



Measuring TPACK and HOTS of Teacher Professional Education Students Based on Lesson Plans

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Abstract: The manifestation of the technological age is that humans use technology, so education must prepare professional teachers who understand technology. Technology, content, and pedagogic-based learning occurred during COVID-19, known as technological pedagogical content knowledge (TPACK). TPACK research, so far as expertise using questionnaires, rarely studied TPACK designed by teachers. This quantitative study aims to determine the ability of TPACK in lesson plans (LP) of teacher professional education (TPE) students at UIN Sunan Ampel and its effect on HOTS. Data was collected by scoring LP based on TPACK and HOTS instruments. Data on students' ability to design lesson plans were analyzed using SEM path analysis with AMOS application to measure the influence of the TPACK component (TK, CK, PK, TPK, TCK, PCK) for TPACK and HOTS. The results showed that TPACK components ((pedagogic ability (PK) and technology-based pedagogic ability (TPK)) indirectly affect TPACK. Technology-based content capability (CTK) and TPK directly affect TPACK. The TPACK component involves HOTS in a negative direction except for content capability (CT), which affects HOTS positively.

Keywords: HOTS; lesson plan; professional teacher; teacher professional education; TPACK

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INTRODUCTION

The demands of the global world change all aspects of life, including education. Learning must equip students to live in a technology-based 21st century. Students must learn 21st-century skills: critical, creative, collaborative, and analytical thinking. These skills are used to anticipate globalization and to make students adaptive. Learning technology century requires students to master technology. Teachers must help students learn to use technology so that students can access and use technology to increase their understanding. The teacher's content knowledge determines technology-based learning. Teacher pedagogical abilities are also needed to teach technology-based materials. Technological literacy is vital in learning (Falloon, 2020; Hatlevik et al., 2018; Lawrence & Tar, 2018; Uerz et al., 2018). Teachers must be able to find, access, and use information from the internet to make the material more enjoyable and easy to understand (Breakstone et al., 2018; Puspitarini & Hanif, 2019). Pedagogic capabilities, technology, and teaching material in learning are technology pedagogical and content knowledge (TPACK) (Kali et al., 2019; Mishra & Koehler, 2006; Nuangchalem, 2020).

Teachers who master technology-based science and educational content for learning are one indicator of professional teachers. The use of technology during the COVID-19 pandemic provides valuable lessons (Wakhidah et al., 2021). Although there are still many obstacles, it gives awareness to all parties that technology is still needed even though the pandemic is over (Amit et al., 2020; Onyema, 2020; Poe, 2020; Littenberg-Tobias & Reich, 2020; Richter, 2020; Wakhidah et al., 2021). Much research has been done on TPACK on prospective teachers. Still, not much research has analyzed TPACK on teacher professional education (TPE) participant teachers, where these teachers have taught for more than five years, so they are expected to have good educational competence based on experience as teachers. The TPACK research using a questionnaire shows that the TPACK of TPE teachers is still relatively low (Sahin, 2011), but they have not linked the TPACK component. Implementation of TPACK in the TPE program using siaga.pendis application in the Islamic Religious Education study program at Mataram Islamic State University in 2019. This research only describes the implementation of using LMS in equipping TPE participants with TPACK without analyzing TPACK and its components.

Research on TPACK and its components was carried out using a survey and a questionnaire to find out knowledge about TPACK (Graham et al., 2009; Kaplon-Schilis & Lyublinskaya, 2020; Manik & Shareef, 2014;

Roussinos & Jimoyiannis, 2019; Sojanah et al., 2021). Knowledge of TPACK is limited to learning that has yet to be tangible through teacher activities and work (Dewi et al., 2022; Max et al., 2023; Vivian & Falkner, 2019). The work or design of teachers based on TPACK needs to be examined to identify the fundamental abilities of teachers' TPACK (Ammade et al., 2020; Tondeur et al., 2020). The actual ability of TPACK as a teacher's design, for example, by analyzing lesson plans (Dewi et al., 2022), still needs to be carried out, especially for teachers who take TPE. TPACK analysis for TPE teachers needs to be done after a deep understanding of material and education, so slices of TPACK components are drawn to determine the weaknesses of teacher competence in preparing TPACK-based lesson plans. Through material immersion modules and workshops, TPE students deepen their knowledge to improve the quality of learning. The TPE program through SPADA has provided knowledge and skills in creating professional teachers, but not all teachers have mastered it. Through the TPE program, teachers get strengthened regarding academic skills and material according to science and technology because all learning activities are presented as applications.

