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RESEARCH ARTICLE WWW.PEGEGOG.NET

The effect of Project-Based Learning on Technological Pedagogical Content Knowledge among Elementary School Pre-Service Teacher

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Abstract

The ability to integrate technology in learning, also known as Technological Pedagogical Content Knowledge (TPCK), is one of the competencies that teachers must master in the era of the Industrial Revolution 4.0. TPCK can be prepared when a teacher becomes a pre-service teacher at a university. The goal of this study was to describe the impact of Project-Based Learning (PjBL) on TPCK in elementary school pre-service teachers. This research is an experimental study with a one-group pretest-posttest design. A total of 94 pre-service elementary school teachers are included in this study's sample. Data collection instruments to measure TPCK are questionnaires and assessment sheets. The questionnaire was used to measure TK, PK, CK, TCK, PCK, and TPK. The assessment is used to measure TPCK. TPCK is assessed using the outcomes of student-created learning materials. The data is analyzed using descriptive statistics and inferential statistics. To describe the distribution of TPCK data, descriptive statistics are used. To test the study hypotheses, inferential statistics are used. The paired sample t-test was used to test the hypothesis. The descriptive analysis results suggest that the TPCK for pre-service teachers is in the high range. The results of hypothesis testing show a significant effect of using PjBL on TPCK of pre-service elementary school teachers. These findings highlighted PjBL's potential for TPCK development.

Keywords: Elementary school, PjBL; TPCK.

Introduction

Professional teachers are prepared since they are students at the university. Pre-service teachers do not have to master the content or subject matter but also must master the learning model and use of technology in learning. This coincided with the emergence of Education 4.0. Education 4.0 is a term used by education experts to describe how to implement technology into learning. Education 4.0 requires pre-service teachers to master technology to be integrated into the learning process.

Competence in the field of information and communication technology contributes to self-development and the learning process. This statement is supported by Minister of Education Regulation no. 22 of 2016 in the standard process, specifically the learning principle utilized, which states that teachers must be able to use information and communication technology to improve the efficiency and effectiveness of learning (Kemendikbud, 2016)Emerald Publishing Limited. Purpose: This paper examines the influence of three dimensions of customer knowledge management – knowledge from customer, knowledge for customer and knowledge about customer – on innovation capabilities (speed and quality. Pre-service teachers must be trained with teaching methods how to use information technology and computers, strengthen mastery of scientific content and learn how pupils think and learn (Alayyar et al., 2012). In other words, to improve the quality of education, including the quality of learning in primary schools, efforts must be made to improve the quality of preparation of pre-service teachers in tertiary institutions.

Referring to the Law on Teachers and Lecturers, several skills that must be possessed by teachers include pedagogical and professional skills (UU Nomor 14, 2005). Pedagogical and professional abilities are also known as pedagogical content knowledge (PCK). Shulman invented the PCK concept (1987). Mishra & Koehler (2006)while addressing the complex, multifaceted, and situated nature of this knowledge. We argue, briefly, that thoughtful pedagogical uses of technology require the development of a complex, situated form of knowledge that we call Technological Pedagogical Content Knowl- edge

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(TPCK based on Shulman's concept of PCK, added a technological component to PCK by popularizing the terms technological pedagogical and content knowledge (TPCK). TPCK is a framework for understanding the link between pedagogical knowledge, content knowledge, and the use of technology (Mishra & Koehler, 2006)while addressing the complex, multifaceted, and situated nature of this knowledge. We argue, briefly, that thoughtful pedagogical uses of technology require the development of a complex, situated form of knowledge that we call Technological Pedagogical Content Knowl- edge (TPCK. TPCK is composed of seven components, three of which are core components and four of which are interactions of the three main components (Yan et al., 2018)with respect to three criteria: (1. Technological knowledge (TK), pedagogical knowledge (PK), and subject knowledge are the three basic components (CK). Technological pedagogical knowledge (TPK), technological content knowledge (TCK), pedagogical content knowledge (PCK), and technological pedagogical content knowledge (TPCK) are the four interaction components (TPCK).

Technological knowledge (TK) refers to pre-service teachers' understanding of what technology, software, or applications can be implemented for learning. TK also includes the ability to adapt to and learn new technologies (Rosyid, 2017). Pedagogical Knowledge (PK) PK is teachers' or pre-service teachers' knowledge of student characteristics, the design of lesson plans, the evaluation of learning outcomes, and what methods/models/learning techniques can be implemented in elementary school mathematics learning. Content Knowledge (CK) denotes a pre-service teacher's broad and deep knowledge of the subject area or material content.

