

# The First International Conference on Neuroscience and Learning Technology (ICONSATIN 2021)

Jember, Indonesia • 18–19 September 2021

Editors • Arika Indah Kristiana and Ridho Alfarisi



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# Teacher professional knowledge: The implementation of STEM pedagogical content knowledge in pandemic era

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# Teacher Professional Knowledge: The Implementation of STEM Pedagogical Content Knowledge in Pandemic Era

Pramudya Dwi Aristya Putra <sup>1, a)</sup>, Erlia Narulita <sup>2, b)</sup>

<sup>1</sup>*Department of Science Education, Faculty of Teacher Training and Education, University of Jember, Jember, Indonesia*

<sup>2</sup>*Department of Biology Education, Faculty of Teacher Training and Education, University of Jember, Jember, Indonesia*

<sup>a)</sup> *Corresponding Author : pramudya.fkip@unej.ac.id*

<sup>b)</sup> *erlia.fkip@unej.ac.id*

**Abstract.** Teaching in STEM education has been challenged in the Asian context, particularly in the pandemic era. The teacher experience investigated to teach STEM in the classroom with a specific topic in physics give different phenomena related to teaching in the pandemic. This study aimed to investigate the teacher experience in implementing STEM education approaches based on the teacher's professional knowledge. The concept of pedagogical content knowledge (PCK) was a theoretical framework to adopt the criteria such as Pedagogical knowledge regarding STEM education, content knowledge regarding STEM education, Students' STEM education knowledge, STEM education curriculum knowledge, and Assessment Knowledge on STEM education. The narrative analysis was utilized in this study that described the teacher's situation in implementing STEM. The data collection uses three strategies: interview, documentation, and observation. The results indicated that teachers were teaching STEM education based on their perspective in understanding STEM education.

## INTRODUCTION

The integration between science, technology, engineering, and mathematics has been implemented globally, and it is believed that the approaches could improve student achievement [1] [2]. Teachers need to understand when adopting the STEM educational approaches in the classroom for supporting students. Some teacher activities have been utilized: STEM literacy [3], booster on a conceptualization of STEM education [4], integrating between STEM and engineering process [5]. All those activities were a teacher's effort to implement STEM educational approaches effectively in the classroom.

The development a conceptualization of STEM integrated education in the classroom was a challenge [6] [7]. The option of integrating between STEM is using the inter-discipline model, multidiscipline model, or transdisciplinary model [8]. The Interdisciplinary model focuses teachers in integrating between subjects using a specific topic. The subject composer could not separate the domain of subjects. The multidisciplinary subjects are the teacher using domain subject, which still appears the subject's composer. The transdisciplinary subjects are when teachers integrate not only in STEM subjects but also using other subjects.

Additionally, the conceptualization of STEM education has been investigated by the previous research. The models were found in the STEM professional development program for the teacher, including STEM as an acronym; Real-world Problem Solving as Context; Science as Context; Science, technology, engineering, and mathematics as separate disciplines; Integrated disciplines, Engineering Design Process as Context; Science and Engineering Design Process as context; and Engineering as Context [6] [9]. However, the engineering to infuse in the STEM discipline is a challenge in the Asian Context because engineering has not met the particular subject in Asia [10].



The implementation of STEM education approach in the classroom could be evaluated by focusing on how the mixture of content knowledge and pedagogical practices. Pedagogical Content Knowledge (PCK) is defined as the blend between pedagogical knowledge and content knowledge with a particular topic and particular subject [11]. The component of PCK was also divided into two categories: teacher knowledge and belief. Teacher knowledge is a teacher's capability for mastering the content area to explain structurally and organize the teacher [12]. An example of teacher knowledge is a concept of physics, chemistry, biology, or earth and space in natural science. While the teacher's belief is the teacher's confidence to be able to influence students in learning, motivate, and promote the science concept to achieve in the domain of knowledge [13]. The PCK is a challenge in the learning process when implemented in integrated subjects [14]. This situation occurs because the PCK is in a specific topic or specific subject. This study was aimed to investigate science teachers in the implementation of teacher professional knowledge in STEM education. The research question to guide the research in this study is: How do teachers implement the STEM educational approach based on the teachers' professional knowledge?

