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Enhancing Technological Pedagogical and Content Knowledge (TPACK) of Elementary School Teachers Through 21stmisE Workshop

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Abstract: This study was to determine the effectiveness of the 21stmisE workshop in improving the TPACK of elementary school teachers. A quantitative research with a pre-test and post-test control group design was employed. The 21stmisE workshop involved 60 elementary school teachers from Surakarta, Indonesia. The sampling technique was carried out by stratified purposive sampling. The instruments included test, questionnaire, and peer-teaching assessment sheets. Data were analyzed using descriptive analysis, independent sample t-test, and normalized gain. The results showed that the 21stmisE workshop was effective in fostering the TPACK of elementary school teachers. This was proven by an increase in n-gain scores which reached 0.76 (high category). The effectiveness of the 21stmisE workshop in promoting TPACK can be used as a recommendation that the 21stmisE workshop is one of the programs that can improve the quality of elementary school teachers in teaching science. Thus, it can be used as a tool to develop the professionalism of elementary school teachers in a sustainable manner. Policymakers, both principals and education offices at various levels, can continue to motivate teachers under their auspices to participate in this kind of workshop.

Keywords: *21stmisE workshop; TPACK; elementary school teacher*

A. INTRODUCTION

Teachers are one of the professions that require special skills in carrying out each of their duties professionally. The teacher's task is not only to convey subject matter to students but also to package various learning experiences to make it more interesting to make it easier for students to understand the lesson (Rochintaniawati et al., 2019). In this context, teachers need a tool or technology that is able to transfer material to make it easier for students to understand. It describes a framework of Technological Pedagogical and Content Knowledge (TPACK). TPACK is an understanding that is built from the interaction between understanding content, pedagogy, and technology (Koehler et al., 2013; Koehler et al., 2014). Thus, it can be said that if the teacher's TPACK is good, then the teacher has become a professional teacher in carrying out his duties (Maharani, N.W.A.U.S, et al. 2022). Teacher TPACK is one of the highlights for achieving educational goals in Indonesia because, with a good TPACK, teachers are able to arrange learning tools, use technology well in learning activities (Nurmatin & Purwianingsih, 2017).With a good TPACK which is evaluated continuously, teachers are able to condition student activities to be more active and followed by high learning outcomes (Yanti & Riandi, 2019); (Resbiantoro, G, 2016); (Kholid, M.N, el.al, 2023).

In Indonesia, science in elementary schools is one of the lessons taught by classroom teachers and not subject teachers. The position and task of this class teacher are to teach several lesson content, one of which is science content which has been thematically structured in student books. Although taught thematically and/or flowing with other subject matter, elementary school teachers are still required to understand and teach science concepts well. Teachers are required to teach science material using various approaches, models, and innovative technology-based learning strategies to students. In other words, the TPACK of elementary school teachers in science lesson content is in good condition, so that the science material can be understood by students well. However, based on observations in the field, elementary school teachers in Surakarta tend to not understand the concept of science well, and still experience misconceptions. They still apply various approaches and learning models that are not in accordance with the characteristics of the science concept and have not fully integrated the technology that can help transfer the concept. This is indicated by the achievement of the TPACK score in the science field, which is 55.612 (enough category), so it needs to be improved. This condition is reinforced by Nurdiana (2016) who also stated that the competence of elementary school teachers in the field of science needed to be improved. According to him, many teachers, especially elementary school teachers, have not received training to improve their competence.

Improving competence in the field of science for teachers needs to be improved so that the teaching and learning process can run effectively (Anif, S & Zain, Al, 2015). This can be done if the teacher has a good understanding of the content and understanding of the material or pedagogic skills skills (Tanang et al., 2014). Improving science competence for elementary school teachers can be done through various teacher professional development activities, including training activities, workshops, further studies, seminars, and comparative studies (Chiappeta & Koballa, 2010; Kang, 2007); (Fitriansyah, et. al, 2020). Recommendation from (Chang et al., 2010); that studies on professional development and issues related to science will become a deeper concern at the end of this year. This shows that problems in science learning can be solved through teacher professional development activities. In the 21st century, improving teacher competence needs to be equipped with soft skills so that teachers are able to face various global challenges. The workshop is one of the continuous professional development processes in which teachers review, renew, and expand their commitment as agents of change for teaching purposes (Day, 1999). The 21stmisE workshop is one of the professional development processes for elementary school teachers in teaching science. This workshop is designed to increase TPACK in the field of science through handling the condition of teacher misconceptions in understanding science material. Teachers are equipped with the knowledge and skills to be able to carry out technology-based teaching that is adapted to the demands of learning in the 21st century. The activities carried out during the workshop accommodate the teacher's professional development process and apply learning steps that can change the way teachers teach science. The six activities in the 21stmisE workshop (i.e. prepare, investigate, mini lesson, plan, apply, and reflect) condition the teacher's TPACK to increase, both in terms of knowledge and skills in applying it to a teaching (Desstya et al., 2019). The 21^{st}misE workshop is carried out for 33 hours of lessons.

In fact, so far, the improvement of TPACK in the science field has been carried out through several activities, including TPACK development courses (Aktas & Ozmen, 2020) which is carried out in several stages, namely a training course, lesson plans involving the application of micro-teaching, and school application. Second, it is carried out through education that has been programmed within a certain period of time, namely learning to program, designing lessons, and developing programs (Kim & Lee, 2018). The increase in TPACK has been carried out through the provision of TPACK-based website facilities (Wilujeng et al., 2020). This website uses IT technology in which it provides various science content, several theories, and applications of learning models that are in accordance with the nature of science. The description above illustrates that the implementation of the 21stmisE workshop for increasing TPACK in the science field has not yet been implemented. Thus, it is important to conduct a study to test the effectiveness of the 21stmisE workshop in increasing the TPACK of elementary school teachers in science.