Technological content knowledge (TCK) refers to a teacher's ability to explain a subject using technology that has not been done before (Guerra et al., 2017). Pedagogical content knowledge (PCK) is a combination of fundamental material knowledge, pedagogy, and context (Hurrell, 2013). TPCK is an optimization of TK used in learning to integrate CK, PK, and PCK into a unified whole that can produce an effective, efficient and more interesting learning process. Teacher knowledge to integrate technology in learning makes learning effective and efficient. Technology integration is considered a closely related component of teaching and is included in PCK (Oyanagi & Satake, 2016).

Teachers must have pedagogical skills to understand students cognitively so that they can condition the class, choose appropriate evaluation strategies, and techniques in learning, while content knowledge is required for teachers to master the concepts of the material to be taught to students (Shulman, 1987; Mirici & Uzel, 2019). The study's findings indicate that PCK plays a significant role in the professional development of teachers and pre-service teachers (Anwar et al., 2014). PCK levels in teachers have also been studied, demonstrating the impact of PCK on learning quality (Haron et al., 2021).

Teachers in Indonesia do not completely recognize the significance of this TPCK ability. Teachers in Indonesia are dealing with a lack of content mastery and literacy (Nofrion et al., 2018). According to UNESCO's 2016 Global Education Monitoring report, Indonesian instructors are of poor quality, ranking 14th out of 14 developing countries (UNESCO, 2016). According to the UNESCO report, the results of the Teacher Competency Test in Indonesia continue to fall short of the mark. The average score for the teacher's combined educational and professional characteristics is 54.05. Figure 1 demonstrates that the average teacher competency exam scores in the Special Region of Yogyakarta, the Special Capital Region of Jakarta, and Central Java, which had the highest average score, did not surpass 70. Teachers in the Special Region of Yogyakarta had the greatest average professional and pedagogical knowledge, with scores of 69.62 and 60.94, respectively. This value falls considerably short of the government's threshold of 90.00.

Based on these findings, the TPCK for primary school teachers must be developed at the university level when the teacher is still a student of elementary school teacher education. TPCK for pre-service teachers can be developed through various learning models used in universities. Salah satu model yang dapat digunakan adalah project-based learning (PjBL). PjBL is an active learning approach that is based on real-life situations and incidents, and the findings can be delivered orally or in writing. This learning style allows students to study, explore, and practice independently and according to their abilities, talents, and interests through the scientific process. Meanwhile, teachers offer direction and advice to pupils for them to increase their cognitive thinking skills and learning motivation (Chiang & Lee, 2016). Given this situation, a description of the effect of Project-Based Learning on TPCK among elementary school pre-service teachers is required. Therefore, this study will answer the question of whether Project-Based Learning is effective on TPCK among elementary school pre-service teachers.

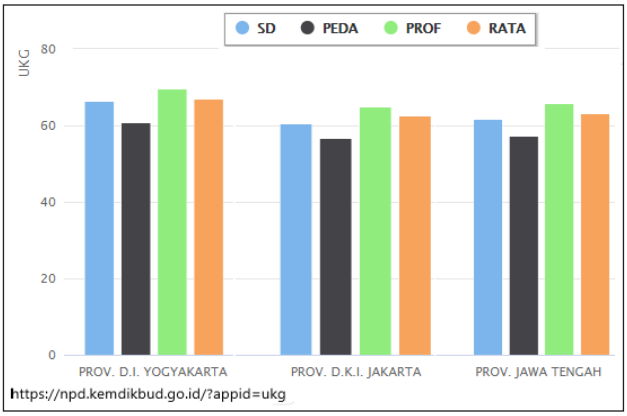

Fig. 1: Result

Method

Research design

The design of this study is an experimental one-group pretest-posttest design. Experiments were carried out in the Integrated Learning course through project-based learning. Students are assigned a project in which they must create learning tools and learning practice films.

Participants.

The study included 94 Ahmad Dahlan University Elementary School Teacher Education students who participated in the Integrated Learning course. Samples were drawn at random from a group of 320 students.

Data collection tools

Questionnaires and assessment sheets are tools used to assess TPCK. The questionnaire was used to assess the following variables: TK, PK, CK, TCK, PCK, and TPK. The TPCK is measured using the assessment sheet. TPCK is assessed using the outcomes of student-created learning materials. The grid to see the level of TPCK is displayed in Table 1.

Data analysis

This study uses descriptive and inferential statistics. A descriptive statistic is used to describe the data. Data analysis in this study compared the score of the questionnaire with the criteria. The standard deviation criteria for determining teacher competence are as in Table 2.

