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STEM-Based Robotics Professional Development for Physics Teachers: A Group-Level Training Evaluation in MGMP Fisika Jakarta

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Abstract

The pre-training survey showed that the MGMP (an association for in-service teachers) Fisika Jakarta participants generally had some familiarity with STEM (Science, Technology, Engineering, Mathematics) education but limited direct classroom experience with educational robotics. This article reports on a professional training program for physics teachers who registered in the MGMP Fisika Jakarta network. The program included an online course with specific STEM modules, hands-on activities with Sphero Indi robots, and discussion of how robotics could be used in physics teaching. Pre-training questionnaire responses were collected from 39 participants, while 36 participants completed the anonymous post-training questionnaire. The responses were analyzed descriptively at the group level, together with open-ended reflections on intended classroom use. Before the training, 29 of 39 teachers (74%) either had only heard about educational robotics without using it or reported no familiarity with it. After the program, responses were concentrated in the moderate to very-high categories for understanding of STEM-based learning and the use of educational robotics in physics teaching, and 31 of 36 respondents (86%) regarded the training as very beneficial. Teachers mainly planned to use robotics through project-based,

problem-based, and collaborative learning activities. These teacher-generated classroom-use ideas were an immediate pedagogical output of the program. The findings indicate positive immediate responses to professional development, while further follow-up is needed to examine whether these intentions are translated into classroom practice.

Keywords: STEM education, educational robotics, physics education, teacher professional development, program evaluation

INTRODUCTION

Educational robotics has been used in education to give students an observable and programmable system through which physical ideas can be explored (Benitti, 2012). A recent systematic review of robotics in physics education reported positive findings for physics learning and problem solving (Lotriet & Gouws, 2026). Similar results appear across STEM education more broadly. In a meta-analysis of 21 studies, Ouyang and Xu (2024) found a moderate positive effect of educational robotics on STEM learning, particularly on students' learning performance and attitudes. These findings make robotics a useful option for integrated STEM activities, but integration involves connecting science, technology, engineering, and mathematics within a meaningful problem or learning goal (Kelley & Knowles, 2016; Thibaut et al., 2018).

When robotics is used in physics lessons, the lesson may involve programming, sensors, calculations, and engineering design, but these elements do not necessarily lead to meaningful physics learning. Darmawansah et al. (2023), for example, found that programming was the most dominant disciplinary component in robotics-based STEM studies. The challenge for physics teachers is how to keep the physics purpose visible while students work with this kind of technology. Bernstein et al. (2022) showed that robotics can be incorporated into disciplinary lessons when the activity is designed around subject-specific learning goals. This means that, through robotics activities, students can work with and apply disciplinary concepts.

Teachers may face limitations when integrating STEM education, including limited time and resources, curriculum and assessment demands, and uncertainty about appropriate pedagogy (Margot & Kettler, 2019; Shernoff et al., 2017). Professional development can provide space for teachers to work through some of these issues before bringing a new approach into their classrooms (Desimone, 2009). Huang et al. (2022) found that STEM professional development commonly combines activities such as learning by doing, learning by design, reflection, and group work, allowing teachers to connect new content with classroom practice. Looking specifically at in-service STEM teachers, Surahman and Wang (2023) similarly found workshops and online programs to be common forms of professional development. More recent work continues to emphasize the need to develop teachers' STEM knowledge alongside their pedagogical and technological capacity (Rehman et al., 2025).

For educational robotics, this professional learning involves both sides of the work: teachers need experience with the technology itself, and they also need to decide what the technology is for in their teaching. Schina et al. (2021), after reviewing 38 studies of educational robotics teacher training, grouped the main practices reported in these programs around collaboration, materials, pedagogy, practice, and feedback or support. Evidence from in-service programs shows why these elements matter. El-Hamamsy et al. (2021), for instance, evaluated a large-scale continuing professional development program involving approximately 350 primary teachers and reported high rates of subsequent adoption of the activities introduced during the training. In another pre-post study, Wu and Zhou (2025) found improvements in self-reported STEM self-efficacy and pedagogical knowledge among 59 in-service teachers who completed a technology-integration course. More recently, Soler et al. (2026) examined 51 in-service teachers working with educational robotics and found that professional learning supported both perceived digital competence and the classroom application of robotics-related skills. These studies show that professional development can help teachers become more prepared to work with STEM and educational robotics.