B. MATERIALS AND METHODS

1. Research Design

This type of research was quantitative with a quasi-experimental design with a nonequivalent control group design.

2. Participant

This workshop involved 60 fourth-grade elementary school teachers (20 males and 40 females), using a stratified purposive sampling technique, from public and private schools, with very good and good school quality, spread over five sub-districts in Surakarta, Central Java, Indonesia. Each category is represented by one teacher from public and private schools. The experimental group (n = 30) was involved in the 21^{st}misE workshop and the control group (n = 30) was involved in the conventional workshop activities. All participants were between 30 and 50 years old. There are 80% of participants have been certified educators. The independent variable in this study was the implementation of the 21stmisE workshop, while the dependent variable was the TPACK of elementary school teachers in the science field.

3. Material

The instrument used to assess teacher TPACK was a 4-point Likert scale questionnaire (18 items), which is used to determine the suitability of the available statements with the actual conditions of the teacher on aspects of TPACK. The TPACK test has a rating scale of 0 to 100 and a peer-teaching score sheet is used to assess the product. The peer-teaching assessment sheet consisted of 22 items in three stages of learning, namely opening, core, and closing learning. All of these instruments were developed based on the established TPACK indicators, for example, Technological Knowledge/TK (e.g., I utilize technology to deliver lessons in the classroom), Pedagogical Knowledge/PK (e.g., I design thematic lessons to reduce misconceptions in science), Content Knowledge/CK (e.g., I understand science concepts well), Technological Content Knowledge/TCK (e.g., I use the internet and technological tools to convey scientific concepts), and Pedagogical Content Knowledge/PCK (e.g., I employ various effective learning strategies to transfer scientific concepts). The reliability coefficient of the questionnaire was 0.85

4. Procedure

Each item in the questionnaire was rated on a scale of 1 to 4, with the criteria of 1 (not good), 2 (poor), 3 (good), and 4 (very good). The minimum score obtained by the teacher was 18 and the maximum score was 72. The rules for determining the final score of the TPACK questionnaire were calculated using the formula:

Questionnaire score =

$$\frac{\textit{the score obtained by the teacher}}{\textit{maximal score}\ (=72)} x100$$

In the TPACK test, the seven indicators were scored respectively 100-76 (there are all descriptors), 51-75 (there are most descriptors), 26-50 (there are some descriptors), and 0-25 (there are few descriptors). The maximum score achieved was 100 and the minimum was 0. The final score of the TPACK test was calculated using the following formula:

TPACK test = the average score of the seven aspects of TPACK

The peer-teaching observation sheet consisted of 22 assessment items, each of which was rated on a Likert scale of 1 to 4, with the provisions of 1 (not good), 2 (not good), 3 (good), and 4 (very good). The minimum score obtained was 22 and the maximum was

88. The final peer-teaching score was calculated based on the formula:

Peer-teaching score =

$$\frac{\textit{the score obtainde by the teacher}}{\textit{maximum score }(=88)} x100$$

The final TPACK score was the average of the TPACK questionnaire scores, TPACK test scores, and peer teaching activity scores, which are calculated using the following formula :

Final score TPACK =

$$\frac{\textit{questionare score} + \textit{test score} + \textit{peer}-\textit{teaching score}\,)}{3}$$

5. Data Analysis

Descriptive analysis was carried out on the data from the results of filling out questionnaires, tests, and observations of the implementation of peer-teaching, which was carried out by processing scores into values. Data analysis to test the hypothesis was done by *t*-test. The *t*-test was used to determine the difference in teacher TPACK in the experimental and control groups. The *t*-test was carried out using SPSS 22. Before testing the hypothesis, a prerequisite test was carried out in the form of a normality test and a homogeneity test. The normality test was carried out to determine the normality of the data from the sample studied. This normality test was carried out on the average teacher TPACK results from the pre-test and post-test both in the group that was treated with the 21stmisE workshop model and those who were not. Normality test was performed with SPSS 22 using Shapiro Wilk. If the value of sig > 0.05, then the data is normally distributed, and if the significance is less than 0.05 then the data is not normally distributed (Priyatno, 2010).

A homogeneity test was conducted to determine whether the sample was taken from the homogeneous variance or not. The homogeneity test on the mean TPACK results in both groups was carried out using Levene's test with SPSS 22. If the value of sig > 0.05, then the sample was homogeneous. Hypothesis testing can be continued if the data is normally distributed and comes from a homogeneous sample. Hypothesis testing was conducted to compare the TPACK pretest-posttest scores of the experimental and control groups. Hypothesis testing was done by using an independent sample *t*-test. If sig (2-tailed) > 0.05, then Ho is accepted and if sig (2-tailed) < 0.05, then Ho is rejected. This test was carried out with the help of SPSS 22 software. Then, normalized gain analysis was used to determine whether there was an increase in the pre-test and post-test scores of the experimental and control groups. Normalized gain is also a test to determine the effectiveness of the applied workshop model.

The average TPACK score of the three types of assessments was analyzed using the normalized gain equation with a minimum score of more than 0.70 in the high category. The equation for calculating *n*-gain is as follows:

$$n\text{-gain} = \frac{post-test-pre-test\ scores}{maximum-\ pre-test\ scores}$$

The n-gain value obtained is then interpreted into 3 categories (Hake, 1998) according to **Table 1**.

Table 1. Categories of n-gain values

N- gain	Category
g > 0.70	High
0.30 ≤ g ≤ 0.70	Moderate
g < 0.30	Low

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C. RESULT AND DISCUSSION

1. Result

The TPACK data for elementary school teachers in the Surakarta area in the control group, during the pretest and post-test, are presented in **Table 2**.

