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Evaluation of the STEM Training Program Implementation in Riau Province: Analysis of Participant Responses in 2023 and 2024

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Abstract

This study evaluates a collaborative STEM training program conducted by the Southeast Asian Ministers of Education Organization Regional Centre for Quality Improvement of Teachers and Education Personnel in Science (SEAQIS) in partnership with PT Pertamina Hulu Rokan (PT PHR) during 2023 and 2024. Utilizing a mixed-methods comparative cross-sectional design, data were collected via purposive sampling from 116 teachers, principals, and supervisors (comprising independent cohorts of n=58 in 2023 and n=58 in 2024) across four regencies in Riau Province. Quantitative data, gathered via a highly reliable Likert-scale questionnaire (α = 0.945), were analyzed using percentages and the non-parametric Mann-Whitney U test to evaluate differences between the two independent cohorts. Qualitative, open-ended responses were analyzed thematically. The findings reveal that the program was well received, with over 90% of participants reporting positive outcomes. Statistical analysis indicated no significant differences across all aspects ($p > 0.05$), including training materials, pedagogical impact, facilitator performance and time allocation, demonstrating highly consistent program effectiveness. However, qualitative findings identified the need for extended duration for complex content, more robust discussion sessions, and continuous follow-up activities to ensure effective classroom application. Ultimately, this study contributes to the discourse on STEM-based Teacher Professional Development (TPD) in developing countries by demonstrating how longitudinal public-private partnerships can provide consistent professional growth, while highlighting the necessity of sustained post-training support to bridge the gap between teacher perception and practical implementation.

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INTRODUCTION

The integration of STEM (Science, Technology, Engineering, and Mathematics) education into school curricula has become increasingly critical worldwide, as it fosters essential twenty-first-century skills such as problem-solving, critical thinking, creativity, and collaboration (Dare et al., 2021; Radeva, 2020). These non-cognitive or "soft" competencies are now widely recognized as indispensable components of modern education, as technical knowledge alone is no longer sufficient to meet the complex, multifaceted challenges of the modern labor market (Rizakhojayeva et al., 2025). These competencies are vital for preparing students to navigate the challenges of a rapidly evolving technological and global workforce driven by automation, artificial intelligence, and shifting socio-economic megatrends (Nguyen et al., 2026; Skrentny & Lewis, 2022; Warsito et al., 2023). Furthermore, global economic reports indicate a widening skills gap, highlighting that analytical thinking, resilience, adaptability, and emotional intelligence will be core requirements for the future-ready workforce, making the alignment of education with these new demands an urgent international necessity (Holik et al., 2023; Mardiyah & Hayat, 2026; OECD, 2025). In Indonesia, where educational systems are undergoing continuous reform to align with global standards and local needs, the promotion of STEM education has emerged as a national priority (Badan Perencanaan Pembangunan Nasional RI et al., 2025). However, effective implementation of STEM learning in classrooms remains a challenge, largely due to teachers' limited experience, confidence, and access to resources necessary for integrating STEM concepts into their teaching practices (Abdul Nasir Kiazai et al., 2020; Lo, 2021; Le et al., 2021).

Recent international studies highlight that educators frequently experience "STEM anxiety" and low self-efficacy, particularly when teaching integrated concepts or subjects like engineering for which they lack adequate pedagogical preparation (Christensen & Osgood, 2023). This intrinsic challenge is highly consequential; when teachers feel underprepared, their anxiety can be inadvertently transferred to their students, negatively impacting student engagement and confidence (Christensen & Osgood, 2023). Furthermore, teachers often struggle with the interdisciplinary nature of STEM, facing difficulties with time constraints, lesson planning, and a lack of specific STEM training (Sa'adah et al., 2025; Madar et al., 2026). In the context of developing nations, these intrinsic pedagogical challenges are severely compounded by extrinsic and systemic barriers. Teachers frequently operate within underfunded systems, facing a lack of modern laboratory infrastructure, inadequate teaching materials, and outdated, theory-heavy curricula that fail to align with practical industry needs (Sunday Adesina & Ogechukwu Obokoh, 2026; Sa'adah et al., 2025). Consequently, inadequate professional development, coupled with persistent resource inequalities and insufficient follow-up support, fundamentally constrains the effective translation of STEM theories into daily classroom instruction (Madar et al., 2026; Mustamin et al., 2025).

