Science Teacher Development in STEM for Indonesia's Curriculum Change

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Abstract: To shorten the gap in the learning process that was disturbed during the pandemic, the Indonesian government established a new Indonesian curriculum in early 2020. On the other hand, the implementation of an integrated approach to STEM education with real-life scenarios is crucial to be understood and implemented by science teachers. Although many teachers have experienced joining STEM-related activities, the implementation is quite low. Therefore, the need for professional development in STEM education to support the implementation of the new Indonesian curriculum is needed. This paper presents an integrated approach to STEM education developed in the context of a collaborative professional development program implemented in synchronous and asynchronous meetings. The program aimed at providing teachers with knowledge and skills to develop STEM-integrated tasks to be implemented in junior high school science classes. This study used a quantitative–qualitative approach to answer the research questions, using mixed methods to collect data. Participants are 40 junior high school teachers who participated in the program for one month in the school year 2022/2023. Based on data collected from worksheets, discussions, and interviews, it was verified that teachers recognized the importance of obtaining training in STEM education. This type of professional development was very relevant and improved their knowledge and skills to implement STEM hands-on practices in class. Finally, teachers could recognize the need to link STEM education with the need to change the student science learning process in line with the new Indonesian curriculum. Our recommendation for further research is that teachers need a quality understanding of curriculum that aligns with specific Science Learning Outcomes (SLO) and the ways to achieve that alternatively through STEM education.

1 INTRODUCTION

STEM education is widely used because it supports 21st-century skills (Rachmawati et al., 2023; Onsee & Nuangchalerm, 2019; Stehle & Peters-Burton, 2019) and promotes high student engagement in science (N. F. Sulaeman et al., 2022). It is a place where students can learn by thinking and making through their joyful exploration and collaboration (Balakrisnan et al., 2023). Former researchers stated that STEM could enhance students' idea comprehension, literacy, and creativity due to its relation to everyday life (Nugroho et al., 2021). Implementing STEM in class needs to consider teachers' mastery of STEM-related concepts and their readiness. However, the readiness of teachers is relatively low (Asiroglu & Akran, 2018; Wijaya et al., 2021). Teachers who are interested in STEM still lack confidence in their ability to teach the transdisciplinary concept in STEM elements [11]. Teacher readiness as the central role factor of a successful STEM class needs to be considered.

Although the introduction to STEM education has been conducted for Indonesian science educators(Rahmasuwarma & Kumano, 2019), the fixed duration of science lessons still became one of the challenges(Arlinwibowo et al., 2023). In line with the need to improve STEM in class, the new Indonesian curriculum was introduced in early 2020, namely the "Merdeka curriculum". This curriculum has an open opportunity to have integrated projects among subjects (Fitriyah & Wardani, 2022; Nugraha, 2022). This new Indonesian curriculum could be a new and innovative strategy in the Indonesian education system since teachers also clarified the

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importance of a flexible curriculum, such as an engineering-based one related to students' projects in science class (Margot & Kettler, 2019). Merdeka curriculum then brings more flexibility curriculum in a class by giving time allocation to integrate subjects and concepts related to real-life experiences (Mahardika et al., 2021). This new curriculum emphasized the integrated project that makes it possible to design a transdisciplinary project with a longer time span.

Regarding the innovative ways of the new Indonesian curriculum, it needs to adhere to the teachers' readiness and mastery of concepts related to STEM. However, the readiness still does not meet the prerequisite. Thus innovative ways to increase teachers' readiness in STEM education are needed (Diana et al., 2021). A number of studies concluded the positive impact of teacher preparation programs and training on their understanding of STEM concepts and readiness to become professional teachers (Song & Zhou, 2021; Toto et al., 2021). The teacher preparation program as the professional development for teachers could improve learner outcomes, increase teacher motivation, and provide some benefits for schools as institutional education (Angus Cole, 2021). Therefore, it needs to be designed related to the real curriculum implementation to gain the highest impact on teachers' readiness and give an overview of students' projects.

This paper presents an integrated approach to STEM education based on environmental issues as scenarios and developed in the context of collaborative Professional Development (PD) targeted to junior high school science teachers. The following research questions are addressed to guide the study: What are teachers' perceptions about science learning outcomes? What are teachers' perceptions of STEM PD? What are teachers' ideas for planning STEM projects?

2 METHOD

In this section, we start by introducing the Collaborative Professional Development (CPD), participants, and then followed by our research methodology.