## METHODS

The methodology in this study was qualitative research with the narrative inquiry approaches [15]. This study told a story of three teachers in describing their experiences to teach STEM educational approaches in the pandemic era. The center of the investigation was how the teacher's implementation of their STEM perspective correlates with the teacher's professional knowledge (see Table 1). The context of the study was before the authors contacted all the participants; they already implemented STEM educational approaches in their classroom (before pandemic). They are implementing STEM educational approaches in the pandemic era to deliver the content of physics.

**TABLE 1.** The teacher professional knowledge was modified by Gess-Newsome [16]

Domain	Definition
Assessment Knowledge on STEM education	Knowledge about teachers' understanding of assessment methodology in the classroom
Pedagogical knowledge regarding the STEM education	Teacher knowledge on the selection of STEM specific topics that apply in the STEM domain
Content knowledge regarding STEM education	Understanding of STEM concepts regarding the National Curriculum
Students' STEM education knowledge	Knowledge of students' areas, including the difficulties of students in following specific subjects in the classroom.
STEM education curriculum knowledge	Knowledge of curriculum program in the STEM context area.

The participants of this study were three physics teachers that initially in Teacher A (teaching experience in 5 years as a physics teacher in Senior High School), teacher B (teaching experience in 7 years as a physics teacher in Senior High School), teacher C (teaching experience in 8 years as a physics teacher). All the participants were selected because they met the criteria: full-time teachers in the public school represented the same standard in the public school; had been experienced in teaching physics for more than five years; they all agreed to be investigated in STEM teaching.

The data collection was in the interview, documentation, and observation. The interview covered the teacher's perception of the STEM approaches, including their perspective, delivery methods, and the assessment in STEM education. The documentation was the teacher's recording when the teachers were teaching STEM in the classroom. The data in the observation was scored using teacher reform observation protocol, including Pedagogical knowledge regarding the STEM education (five items), Content knowledge regarding STEM education (four items), Students' STEM education knowledge (four items), STEM education curriculum knowledge (four items), and Assessment Knowledge on STEM education (three items).

The was transcribed mainly in the interview result because the data was in open-ended questions. The result was coded based on the teacher's perception of STEM education. Based on the video documentation, teaching style was observed using teacher reform protocol utilized in the Likert scale (1 = poor and 4 = good). The analysis for consistency used inter-rater validity specifically Cronbach kappa ( $\kappa$ ), which the score between 0 – 0,5 (rejected), 0,51 – 0,80 (reasonable), and 0,81 – 1 (acceptable) [17].

## RESULTS AND DISCUSSION

The result described the teacher condition in the implementation of STEM education in the pandemic era. Table 2 shows the teachers' perspective on understanding STEM education before implementing the STEM approach in the classroom.

**TABLE 2.** Teacher perception on STEM education before implementing of STEM education approach

Criteria	Teacher A	Teacher B	Teacher C
STEM Perspective	STEM is implementation between science and mathematics that students work together to solve a problem using those concepts	STEM is integrating learning between science, technology, engineering, and mathematics, and it should be thought in sequence methods in the classroom	STEM is a learning approach that connects science, technology, engineering, and mathematics to improve students' understanding of science concepts.
Model Learning that approves in STEM	Problem-based Learning or Inquiry	Project-based learning	Problem-based Learning
Assessment in STEM Education	Assessment in knowledge and skills	Process of learning when students develop a project in STEM education	Performance assessment both in individual learning and in group

After all three teachers expressed their understanding of STEM education, they teach using STEM education in the classroom. The domain of teacher professional knowledge was organized based on the items in the domain (see Table 3 for the teacher score based on the video recording).