Table 2. Descriptive statistics of TPACK in control group

est		Min	Max	Mean	SD
Pre-test	0	32.389	73.885	57.001	10.261
Post-test	0	37.117	61.856	51.299	7.149

Table 2 shows that in the control group, during the pre-test, the lowest and highest TPACK scores were 32.389 and 73,885 respectively. Meanwhile, during the post-test, the lowest and highest scores were 37.117 and 61.856, respectively. The average TPACK score actually decreased, namely at the pretest of 57.001 while the posttest was 51.299. The TPACK score of elementary school teachers in the experimental group, during the pretest and post-test, are presented in **Table 3.**

Table 3. Descriptive statistics of TPACK in experimental group

Te		Min	Max	Mean	SD
Pre-test	0	30.655	69.817	55.748	9.561
Post-test	0	53.149	90.682	75.548	8.90

While in Table 3, it can be seen that in the experimental group, before treatment, the lowest and highest TPACK scores were 30.655 and 69.817, respectively. Meanwhile, after treatment, the lowest and highest scores were 53.149 and 90.682, respectively. The average TPACK score generally increased from pre-test to post-test, namely 55.748 to 75.548.

In the prerequisite test for normality using Shapiro-Wilk, the significance values for the initial TPACK scores of the control and experimental groups were 0.196 and 0.222 (more than 0.05), so it is said that the data are normally distributed. In the homogeneity test using Levene's test, sig values of 0.232 and 0.189 (more than 0.05) were obtained in the experimental and control groups, so that the data came from homogeneous samples.

In testing the hypothesis, a hypothesis has been set for testing, namely: *Ho*: There is no difference in the TPACK of teachers who applied the 21stmisE workshop model to the conventional workshop model. *Ha*: There are differences in the TPACK of teachers who apply the 21stmisE workshop model to the conventional workshop model. Hypothesis testing with the *t*-test is determined if the value of Sig (2-tailed) < 0.05 then Ho is rejected, and if the value of Sig (2-tailed) > 0.05 then Ho is accepted. The results of testing this hypothesis obtained a significance value of 0.000 (smaller than 0.05) so that Ho was rejected. It was concluded that there was a significant difference in teacher TPACK scores in the group that applied the 21stmisE workshop model and the conventional workshop model. The test results with normalized gain show that in the experimental group, *n*-gain is 0.761. This shows that the 21stmisE workshop model is effective in the high category to improve the TPACK of elementary school teachers in science lessons.

2. Discussion

The 21stmisE workshop is a workshop model with six syntaxes or activities, namely prepare, investigate, mini-lessons, plan, apply and reflect (Desstya et al., 2019). This model is effective in increasing the TPACK of elementary school teachers, especially when teaching science. This is reinforced by the findings (Jaipal-Jamani & Figg, 2015) that the workshop model is an effective way to improve several aspects of TPACK. Technological Pedagogical and Content Knowledge (TPACK) is a type of knowledge needed by teachers to teach effectively using technology (Koehler et al., 2013). TPACK is an understanding that arises from the interaction between content knowledge, pedagogy, and technology (Koehler et al., 2014). The results of this study indicate that the understanding of elementary school teachers towards the interaction of science content knowledge, pedagogy, and technology (TPACK) in general who participated in the 21stmisE workshop increased from 55.748 to 75.548.

At the end of the workshop activity, TK showed the lowest mastery of other aspects of TPACK but still experienced an increase, as presented in Figure 1. This increase shows that teachers already have an understanding of computer technology, are able to operate computers, use MS Word programs to document learning administration, understanding how to access the internet, being able to display it in PowerPoint (PPT) form, and using non-ICT technology to help understand science concepts. This increase was seen because, during the workshop, teachers were instructed to observe and analyze video shows about learning technology and then reflect and synthesize them. The results of the synthesis are then applied to complete the project to develop science learning scenarios. Learning scenarios must include several pictures or include a video link from a youtube channel or others. In addition, teachers are also required to determine some simple technology (non-IT) based on ethnoscience to teach science concepts.

These demands or obligations condition the teacher to learn to understand and operate applications and or programs contained in the computer. This is in line with the study conducted by Rust (2014) who found that workshops can provide practical changes for those involved in them. The results of this study indicate that elementary school teachers are becoming more skilled in operating computers and available applications. Teachers are starting to be able to identify some simple technologies such as used syrup bottles, candles, matches, and other objects that are expected to be used to teach science concepts. With this increase, it can be assured that the learning that will be applied in the future can improve student learning outcomes (Hartini et al., 2017)

Pedagogical Knowledge (PK) is a teacher's in-depth knowledge about processes and practices or teaching and learning methods (Koehler et al., 2013). PK appears when the teacher applies to learn (Nuangchalerm, 2011). This study strengthens the results of this study. In addition to understanding the learning model that can reduce science misconceptions, teachers have also been able to apply the learning model in peer teaching activities. The learning model in question is the conceptual change model (CCM). Before joining the 21[st]misE workshop, the teacher did not know and understand CCM. As stated by Yip (2001), CCM is an effective learning model in teaching science. Rollnick and Rutherford (2015) stated that CCM is a learning model that is able to remediate misconceptions. Teachers' understanding of CCM is the main target in the 21[st]misE workshop. This is also reinforced by Redhana et al. (2017). They stated that for more than a decade, this CCM has had a great influence on students' conceptions. This shows that the provision of material on CCM in this workshop activity is to overcome the problems of misconceptions experienced by teachers and students. As reported in previous literature (e.g., Desstya et al., 2019; 2021; Laeli et al., 2020; Soeharto et al., 2019), misconceptions in students and teachers have often occurred in science learning. In this study, the syntax in the CCM was modified and then termed "*Prediction Ibu Kasi*", namely: (i) *Prediction* (allowing students to predict answers to questions that have been given, (ii) *Ideas* (putting ideas to small groups and large groups), (iii) *Prove* (proving predictions that have been stated previously through experiments), (iv) *Apply* (applying understood concepts to everyday life).