In our program, the community partner was MGMP Fisika Jakarta (Musyawarah Guru Mata Pelajaran, a subject-based teacher forum, in our case, specifically Physics subject). The baseline responses indicated a practical need for experience with robotics rather than a complete absence of STEM awareness. Twenty-nine of 39 teachers (74%) had either only heard about educational robotics without using it or reported no familiarity with it, while 32 of 39 (82%) reported using STEM-based learning only one to five times per semester. Research on MGMP as an Indonesian professional learning community also shows the value of regular subject-based meetings for exchanging ideas, finding solutions, and sharing professional experience (Soraya & Supadi, 2022).

Against this background, the program had three immediate objectives: (1) to provide physics teachers with direct hands-on experience using educational robotics; (2) to help them connect robotics activities with physics content and STEM-oriented pedagogical approaches; and (3) to evaluate their immediate group-level responses and intended classroom uses after the program. The evaluation therefore focuses on response distributions and teacher-generated plans.

Integrated STEM and Educational Robotics in Physics Teaching

For this study, the main concern is how the STEM elements are connected in the lesson. A teacher may use programming, sensors, measurement, or engineering design in one activity, but these parts can still remain separate from the physics that students are expected to learn. The role of the teacher is therefore to decide which disciplinary ideas need to stay visible and how the robotics task can help students work with them.

Recent studies with in-service teachers show that this kind of integration is not always straightforward. Mesutoglu and Akgündüz (2026) examined the lesson plans developed by 33 in-service teachers after an engineering-focused STEM professional development program. Their analysis showed that teachers included several expected STEM features, such as real-

world problems and engineering design, but some forms of content integration were still limited. In particular, technology and mathematics were sometimes used in supporting roles rather than being meaningfully connected with the other disciplines.

This disciplinary issue is important in the present study because the participants are physics teachers. Robotics can bring engineering design, mathematics, programming, and technological tools into a physics lesson, but these elements need to support rather than replace the physics content. We therefore use ‘STEM-based robotics’ to refer to robotics activities in which physics remains a clear disciplinary focus while teachers make purposeful connections with other STEM knowledge and practices. In doing so, learning to build or program a robot is not treated as the final goal of the activity. The robot is used as part of a lesson in which students can work with physics ideas through a broader STEM task.

Professional Development for STEM-Robotics Integration

The professional learning needed for robotics also has two sides. Teachers first need enough experience with the equipment and programming to work with it confidently. They then need to decide how that technical experience can be turned into a classroom activity. These are related tasks, but they are not the same. A teacher may learn how to program a robot without yet knowing where it fits in a physics lesson or what students should learn from using it.

Boz and Alleksaht-Snider (2022) followed in-service elementary teachers as they learned coding and robotics in a blended professional learning course. Their analysis showed that teachers' learning was shaped by several parts of the course, including the robotics platforms, instructional guidance, available resources, and collaboration with colleagues. The course also asked teachers to connect coding and robotics with subjects they already taught. This is useful for the present study because it shifts attention from simply learning how a robot works to learning how the technology can be used within existing subject teaching.

In a similar recent professional development study, Yang (2025) organized robotics professional learning around three phases: learning, practice, and reflection and improvement. The participating teachers first developed basic knowledge of coding and robotics, then worked directly with the technology, and later considered how it could be used pedagogically. The study reported gains in robotics pedagogical knowledge, suggesting that direct experience with the technology needs to be accompanied by opportunities to think about its use in teaching.

Professional learning can also continue through interaction with other teachers (Vescio et al., 2008). Lin et al. (2024), studying a teacher learning community for technology-integrated STEM education, found that teachers used the community to seek support, exchange ideas, and work through problems related to lesson design and technology use. More recent work with educational robotics gives further support to this collaborative side of professional development. Soler et al. (2026) studied 51 in-service teachers from 13 schools who took part in robotics-related professional learning. Teachers who also participated in reciprocal peer observation showed stronger development in several areas of perceived digital competence and in the practical use of robotics-related skills than teachers who received conventional

training only. Their study suggests that trying robotics in practice, observing colleagues, and discussing what happens during implementation can extend professional learning beyond the initial training session.

