Improving Early Childhood Teachers' Professionalism in STEM Education

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Abstract

Early childhood teachers who have a deep understanding of STEM are expected to develop learning activities in the classroom by using STEM education as an innovation in learning. This study is aimed to reveal if there was a significant difference between the perceived attitude, knowledge, and application of STEM before and after a group of teachers of early childhood education joined a professional development program, consisting of one-day opening seminar, a two-month online class, and a one-day closing seminar. The researchers applied convenience sampling to select participants. Seventy-seven participants were selected. In addition, the pretest and post-test were conducted before and after the online program. T-test and Pearson's correlation were conducted to analyze the data obtained from the 4 point-Likert-scale questionnaire asking the teachers to reveal their attitudes, knowledge, and application of STEM education. The results show that the teachers' perceived attitude before joining the professional development program is not statistically different from the one after joining the program (t (1,76) = 0.815, p > .05). However, there are statistically significant differences with regard to their knowledge (t (1,76) = 4.127, p < .05) and application (t (1,76) = 5.973, p < .05). Moreover, from quiz analysis, there was statistically improvement on understanding STEM education after professional development program (t (1,66) = 12.84, p < .05). The average score improvement was 33.47. *Also, this study shows an increase in teachers' understanding of STEM and teacher enthusiasm for STEM science based on teachers' opinions.*

1. Introduction

Childhood is a time to play, discover, and wonder. STEM education can facilitate children enter a world of joy and fun, with endless things to ask and investigate. Children want to know more about the world; consequently, most of their questions are related to STEM (science, technology, engineering, and mathematics) subjects. In early childhood, children's natural curiosity drives their desire to learn. STEM education has been promoted as a model that can assist early childhood students in creating a foundation of interdisciplinary knowledge [1].

STEM is a learning model that can be applied by emphasizing elements of science, technology, engineering, and mathematics. The activities of STEM education involved students learning concepts from multiple context areas to solve the problem in a real-life situation [2]. Sanders [3] describes integrated STEM education as an approach that explores teaching and learning between two or more areas of STEM, and collaboration between STEM subjects in schools. Students are engaged in student-centered learning in which they play an active role [3]; meanwhile the teacher's role is as both a teacher and facilitator to guide students in making decisions based on "what and how" to find solutions to existing problems [4]. To bring STEM education into the classroom, teachers need sufficient knowledge on how to teach early childhood students implementing a new learning model [5]. Teachers who do not have sufficient knowledge of STEM education, face more difficulties to apply the STEM model appropriately in the classroom [6]. A previous study found that there is a tendency for early childhood teachers to devote the largest proportion of time to science and math, especially at the pre-school level [7]. It is essential to manage early childhood teachers in a professional development program to develop their knowledge and application of STEM as well as to develop their attitude towards STEM education because teachers are the key implementer of the new model [1]. STEM teaching is an interdisciplinary approach to learning in which students learn and apply concepts in science, technology, engineering, and mathematics. By their nature, early childhood settings are prepared to support STEM learning.

Accordingly, the effectiveness and drawbacks of implementing STEM education are mainly according to teachers' knowledge and understanding on how to apply it in the classroom. Prior studies have found that teachers' attitudes and knowledge have a positive impact on learning in the classroom [8, 9]. The development of a child's play depends also on certain indicators of the professional skills of the teacher in relation to their ability to ensure the self-realization of the child's personality, create a reflexive field, and related communication to the real needs of the child [10]. STEM activities have many advantages for students at the level of Early Childhood Education,

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namely increasing curiosity, increasing courage in students to express opinions and increasing the ability of mathematical aspects that can develop simultaneously with technological abilities for students [11].