Content Knowledge (CK) is knowledge about concepts, principles, relationships, processes, and applications that students must know about the certain subject matter (Ozden, 2008). The statement explains that as a teacher you must also understand the concepts, principles, law, theory, that is a body of knowledge (Sayekti, I.C, et. al, 2019) and relationships before teaching to students. CK in this study refers to teachers' understanding of science concepts in 4th grade, and understanding each sub-subject without any misconceptions, and knowing the ethnoscience aspects of ethnotechnology that are integrated with science. These three indicators can be seen in the determination and in-depth understanding of the material based on the basic competencies that have been presented. The teacher's CK emphasizes the concepts of gravity, the speed of light, and the high and low of sound and teaches them without any misconceptions. Ethnoscience ethnotechnology is a form of cultural knowledge possessed by certain tribes, where this knowledge is used as a basis for developing appropriate technology or techniques and is used to address problems that exist in the local community (Desstya et al., 2019). In this context, the teacher has been able to determine the form of ethnoscience and ethnotechnology, for example making a flute made of bamboo. The concept taught through the process of making this bamboo flute is the high and low sound. The teacher begins to understand that bamboo flute craftsmen have certain techniques that have become a habit or tradition in making flutes. Among them is the making of tone holes from one hole to the next. Making this hole is adjusted to the diameter of the flute used. The teacher's CK is also seen in the results of project tests in designing learning, by determining the "*kentongan*" media to teach the concept of sound. A significant increase in CK was found in participants who attended the 21stmisE workshop. Through the "plan [R]" activity, the teacher begins to design ethnoscience-based ethnotechnology-based science concepts that will be taught.

In the aspect of TPK, teachers have used information and communication technology to facilitate the learning administration process. They have used their laptops to prepare lesson plans and input students' grades during the learning process. During the 21stmisE workshop activities, they were really optimized to work in the preparation of learning administration. Participants have also been conditioned to use various ICT technology platforms to facilitate the learning process. Participants were trained to develop PPT-based learning media which were then used in peer teaching-learning activities. In the PPT, participants integrate video-based material viewing. From the use of non-ICT media, participants have begun to understand that even the simplest tools can be used for science learning media. This is shown when they bring drums, guitars, trumpets, ping pong balls, and baseballs in learning activities. Both media are presented by the teacher through a scientific approach, precisely in observing and associating activities.

In addition, the technology was demonstrated by the teacher at the stage of committing to an outcome of the conceptual change model. An example of an activity at this stage is the teacher showing a baseball and a ping pong ball which are held in their right and left hands, respectively. Both objects will be dropped from the same height. The teacher instructs the students to predict which ball will fall to the floor first. Furthermore, this media also plays a role during activities to accommodate the concept. This stage can help students (especially young learners) to build a concept change or to start the process of reaching a concept. At this stage, the teacher can ask questions, describe the results of observations and the results of student discussions to process information, or begin to form the "why" meaning behind the observations. In this stage, students begin to resolve conflicts that may be in their beliefs and have been observed. This stage is the stage of student experimentation to prove the predictions that have been put forward are true or false.

TCK is knowledge of the technology used by practitioners in a particular content discipline (Graham et al., 2009). TCK deals with the way technology and content relate to each other (Nhwenti, 2015). TCK assists teachers in describing the content of materials where technology can be effectively integrated into the teaching process (Koehler et al., 2013). This statement strengthens the results of this study, that the teacher has been able to teach material about the force of gravity through showing a video of how the waterwheel works in the rice field area. This video show is intended for students to remember the habits or traditions that are owned by the Javanese people in particular and have been passed down from generation to generation. This proves that the teacher has understood the ethnoscience of ethnotechnology and succeeded in identifying it into the concept of the gravitational force. In addition, the teacher has succeeded in finding through internet searching about the lamp (*teplok*) as a form of ethnoscience, ethnotechnology in the concept of light, and making drums that represent the concept of sound. After the ethnoscience searching activity of the Javanese ethnotechnology, they then brought drums and *telok* lamps into the peer teaching activity. In teaching this concept, the form of PPT presentation is also used. This shows that there is a significant difference in participants who take part in the 21stmisE workshop, who have increased knowledge about IT and non-IT-based technologies in teaching science concepts.