These studies help define the role of professional development in the present study. The MGMP training was not intended only to introduce teachers to robotics equipment. It gave teachers opportunities to work with the technology, consider its connection with physics teaching, discuss possible classroom activities, and develop plans with other physics teachers. Professional development is therefore treated here as a process that connects technical experience with pedagogical decision-making and lesson planning.

Teacher Readiness for STEM-Robotics Integration

Readiness is used in a limited sense in this study. We did not assess how teachers taught a robotics-based lesson or evaluate their ability to manage students during the activity. The data instead show what teachers understood, how familiar they were with robotics, how ready they felt to use it, and what they planned to do after the training.

Some recent work on educational robotics helps to place this use of readiness in context. Măță and Tzafilkou (2025) studied 307 pre-service and in-service teachers and found that teachers who were more familiar with educational robotics also tended to report stronger self-efficacy, more positive attitudes, and greater openness to using it. In-service teachers reported lower self-efficacy than pre-service teachers. Familiarity is therefore relevant, especially for practicing teachers.

Readiness can also be defined much more broadly than it is measured in the present study. Papagiannopoulou et al. (2025), for example, developed the TRi-Robotics scale with 817 in-service teachers. Their scale includes self-efficacy, commitment, and affective conditions. We did not use this scale, and our questionnaire was not designed to measure these three dimensions. Here, the term refers more simply to teachers' reported preparedness to begin integrating the robotics activities introduced during the training into their physics teaching.

Reher et al. (2025) followed 105 in-service STEM teachers across eight professional development programs. Teachers reported gains in several areas of professional knowledge, but their self-efficacy and technology commitment did not change significantly. Different parts of professional learning do not necessarily move together. We take the same cautious approach in this study. Higher post-training ratings are treated as evidence of teachers' immediate responses to the program, not as evidence that their classroom practice or teaching competence had already changed.

METHODS

Evaluation Design

This article reports a group-level pre- and post-training evaluation of a STEM-based robotics professional development program for physics teachers. Data were collected at two points to describe the distribution of teachers' responses before and immediately after the program. Because the questionnaires were anonymous and no individual identifiers were collected, the

pre- and post-training responses could not be paired. The analysis therefore does not estimate individual change, learning gain, or causal program impact; it describes group-level response patterns at the two survey points (Marsden & Torgerson, 2012). The pre-training questionnaire had 39 responses and the post-training questionnaire had 36 responses.

Participants and Community Partner

The professional development program involved 39 physics teachers who were members of MGMP Fisika Jakarta. The participants taught in public and private senior high schools and had between 3 and more than 20 years of teaching experience. Their previous experience with STEM education and educational robotics also varied. Participation in the program was voluntary. The pre-training responses showed that most teachers had some familiarity with STEM as an educational approach, while experience with robotics in teaching was much less common. Fewer than one quarter of the participants reported that they had previously tried using robotics in a teaching context. Of the 39 teachers who completed the pre-training questionnaire, 36 also provided post-training responses.

Professional Development Program

The professional development was organized in three stages. The first was an online preparation phase conducted through Zoom from 23 to 29 April 2025. During this phase, teachers were introduced to the main ideas of STEM education and prepared for the practical robotics activities.

The second stage was an eight-hour hands-on session held on 30 April 2025. Teachers worked with Sphero indi robots and gained direct experience with their operation and programming. The practical activities were then connected to discussions about possible uses of robotics in physics teaching. Teachers considered which physics topics could be explored through robotics and how the activities might be organized within a STEM-oriented lesson.

Following the practical session, teachers reflected on how they might use STEM-based robotics in their own teaching. They were asked to describe possible classroom applications, including the type of learning activity they would consider and how robotics might be connected with physics content. Teachers also completed the post-training questionnaire. These activities were intended to capture their immediate responses to the training and their initial plans for future classroom use.