To test the research hypotheses, inferential statistics were applied. The paired sample t-test was used to test the hypothesis. A prerequisite test for normality is undertaken before evaluating the hypothesis. The SPSS program was used to help with the data analysis procedure.

Results

This study's findings are based on data gathered during the research. Table 3 shows the research findings in the form of descriptive data from questionnaires administered before and after learning utilizing Project-Based Learning.

Table 3 shows the average TPCK after learning using Project-based Learning is 110.83. Referring to Table 2, this

Table 1: Grid Level of Understanding among Elementary School Teachers

Competency	*Indicator*	*Item number*
TK (K 1- K10)	1. Knowing various technological tools that can be used for learning (computers, gadgets, projectors, etc.)	1
	2. Knowing various applications that can be used as learning media	2
	3. Knowing various applications to present questions	3
	4. Always finding out about the latest technology in learning in elementary schools	4-5
PK (K 11 - K 22)	1. Understanding the characteristics and psychology of school students Basic	6
	2. Understanding various learning strategies	7
	3. Understanding types of learning evaluation in primary schools	8
	4. Always seeking information about various theories, strategies, and evaluations of learning in primary schools	9-10
CK (K 23 - K 28)	1. Mastering the foundation of education in elementary school	11
	2. Mastering learning materials in elementary school	12
	3. Have the ability to develop indicators, and learning objectives	13-14
	4. Have a ki ability to develop questions	15
PCK (K 29 - K 32)	1. Able to apply learning strategies in delivering learning materials	16
	2. Able to choose appropriate strategies in delivering learning materials	17
	3. Able to choose the right evaluation of a material	18
	4. Able to design lesson plans	19
	5. Doing reflection on learning	
TPK	1. Able to choose the right technology according to the characteristics and psychology of students	21-22
	2. Use technology to find information about learning in elementary schools	23
	3. Able to combine learning strategies and technology	24
	4. Able to choose the right application in providing evaluation	25
TCK	1. Able to choose technology that is appropriate to certain material	26-27
	2. Able to present material into learning media	28
	3. Able to present questions in various applications/platforms	29-30

Table 2: Criteria

Standard Deviation	*Range*	*Criteria*
Mi + 1.5 Sbi <X ≤ Mi + 3 Sbi	120 <X ≤ 150	Very High
Mi + 0.5 Sbi <X ≤ Mi + 1.5 Sbi	100 <X ≤ 120	High
Mi-0.5 Sbi <X ≤ Mi + 0.5 Sbi	80 <X ≤ 100	Moderate
Mi-1.5 Sbi <X ≤ Mi -0.5 Sbi	60 <X ≤ 80	Low
Mi-3 Sbi <X ≤ Mi -1.5 Sbi	30 <X ≤ 60	Very Low

score is in the High criteria. Table 3 also shows an increase in the average before and after the experiment of 30.01. The average score based on the TPCK aspects is presented in Table 4.

Table 4 shows an increase in all aspects of the TPCK criterion. Before the study, four elements achieve the moderate criteria and three that reach the low criteria. Following project-based learning, the requirements for these components become more stringent. Aspects of TK, TPK, TCK, PCK, and TPCK grew and were in the High category, while PK and CK were in the Very High category.

The hypothesis is tested after the evidence has been described. A normality test was performed before evaluating the hypothesis. Table 5 displays the results of the normality tests.

Table 3: Descriptive Data

Analisis Deskriptif	*Before*	*After*
Rata-rata	80,83	110,82
Standar Deviasi	10,80	10,78
Skor Maksimal Empiric	110	140
Skor Maksimal Ideal	150	150
Skor Minimal Empiric	44	70
Skor Minimal Ideal	30	30

Table 5 shows that the significance value is more than 0.05 (Sig. > 0.05) so it can be concluded that the data is normally distributed. The results of hypothesis testing using paired t-test are shown in Table 6.

Table 6 shows that the significance value is less than 0.05 (Sig.<0.05) so it can be concluded that there is an average difference significantly in mean TPCK scores before and after the experiment. So it can be concluded that Project-based learning affects increasing students' TPCK.