A lesson plan prepared by a teacher can use the TPACK that the teacher already has (Harris et al., 2010; Kapici & Akcay, 2023; Koh, 2013; Schmid et al., 2021). Mastery of the teacher's skills and knowledge can be seen in the lesson plans and teaching practices (König et al., 2020; Tanak, 2020). The TPE program is expected to improve the quality of education because teachers are equipped with the material for the following fields of science: educational skills, IT, and research abilities. One measure of teacher quality is how to prepare lesson plans (Backfisch et al., 2020; Fujii, 2019; Praetorius et al., 2018). The lesson plans are adequately designed to describe pedagogic abilities and skills in using technology and are supported by scientific material content (Bayram-Jacobs et al., 2019; Dong et al., 2020). TPACK mastery can increase HOTS (Liando et al., 2023; Manik & Shareef, 2014; Sinuraya et al., 2021). Producing material content properly improves critical thinking (Van Laar et al., 2020). Students who master information technology make it possible to design creative content on learning media and problem-solving (Dita et al., 2021). Information technology provides a learning process to be collaborative through social media to facilitate student collaboration (Al-Rahmi et al., 2018; Alamri et al., 2020; Ansari & Khan, 2020; Qureshi et al., 2023; Saqr et al., 2018). Creative students should be able to design technology-based assessments that make the assessment process more accessible and measurable. Problems in the learning process can be solved by choosing alternative solutions offered by the internet. This study aims to determine students' ability to design lesson plans based on TPACK at TPE workshops and the effect of TPACK and TPACK components in lesson plan design on high-order thinking skills HOTS abilities.

METHODS

The type of research used is quantitative descriptive (Creswell, 2007) to analyze the magnitude of the influence of each TPACK component on TPACK and HOTS. The research subjects were TPE students at Madrasah Ibtidaiyah UIN Sunan Ampel Surabaya in 2022. Ninety-seven respondents were involved in this study, divided into five classes/waves: A, B, C, D, and E. Each course contains approximately 20 participants. The research subjects come from areas throughout Indonesia. The research steps include (1) problem analysis; (2) collection of lesson plans for TPE teachers; (3) preparation of research rubrics; (4) focus group discussion (FGD) on perfecting the rubric (5) rubric expert validation; (6) TPACK and HOTS assessment through lesson plan; (7) data collection on TPE student lesson plans from the TPE study program at UIN Sunan Ampel Surabaya; (8) scoring the lesson plan based on the indicators in the research instrument; (9) data input and preparation for quantitative data analysis; (8) data analysis. The research data was TPACK ability scores and their components and high-order thinking skills HOTS), which are reflected in TPE students' lesson plans. The score is obtained by assessing the TPACK and HOTS indicators.

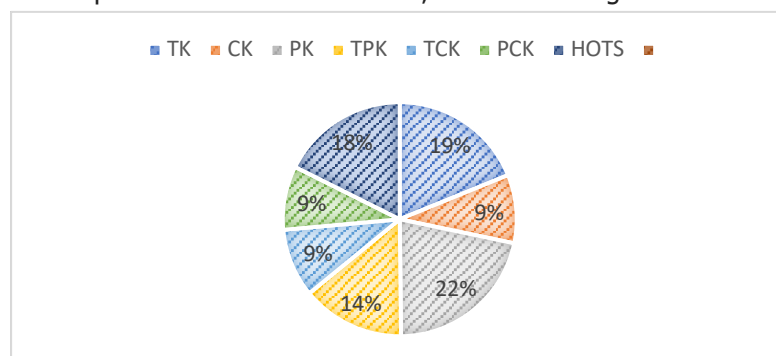
The TPACK and HOTS indicators used in the research instrument are as follows. The data obtained was analyzed using SEM path analysis with AMOS application to determine the effect and contribution of the TPACK components (TK, CK, PK, PCK, TCK, and TPK) on TPACK and HOTS. The steps start by testing the validity and reliability of the instrument to find the tool used in research on AMOS by knowing the loading factor, which is the estimated value of the TPACK variable or component. Instrument items are declared valid if the value is > 0.5 (Singerin, 2022). Then, the model's accuracy tested the hypothesis and the influence of exogenous variables on endogenous variables.