Data Collection

Data were collected through pre- and post-training questionnaires developed for the evaluation of the professional development program. The questionnaires were designed for this program rather than adapted from an established psychometric instrument and were not formally validated or pilot-tested. The items are treated as program-evaluation items (Boateng et al., 2018).

Both questionnaires included five-point Likert-type items, ranging from 1 (very low) to 5 (very high), together with open-ended questions. The pre-training questionnaire asked about teachers' previous use of STEM-based learning, their understanding of STEM, and their

familiarity with educational robotics. The post-training questionnaire asked about their understanding following the program, perceived readiness to use robotics in physics teaching, perceived usefulness of the training, and their intended classroom use of STEM-based robotics. The open-ended part of the post-training questionnaire invited teachers to reflect on how they might use robotics in future physics lessons. These responses were used to examine the types of learning activities teachers were considering after the training. All responses were anonymous. As no identifiers were collected, the 39 pre-training responses could not be matched with the 36 post-training responses at the individual level. TABLE 1 lists the closed-response items reported in this article.

TABLE 1. Closed-Response Questionnaire Items Reported in the Evaluation

Survey Item	Question	Response Categories
Pre 1	How often do you use a STEM approach in physics teaching?	Very often; Often (>5 times per semester); Occasionally (3–5 times per semester); Rarely (1–2 times per semester); Never
Pre 2	How would you rate your understanding of basic STEM concepts before the training?	Very strong understanding (able to teach and apply STEM); Good understanding (able to explain STEM); General understanding but not yet in depth; Limited understanding; No understanding
Pre 3	How familiar were you with the use of educational robotics in teaching before the training?	Very familiar (regularly used and integrated robotics); Familiar (used robotics frequently); Somewhat familiar (had tried using robotics); Limited familiarity (had heard of robotics but never used it); Not familiar at all
Post 1	After the training, how would you rate your understanding of STEM-based learning?	Very high; High; Moderate; Low; Very low
Post 2	After the training, how would you rate your understanding of the use of educational robotics in physics teaching?	Very high; High; Moderate; Low; Very low
Post 3	How beneficial was the training for supporting innovation in your physics teaching?	Very beneficial; Beneficial; Moderately beneficial; Not beneficial; Not at all beneficial

Data Analysis

The quantitative questionnaire data were analyzed descriptively. Frequencies and percentages were calculated for individual items. Where pre- and post-training items addressed comparable topics, response distributions and group-level mean scores were presented side by side. Because individual responses could not be matched, these comparisons describe differences between the two groups of responses rather than individual changes or gains (Marsden & Torgerson, 2012). The open-ended post-training responses were analyzed for recurring patterns in teachers' intended use of robotics, informed by thematic analysis principles (Braun & Clarke, 2006, 2021). The qualitative analysis concerns teachers' intended classroom use.

RESULTS AND DISCUSSION

Pre-Training Profile

The pre-training questionnaire was completed by 39 physics teachers. Eighteen teachers (46%) reported using STEM-based learning three to five times per semester, while 14 (36%) used it only once or twice. Four teachers (10%) had never used STEM-based learning, and three (8%) reported using it more than five times per semester (FIGURE 1).

How often do you use a STEM approach in physics teaching?

39 responses



FIGURE 1. Frequency of STEM-Based Learning Used in Physics Teaching before the Training ($n = 39$)

Teachers also reported different levels of understanding of basic STEM concepts. Twenty-four teachers (62%) described their understanding as general but not yet in depth, while 12 (31%) reported having limited understanding. Two teachers (5%) indicated a good understanding of STEM, while one (3%) reported no understanding of the basic concepts (FIGURE 2).

How would you rate your understanding of basic STEM concepts before the training?

39 responses



FIGURE 2. Self-Reported Understanding of Basic STEM Concepts before the Training ($n = 39$)

Experience with educational robotics was more limited. Twenty-six teachers (67%) had heard about robotics but had not used it in their teaching. Nine (23%) had tried using robotics in a learning activity, three (8%) reported no familiarity with educational robotics, and one teacher (3%) reported being familiar with its use in teaching (FIGURE 3).

How familiar were you with the use of educational robotics in teaching before the training?