The number of kindergarten teachers in Indonesia reaches 358,057 people [12]. One of the obstacles experienced is the fact that not all teachers can be accommodated in various seminars and training conducted by the government in improving the teaching quality of the teachers. Therefore, in order to assist in overcoming the limitations of facilities for developing the ability of kindergarten teachers, the research team has held several training sessions for kindergarten teachers. The purpose of this study is. [to reveal if a professional development held can assist in overcoming the issue mentioned previously] The main research questions are formulated as follows:

i. What is the condition of early childhood teachers encompassing attitudes, knowledge, and application of STEM before and after STEM online professional development program?

ii. What is the relationship between teachers' attitudes, knowledge, and application of STEM learning?

Learning with the STEM approach is aligned with changing the early childhood education curriculum that needs to be carried out in Indonesia. The curriculum should be responsive in dealing with the needs of a dynamic world with the aim of preparing students to be ready in (1) changing conditions and the needs of an increasingly complex world demanding human resources who are responsive to all changes and critical of the problems they face; (2) globalization in the economic sector which resulted in increasingly looser boundaries between countries, in terms of fulfilling employment; and (3) the rapid development of science and technology has insisted the fact that the world is borderless [13]. In the field of early childhood, there are many innovative activities aimed at improving children's knowledge and skills in the fields of science, technology, engineering, and mathematics (STEM). The activity aims to implement a STEM program or curriculum by providing effective professional development for early childhood educators [11].

In the 2014 Regulation of the Minister of Education and Culture of the Republic of Indonesia, development policy according to the age level of children includes aspects of religious and moral values, physical-motor, cognitive, language, socio-emotional, and art. Cognitive elements consist of (1) learning and problem-solving, including the ability to solve simple problems in daily life in a flexible and socially acceptable way and apply knowledge or experience in new contexts;, (2) logical thinking, including various differences, classifications, patterns, initiative aspect, planning and cause-effect recognition;, and (3) symbolic thinking, including the ability to recognize, mention, and use the concept of numbers, letters, various objects and imagination in the form of pictures [14].

2. Methods

Participants in this study were 77 early childhood teachers in Indonesia. The participants were selected based on convenience sampling. The participants were selected from different areas in Indonesia; 2.6% Ambon, 13.0% Ende, 33.8% West Kalimantan, 2.6% South Kalimantan, 5.2% North Kalimantan, 3.9% Lombok, 6.5% Maluku, and 32.5% Surabaya (Table 1). The teachers have various teaching experiences (23.4% less than 6 years, 18.2% 6-10 years, 24.7% 11-15 years, and 33.8% more than 15 years) (Table 1). To collect the data, the researchers surveyed all teachers who were in attendance at the online professional conferences. The questionnaires were administered before and after the professional development program implementation and was conducted using an online platform during the opening seminar and and the closing seminar. The teachers took an overage of 30 minutes to complete the questionnaire. The questionnaire was used to explore teachers' attitudes, knowledge, and application of STEM education.

2.1. The Professional Development Program

Teachers need STEM education to improve their ability to teach early childhood students. A professional development program (PDP) can then be carried out for this particular purpose: to build teacher confidence and competence, both in terms of STEM expertise and STEM pedagogy [15]. At the early childhood education level, many early childhood educators are reluctant to engage in intentional teaching of mathematics, science, and technology [16].

The PDP in this study is divided into three (3) important main events in this research. First, initial seminars and professional development programs related to STEM were attended by 170 participants. Second, the activities in the online class in the learning management system (LMS) which was made specifically for the research subjects were participated by 116 teachers. For the online class activities, the research team presented modules used as the part of the online learning modules for early childhood teachers. These learning modules comprised, among others, alternative activities for early childhood teachers to use in their teaching learning. At the end of these modules, techniques for implementing online learning were also presented.

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Teachers the teachers of early childhood education participated in a 3-month professional development program which was aimed to engage them in STEM education. The PDP provided them the opportunities to learn STEM activities developed by the authors. Before the online professional conference, the teachers filled out a questionnaire regarding their attitude, knowledge, and application of STEM education.