Table 1. TPACK and HOTS Component Assessment Rubric in Lesson Plans

No	Lesson Plan Components Assessed
A	Content Knowledge (CK)
1	Mastered content material (see in the presentation material)
2	Give understanding to students by giving relevant examples _
3	Convey material in a manner clear, logical, and coherent
4	Use reference latest in serve material
5	Designing encouraging learning _ Students think
B	Pedagogical Knowledge (PK)
1	Prepare appropriate lesson plans with level school and age student
2	Using a suitable model/strategy with material
3	Able to prepare worksheet
4	Arranging Steps learning collaborative
5	Reflect and give strengthen learning
6	Using a variety of assessment techniques
C	Technological Knowledge (TK)
1	The teacher is capable of using a computer to prepare plans for learning (Carver, 2016)
2	The technology used _ is interesting for the student
3	The technology used _ to increase motivation and interest in students in Study
4	The technology used _ and mastered by students by level development
5	The technology used _ helps the learning process
D	Technological Content Knowledge (TCK)
1	Technology used _ understudied material _ student
2	Technology/application specifically used _ to increase understanding of student
3	Technology used _ increase activity Study student
E	Technological Pedagogical Knowledge (TPK)
1	Use technology to introduce to the real world in learning
2	Technology following strategy/model/ method learning
3	Use technology in activity study and assessment
4	Facilitate student for thinking level tall through use technology for build knowledge
5	Provide room class/environment Study based technology
F	Pedagogical Content Knowledge (PCK)
1	Model/strategies/ methods by studied material _ student
2	About measuring understanding studied material _ student
3	Got it, the student without technology
G	TPACK
1	Choosing a model/strategy/ method is supported appropriate technology _ in learning
2	Use content knowledge, technology, and pedagogic knowledge to realize effective learning

RESULT AND DISCUSSION

The capabilities of TPACK and its components and HOTS owned by TPE students can be seen in Figure 1. Figure 1 shows that the TPACK component's highest ability is the pedagogic component (PK), and the lowest is content-based pedagogic (PCK). TPE students have more than five years of teaching experience, so students have sufficient pedagogic knowledge. It should be noted for TPE managers that PCK must be concerned because learning teaches material content with appropriate teaching methods. Path analysis shows the relationship and magnitude of the TPACK component to TPACK and HOTS, as shown in Figure 2.

**Figure 1.** The average value of the TPACK and HOTS components

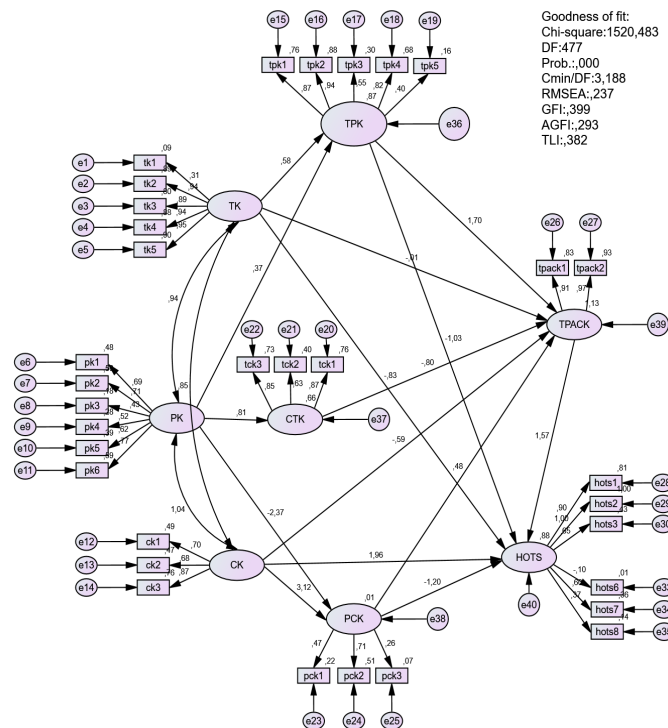


Figure 2. Pathway Analysis of the Relationship between TPACK and HOTS Components

The results of data analysis using SEM AMOS show that indicators of exogenous and endogenous variables are valid and reliable. The results of the data analysis show that the instruments in this study are valid and reliable. The results of the hypothesis test showed that there was a direct effect between TPACK components. The direct relationship between TPACK and HOTS components is shown in Table 2.