39 responses



FIGURE 3. Self-Reported Familiarity with Educational Robotics before the Training ($n = 39$)

Overall, the pre-training responses show that most participants had some prior exposure to STEM education, although its classroom use was generally occasional. Direct experience with educational robotics was less common.

Post-Training Responses

The post-training questionnaire was completed by 36 teachers. Because all responses were anonymous, they could not be linked to the pre-training responses at the individual level. The findings in this subsection therefore describe the distribution of responses after the program. After the program, 22 teachers (61%) rated their understanding of STEM-based learning as high and six (17%) as very high. The remaining eight teachers (22%) selected the moderate category. No respondents selected low or very low (FIGURE 4).

After the training, how would you rate your understanding of STEM-based learning?

36 responses

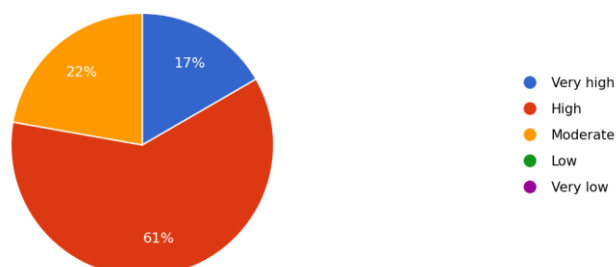


FIGURE 4. Self-Reported Understanding of STEM-Based Learning after the Training ($n = 36$)

Teachers were also asked about their understanding of how educational robotics could be used in physics teaching. Twenty teachers (56%) rated their understanding as high, five (14%) as very high, and 11 (31%) as moderate. No respondents selected low or very low (FIGURE 5).

After the training, how would you rate your understanding of the use of educational robotics in physics teaching?

36 responses

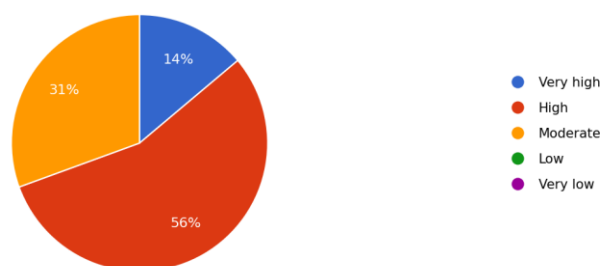


FIGURE 5. Self-Reported Understanding of Educational Robotics Use in Physics Teaching after the Training ($n = 36$)

The teachers also responded positively when asked about the usefulness of the program for supporting innovation in physics teaching. Thirty-one teachers (86%) rated the training as very beneficial, four (11%) as beneficial, and one (3%) as moderately beneficial. None selected either of the negative response categories (FIGURE 6).

How beneficial was the training for supporting innovation in your physics teaching?

36 responses



FIGURE 6. Perceived Usefulness of the Training for Supporting Innovation in Physics Teaching ($n = 36$)

The post-training responses were therefore concentrated in the moderate-to-very-high categories for both STEM-based learning and the use of educational robotics in physics teaching. Almost all respondents also regarded the program as beneficial or very beneficial. These findings describe teachers' immediate responses to professional development and are not treated as evidence of individual gains or subsequent changes in classroom practice.

Intended Classroom Use of STEM-Based Robotics

The open-ended responses provided additional information about how teachers were considering using robotics after the training. Three themes appeared in their responses: project-based learning, problem-based learning, and collaborative learning.

Project-based learning was the most frequently mentioned approach and teachers connected possible activities with physics topics such as motion, electricity, and waves. Problem-based learning appeared in responses that positioned robotics within a problem or challenge for students to work through. Teachers described activities in which students could consider possible solutions, test them using robotics, and make adjustments based on the results. In

these responses, operating the robot was not presented as the activity by itself but as part of a wider problem-solving process. Collaborative learning was also common in teachers' plans. Several respondents described students working in groups during robotics activities, sharing tasks, discussing possible solutions, and helping one another as they worked. Some teachers also considered using robotics outside regular physics lessons, including in science clubs or activities involving more than one subject area.

These responses show how teachers were beginning to connect their experience during the training with possible classroom applications. They represent teachers' intended use of STEM-based robotics immediately after the program and do not show whether these plans were later implemented in practice.