Online professional development programs were conducted synchronously and asynchronously using the zoom platform and a website-based LMS platform. The materials provided for the professional development program have four themes including animals, plants, recreation and job-occupation. In each theme, there are two STEM video activities based on the early childhood curriculum in Indonesia. An example of a STEM-based activity shown in the learning video on or a Plant theme indicates the following steps:

i. Make a circle pattern to coat the paper plate, cut out the circle pattern, and line the plate with paper that has been cut using liquid glue.

ii. Line the paper plate. The underside is colored brown. The top is colored blue.

iii. Prepare a hole punch to punch holes in the brown side.

iv. Cut a few strands of wool. Next, put tape on each end of the thread.

v. Insert the wool thread in the provided hole.

vi. Form a carrot pattern on the orange foam heart. The carrot leaf pattern is on a green foam heart. Cut according to the pattern, then paste the carrot leaf pattern on the carrot pattern.

Implicitly, some crucial elements with regard to STEM education in the steps exemplified above are indicated. The science element in this activity is to introduce an example of a plant, namely carrots. The teacher explains the parts of carrots and which parts of carrots are used to become carrot seeds. Next, the teacher explains the environment/place to plant carrots to support their growth and what carrots need to grow. The technology element in this activity is the use of several tools to draw the shape of carrots and their leaves. The teacher uses scissors to cut the paper or uses a perforator to make holes in the paper. Engineering elements are carried out in several activities. The activity in this engineering element is to design a pattern for the parts of the carrot and the place where the carrots are planted to form the carrots that have been planted. In this activity, the teacher uses a pencil to make a pattern on the paper and cuts the paper according to the pattern. Next, the teacher arranges the carrot parts so that they become a carrot image. Mathematics elements in this activity are contained in the following things. First, the teacher introduces the circle pattern and parts of the circle such as the center of the circle, the radius of the circle and the diameter of the circle. Second, the teacher shows that the length of the diameter of the circle is equal to twice the length of the radius of the circle. Third, the teacher determines the length of the diameter of the circle made so that it fits the size of the paper plate. Fourth, the teacher determines the length of the wool thread needed.

Table 1. Participants' personal and professional demographics

	Groups	N	Percentage
Teaching experience	Less than 6 years	18	23.40%
	6-10 years	14	18.20%
	11-15 years	19	24.70%
	More than 15 years	26	33.80%
Age	Less than 31 years	11	14.30%
	31-40 years	24	31.20%
	41-50 years	28	36.40%
	More than 50 years	14	18.20%
Area	Ambon	2	2.60%
	Ende	10	13.00%
	West Kalimantan	26	33.80%
	South Kalimantan	2	2.60%
	North Kalimantan	4	5.20%
	Lombok	3	3.90%
	Maluku	5	6.50%
	Surabaya	25	32.50%
Level of education	Senior high	8	10.40%
	Diploma	4	5.20%
	Bachelor	61	79.20%
	Master	4	5.20%
Gender	Male	1	1.30%
	Female	76	85.70%

2.1.1. Quiz. The teachers were given a quiz before and after the PDP. The quiz was employed to check teachers' understanding of STEM education. This quiz was developed by authors consisted of 8 true-false items. Each item was related the conceptions of STEM education. For instance, STEM education at early childhood is crucial for the development of students' literacy.

2.1.2. Questionnaire. A set of questionnaire adapted from Wahono and Chang (2019) [17] was utilized. It consisted of 30 items that measured three domains: attitude, knowledge, and application of STEM education. The attitude domain consisted of three items related to feeling about STEM education. For example, "I am very interested to know more how to apply the mathematical, technology, and engineering approaches in teaching in the classroom". The knowledge domain comprised **4** four items related to the understanding of STEM education. For example, "I am convinced that STEM compile of integrated science, technology, engineering, and math or compile of at least two of those discipline". The application domain consisted of 23 items related to how to apply STEM model in the classroom. For instance, "I prepare or ask students to bring simple material to design a particular model, together to search for information through the website or following a particular procedure to produce something and calculate the appropriate form (maximum length, breadth ideal, etc. for the design". The responses to the questionnaire items were rated by the teachers on a 4-point Likert scale: 1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree. Cronbach's Alpha indicated high reliability for each domain (Knowledge, a = 0.90; application, a = 0.86; attitude a = 0.86).