In the PCK aspect, teachers understand and have applied various strategies, models, and learning methods to teach science material. This is in line with the results of research (Aldahmash et al., 2019) that increasing PCK has been emphasized in various professional development activities in the science field. The increase in PCK in this study was also seen in the teacher's ability to evaluate science learning. This refers to (Park & Oliver, 2008) that PCK has been manifested in the form of knowledge in action. PCK is knowledge of how to combine pedagogic and content effectively (Shulman, 1987). This PCK conceptualization from Shulman is a transformation of material in teaching activities. This transformation occurs when the teacher interprets the subject matter, finds various ways to teach it, and adapts the learning material to alternative conceptions and students' prior knowledge (Nhwenti, 2015). As has been found in this research, the transformation of science material about the force of gravity, the concept of sound, and light is carried out through a conceptual change model (CCM) and a scientific approach. Teachers have implemented six stages of CCM, namely: 1) commit to an outcome, 2) expose beliefs, 3) confront beliefs, 4) accommodate the concept, 5) extend the concept, and 6) go beyond. In the commit to an outcome stage, the teacher asks questions about the concept of light being taught. The questions are "*What is seen in the shape of a pencil when viewed from a glass filled with clear water?*" and "*What would happen if the flashlight was turned on and pointed at a glass of clear water?*". From these questions, students are instructed to predict and discuss them in small groups. The results of this discussion are then presented in front of the class. Then there was a question and answer to confirm the prediction results of each of the other groups. This stage is to expose beliefs and confront beliefs. They can discuss with each other and even ask for scientific answers from material experts that may be presented in class. To prove the correctness of these predictions, it is carried out by means of experimental evidence. This stage is to accommodate the concept. Through experimentation, students will build a concept change or to start the process of reaching a concept. That is, at this stage, students will experience a change in understanding of the concept. Extends the concept, helping students to apply the concept to different conditions, including in their daily lives. The teacher can ask students to give examples where they have seen concepts that have been observed or discussed or may bring their own examples. The PCK of teachers who attended the 21stmisE workshop was significantly different from that of teachers who did not. They have understood CCM as a learning model that can be used to improve the understanding of concepts for both students and teachers themselves.

The TPACK framework describes the complex interactions between teachers' knowledge of content understanding, pedagogical understanding, and technological understanding. These three interactions lead to four additional areas, namely pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge

(TPK), and technological pedagogical content knowledge (TPCK) (Farrell & Hamed, 2017; Koehler et al., 2013). In this 21[st]misE workshop, the increase in the TPACK of teachers in the science sector can be seen in their ability to determine laptops (as ICT media), ping pong balls, and baseballs (non-ICT media) to teach sound material and the earth's gravitational force. In detail, the TPACK of teachers can be seen when participants complete project tests and carry out peer teaching activities. When peer-teaching, the teacher has shown his ability to teach the gravity force material, through a scientific approach and a conceptual change model. Through video shows, the teacher shows the waterwheel which is still used by farmers to irrigate the fields. Next, the teacher gives a question by bringing a ping pong ball and a baseball which are held in their right and left hands, respectively. The question is "*Which ball will fall first to the floor if the two balls held are dropped from the same height at the same time?*". Giving these questions instructs students to predict and look for strong sources to be able to answer them. Students are conditioned to discuss with friends in one group, which is then presented in front of the class to be discussed with other friends.

After going through the discussion, students were instructed to prove by experiment, namely by dropping both balls from the same height and simultaneously. This verification was carried out several times in order to obtain valid data. Through this experiment, students will find out how true the predictions have been. Thus, students gain a correct understanding of the concept. In the next step, the teacher instructs students to apply the concept that has just been understood in everyday life. In this case, students apply the concept of gravity to the fall of a coconut or mango fruit from the tree. This study shows that the 21[st]misE workshop is effective in improving teacher TPACK. With this TPACK, teachers are able to provide technology-based learning for students in learning science. This is in line with Prabowo (2015) who argued that if the teacher understands the substance of the material in science, then he can apply learning that provides various experiences for students to understand natural phenomena, so it is necessary to adjust the model and learning media to be able to achieve certain learning.

The achievements of each TPACK indicator before and after being given treatment are presented in **Figure 1.**

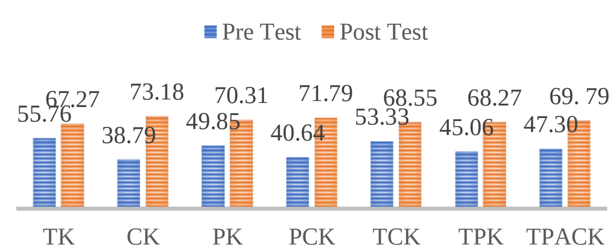

Figure 1 TPACK scores before and after treatment

The increase in TPACK through the 21[st]misE workshop was facilitated starting from the "Prepare" stage, namely the teacher's activity paying attention to video shows about learning misconceptions, ethnoscience, ethnotechnology, and learning technology. Based on the video, they were asked to determine in which session the model teacher taught the correct concept. Next, the teacher is asked to analyze the ethnoscience of ethnotechnology contained in the Basic Competencies that have been presented. In the content about learning technology, the teacher is asked to analyze the advantages and disadvantages if the teacher uses a variety of technologies that have been broadcast. It can be seen that TK, CK, and PK teachers are starting to increase because teachers have been provided with materials related to science concepts, various kinds, and functions of technology, as well as an understanding of CCM. This first stage conditions teachers to have critical thinking and problem-solving skills, communicate, and collaborate.

At the Investigate [Se] stage, teachers are facilitated to conduct science experiments, where the experimental steps refer to the conceptual change model (CCM), namely commit to an outcome, 2) expose beliefs, 3) confront beliefs, 4) accommodate the concept, 5) extend the concept, and 6) go beyond. They learn by doing it themselves. As stated by Duschl and Bybee (Widowati et al., 2017), learning science by doing can increase science knowledge and understand how science concepts work dynamically. Through the steps in the CCM, teachers are easier to adapt and design in a lesson. It can be seen that at this stage, the instructor improves the aspects of content knowledge (CK) and pedagogical knowledge (PK).