Program Outputs and Follow-Up Needs

The program produced two immediate outputs. First, teachers completed the hands-on robotics activities using Sphero indi and gained direct experience with the equipment introduced during the training. Second, they developed initial ideas about how robotics could be used in physics teaching. These ideas were reflected in the classroom approaches described in the previous subsection. The program did not require participants to produce complete lesson plans, so these outputs are better understood as practical experience and early planning for classroom use.

The feedback collected after the program also showed strong interest in continuing the activities. Several teachers asked for similar workshops to be offered more regularly and to reach a wider group of physics teachers. One participant wrote, "I hope this can be held regularly and reach MGMP groups in different areas, so more physics teachers can learn about STEM-based robotics and microcontrollers" (P8). Another participant expressed a similar expectation for continued collaboration, writing, "I hope we can continue this collaboration and have activities like this more often" (P9).

Participants also suggested practical forms of follow-up support. One teacher proposed, "I hope there can be follow-up training, with tutorial videos, and if possible, participants can take some equipment back to school" (P19). This comment points to two needs that may affect future classroom use: continued access to learning resources and opportunities for further technical support after the initial workshop.

Time was the clearest concern raised about the implementation of the training itself. One participant commented, "The time still felt too short because we did not get through all three training modules" (P28). Another suggested reducing the number of tasks during the robot-car practice so that more time could be used for other related material (P27). These comments indicate that the eight-hour practical session was useful but still felt intensive for some participants.

This feedback suggests that participants were interested not only in repeating the program but also in extending it through follow-up workshops, wider MGMP participation, tutorial materials, and continued access to robotics equipment. These suggestions provide a practical basis for planning the next stage of collaboration with MGMP Fisika Jakarta.

The pre-training responses show an important starting point for the program. Most participants were not completely new to STEM education, but its use in their physics teaching was generally occasional, and direct experience with educational robotics was uncommon. This difference between knowing about an educational approach and having experience using it is relevant for professional development. Previous research has shown that teachers may value integrated STEM while still facing practical and pedagogical difficulties in bringing it into their classrooms, including limited resources, curriculum demands, and lack of support (Margot & Kettler, 2019). Educational robotics can add further demands because teachers have to become familiar with the technology while also deciding how it can be used for teaching (Chalmers, 2018; Schina et al., 2021). In this program, the hands-on session therefore addressed an area in which many of the participating physics teachers had little previous experience.

The post-training responses provide a picture of how teachers viewed their understanding immediately after this experience. Responses were concentrated in the moderate to very-high categories for both STEM-based learning and the use of educational robotics in physics teaching, and most participants viewed the program as beneficial. These findings cannot be read as individual improvement because the anonymous pre- and post-training responses could not be matched. Even so, the pattern is consistent with recent professional development studies in which teachers were given direct experience with technology together with opportunities to consider its pedagogical use. Yang (2025), for example, reported positive changes in robotics pedagogical knowledge after a program organized around learning, practice, and reflection. Wu and Zhou (2025) also found higher self-reported STEM pedagogical knowledge and self-efficacy among in-service teachers following a technology integration course. The contexts and research designs of these studies differ from the present program, but they point to the value of giving teachers opportunities to work with a technology rather than discussing its classroom potential only in abstract terms.

The teachers' reflections on future use add another part to this picture. Project-based learning, problem-based learning, and collaborative learning appeared repeatedly in their plans. This is relevant because the teachers did not describe robotics only as equipment that students would learn to operate. Instead, they placed it within activities in which students could work on projects, solve problems, test ideas, or work with peers. Project-based and inquiry-oriented approaches are also common in educational robotics teacher training reported in the literature (Schina et al., 2021). For the present study, however, a more important point is the connection with physics. Teachers mentioned topics such as motion, electricity, and waves when considering possible robotics activities. This shows an initial attempt to connect the technology with disciplinary content rather than treating robotics as a separate subject.

