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The Influence of Project Based Learning Model with TPACK Approach on the Teaching Skills of Pre-Service Science Teachers

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Abstract. The purpose of this research is to determine the influence of project-based learning model with the TPACK approach on the teaching skills of pre-service science teachers. This study used a pre-experimental model in the form of a one-shot case study. The sample used consisted of 98 pre-service science teachers who took the microteaching course. The data collected was the teaching skills of pre-service science teachers, which was obtained using observation sheets. The research data was analyzed descriptively by percentage. The results showed that the teaching skills of the 98 pre-service science teachers consisted of 38% in the very good category, 45% in the good category, 15% in the satisfactory category, and 2% in the less than satisfactory category. The average teaching skills of pre-service science teachers after attending lectures that applied the project-based learning model with the TPACK approach were in the good category. The results of the study showed that the project-based learning model with the TPACK approach had a positive effect on the teaching skills of pre-service science teachers. The PBL model with TPACK approach can be an effective alternative for enhancing the quality of pre-service science teachers. It also has implications for teacher education programs and professional development initiatives.

INTRODUCTION

Effective learning requires teachers who are able to integrate technology into teaching. However, not all teachers have the ability to do so. A preliminary study found that physics teacher candidates and physics education students have an understanding of technology but do not fully understand its integration into learning [1]. A learning model is needed to improve the ability of teacher candidates to integrate technology into teaching.

One learning model that can improve the ability of pre-service teachers, especially science teachers, to integrate technology into learning is the project-based learning model with a TPACK approach. TPACK stands for Technological Pedagogical Content Knowledge, which refers to a teacher's knowledge of how to use technology based on an analysis of the material's characteristics and pedagogical aspects [1,2]. The TPACK framework focuses on designing and evaluating teacher knowledge that is concentrated on effective student learning in various content areas [3,4,5]. The TPACK framework highlights the integral role of content in teaching with technology in educational settings [6]. TPACK is a combination of three types of knowledge: knowledge of technology (T), knowledge of pedagogy (P), and knowledge of content (C) [7-13]. It is important for science teachers to master all three types of knowledge, as they influence how a subject is taught.

The integration of TPACK and Project-Based Learning (PBL) can provide a powerful approach to teaching and learning. PBL is a student-centered pedagogy that involves a dynamic classroom approach in which students acquire a deeper knowledge through active exploration of real-world challenges and problems [14]. PBL is a teaching method that encourages students to learn by doing, and it is an effective way to develop critical thinking, problem-solving, and collaboration skills [14]. The PBL model can be used to develop the TPACK of pre-service science teachers by providing them with opportunities to apply their knowledge in real-world contexts [14]. The

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PBL model can also be used to develop the TPACK of pre-service science teachers by providing them with opportunities to collaborate with their peers and to develop their problem-solving and critical thinking skills [14].

The study is significant because it aims to improve the teaching skills of pre-service science teachers by using the PBL model with the TPACK approach. The study will contribute to the development of the TPACK framework and provide insights into how to incorporate technology into teaching and learning processes more effectively and closer to pedagogical and content knowledge [14]. The study will also provide insights into how to use the PBL model to improve the teaching skills of pre-service science teachers.

METHOD

This research is a quantitative using pre-experimental model with one-shot case study. The research subjects were 98 students who took micro teaching courses in the odd semester of 2022/2023. The implementation of PBL with TPACK approach consists of the steps of starting with the essential question, designing a plan for the project, creating a schedule, monitoring the students and the progress of the project, assessing the outcome, evaluating the experience. The PBL model adopted by Lucas [15]. The syntax and student activities during the lecture are presented in Table 1.

Table 1. Syntax of PBL with TPACK Approach for Microteaching Course

No	Syntax	Activities	
		lecturer	Students
1	Starts with the essential question	Stimulate students by showing a video of a teacher teaching by applying conventional methods and not implementing technology.	Students observe the video and pay attention to the students' responses. Students formulate problems by asking questions, how to make students more enthusiastic about learning.
2	Design a plan for the project	Ask students to design a project to create learning tools that integrate TPACK.	Students make a design that includes learning tools that integrate TPACK equipped with supporting attachments.
3	Creates a schedule	Asking students to determine the schedule and division of work tasks.	Students make a schedule of activities and division of tasks.
4	Monitor the students and the progress of the project	Monitor and observe the progress of student project tasks	Implement the designed project and make documentation
5	Assess the outcome	Assess the product developed by students	Presenting learning tools that integrate TPACK complete with supporting attachments.
6	Evaluate the Experience	Provide evaluation and feedback for the results and student learning process. Provide further projects in the form of implementation of learning tools that integrate TPACK that have been developed.	Correct deficiencies and improve the next project.

Data on the teaching skills of pre-service science teachers are taken when they carry out teaching practice using the learning tools that have been developed. The data was collected using an observation sheet consisting of 24 questions containing teaching skill indicators. Student teaching skills data were analyzed using descriptive percentage analysis.