Professional development programs for teachers play a pivotal role in addressing these challenges (Yung Jong et al., 2021). Contextualized within a growing global trend, educational institutions and policymakers are increasingly leveraging public-private partnerships (PPPs) to drive educational reform and innovation (Adamson & Taneja, 2025). Recent international evaluations of corporate-sponsored teacher training highlight that collaborating with industry partners provides the critical technical expertise, operational capacity, and real-world resources necessary to bridge the widening gap between traditional academic curricula and modern workforce demands (Sunday Adesina & Ogechukwu Obokoh, 2026). Furthermore, corporate involvement, often driven by Corporate Social Responsibility (CSR) initiatives, has proven highly effective in complementing government efforts to scale STEM education and equip teachers with industry-relevant pedagogical tools (Horsu, 2024; Prastika et al., 2025). Recognizing this, SEAMEO QITEP in Science (SEAQIS), in collaboration with PT Pertamina Hulu Rokan (PT PHR), has implemented a series of professional development initiatives focused on enhancing teachers' STEM competencies (SEAMEO QITEP in Science, 2023; 2024). These programs are designed to improve teachers' content knowledge, pedagogical skills, and capacity to employ innovative, student-centered instructional strategies. By incorporating hands-on activities, project-based learning approaches, and localized STEM contexts, the programs aim to provide teachers with practical tools and strategies that are directly applicable in their classrooms (Devi et al., 2022).

While the importance of professional development in supporting STEM education is well documented (Agudelo Rodríguez et al., 2024Yung Jong et al., 2021; Anderson & Tully, 2020; Cheng & Yeh, 2022), limited empirical evi-

dence exists regarding the efficacy of such collaborative programs in Indonesia, particularly from the perspective of participating teachers. Understanding teachers' perceptions of the program's content, facilitators, and logistical support is essential for evaluating program impact and guiding future improvements. Therefore, this study aims to:

1. Evaluate the perceptions of participants regarding the collaborative STEM training program organized by SEAQIS and PT PHR in 2023 and 2024.
2. Compare participant responses to identify any significant changes or improvements between the two years.
3. Provide recommendations for future iterations of the program based on participant feedback.

By addressing these objectives, the study seeks to provide empirical insights into the outcomes of this collaborative professional development initiative, contributing to the broader discourse on enhancing STEM education in Indonesia and offering practical guidance for designing impactful teacher training programs.

METHOD

This study employed a comparative cross-sectional evaluation design to assess independent cohorts participating in the STEM training programs conducted in 2023 and 2024. The total sample consisted of 116 participants, comprising two distinct and independent groups of 58 teachers, principals, and supervisors per year. Participants were selected via purposive sampling across four regencies in Riau Province: Bengkalis, Kampar, Rokan Hilir, and Siak.

Data were collected using a mixed-methods evaluation instrument featuring both a 4-point Likert-scale questionnaire and open-ended qualitative prompts. The quantitative survey assessed four primary domains: training materials (e.g., "The training materials are relevant to the needs"), facilitator effectiveness (e.g., "The training materials were well prepared by the facilitator"), time allocation (e.g., "The allocated time was used effectively"), and logistical support. The instrument demonstrated excellent internal consistency and reliability, yielding a combined Cronbach's alpha (α) of 0.945 ($\alpha = 0.960$ for the 2023 cohort; $\alpha = 0.927$ for the 2024 cohort).