Table 2. Hypothesis Test Results for the Direct Effect of TPACK and HOTS Components

Direct Relationship	Standardized	C.R.	P	Summary
TPK <--- TK	3,451	1,712	0.087	No Significant
TPK <--- PK	0.988	2,183	0.029	Significant
CTK <--- PK	2,248	4,508	***	
PCK <--- PK	-2,361	-1,295	0.195	No Significant
PCK <--- CK	2,175	1,553	0.120	No Significant
TPACK <--- TK	-0.054	-0.018	0.986	No Significant
TPACK <--- CK	-0.964	-1,897	0.058	No Significant
TPACK <--- PCK	1,132	1,864	0.062	No Significant
TPACK <--- CTK	-0.681	-2,346	0.019	Significant
TPACK <--- TPK	1,491	2,544	0.011	Significant
HOTS <--- TK	-4,171	-0.778	0.437	No Significant
HOTS <--- CK	3,070	2,009	0.045	Significant
HOTS <--- PCK	-2.682	-1,558	0.119	No Significant
HOTS <--- TPK	-0.863	-1,180	0.238	No Significant
HOTS <--- TPACK	1,489	1,919	0.055	No Significant

From Table 2, pedagogic abilities (PK) influence technology-based pedagogic abilities (TPK). These pedagogic abilities (PK) also influence technology-based content abilities (CTK). Technology-based content capabilities (CTK) and technology-based pedagogic abilities (TPK) have an impact on technology-based pedagogic content capabilities (TPACK). All TPACK components do not affect HOTS except content capability (CK). Content has an influence on HOTS with a significance value of 0.045. Pedagogic ability (PK) influences technology-based pedagogic abilities (TPK). This pedagogic ability (PK) affects technology-based content capabilities (CTK). Technology-based content capabilities (CTK) and technology-based pedagogic abilities (TPK) have an impact on technology-based pedagogic content capabilities (TPACK). TPACK components contribute to

TPACK directly or indirectly. The results of regression calculations with AMOS show that the R-value of technology-based pedagogic abilities (TPK) is 0.870, meaning that TK and PK variables affect 87.0% of TPK and 13% of other factors. The relationship between TK and TPK has a path coefficient value of 0.577 (positive direction). The relationship between PK and TPK has a path coefficient value of 0.369 (positive direction). The R square value for technology-based content capability (CTK) is 0.661, meaning that the PK variable has a 66.1% influence on CTK. The relationship between PK and TPK has a path coefficient value of 0.813 (positive direction). PK and CK variables have an effect of 1.2% on TPK. In the PK to PCK relationship, the path coefficient value is -2,366 (negative direction). In the CK to PCK relationship, the path coefficient value is 3,116.

Technology-based pedagogic content capability (TPACK) is influenced by technological ability (TK), content ability (CK), content-based pedagogic ability (PCK), technology-based content ability (CTK), and technology-based pedagogic ability (TPK) of 113.1% of the TPACK. TK and TPACK have a path coefficient value of -0.010 (negative direction), and the relationship between CK and TPACK has a path coefficient value of -0.586 (negative). The relationship between PCK and TPACK has a path coefficient value of 0.480 (positive direction). The relationship between CTK and TPACK has a path coefficient value of -0.801 (negative direction). The relationship between TPK and TPACK has a path coefficient value of 1.697 (positive direction). The relationship between HOTS and the TPACK component can be seen from the R square value of 0.883, meaning that the TK, CK, PCK, TPK, and TPACK variables have an effect of 88.3% on HOTS. In the relationship between TK and HOTS, the path coefficient value is -0.835 (negative direction). The relationship between CK and HOTS has a path coefficient value of 1,964 (positive direction). The relationship between PCK and HOTS has a path coefficient value of 1.198 (negative direction). The path coefficient is -1.033 (negative) for the relationship between TPK and HOTS. The relationship between TPACK and HOTS has a path coefficient value of 1.566 (positive direction).