2.1.3. Data Analysis. Quantitative data obtained from pre and post questionnaire and quiz to explore teachers' attitudes, knowledge, and application of STEM model were analyzed using SPSS 23 statistical package. The teachers' perceptions of STEM education were analyzed. A repeated measured t-test was applied to analyze the pre-test and post-test scores of teachers' attitudes, knowledge, and application of STEM education. For all tests, significance was reported at the $p < .05$ level.

3. Results

To understand the effect of the online professional development program on the teachers' knowledge and application of STEM education, and attitude towards STEM education, the pre-test and post-test were analyzed using a repeated measured t-test. Table 2 shows the means and standard deviation for the scores for each STEM domain. It can be seen that the means posttest scores were higher than the mean pretest score in all STEM domains - − attitude, knowledge, and application. The pretest and posttest mean scores and standard deviations for each STEM domain are attitude (M_1=3.718, SD_1=0.409; M_2=3.762, SD_2=0.386), knowledge (M_1=3.060, SD_1=0.635; M_2=3.377, SD_2=0.526), and application (M_1=2.778, SD_1=0.491; M_2=3.126, SD_2=0.491). were reported to be M_1=3.718, SD_1=0.409; M_2=3.762, SD_2=0.386 for attitude, M_1=3.060, SD_1=0.635; M_2=3.377, SD_2=0.526 for knowledge and M_1=2.778, SD_1=0.491; M_2=3.126, SD_2=0.491 for application.

3.1. Teachers' Perceived Attitudes of STEM Education

With regard to attitude domain, this study found that there was not statistically significant difference (t (1,76) = 0.815, p > .05).

Table 2. Repeated t-test for Attitude toward STEM education (N=77)

	Mean	SD	t_{value}	p
Pretest	3.718	0.409	0.815	.428
Posttest	3.762	0.386		

Note: **p <.05 is statistically significant. M: Mean score, SD: standard deviation, p: probability value.

From teachers' opinions about STEM activity, the majority of the teachers responded positively about the videos of STEM activity. They wanted to implement STEM activity in their classroom:

"*In my opinion, the activity is very good to be implemented in the classroom because it can introduce STEM to students and at the same time children can recognize various kinds of fruits and vegetables even though only through activities in class*".

"*The activities are good, interesting, and can be implemented in the class, this activity can introduce STEM learning whose contents include introducing names, shapes, colors, quantities, names of tools, how to use and so on*".

"*Planting activities can be carried out by children, although they still need the help of educators in several activities, 6 aspects that are expected to appear are fulfilled and the stem method can also be carried out in these activities, introducing the concept of numbers, various vegetables, making patterns, cutting, pasting and weaving*".

Based on the participants' comments above, the participants showed interest in developing learning in the classroom with STEM activities. STEM education aims to cultivate students' abilities and tendencies to identify questions and solve problems related to STEM-related problems and nature and the world designed according to the curriculum to achieve maximum learning goals [18].

3.2. Teachers' Perceived Knowledge of STEM Education

The results of the questionnaire - As of knowledge domain, there was a statistically significant difference

(t (1,76) = 4.127, p < .05) (see Table 3).

Table 3. Repeated t-test for Knowledge of STEM (N=77)

	Mean	SD	t_{value}	p
Pretest	3.060	0.635	4.127	.000**
Posttest	3.377	0.526		

Note: **p <.05 is statistically significant. M: Mean score, SD: standard deviation, p: probability value.

The results of the quiz - Table 4 shows the quiz score before professional development programs (pretest) and after the professional program (posttest). From 77 participants, only 67 completed the quiz. The results of the statistical analysis revealed that there was statistically improvement on understanding STEM education after the PDP (t (1,66) = 12.84, p < .05). The average score improvement was 33.47.