Discussion

Education is one of the most important factors in developing a good nation. Teachers are the primary players who play a critical role in achieving educational objectives (Juhji, 2016). Competence is required of teachers. Technological Pedagogical Content Knowledge (TPCK) is a competency that all teachers must possess (Mishra & Koehler, 2006)while addressing the complex, multifaceted, and situated nature of this knowledge. We argue, briefly, that thoughtful pedagogical uses of technology require the development of a complex, situated form of knowledge that we call Technological Pedagogical Content Knowl- edge (TPCK. To build skills in the 21st century, teachers must be experts in professional problem solving and know the educational content of technology (Ball et al., 2008)

Table 4: The average score based on the TPCK aspects is presented in Table 4

	Before		*After*	
Aspect	*Mean*	*Criteria*	*Mean*	*Criteria*
TK	80,11	Moderate	110,11	High
PK	90,53	Moderate	120,53	Very high
CK	83,25	Moderate	113,25	Very High
TPK	83,64	Moderate	113,64	High
TCK	78,12	Low	103,48	High
PCK	73,44	Low	108,13	High
TPCK	76,72	Low	106,72	High

Table 5. One-Sample Kolmogorov-Smirnov Test

Statistic		*Kolmogorov-Smirnov*		
		Statistic	*df*	*Sig.*
TPCK	pre	.124	94	.267
	post	.122	94	.135

Table 6: paired T-test

		Paired Differences							
				95% Confidence Interval of the Difference					
Mean		*Std. Deviation*	*Std. Error Mean*	*Lower*	*Upper*		*t*	*df*	*Sig. (2-tailed)*
Pair 1	pre-post	95,825	2.36511	.33118	3.07990	4.41029	11.308	94	.000

Since the teacher is a student in college, the importance of TPCK must be prepared. Teacher education is the most crucial step in the development of a professional teacher. Teachers' professional competency is critical in assisting pupils in developing their skills in carrying out scientific thinking processes. Professional competence assists teachers in improving their understanding of elementary school education, understanding student developmental psychology, mastering learning materials with various types of strategies by designing learning media and resources, and assessing and evaluating the learning process following the indicators and learning objectives set TPCK for pre-service teachers can be developed through various learning models used in universities. Project-based learning is one model that can be used (PjBL).

The study's findings, as shown in Table 4, indicate that PjBL is an effective method for improving the TPCK of pre-service primary school teachers. The findings of this study are consistent with the findings of Hosseini & Tee (2012)college and university, computer technology is still not being utilized to its full potential. It seems that teachers still do not have adequate knowledge about using technologies for instructional purposes. Accordingly, a qualitative case study research was conducted to determine the conditions that influence the development of teachers' knowledge for integrating technology in teaching. For this purpose, 30 pre-service teachers participated in a course to learn integration of technology in teaching; the course was designed and led by a constructivist instructor. In this context, Technological Pedagogical Content Knowledge (TPCK, who found that PjBL activities increased instructors' TPCK. Student-centred, motivated and dedicated students to their team, focus on the process of finding solutions rather than improving results, projects generated by students based on the problem uncovered are some of the key concepts of project-based learning (Yasin & Rahman, 2011).

According to Table 4, the score for each facet of the TPCK has increased. This implies that students can enhance TPCK skills through project assignments. The first PjBL activity in this study is to present real-life problems. The real-life concerns presented are issues that arise in primary schools. The second level is working in small groups to collaborate. Students discuss examining problems at school, such as student learning difficulties, materials, and curriculum. This activity is expected to boost pre-service teachers' CK and PK. Although students do not receive new material regarding CK and PK from the instructor, sharing experiences and discussing CK and PK will help them learn more about them (Guzey & Roehrig, 2009). They discuss several topics to determine the theme of the project to work on and how the contents will be taught. Their PCK evolved in this manner as a result of intragroup contact (Rose & Cavin, 2007).

This study's objective is to create learning tools such as lesson plans, student worksheets, and learning films. Students learn technology by completing design challenges. Students are allowed to develop the project in groups. Each project-based learning provides students with the opportunity to design a final product to develop scientific skills. Students are free to develop their ideas to create the best project, as well as monitor, evaluate, and receive feedback from the teacher (Kubiatko & Vaculová, 2011). This project is accomplished in 6 months (March-August 2021), with 14 meetings. At each meeting, pre-service teachers present the status of their projects and receive comments from peers and instructors. Pre-service teachers' attitudes about technology began to shift. According to feedback, the group was searching for or developing materials about the chosen content. As a result, the groups continued to learn by doing while paying close attention to the comments they received. These activities increased pre-service teachers' TK, TCK, and TPK. This finding is consistent with earlier research (Lee, 2011) which found that carrying out the project in class and receiving comments from others provided an opportunity to interact with real-world challenges and explore new ideas.

Conclusion

The results of this study indicate that project-based learning (PjBL) is effective in increasing the technological pedagogical content knowledge of elementary school teacher candidates. These findings demonstrated the potential of PjBL for the development of TPCK. Aspects of TK, TPK, TCK, PCK, TPCK are in the High category, while PK and CK are in the Very High category. The activities carried out by pre-service teachers following the PjBL phases have resulted in improvements in these areas.

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