Through the Mini-lesson [Mi] stage, the teacher gains a deeper understanding of the material that has been obtained in the previous broadcast. The instructor provides a detailed explanation regarding misconception learning, ethnoscience, ethnotechnology, and learning technology that has been broadcast in the Prepare [Si] stage. At the Plan [R] stage, the teacher begins to design learning in the form of lesson plans, with material provisions on the concepts of light, sound, and gravity, scientific approaches, and CCM. In the experimental group, the teacher has succeeded in designing learning into the lesson plans well. Armed with the understanding they got at the Investigate [Se] stage, they got a detailed picture when compared to the control group which only delivered this material theoretically. At this stage, the teachers apply the results of the learning design into peer teaching activities. Peer teaching, which was accompanied by two instructors, was carried out for 35 minutes. The reflection stage is the last stage of the workshop activity which serves to confirm and straighten the lesson plans to design and peer teaching activities carried out by the teacher. At the reflection stage, participants are believed to have an understanding of TPACK for themselves and their colleagues. From the Mini-lesson [mi], Plan [R], Apply [Te], and Reflect [Ri], the instructor has facilitated teachers with understanding content integrated with technology (TCK), content integrated with pedagogic (PCK), technology with pedagogic (TPK), and integrated pedagogic and content technology (TPACK).

Increasing teacher TPACK is an increase in teacher professionalism. The 21stmisE Workshop is one of the teacher professional development programs in teaching science, which is accompanied by facilitators from educational staff printing institutions (LPTK). As stated by Purwoko et al. (2017), the improvement of teacher competence can be realized through a partnership program from the teacher working group with educational staff printing institutions in higher education. The facilitators in this 21stmisE workshop are educators from LPTKs who have expertise in science and learning in elementary schools. These 21stmisE workshop activities are very important because the quality of science learning depends on the teacher (Rubini et al., 2018). As suggested by Fitriansyah et al. (2020), teacher professional development activities should be carried out based on active learning, coherence, and be carried out in two. This statement contradicts the results of this study, which states that workshop activities that are effective in increasing teacher professionalism are carried out for 3 days to thoroughly explore the problems of science misconceptions found in the field.

Teachers need a solid foundation for their initial education. They also need to understand themselves as learners who are ready to learn and adapt their practices throughout their careers (Livingston & Livingston, 2014). It can be said that even though teachers transfer knowledge to their students, they must still be ready to learn and learn to upgrade their knowledge and competence in the field of science in order to meet the needs of their students. This is in accordance with previous research (e.g., Bogotch, 2021; Johnson et al., 2021; Kennedy, 2014; Malawi, 2011). They argued that teachers' professional development activities can affect their teaching practice. When teachers understand the characteristics of science material, they will teach science appropriately, without any misconceptions.

Teacher professionalism is highly dependent on teacher competence. Professional teachers are supported by the four required competencies (Johnson et al., 2021), namely professional, pedagogic, personality, and social competencies (MoE, 2005). All of this requires a strong awareness and contribution (Hasbullah et al., 2019) from teachers so that they are able to reflect and improve their performance as a form of improving their professionalism (Makovec, 2018). Teacher professional development activities need to be carried out continuously to improve their knowledge and skills (Poell, 2018). The development of teacher professionalism is the actualization of its role in improving student learning outcomes (Gjedia & Gardinier, 2018; Hasbullah et al., 2019; Livingston, 2016). This shows that the development of teacher professionalism, especially in the field of science, is for the benefit of developing student achievement. The implementation of this activity is not through coercion from any party, including the government, but from the awareness that arises from themselves so that they have good competence so that they are ready to become a coveted educator. So it needs to be cultivated that professional development activities in general, and especially in the field of science for teachers are not the needs of schools or the education office, but the needs of individual teachers.

The 21stmisE workshop is effective in increasing teacher TPACK, which means that this activity is one of the activities for the continuous professional development of elementary school teachers. Ersanli (2016) also stated that workshop activities for teachers have a positive influence on the TPACK sub-categories, such as aspects of content knowledge, pedagogical knowledge, and pedagogical content knowledge. This statement strengthens the results of this study that the increase in the three TPACK subcategories above also indicates a significant increase in the integration between the other two aspects and the integration between the three. After attending this workshop, teachers are able to apply the knowledge gained into the actual teaching process, so that the resulting impact is good student learning achievement. This statement was reinforced by Winarsih and Mulyani (2012) who claimed that teachers were professional and able to learn well to have implications to improve students' ability to build their knowledge and apply them in everyday life

D. CONCLUSION

Based on the results of this study, it was concluded that the 21stmisE workshop was effective in improving the TPACK of elementary school teachers in teaching science content. The results of hypothesis testing obtained a significance value of 0.000 (< 0.05) so that Ho (there is no difference in teacher TPACK applied by the 21stmisE workshop model with the conventional workshop model) is rejected, so there is a significant difference in the teacher TPACK score between groups in favor of teachers in the 21stmisE workshop. The n-gain score reached 0.76 (high improvement). The effectiveness of the 21stmisE workshop in increasing TPACK in the science field can be used as a recommendation that the 21stmisE workshop is one of the programs that can improve the quality of elementary school teachers in teaching science so that it can be used as a tool to develop the professionalism of elementary school teachers in a sustainable manner. Policymakers, both principals and education offices at various levels, can continue to motivate teachers under their auspices to participate in such workshops.

REFERENCES

Aktas, I., & Ozmen, H. (2020). Investigating the impact of TPACK development course on pre- service science teachers' performances. Asia Pacific Education Review, 21(3), 667–682. https://doi.org/10.1007/s12564-020-09653-x

Anif, S & Zain, A. (2015). Efektivitas Model Peningkatan Kompetensi Profesional Guru Biologi Berbasis Continuous Professional Development (CPD) di Karesidenan Surakarta. Varidika. 27 (2), 162- 173.

Bogotch, I. (2021). Afterword: Inserting social justice into professional development. Professional Development in Education, 47(1), 191-196. https://doi.org/10.1080/19415257.2020.1848490

Chang, Y. H., Chang, C.-Y., & Tseng, Y. H. (2010). Trends of science education research: An automatic content analysis. Journal of Science Education and Technology, 19(3), 315–331. https://doi.org/10.1007/s10956-009-9202-2

Chiappeta, E. L., & Koballa, T. R. (2010). Science instruction in the middle and second schools: Developing fundamental knowledge and skill (7th ed.). Allyn and Bacon.