Making such connections is not necessarily simple. Studies with in-service teachers have shown that integrated STEM lesson design is shaped by teachers' disciplinary backgrounds and that the different STEM components are not always integrated to the same degree (Mesutoglu & Akgündüz, 2026). The reflections in the present study are much more limited than the lesson plans analyzed in those studies, so they cannot show whether the teachers had

achieved strong disciplinary integration. They do show the direction in which teachers were beginning to think: robotics was being connected with physics content and with a pedagogical approach. Whether those connections would remain visible in a fully developed lesson and during classroom teaching would need to be examined separately.

The practical output of the program should also be interpreted at the same level. Teachers left the session with direct robotics experience and written ideas about possible classroom uses, but the present data do not establish whether these ideas became completed lesson plans or classroom enactments. The reported concerns about access to kits, curriculum time, and continuing technical or pedagogical support are therefore important for the next phase. They point to conditions that may shape implementation and should be examined directly in follow-up work rather than being treated as outcomes already resolved by the training.

The MGMP setting provides a practical structure for that follow-up. Indonesian research describes MGMP as a subject-based professional learning community in which regular meetings can support idea exchange, shared problem solving, and professional collaboration (Soraya & Supadi, 2022). Research on technology-integrated STEM learning communities also shows that interaction with colleagues can support teachers when they face problems with technology use and instructional design (Lin et al., 2024), while educational-robotics work suggests that peer observation and discussion can extend professional learning into classroom implementation (Soler et al., 2026). For MGMP Fisika Jakarta, a reasonable next step is therefore a cycle of lesson adaptation, classroom trial, peer discussion, and revision, together with resource sharing and later evaluation. This is a proposed sustainability route, not a measured outcome of the present program.

What we captured, therefore, was how teachers viewed their understanding and possible classroom use of robotics immediately after the training. Their open-ended responses tell us what they were considering doing, but not whether those ideas were later put into practice. This distinction is important because changes in one area of teacher learning do not always appear in others. Reher et al. (2025), for instance, reported gains in teachers' self-assessed professional knowledge after STEM-focused professional development, while self-efficacy and technology commitment showed no significant change. In our case, the positive responses after the program are best treated as an early indication of how teachers understood and responded to the training. A later follow-up would be needed to see whether these initial ideas developed into lesson designs, classroom use, or continued engagement with educational robotics.

CONCLUSION

The program introduced physics teachers in MGMP Fisika Jakarta to the practical use of educational robotics within a STEM context. Before the training, most participants were already familiar with STEM in general, but they used it only occasionally in class and had limited experience with robotics. After the training, teachers reported stronger understanding of STEM-based learning and of how robotics could be used in physics teaching, and most viewed the program positively. The open-ended responses also showed that teachers were not

thinking about robotics only as a technical tool. They linked it to project-based, problem-based, and collaborative activities, and connected these ideas with physics topics they might teach. At this stage, these responses are better read as early teaching ideas rather than evidence of classroom change. The program therefore appears to have helped teachers move from initial exposure to a clearer sense of how robotics might fit into their own teaching.

The next step is to see what happens after the training. Follow-up activities through the MGMP network could support teachers in adapting activities, trying them in class, discussing difficulties with colleagues, and revising their plans. Future evaluations should also use matched pre- and post-training responses where possible and include stronger measures if teacher readiness or competence becomes a main outcome.

DECLARATIONS

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Conflict of Interest. The authors declare no conflict of interest.

Author Contributions. ASB: Conceptualization, program development, writing – original draft, writing – review and editing. HP, WF, WYP, ADM, NS, M, NP, and DM: Program implementation, data processing and analysis, writing – review and editing. All authors reviewed and approved the final manuscript.

Use of AI. Grammarly was used for grammar and language correction. ChatGPT (OpenAI) was used only to help translate selected open-ended responses from Indonesian into English. The authors checked all translations against the original responses and take full responsibility for the final content.

Consent for Publication. Not applicable. No identifiable personal information is reported in this article.

Ethics Approval. This program evaluation used anonymous questionnaire data and was conducted as part of a community service program approved by LPPM, Universitas Negeri Jakarta.

Informed Consent. Participation in the program and the evaluation questionnaires was voluntary. Participants were informed about the purpose of the evaluation, and responses were collected anonymously.

Data Availability. The anonymized data supporting the findings of this study are available from the corresponding author upon reasonable request.

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