For the quantitative data analysis, the two implementation years were treated as independent samples to compare overall program effectiveness over time. Prior to conducting the inferential statistics, the individual Likert-scale item scores corresponding to each primary domain (as detailed in Table 1) were averaged to create the composite variables (i.e., 'Quality of Materials', 'Effectiveness of Facilitators', 'Appropriateness of Duration', and 'Overall Satisfaction'). Because the survey utilized an ordinal Likert scale, which does not assume a normal distribution, non-parametric statistical methods were required[h4.1]. Consequently, the Mann-Whitney U Test was employed to assess significant differences in the median responses between the two independent cohorts (2023 and 2024). The use of this non-parametric test is methodologically validated for this context; recent simulation studies demonstrate that the Mann-Whitney U test performs similarly well or better than parametric alternatives (such as the Student's t-test or Welch's t-test) when analyzing independent Likert-type data (Simsek, 2023). Following the inferential analysis, descriptive statistics (percentages) were also calculated to summarize general satisfaction, while the qualitative open-ended responses were analyzed thematically to identify key programmatic benefits and specific areas for continuous improvement.

RESULT AND DISCUSSION

The results in Table 1 showed that participants' perceptions of the training program in both years were highly positive. For most aspects, the percentage of positive responses (ratings of "good" and "excellent") exceeded 90%. However, slight variations were observed between the two years. The highest rating was 95% from 2024 participants, who indicated that the facilitators had prepared the training materials very well, followed by 90% of 2023 participants who rated the training materials as excellent in supporting teachers' competencies. These results indicate that the training was generally satisfactory to the participants.

Although most aspects were rated positively by the participants, there were some areas that require attention. This is reflected in the percentages of "fair" and "poor" ratings: 3% of participants in 2023 rated the reflection activities in each training session and the internet connection quality as fair; 3% of participants in 2024 rated logistical support, particularly audio quality, as fair and 2% rated video quality as fair; in addition, 2% of participants in 2024 rated the training equipment as poorly prepared. Although these values are small, they should still be addressed and revised to further improve training program.

Table 1. Participants' Perceptions of STEM Training in 2023 and 2024

Aspects	Statements	Excellent		Good		Fair		Poor	
		2023	2024	2023	2024	2023	2024	2023	2024
Program content	The training materials are relevant to the needs	88%	84%	12%	16%	0%	0%	0%	0%
	The time provided to complete tasks is sufficient	66%	57%	34%	43%	0%	0%	0%	0%
	The allocated time was used effectively	81%	72%	19%	28%	0%	0%	0%	0%
	The training materials support the improvement of teachers' competencies	90%	84%	10%	16%	0%	0%	0%	0%
	The structure of the training materials is systematic	81%	90%	17%	10%	2%	0%	0%	0%
	There were interesting aspects during the training	79%	86%	21%	14%	0%	0%	0%	0%
	My knowledge increased after participating in the training	79%	83%	21%	16%	0%	0%	0%	2%
	My skills improved after participating in the training	67%	78%	33%	22%	0%	0%	0%	0%
	The training activities conducted were in line with the training materials	84%	86%	16%	14%	0%	0%	0%	0%
Facilitator	The facilitator helped me master all the training materials	81%	90%	19%	10%	0%	0%	0%	0%
	The facilitator was able to answer participants' questions	83%	88%	17%	12%	0%	0%	0%	0%
	The training materials were well prepared by the facilitator	83%	95%	17%	5%	0%	0%	0%	0%
	Training equipment was well prepared	84%	78%	16%	21%	0%	0%	0%	2%
	The facilitator used a variety of training media	78%	78%	22%	22%	0%	0%	0%	0%
	The training media used were appropriate for the materials	81%	84%	19%	16%	0%	0%	0%	0%
	Reflection activities were conducted in each training session	76%	76%	21%	24%	3%	0%	0%	0%
Logistical support	The available internet connection	66%	91%	31%	9%	3%	0%	0%	0%
	Audio quality during the training	71%	69%	29%	28%	0%	3%	0%	0%
	Video quality during the training	71%	78%	29%	21%	0%	2%	0%	0%
	The committee provided assistance during the training	84%	72%	16%	28%	0%	0%	0%	0%
	The food/beverages served were varied	88%	71%	12%	29%	0%	0%	0%	0%
	Min	66%	57%	10%	5%	0%	0%	0%	0%
	Max	90%	95%	34%	43%	3%	3%	0%	2%
	Average	79%	80%	21%	19%	0%	0%	0%	0%

To identify significant differences in the implementation between the two years, the Mann-Whitney U Test was conducted. The results, shown in table 2, indicated that there were no significant differences in responses between the two years ($p > 0.05$). This suggests that the training program's effectiveness remained consistent across both years.