Day, C. (1999). Developing teachers: The challenges of lifelong learning. Falmer Press.

Desstya, A., Prasetyo, Z. K., & Suyanta. (2019). Model workshop 21stmisE bagi guru sekolah dasar pada muatan pelajaran IPA [Universitas Negeri Yogyakarta]. http://eprints.uny.ac.id/id/eprint/68154

Desstya, A., Prasetyo, Z. K., & Suyanta. (2021). Diagnosing elementary teacher's misconceptions of gravity. Journal of Physics: Conference Series, 1720(012001), 1–10. https://doi.org/10.1088/1742-6596/1720/1/012001

Ersanli, C. Y. (2016). Improving technological pedagogical content knowledge (TPACK) of pre-service english language teachers. International Education Studies, 9(5), 18. https://doi.org/10.5539/ies.v9n5p18

Farrell, I. K., & Hamed, K. M. (2017). Examining the relationship between technological pedagogical content knowledge (TPACK) and student achievement utilizing the florida value-added model. Journal of Research on Technology in Education, 1523(June), 1–21. https://doi.org/10.1080/15391523.2017.1328992

Fitriansyah, et. al. (2020). Critical Review: Professional Development Programs to Face Open Educational Resou-rces in Indonesia. Indonesian Journal on Learning and Advanced Education. 2

(2). 109-116. DOI: 10.23917/ijolae.v2i2.9662.

Gjedia, R., & Gardinier, M. P. (2018). Mentoring and teachers' professional development in Albania. European Journal of Education, 53(1), 101–117. https://doi.org/10.1111/ejed.12258

Graham, B. C. R., Burgoyne, N., Cantrell, P., Smith, L., Clair, L. S., & Harris, R. (2009). TPACK development in science teaching: Measuring the TPACK confidence of inservice science teachers. TechTrends, 53(5), 70–79. https://doi.org/10.1007/s11528-009-0328-0

Hartini, S., Misbah, Dewantara, D., Oktovian, R. A., & Aisyah, N. (2017). Developing learning media using online prezi into materials about optical equipments. Jurnal Pendidikan IPA Indonesia, 6(2), 313–317. https://doi.org/10.15294/jpii.v6i2.10102

Hasbullah, R., Moeins, A., & Indonesia, J. (2019). The influence of professionalism, achievement motivation and empowerment against the work discipline and its implication on teacher performance: Empirical study on high school teacher in high school teachers in Karawang Regency. International Journal of Business and Commerce, 5(06), 18–36.

Jaipal-Jamani, K., & Figg, C. (2015). A case study of a TPACK-based approach to teacher professional development: Teaching science with blogs. Contemporary Issues in Technology and Teacher Education, 15(2), 161–200. https://citejournal.s3.amazonaws.com/wp-content/uploads/2015/03/v15i2Science2.pdf

Johnson, C. S., Sdunzik, J., Bynum, C., Kong, N., & Qin, X. (2021). Learning about culture together: Enhancing educators cultural competence through collaborative teacher study groups. Professional Development in Education, 47(1), 177-190. https://doi.org/10.1080/19415257.2019.1696873

Kang, N. H. (2007). Elementary teachers' teaching for conceptual understanding: Learning from action research. Journal of Science Teacher Education, 18(4), 469–495. https://doi.org/10.1007/s10972-007-9050-y

Kennedy, A. (2014). Understanding continuing professional development: the need for theory to impact on policy and practice. Professional Development in Education, 40(5), 688–697. https://doi.org/10.1080/19415257.2014.955122

Kim, S., & Lee, Y. (2018). Development and application of the TPACK-P education program for pre-service teachers' TPACK. International Journal of Engineering & Technology, 7(3.34), 654–662.

Koehler, M. J., Mishra, P., Akcaoglu, M., & Rosenberg, J. M. (2013). The Technological pedagogical content knowledge framework for teachers and teacher educators. In Commonwealth Educational Media Centre for Asia (pp. 1–8).

Koehler, M. J., Mishra, P., & Cain, W. (2013). What is technological pedagogical content knowledge (TPACK)? Journal of Education, 193(3), 13–19. https://doi.org/10.1177/002205741319300303

Laeli, C. M. H., Gunarhadi, & Muzzazinah. (2020). Misconception of science learning in primary school students. Advances in Social Science, Education and Humanities Research, 657–671. https://dx.doi.org/10.2991/assehr.k.200129.083

Livingston, K. (2016). Teacher education's role in educational change. European Journal of Teacher Education, 39(1), 1–4. https://doi.org/10.1080/02619768.2016.1135531

Livingston, K., & Livingston, K. (2014). Teacher educators: Hidden professionals ? European Journal of Education, 49(2), 218–232. https://doi.org/10.1111/ejed.12074

Kholid, M.N, et.al. 2023. A systematic literature review of Technological, Pedagogical and Content Knowledge (TPACK) in mathematics education: Future challenges for educational practice and research. 10 (2). 1-18. https://doi.org/10.1080/2331186X.2023.2269047.