Result and Discussion

The results of the research on the teaching skills of pre-service science teachers are presented in Figure 1. Figure 1 shows the profile of teaching skills of pre-service science teachers who are mostly in the good and very good categories. This shows that the application of PBL with the TPACK approach can positively affect the teaching skills of pre-service science teachers.

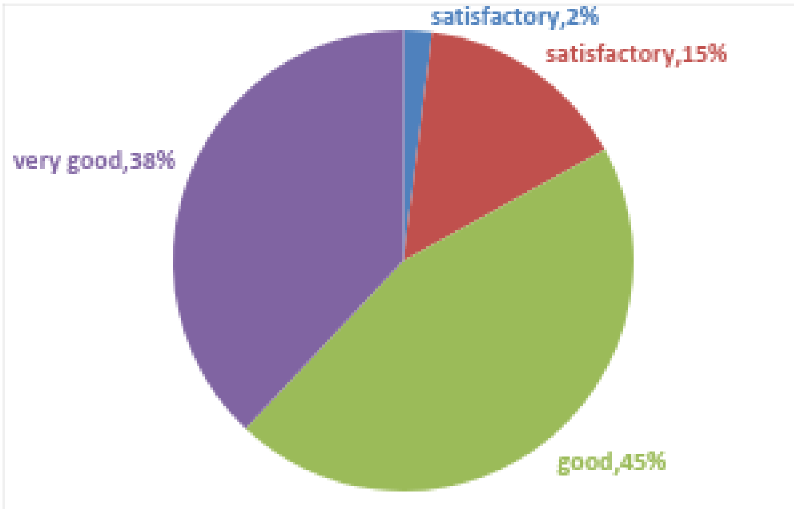

Figure 1: Profile of Pre-Service Science Teacher Teaching Skills After Attending Lectures Implementing the PBL with TPACK Approach

Classically, the teaching skills of a pre-service science teacher received an average score of 84.06 which was categorized as very good. This achievement was obtained because in learning that implements PBL with TPACK approach, students are taught social, collaborative, critical thinking, problem solving, and technology skills that are relevant to the material. PBL directs students to create a project that will build their knowledge, so pre-service science teachers who learn with this model will be trained in making projects that are relevant to the material being taught [16, 17]. PBL encourages students to be more active, creative, and work together in groups, so that pre-service science teachers who learn with this model will be trained in developing social and collaborative skills [16]. PBL uses problems as the first step in collecting data and solving complex problems in learning, so that pre-service science teachers who learn with this model will be trained in developing critical thinking and problem-solving skills [16, 17]. PBL is based on TPACK, which integrates technological, pedagogical, and content knowledge, so pre-service science teachers who learn with this model will be trained in developing technological and pedagogical skills relevant to the material being taught [14,17,18].

This study also produced a profile of the teaching skills of pre-service science teachers in terms of each indicator. Table 2 shows that most students are in the good and very good categories in all indicators.

Table 2: Profile of Pre-Service Science Teachers' Teaching Skills in Terms of Each Indicator

Indicator of Teaching Skills	less than satisfactory (%)	satisfactory (%)	Good (%)	very good (%)
Skill in opening the lesson	0,61	8,91	38,58	51,89
Skill in attracting attention and motivating students	1,96	17,85	47,43	32,76
Skill in applying depth and breadth of material (including no misconceptions)	1,83	12,47	44,99	40,71
Skill in presenting completeness of material (conceptual integrity)	0,86	11,98	45,11	42,05
Skill in applying correct concepts/procedures	0,49	11,63	44,80	43,08

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Skill in using learning methods, models, and approaches	1,59	14,43	47,56	36,43
Skill in applying educational learning with a TPACK approach based on the industrial revolution 4.0 platform	1,22	11,87	46,76	40,15
Skill in developing interaction variations	2,20	19,58	45,04	33,17
Skill in managing the class	1,96	17,14	45,04	35,74
Skill in utilizing time	0,86	14,43	44,87	39,73
Skill in organizing learning resources and/or teaching materials	0,61	13,19	49,69	36,51
Skill in using information technology in learning	0,86	10,88	43,77	44,50
Skill in using learning media	1,10	9,78	44,87	44,25
Skill in integrating critical thinking, creative thinking, reflective thinking, and decision making into learning activities through inquiry-based activities	1,59	19,61	53,80	25,00
Skill in regulating volume and intonation of voice	1,59	14,93	41,13	42,35
Skill in using good and correct language orally and in writing (according to the subject being taught)	0,49	11,76	43,50	44,24
Skill in developing high-level thinking skills (HOTS)	3,68	20,55	54,29	21,49
Skill in using nonverbal communication (gestures)	2,08	18,01	46,81	32,97
Skill in creating a fun learning atmosphere	1,72	16,81	42,82	38,53
Skill in dressing and/or appearing politely	0,24	3,90	31,59	64,27
Skill in conducting process assessments	0,61	13,68	49,82	35,90
Skill in conducting HOTS-based learning outcome assessments	3,29	20,02	50,85	25,83
Skill in providing reinforcement and punishment	2,07	16,59	46,46	34,88
Skill in closing the lesson.	0,61	9,77	32,97	56,65

