering Design Process (EDP) stages, and noticeably improve their readiness to launch STEAM learning in their classrooms.

Based on these scientific findings, it is recommended that educational institutions provide systemic support, such as allocating dedicated collaboration time for teachers and providing adequate learning resources. Sustained group mentoring programs are highly recommended to maintain the consistency of STEAM integration across educational environments.

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