2.1 Collaborative Professional Development for Science Teacher

Our research is part of continuous collaborative professional development among science teachers in a city around East Kalimantan Province, Indonesia. The program entitled "Professional Development for Science Teachers in STEM Education for Supporting Indonesian Curriculum" includes one-week workshops with altogether 36 hours duration (Table 1). The workshops aim to support science teachers' development of knowledge and skills in science, technology, engineering, and mathematics in relation to the new Indonesian curriculum. The curriculum was introduced in 2020, and gradually more and more schools are starting to use this curriculum. Science topics prepared in the STEM projects related to water and plants.

Table 1: CPD Workshops Schedule.

Workshops	Date	Duration
New Indonesian Curriculum and the Science Learning Outcome	14/02/2023	2 hours
Re-introduce STEM Education	15/02/2023	2 hours
Engineering Element through Paper Tower Project	15/02/2023	2 hours
STEM Project 1 Water Turbidity Measurement	15/02/2023	4 hours
STEM Project 2 Water Filtration	16/02/2023	4 hours
STEM Project 3 Eco-print	16/02/2023	4 hours
STEM Education and Its Representation in new Indonesian curriculum	17/02/2023	4 hours
Designing Module for STEM Project	17/02/2023	4 hours
Re-analyze the Module with School Context	18/02/2023	4 hours
Final Presentation	19/02/2023	6 hours
Total		36 hours

Table 2: Participants Demographic.

Gender	Number of Participants	Percentage (%)
Male	6	15
Female	34	85
Total	40	100

Table 3: Worksheets List.

Worksheet	Group	Individual
Science Learning Outcome		√
Example of STEM Project Water Turbidity Measurement	√	
Water Filtration	√	
Eco-print	√	
Your Own STEM Project	√	

2.2 Participants of Collaborative Professional Development

The CPD was developed in partnership with the Science Teacher Association, corporate social responsibility, and a national university in East Kalimantan province. The participants consist of 40 science teachers in Junior High Schools interested in developing their professional knowledge and skills related to STEM education. Participants' demographics can be seen in Table 2.

2.3 Methodology of Research

This study used a mixed methodology with a qualitative approach and also a quantitative approach. The qualitative methodology with an interpretative approach by some authors during the workshops (Cohen et al., 2007). This part of the research aims to understand a phenomenon in its real context from the participants throughout the workshop schedule. Then the quantitative approach was utilized to find the trend of participants' responses to worksheets through statistically descriptive (Fraenkel et al., 2012). The identities of our participants are fictitious to preserve their identities.

In each section of the workshops, participants were invited to fill in individual worksheets or group worksheets. At the end of the program, participants presented their individual written reports about their STEM Project ideas. All participants answered voluntarily with all the worksheets (Table 3). All the worksheets were previously validated by authors involved in each worksheet's constructions.

3 RESULTS AND DISCUSSION

In this section, the results and discussion are presented based on the participants' responses to the five worksheets during the workshops in Bontang City, East Kalimantan, Indonesia.

3.1 Perspective of Science Learning Outcome (SLO)

The topic of science learning outcome is presented at the beginning of our workshop. This section is essential because the alignment between the STEM workshop with the new Indonesian curriculum became the foundation of the whole program. We found that 85 percent of participants were familiar with the new Indonesian curriculum from the first individual worksheet. Due to the gradual implementation of the new curriculum, some participants stated that they were still using the former curriculum for this semester. From the SLO, most of the participants realized that the SLO in the new Indonesian curriculum opens the flexibility of arrangement and multi-disciplinary projects.

F15: In the 2013 curriculum, science learning outcome (SLO) and the flow of SLO have been determined, while in the *Merdeka* curriculum, teachers can design their own flow of SLO.

F17: *Merdeka* curriculum emphasizes the profile of Pancasila (which is six main skills for Indonesian that are also translated from 21st-century skills) and direct action of these values through projects. In addition, the material can be flexible according to the student's ability in school and can be continued to discuss in the following semester. In

contrast, the 2013 curriculum requires all material to be taught in one specific semester.

Since the new Indonesian curriculum transformed into certain novelties compared to the previous curriculum (Mulyadin et al., 2023), however, participants had already known the comparison in the essential contents, freedom of students, teachers, and school in the implementation, and employing activities through a project that emphasizes the profile of Pancasila. This perspective of SLO could be beneficial in developing the lesson plan, including the active learning classrooms. The active learning class, such as the project activity, positively related to students' learning outcomes (Mueller et al., 2015). Through the workshop, science teachers' professional development of knowledge and skills in STEM concerning the new Indonesian curriculum could be supported.