Based on Table 2. The application of PBL with TPACK approach in learning can improve the teaching skills of pre-service science teachers. This is because PBL is a learning model that uses real-world problems as a context for students to learn about critical thinking and problem-solving skills, as well as to gain essential knowledge and concepts from the subject matter [19]. Meanwhile, TPACK is a teacher's knowledge framework for integrating technology which consists of three main components, namely technological knowledge (TK), pedagogical knowledge (PK) and content knowledge (CK) [9,14,19,20].

The combination of PBL and TPACK can have a positive impact on improving the teaching skills of pre-service science teachers from various aspects:

1. Improved Problem-Solving Ability

PBL designed with real-world problems can train the problem-solving skills of pre-service science teachers. This ability is very important in the process of learning science. PBL is a learning model that encourages pre-service science teachers to actively seek solutions to given problems. In this process, pre-service science teachers learn how to analyze problems, formulate problem-solving strategies, and apply their knowledge to solve those problems. This directly contributes to the improvement of students' problem-solving skills.

The integration of TPACK allows the utilization of technology to improve problem solving skills. With this approach, pre-service science teachers can design and implement effective learning by utilizing appropriate technology, effective pedagogical strategies, and a deep understanding of the content being taught. For example, by utilizing ICT-based learning media.

2. Improving Teaching Skills

PBL and TPACK both emphasize student-centered learning so that pre-service science teachers are trained to improve facilitation and communication skills in teaching [21]. TPACK also trains science teacher candidates to integrate technology in learning such as the use of interactive media.

3. Improved Understanding of Teaching Materials

PBL allows students to actively construct knowledge and skills through real-world, authentic activities similar to those experts engage in. This helps improve understanding as students apply concepts to solve meaningful problems. TPACK enables teachers to make pedagogically sound decisions about how to integrate technology to represent content in ways that facilitate student understanding. The interaction of technological, pedagogical, and content knowledge supports student learning. PBL and TPACK both encourage pre-service science teacher to understand the teaching material deeply to teach it well [19]. This in-depth understanding of science subject matter is important so that pre-service science teachers can explain concepts correctly to students. The combined approach of PBL and TPACK allows for student-centered, contextualized learning through technology-supported projects. This results in improved comprehension and retention of concepts as students actively apply their knowledge and skills.

4. Increased Creativity

PBL gives students autonomy and flexibility to explore their potential, which leads to more creative ideas. The application of the PBL model can improve creative thinking skills. PBL involves solving real-world, open-ended problems that require students to think creatively and come up with innovative solutions. This encourages idea generation and treating familiar ideas in new ways. The collaborative nature of PBL also contributes to creativity, as students are exposed to diverse perspectives when working in teams. PBL aligns with the upper levels of Bloom's taxonomy involving analysis, evaluation, and creation, thus contributing to students' progression from basic knowledge to creativity.

Overall, the authentic, student-cantered nature of PBL, along with the integration of technology using TPACK, provides an engaging environment for students to think creatively, innovatively solve problems, and develop creative products. This makes PBL with TPACK effective for fostering creativity. The TPACK framework supports PBL by providing a technology component. Technology tools can help students create and share creative products for their PBL projects. PBL and TPACK encourage pre-service science teachers to be creative in designing lessons and utilizing various learning resources. This creativity is important so that science learning becomes more interesting and meaningful for students.

Conclusion

The results showed that the teaching skills of the 98 pre-service science teachers consisted of 38% in the very good category, 45% in the good category, 15% in the satisfactory category, and 2% in the less than satisfactory category. The average teaching skills of pre-service science teachers after attending lectures that applied the PBL with TPACK approach were in the very good category. The study found that the PBL model using the TPACK approach can improve the teaching skills of pre-service science teachers.

The study has implications for teacher education programs and professional development initiatives. The study suggests that the PBL model using the TPACK approach can be used to develop the teaching skills of pre-service science teachers. The study also suggests that the TPACK framework can be used to design and evaluate teacher knowledge that is concentrated on effective student learning in various content areas. The study provides insights into how to incorporate technology into teaching and learning processes more effectively and closer to pedagogical and content knowledge.

The application of the PBL model with TPACK approach has a positive effect on improving the teaching skills of pre-service science teachers. The improved teaching skills include problem solving ability, teaching skills, understanding of teaching materials, and creativity. Therefore, PBL with TPACK approach can be used as an effective alternative to improve the quality of pre-service science teachers.

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