- a. Pedagogical knowledge regarding the STEM education  
The result indicated that the teacher A's lesson in the classroom was less in STEM education. On the other hand, the learning environment that teacher A brought in traditional practices. For example, teacher A still focused on showing science phenomena than the real-world problem. She began with establishing students about the swings (pendulum motion) and asking students, "what is the cause of a harmonic motion?" Teacher B and teacher C focused on utilizing related subjects that use the silo subject.
- b. Content knowledge regarding STEM education  
Teacher A selected the simple pendulum as a topic in her lesson. She gave student's challenge to build a playground swing with the several criteria needed. Teacher B used elasticity as a topic in her classroom. She wanted the student to develop an enjoyable spring-bed for the customer. Teacher C used the theory of kinetic gases and asked students to design a hot balloon air. Teacher A uncertain that the student got an adequate understanding of the topic thought. She did reflect that she should explain the concept in front of the classroom before giving a science project to students. Teacher B had difficulty to integrate between several subjects in one lesson.
- c. Students' STEM education knowledge  
Teacher A explained that students were challenged to join in her room. Students had disregarded when the students designed their prototype. Students were hard to connect with the previous lesson in their classroom. Teacher B looked at their students' difficulties when they arranged the spring in her classroom. Students needed deep explanations about the spring arrangement. Teacher C observed that her students were unfamiliar with the hot balloon concepts. Students worried when they selected the material of the balloon, and it would be burnt.
- d. STEM education curriculum knowledge  
In the learning STEM activities, teacher A targeted that students know the physics concept basics in the physics vibration. The concepts included amplitude, period, and frequent to join in her classroom. Teacher B expected that students have already know the spring arrangement in series and parallel. Teacher C asked the students to learn Archimedes law before join in her classroom.

e. Assessment Knowledge on STEM education

All the teachers in the STEM classroom implemented students' portfolios to assess the students. They revealed that all the process in STEM classroom was essential to support students' evaluation. Also, teacher B and teacher C used group observation. Communication between students was needed to build a good design and successfully in the classroom in the STEM classroom.

**TABLE 3.** Mean score from two experts on Teacher Professional Knowledge in STEM education

	Domain	Teacher			Cronbach Kappa ( $\kappa$ )
		A	B	C	
1	Pedagogical knowledge regarding the STEM education	2.20	2.90	3.20	0.714
2	Content knowledge regarding STEM education	2.20	2.50	3.30	0.871
3	Students' STEM education knowledge	2.87	3.00	3.37	0.871
4	STEM education curriculum knowledge	3.25	3.38	3.63	0.870
5	Assessment Knowledge on STEM education	2.00	2.50	2.50	0.800

Teacher has been challenged to integrate science, technology, engineering, and mathematics mainly in the pandemic era. They still implemented the STEM approaches using separate subjects than integrated STEM (18). The applied curriculum was the one factor that STEM education was rare for the teacher—teachers less experienced in integrating STEM subjects (19). The content knowledge regarding STEM had a low score in teacher A and teacher B in the STEM classroom. The mastery of content knowledge in STEM education was also essential to build the understanding of STEM education in the classroom. Teachers should understand both STEM content knowledge and STEM conceptual (4). The lowest score in the professional teacher knowledge in STEM education was in the assessment knowledge toward STEM. In line with the previous research, the result was that the STEM education assessment lacked mastery for the teacher, mainly in Asian context study (20). The assessment in STEM education should improve the student's performance about the students' ideas, learning tasks, and adoption of evidence-based teaching practices in the STEM field.

This finding described the implementation of STEM education in the pandemic time of covid-19. When the teacher efforted to organize the STEM classroom, the situation unpredictable had risen at that time. The teacher's communication with the students also gives a challenge for that situation. Moreover, the limitation of this study also in the teacher selection was only in the female teacher.

## CONCLUSION

The finding in this study informed that there were vary of the implementations of STEM education based on the different teachers' perceptions in the STEM approaches. In the performance of teacher professional knowledge in STEM education, the perception of STEM education drove the teacher way to teach STEM in the classroom. Teaching STEM should give attention to balance in the mastery of content knowledge and the concept of STEM education. Teachers lack the implementation of the STEM assessment in the pandemic era. The situation in the classroom was less of the activities for involving students' communication, particularly to a workgroup.

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