Table 4. t-test for quiz before and after professional development program (N=67)

	Mean	SD	t_{value}	p
Pretest	48.06	17.59	12.84	.000
Posttest	81.53	18.11		

3.3. Teachers' Perceived Application of STEM Application

Table 5 shows the pretest and posttest scores of teachers' perceived application of STEM education. This study found that there was a statistically significant difference in teachers' perceived application of STEM education (t (1,76) = 5.973, p < .05).

Table 5. Repeated t-test for Application of STEM domain (N=77)

	Mean	SD	t_{value}	p
Pretest	2.778	0.491	5.973	.000**
Posttest	3.126	0.491		

Note: **p <.05 is statistically significant. M: Mean score, SD: standard deviation, p: probability value.

3.4. Correlation between attitude, knowledge, and application of STEM education

A follow-up examination of how teachers' attitude related to knowledge, and application of STEM education. Researchers have analyzed the post-test score using Person's correlation. The results show that there was a significant positive correlation between attitude and knowledge, (r (75) = 0.43, p < .05) (Table 6). The results also indicate that there was significant positive correlation between attitude and application, (r (75) = 0.39, p < .05). The results also indicate that there is significant positive correlation between knowledge and application, (r (75) = 0.74, p < .05).

Table 6. Correlation among the teachers' attitude, knowledge, and application

	M	SD	1	2	3
1. Attitude	3.76	0.39	1		
2. Knowledge	3.38	0.53	0.43**	1	
3. Application	3.30	0.49	0.39**	.74**	1

Note: **p <.05 is statistically significant. M: Mean score, SD: standard deviation.

4. Discussion

The understanding of STEM for Early Childhood Education teachers can be seen in several things obtained in this study. This study aims to reveal whether there is an increase in teachers' understanding of STEM and whether there is a significant difference between teachers' perceived attitudes, knowledge, and application of STEM before and after the professional development program. The professional development program activities were carried out in three parts, namely opening seminars, asynchronous learning processes through online classes, and closing seminars. a closing seminar

At the opening seminar activity, the teacher teachers took a STEM quiz. Furthermore, in asynchronous learning activities, teachers studied learning modules that have had been prepared based on the applicable curriculum in Indonesia by presenting discussion activities between Childhood Education teachers in Indonesia, which consist consists of several provinces in Indonesia. The asynchronous learning process ends ended with the peer-teacher assessment process giving each other an assessment of the lesson plans. And at the closing seminar, the teacher presented a lesson plan by applying STEM elements in the activity, took a STEM quiz and continued to deliver material related to the field of Early Childhood Education and information related to STEM.

The findings from this study revealed that there were not significant differences in attitudes before and after online professional development program. One of possible explanation for this finding is that early childhood teachers in Indonesia already have had high attitudes towards STEM education before they participated in online professional development program (M=3.18). Moreover, the difference between pretest and posttest scores was statistically significant on knowledge and application. This indicates that the STEM online professional development program has proved to be meaningful for teachers to improve their understand of STEM model. Participating in the STEM professional development program provides

early childhood teachers STEM content and influence their knowledge of STEM learning [5].

5. Conclusion

The use of STEM videos has allowed teachers to understand how to design and implement STEM learning in early childhood school. The teachers finally increase their knowledge of STEM and understand how to teach science, technology, engineering, and mathematics in learning topics according to the curriculum. [6]. In discussion activities, teachers from various different places in Indonesia share their experiences and knowledge through feedback given after watching videos of educational game tools that have been designed to be STEM based. More than 50% of teachers gave a positive response to the videos that have been designed by emphasizing STEM education so that it shows that there are new things that teachers get from these activities.

Moreover, there is a significant correlation between teachers' attitudes, knowledge, and application of STEM. And a highly significant correlation between knowledge and application. This indicates that teachers with high attitudes towards STEM education perform better knowledge on how to apply STEM. The previous study has found that attitude has positive correlation with knowledge [19].

The findings have implications for early childhood teachers to develop knowledge and how to apply STEM. Teachers of young learners need to be engaged in professional learning community [20]. It benefits from understanding what STEM is termed in early childhood education [21].

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