TPACK components (TK, CK, PK, TPK, TCK, and TPK) affect TPACK ability (Habibi et al., 2020; Kaplon-Schilis & Lyublinskaya, 2020; Li et al., 2022; Masrifah et al., 2018; Santos & Castro, 2021; Tanak, 2020; Yang et al., 2021) and higher-order thinking (Goradia, 2018; Long et al., 2022; Wijnen et al., 2021). Increasing the ability to think highly through technology is realized if technology is used under the learning model. Technology only helps TPE students to complete their pedagogical abilities to improve higher-order thinking skills (Afikah et al., 2022; Heong et al., 2019; Retnawati et al., 2018; Suwarma & Apriyani, 2022) and build knowledge (Cadavieco et al., 2020; Sequeda et al., 2019; Ye et al., 2018). None of the lesson plans TPE students provide technology space to provide technology-based learning spaces. This is understandable because all activities in schools in Indonesia are carried out face-to-face, so technology-based learning spaces do not need to be developed in lesson plan designs. TPE students have been provided with pedagogic abilities and material content during lectures. Pedagogic abilities, such as designing lesson plans and teaching methods, determine what technology the teacher will use when teaching the material (Nguyen & Bower, 2018; Sudargini & Purwanto, 2020). Teachers who have not received technology material during college will find it difficult to teach using technology (Nithitakharanon & Nuangchalem, 2022; Wakhidah et al., 2021). During the Covid 19 pandemic, teachers had no difficulties using technology, even though some teachers were over 45 years old because teachers were trying to learn technology. This is consistent with the results of data analysis that pedagogic ability (PK) significantly influences technology-based pedagogic ability (TPK).

This pedagogic ability (PK) influences technology-based content capabilities (CTK). Teaching ability affects a teacher's ability to mix material content into technology that students better understand (Nithitakharanon & Nuangchalem, 2022). Pedagogic abilities lead teachers to design learning content, for example, making learning media that contains material by making YouTube or images that are easier to understand. This is especially true for challenging, complex, and abstract materials. Examples of knowledge and experience teaching the digestive system of complex and abstract food, video media, or technology-based images can be used to help students observe the process or mechanism of food digestion in the stomach. The use of videos can improve understanding of technology-based content (Ampomah, 2018). The ability to prepare good technology-based lesson plans and worksheets is expected to increase student understanding.

Technology-based content capability (CTK) affects technology-based pedagogic content capability (TPACK). Technology-based content capability (CTK) is the teacher's ability to present material content using appropriate supporting technology so that students understand the material better. An indicator of technology-based content capability is the ability to use technology per the material being studied to increase student understanding. Teachers who teach the respiratory system using video technology make it easier for students to understand gas exchange in the lungs. In addition, technology can also increase student learning activity (Bernacki et al., 2020; Geng et al., 2019); for example, when students use Google Classroom, they can carry out the discussion process online. The TPACK ability indicator is a teacher's ability to use content knowledge, technology, and pedagogic knowledge to realize effective learning. The use of technology-based content affects TPACK because it creates effective learning.

Technology-based pedagogic abilities (TPK) influence technology-based pedagogic content abilities (TPACK). Technology-based pedagogic knowledge and skills, such as using technology to introduce students to the real world in learning, for example, with augmented reality, can facilitate students in achieving their learning goals (Costa et al., 2020; Hwang et al., 2016; Wu et al., 2018). Technology-based pedagogic abilities (TPK) also encourage teachers to choose technology according to learning strategies/models/methods. Learning models that follow technology lead students to achieve effective learning. In addition, technology-based pedagogic knowledge trains students' higher-order thinking. Technology-based pedagogic knowledge can enhance learning activities and even help the assessment process when using technology. Students who use technology to seek information can construct knowledge through a technology-based learning environment. Technology-based pedagogic knowledge leads students to learn well and achieve their learning goals. Technology, including TPE students, is new and exciting for students, so pedagogic skills and content are no longer interesting to learn. It is proven that PK has no effect on PCK, and CK has no impact on PCK. So far, teacher education has only taught content and pedagogic knowledge so that students are no longer interested in content and academic development when participating in TPE. TPE students feel that teaching with material content is their daily work, so they pay little attention to new things presented by the supporting lecturers. Based on experience when participating in the workshop module, namely the development of learning tools, students are reluctant to change the indicators suggested by a lecturer. Lecturers try to improve the indicators formulated by students. Still, this research document shows that the formulation of indicators and learning objectives remained the same during the workshop activity.