Koehler, M. J., Mishra, P., Kereluik, K., Shin, T. S., & Graham, C. R. (2013). The technological pedagogical content knowledge framework. Handbook of Research on Educational Communications and Technology, 101–111. https://doi.org/10.1007/978-1-4614-3185-5_9

Maharanai. N.W.A.U.S, et al. (2022). Instrumen Tes Pengetahuan Technological Pedagogic Content Knowledge (TPACK untuk Calon Guru Sekolah Dasar. Jurnal Pedagogi dan Pembeajaran. 5 (3). 428-436. https://doi.org/10.23887/jp2.v5i3.53383

Makovec, D. (2018). The teacher's role and professional. International Journal of Cognitive Research in Science, Engineering and Education, 6(2), 33–45. https://doi.org/10.5937/ijcrsee1802033M

Malawi, Ibadullah. "Peningkatan Kompetensi Guru Dalam Rangka Mewujudkan Guru Yang Profesional." Premiere Educandum, vol. 1, no. 01, 2011, doi:10.25273/pe.v1i01.31.

Nhwenti, M. (2015). TPACK constructs : A sustainable pathway for teachers professional development on technology adoption. Creative Education, 6 (January), 1697–1709. https://doi.org/10.4236/ce.2015.616171

Nuangchalerm, P. (2011). In-service science teachers' pedagogical content knowledge. Studies in Sociology of Science, 2(2), 33–37. https://doi.org/10.3968/j.sss.1923018420110202.034

Nurdiana, U. (2016). Technological pedagogical content knowledge (TPCK) melalui jejaring media sosial facebook dan google drive. Karya Tulis Simposium Guru, 1-20.

Nurmatin, S., & Purwianingsih, W. (2017). Capturing the PCK ability of prospective science teachers using coRe and PaP-eR. Jurnal Pendidikan IPA Indonesia, 6(2), 271–276. https://doi.org/10.15294/jpii.v6i2.9507

Pemerintah Indonesia. (2005). Undang-undang nomor 14 tahun 2005 tentang Guru dan Dosen. Jakarta.

Prabowo, S. A. (2015). The effectiveness of scientific based learning towards science process skill mastery of PGSD students. Jurnal Pendidikan IPA Indonesia, 4(1), 15–19. https://doi.org/10.15294/jpii.v4i1.3495

Priyatno, D. (2010). Teknik mudah dan cepat melakukan analisis data penelitian dengan SPSS dan tanya jawab ujian pendadaran. Gava Media.

Redhana, I. ., Sudria, I. B. N., Hidayat, I., & Merta, L. M. (2017). Identification of chemistry learning problems viewed from conceptual change model. Jurnal Pendidikan IPA Indonesia, 6(2), 356–364. https://doi.org/10.15294/jpii.v6i1.9594

Resbiantoro, G. (2016). Self-efficacies of prospective mathematic teachers' technological pedagogical content knowledge (TPACK). Jurnal Varidika. 28 (2). 102-115.

Rochintaniawati, D., Riandi, R., Kestianty, J., Kindy, N., & Rukayadi, Y. (2019). The analysis of

biology teachers' technological pedagogical content knowledge development in lesson study in West Java Indonesia. Jurnal Pendidikan IPA Indonesia, 8(2), 201–210. https://doi.org/10.15294/jpii.v8i2.19303

Rollnick, M., & Rutherford, M. (2015). The use of a conceptual change model and mixed language strategy for remediating misconceptions on air pressure. International Journal of Science Education, 15(4), 363–381. https://doi.org/10.1080/0950069930150402

Sayekti, I.C., Rini, I.F, Hardiansyah, F. (2019). Analisis Hakikat IPA Pada Buku Siswa Kelas IV Sub Tema I

Tema 3 Kurikulum 2013. Profesi Pendidikan Dasar. 6 (2). 129-144. http://dx.doi.org/10.23917/ppd.v1i2.9256.

Shafie, H., Majid, F. A., & Ismail, I. S. (2019). Technological pedagogical content knowledge (TPACK) in teaching 21st century skills in the 21st century classroom. Asian Journal of University Education, 15(3), 24-33.

Shulman, L. (1987). Knowledge and teaching: Foundations of the new reform. Harvard Educational Review, 57(1), 1–23. https://doi.org/10.17763/haer.57.1.j463w79r56455411

Soeharto, Csapo, B., Sarimanah, E., Dewi, F. I., & Sabri, T. (2019). A review of students common misconception in science and their diagnostic assessment tools. Jurnal Pendidikan IPA Indonesia, 8(2), 247–266. https://doi.org/10.15294/jpii.v8i2.18649

Tanang, H., Djajadi, M., Abu, B., & Mokhtar, M. (2014). Challenges of teaching professionalism development: A case study in Makassar, Indonesia. Journal of Education and Learning, 8(2), 132–143.

Widowati, A., Nurohman, S., & Anjarsari, P. (2017). Developing science learning material with authentic inquiry learning approach to improve problem solving and scientific attitude. Jurnal Pendidikan IPA Indonesia, 6(1), 32–40. https://doi.org/10.15294/jpii.v6i1.4851

Wilujeng, I., Tadeko, N., & Dwandaru, W. S. B. (2020). Website-based technological pedagogical and content knowledge for learning preparation of science teachers. Cakrawala Pendidikan, 39(3), 545–559. https://doi.org/10.21831/cp.v39i3.31228

Winarsih, A., & Mulyani, S. (2012). Peningkatan profesionalisme guru IPA melalui lesson study dalam pengembangan model pembelajaran PBI. Jurnal Pendidikan IPA Indonesia, 1(1), 43–50. https://doi.org/10.15294/jpii.v1i1.2012

Yanti, M., & Riandi, R. (2019). Analisis technological pedagogical content knowledge (TPACK) guru IPA untuk mengidentifikasi profil content knowledge (CK) guru pada materi global warming. Wahana Pendidikan Fisika, 4(1), 37. https://doi.org/10.17509/wapfi.v4i1.15815

Yip, D. Y. (2001). Promoting the development of a conceptual change model of science instruction in prospective secondary biology teachers. International Journal of Science Education, 23(7), 755–770. https://doi.org/10.1080/09500690010016067