Table 2. Mann-Whitney U Test Results for 2023 and 2024

Aspect	U-statistic	P-value
Quality of Materials	1537.0	*0.344*
Effectiveness of Facilitators	1537.0	*0.276*
Appropriateness of Duration	1595.0	*0.411*
Overall Satisfaction	1830.0	*0.184*

For the qualitative data, thematic analysis of the open-ended responses revealed the following key themes:

- **Positive Feedback:** many participants highlighted the relevance of the STEM content and the practical approach used in the training. The integration of local context and real-world applications (such as use of local waste as a valuable resource in implementation and co-curricular STEM project activities) was especially appreciated.
- **Suggestions for Improvement:** participants suggested extending the duration of the training to allow for more in-depth coverage of advanced STEM topics, particularly robotics. There was also a desire for more hands-on activities and follow-up training sessions.
- **Facilitator Praise:** facilitators were consistently praised for their clear explanations and engagement with participants. Some participants requested more interactive sessions with facilitators.

The findings show consistently high participant satisfaction across both cohorts and across core dimensions (training materials, facilitator quality and performance, and logistical support) with only isolated "fair/poor" ratings. This pattern is consistent with established scholarship on effective teacher professional development (TPD). Affouneh et al. (2020) identify program design, availability of training materials, and scheduling as external factors that influence STEM TPD. Darling-Hammond et al. (2017) further emphasize that a strong content focus, active learning, coherence with teachers' goals and context, adequate duration, and collective participation are hallmarks of effective TPD. Recent systematic reviews bolster these findings on a global scale. For instance, a systematic review of 48 empirical studies by Lo (2021) confirms that developing a strong content focus (specifically pedagogical content knowledge), providing sample STEM instructional materials, active learning, and ongoing collaboration are the most frequently reported elements of highly effective integrated STEM TPD. Similarly, a recent review by Boz (2023) highlights that active learning, where teachers are explicitly offered opportunities to observe modeled practices, engage in lesson planning, and reflect, is critical for teachers to successfully acquire intended STEM knowledge and skills. Furthermore, Lynch et al. (2019) meta-analysis demonstrated that programs emphasizing pedagogical content knowledge and new curriculum materials yield significantly positive effects on overall student achievement. Likewise, Tupamahu et al. (2025) report that engaging, interactive formats, knowledgeable facilitators, and collaborative opportunities among educators are key drivers of TPD effectiveness. When these elements are present, teachers typically report high satisfaction and perceive the training as useful.

Participants' positive views of facilitator effectiveness are particularly consequential. Prior work finds that facilitators who blend content expertise with pedagogy, varied media and delivery strategies, as well as the interaction with the participants tend to drive higher engagement and perceived utility (Perry & Booth, 2024; Onrubia et al., 2022). International scholarship underscores that coaching and expert support are vital for scaffolding teachers' implementation of unfamiliar, interdisciplinary STEM curricula and new instructional approaches (Lo, 2021). As Boz (2023) emphasizes, effective facilitators and PD leaders do more than just deliver content; they create collaborative and collegial learning environments that nurture trust and critical dialogue, which is essential for transforming individual teaching practices into sustained communities of practice. When facilitation combines these elements, participants are more likely to remain attentive, see direct relevance to their work, and rate professional development as impactful.

Positive feedback on integrating local context and real-world applications aligns with integrated-STEM reviews identifying these as signature practices teachers value because they make professional learning directly transferable to classroom instruction. This is in line with Holmes et al. (2021), who show that localized learning is an effective pedagogical approach for

strengthening STEM learning in schools; likewise, Lindner (2020) argues that STEM education is most effective when learning activities are explicitly connected to students' everyday lives.