3.2 Perception of STEM PD

Most of the participants have experience with STEM PD in the former curriculum. However, they argue that it is difficult to implement the STEM approach in their regular science teaching because of the limitation of time and the strict SLO in the former curriculum. This perception of confusion between beneficial but challenging to implement is also found in science teachers in many other countries, such as the US (Margot & Kettler, 2019) and Europe (Thibaut et al., 2018). Through a series of workshops, teacher perspectives start emerging from the disciplinary understanding of science concepts to transdisciplinary understanding among STEM elements. Although global research stated that engineering across K-12 is emerging as a significant area in STEM (Abdulwahed & Hasna, 2017; Wijaya et al., 2021), its presence within integrated STEM education on science teachers' perspective deserves heightening. Through the group and class discussions, participants stated that the engineering element is less understood among the STEM elements.

The specific session in the PD about engineering tried to clarify the iterative process of engineering that consists of two main steps, which are (a) defining problems by specifying criteria and constraints for possible solutions, (b) optimizing the solution by systematically trying and testing, and then making decisions. Broadening the role of engineering design and elevating it to the same level as scientific inquiry(English, 2017) has become an interesting part that needs further concern. Although engineering can link the mathematics, science, and technology elements, engineering still requires greater recognition in these experiences.

M2: First time getting to know about STEM project in cooperation with the New Indonesia curriculum (project to strengthen the student characters), which didn't yet apply in my school. The effectiveness of teamwork through sharing gives an insightful experience.

F6: Through the STEM project, students could improve soft skills by practicing the flow of STEM, starting with defining problems, how to reach the solution, and preventing further similar ones. This transformation from focusing class on the material to students' process is needed, especially for implementing technology in class, which needs the teacher's supervision.

Teachers' significant increases in their knowledge to teach STEM could be seen by the improved understanding of STEM processes related to encouragement from the curriculum to conduct project-based learning. They could understand the main concept of STEM by participating in the scenario of the project based on teamwork. They also did the improvement on their social skill which were part of the learning outcome in the new curriculum. Projects have the engineering part of the new curriculum which also the elements of STEM (Syaputra et al., 2023). The engineering aspect linked with the project was also successfully promoted to teachers by their process in doing the projects. They also mentioned that PD gives them new insights into the importance of using technology in class to answer the challenge of 21st-century skills.

Most teacher participants, like common science teachers in Indonesia, did not have experience taking STEM courses during their teacher preparation program (N. F. Sulaeman et al., 2022). Therefore they mentioned that PD and the opportunity to collaborate with other teachers increase their ability to integrate STEM content into their curriculum effectively. Teachers reported significant increases in their confidence, knowledge, and efficacy in teaching STEM after attending professional development programs. Variation among teachers' age, gender, experience, and former PD of STEM education may influence their support and enthusiasm for STEM education initiatives.

Table 4: Planning STEM Project by Participants.

Project Name	Frequency	STEM Element
Eco print	I	S-E-M
Trash: Reduce, Reuse, Recycle	II	S-T-E-M
Balance Nutrition	II	S-T-E-M
Green School	II	S-T-E

3.3 Challenges of Making a New STEM Project

At the end of PD, participants designed their own STEM project in groups. The topic could be a continuation of the STEM project example in Table 1, or their new idea based on their understanding of SLO and school context. The result was analyzed by the authors and summarized in Table 4. From the result, most of the group proposed their original ideas for the STEM project, and only one group proposed to continue and re-design the eco print project. The projects related to environmental issues were mainly found because of the relation with awareness of the environment in the new Indonesian curriculum. These ideas showed their understanding of the crucial real-world context in STEM projects [26] beyond science content only (Dare et al., 2021). Although the linkage among STEM elements is mostly found, some project planning did not show components of technology or mathematics clearly.

Although the PD last workshops facilitated a group of teachers to design their own STEM project idea, the challenges to implement it were still found during the group discussion. The most common difficulties science teachers state in implementing STEM are teachers' insufficient comprehension of the elements of STEM and the linkage among them. Many arguments arise during the discussion, such as "Where is the engineering element on our STEM project?". Moreover, the other challenges revolve around the duration of conducting a STEM approach to learning, low self-efficacy in its implementation, the lack of facilities, and limited support in the school schedule and funding to conduct a STEM approach to learning.

4 CONCLUSION

Data collected from worksheets, discussions, and interviews verified that teachers recognized the importance of obtaining training in STEM education. This type of professional development was very relevant and improved their knowledge and skills to implement STEM hands-on practices in class. Finally, teachers could recognize the need to link STEM education with the need to change the student science learning process in line with the new Indonesian curriculum. Our recommendation for further research is that teachers need a quality understanding of curriculum that aligns with specific SLO and the ways to achieve that alternatively through STEM education. PD in STEM education needs to be a longitudinal study to support not only conceptual understanding and planning but also the implementation and reflection of the result.

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