TK and CK do not directly have a significant effect on TPACK. Good technological skills and expertise in material content do not guarantee effective learning. Using technology-based media, if not accompanied by pedagogic knowledge, causes learning to become less focused. For example, using videos about the universe with advanced technology will only be effective if it is within the ability of students to think. Pedagogic knowledge provides guidelines for material taught to elementary school children studying the solar system. Good content knowledge does not guarantee effective learning. Teachers who teach with lectures without looking at the students' conditions, whether the students understand or do not understand, where the teacher thinks that what the teacher understands must also be understood by students, do not lead to effective learning. That is the reason why TK and CK do not directly affect TPACK. Based on the study's results, improving teachers' technological capabilities and content is necessary. Teachers who take part in TPE graduated after 2000 when technology developed rapidly, but technology training in learning remains a government priority in improving teacher quality. Constructing material content can be enhanced through training, subject-teacher meetings, and peer learning. The exciting thing in the millennial era is that content pedagogic knowledge (PCK) does not influence TPACK. This finding needs to be observed, as conventional learning has the potential to be ineffective in the millennial generation. Traditional learning causes students to get bored, sleepy, and potentially busy because they need more motivation to learn. The relationship between HOTS and the TPACK component can be seen from the R square value of 0.883, meaning that the TK, CK, PCK, TPK, and TPACK variables have an effect of 88.3% on HOTS. In the relationship between TK and HOTS, the path coefficient value is -0.835 (negative direction). The relationship between CK and HOTS has a path coefficient value of 1.964 (positive direction). The relationship between PCK and HOTS has a path coefficient value of 1.198 (negative direction). The path coefficient is -1.033 (negative) for the relationship between TPK and HOTS. The relationship between TPACK and HOTS has a path coefficient value of 1.566 (positive direction).

Higher-order thinking skills (HOTS) are related to TPACK. TPACK and its components have an effect of 88.3%. This means that the material's content, packaged in the latest technological nuances and taught with good pedagogy, will improve high-level thinking. For example, the material "solar system" using augmented reality taught with a cooperative model can facilitate high-level thinking. This is supported by research (Gaol et al., 2022) that learning using a scientific approach can improve critical thinking, problem-based learning models to improve critical thinking (Dewi, 2025), and inquiry learning models (Vari, 2023). Skills and knowledge are compatible with problem-based learning and project-based learning. Both of these learning are very much in line with the implementation of the Merdeka curriculum, so they must be taught in material immersion modules and workshops to be implemented in teaching practice. The findings in this study are that the CK component contributes to HOTS in a positive direction, while other parts have a negative tendency. TPE students' concept understanding will develop high-level thinking (Alatas, 2014; Erman et al., 2021; Nugraha et al., 2022). Content knowledge strongly supports high-level thinking (Wakhidah, 2012). Teachers have implemented high-level thinking in learning but must be aware of it. This was revealed by research (Erman & Wakhidah, 2020). Teachers have taught high-level thinking through TPACK-based learning, primarily through content components (Sahidin & Pradjono, 2022). Based on the results of this study, HOTS needs to be taught more deeply to TPE students. TPE students who have taught in schools learn HOTS not to be known but must be done continuously so that they can encourage and facilitate students to think at a high level.

CONCLUSION

The TPACK component makes a positive contribution to TPACK indirectly, namely in pedagogic abilities (PK) influencing technology-based pedagogic abilities (TPK) and technology-based content abilities (CTK). Technology-based pedagogic abilities (TPK) and technology-based content abilities (CTK) directly affect TPACK. The content component that influences HOTS is content capability (CT). The results of this study indicate that the implementation of TPE UIN Sunan Ampel Surabaya is effective in increasing student TPACK through lesson plan design. The findings of this study should serve as a basis for developing a model of professional teacher education that can facilitate students to improve their TPACK and HOTS skills simultaneously so as to produce high-quality professional teachers.

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