In addition to the main findings, further analysis reveals variations across specific aspects that are worth discussing. While ratings for training materials and facilitators consistently remained high (above 80–90%), the aspects of duration and logistics showed more fluctuation. In 2023, 66% of participants considered the allocated time sufficient, yet this figure decreased to 57% in 2024. This suggests that although the training content was perceived as highly valuable, limited time posed a challenge for participants to fully engage with the materials, particularly advanced topics. In other words, the quality of the content did not always align with satisfaction regarding time management.

This quantitative result is reinforced by the qualitative data, in which participants explicitly suggested extending the training duration and incorporating more hands-on activities. This interpretation is consistent with prior research: Alan et al. (2019) and Wu et al. (2021) identify program duration as a critical determinant of STEM teacher-training effectiveness, and Aldahmash et al. (2019) report that short training cycles do not improve teachers' attitudes toward teaching STEM. Accordingly, extending the duration, while preserving the effectiveness of the training materials, methods, and facilitation strategies, should yield greater gains in participants' knowledge and skills. The consistency between quantitative and qualitative findings strengthens the validity of the conclusion that training duration is a critical issue that should be addressed in future program designs.

Because the 2023 and 2024 implementations followed the same program structure and facilitation strategy (albeit with different target participant groups), the absence of statistically significant differences between years suggests that the program has been delivered with strong implementation fidelity and is reliably producing comparable participant reactions across cohorts. In practical terms, the high ratings in most dimensions signal that the design features teachers value, such as clear learning objectives, structured and systematic materials, varied media, and responsive facilitation, were preserved from year to year and met participants' expectations (Darling-Hammond et al., 2017).

Despite the positive feedback, there are areas that could be enhanced in future iterations. Items related to session reflection routines, material preparation, and logistics: internet, audio, video, and equipment readiness suggest that micro-level delivery factors can influence the overall experience despite a strong core design. Addressing these through a standardized pre-session AV and equipment checklist, clear troubleshooting protocols, and timeboxed reflection activities in each session would likely elevate an already positive experience.

Additionally, because this study focused solely on participants' perceptions, it does not capture the program's overall effectiveness. While perception data are useful for monitoring perceived quality and relevance, they do not demonstrate gains in teacher learning or transfer to classroom practice. To strengthen claims of effectiveness, future cohorts should triangulate reaction data with brief pre/post knowledge checks, self-efficacy or performance measures, and short follow-up indicators of practice (such as observation rubrics, implementation logs, or student work samples) to document growth beyond satisfaction.

Furthermore, to sustain and scale these gains, the program should also cultivate strong engagement with school regulators at district and provincial levels. Their involvement is crucial for enabling timely follow-up actions, aligning policies and resources, and facilitating broader dissemination across schools. In parallel, a structured mapping of STEM practices in participating schools (combining baseline and periodic scans of curricula, projects, resources, and teacher practices) would supply the system-level evidence needed by the central government to prioritize support and scale the national STEM agenda. Together, these steps would ensure the program continues to meet educators' evolving needs while strengthening Indonesia's STEM education ecosystem.

CONCLUSION

This study has evaluated the collaborative STEM training program conducted by SEAQIS and PT PHR in 2023 and 2024. The findings indicate that the program has been well-received by participants, with no significant differences between the two years. However, feedback from participants highlights areas for improvement, particularly in the duration and depth of the training content. Future iterations should extend training duration, increase hands-on activities, and include follow-up sessions to reinforce learning, while embedding a robust evaluation framework with short post-training assessments to evidence

gains in teacher knowledge and classroom practice beyond satisfaction. Sustained engagement with district and provincial school regulators is essential to enable timely follow-up, align resources, and support wider dissemination. In parallel, a structured mapping of STEM practices in participating schools will provide system-level evidence for prioritization and national scaling. This would ensure that the program continues to meet the evolving needs of educators and helps foster a more effective STEM education framework across Indonesia.

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