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Analysis of TPACK Competence of Elementary School Physical Education Teachers: A Cross-Sectional Study

Entan Saptani✉[1], Anin Rukmana[2] & Tedi Supriyadi[3]

Physical Education of Elementary Teacher Education Program, Universitas Pendidikan Indonesia, Bandung, Indonesia

✉ entansaptani@upi.edu

Abstract. One of the obstacles to teaching physical education in the 21st century is the necessity for teachers to integrate technology-based learning. The TPACK framework plays a crucial role in enhancing the quality of instruction in physical education. This study aims to map the TPACK competencies of physical education teachers. A cross-sectional survey design with a quantitative approach was employed, utilizing convenience sampling techniques. The research participants consisted of 14 physical education teachers from North Sumedang in Sumedang Regency. Data were analyzed using descriptive statistics through the SPSS 20 program. The results indicated that the understanding of the Content Knowledge component was 78.57, categorized as sufficient; Pedagogical Knowledge was 83.48, classified as excellent; Technological Knowledge was 73.21, also sufficient; Pedagogical Content Knowledge was 79.64, appropriate; Technological Content Knowledge was 73.21, sufficient; Technological Pedagogical Knowledge was 74.55, appropriate; and Technological Pedagogical and Content Knowledge was 79.17, also appropriate. The application of TPACK in the learning process showed that 78% of teachers have mastered it; similarly, 78% of teachers demonstrated mastery in implementing learning, while 77% of teachers showed proficiency in evaluating learning. Thus, physical education teachers in the North Sumedang sub-district effectively integrate technology, pedagogy, and content in their physical education instruction. This finding underscores the importance of ongoing support and training to enhance teachers' TPACK competencies, ensuring effective technology integration in physical education.

Keywords: Cross-sectional Study; Physical Education; TPACK; Teacher Competency; Technology Integration.

1. Introduction

The 21st-century paradigm indicates that technological advancement is essential for educational progress (Nugroho et al., 2019). This discussion necessitates the use of ICT into the educational framework (Cengiz, 2014; Ng et al., 2021; Talebian et al., 2014). The integration of technology to enhance educational quality is regarded as a norm across all disciplines, including physical education (PE). Consequently, physical education instructors must possess the ability to incorporate ICT technology into the educational process. Schools are adapting to technological advancements by augmenting the time dedicated to ICT skills, potentially at the expense of other disciplines. Physical education is at risk of being marginalized, as technology and physical education frequently occupy opposing ends of the educational spectrum; the former is perceived as necessitating minimal movement, while the latter demands physical activity (Pyle & Esslinger, 2014). The implications render the relationship between Physical Education and technology appear incongruous.

1.1. Problem Statement

Related to the above, the results of a survey by the Federation of Indonesian Teachers' Unions (FSGI) of 602 people from 14 provinces revealed that only 8% of teachers understood the use of technology in learning (Izzama et al., 2020). As a result of teachers' reduced ability to master technology, student learning outcomes are not achieved (Nopiyanto, 2020). Another impact due to PE teachers' lack of ICT capabilities is an obstacle to implementing PE learning boldly during the pandemic (Akbar et al., 2021). Therefore, increasing the competence of PE teachers who can integrate ICT into learning is necessary. This success is also closely related to the curriculum support for PE teacher education in producing quality candidates. Teacher quality is considered essential in physical education learning in schools (Maksum, 2010). Thus, PE teachers in the 21st century are not only required to master physical education as a motor skill but also be able to teach physical education based on ICT technology in the learning process. This investigation also requires teachers to master content, pedagogy and technology (Niess, 2011). This aligns with the concept of technological, pedagogical and content knowledge (TPACK), where TPACK plays a role in increasing the quality and quantity of teachers in physical learning, including content, pedagogy, and technology (Baert, 2014).

1.2. Related Research

Several relevant studies related to TPACK teachers were explored. Kartal & Çınar, (2022) explored the development of TPACK of 33 pre-service elementary mathematics teachers (PST) through a survey. The research results showed that the participants had not utilized technology effectively and efficiently in their microteaching sessions in the first lesson in teaching their students. After teaching their first lesson at school, PSTs improved their teaching significantly. Through his research, he recommends providing more opportunities for PSTs to teach with technology in the classroom and to assess their teaching practices reflectively. Sojanah et al., (2021) explored the influence of teaching experience, training, facilities and infrastructure, self-efficacy, and motivation on TPACK economics teachers. The research results revealed that teaching experience, training, facilities and infrastructure, self-efficacy, and motivation positively influenced TPACK teachers. Through the design mix method ex, Dalal et al., (2017) explored the effects of one semester of professional technology development for secondary school teachers from developing countries. The survey assessed international teachers' technology integration capabilities using the TPACK framework and design tasks to understand their decision-making. Number 16 teachers showed improvement in TPACK skills. Additionally, Teachers learn to consider the affordability of technology, but access issues influence their choice and use of technology in instructional planning.

In contrast to the results of the study above, this study pays attention to the TPACK competencies of elementary school PE teachers. This study is focused on investigating the TPACK abilities of prospective elementary school physical education teachers in carrying out the learning process. It is hoped that the contribution of this research can be considered in formulating a curriculum for prospective PE teacher education in creating professional PE teachers in the 21st century. This study's originality is its emphasis on mapping the TPACK competencies of primary school physical education instructors in Sumedang Regency using a cross-sectional approach, a topic that has not been extensively explored in this context. This study explicitly investigates the implementation of TPACK in physical education, distinguishing itself from other research that focuses on pre-service teachers or subject-specific educators, given the unique aspects of technology integration in this field. This study specifically assesses teachers' proficiency in each element of TPACK in the context of learning, implementing, and evaluating physical education, thereby offering a more thorough understanding of teacher preparedness to meet the challenges of 21st-century education in this domain.

1.3. Research Objectives

This study aimed to delineate the TPACK competencies of physical education instructors in primary schools within Sumedang Regency. This study seeks to examine educators' competencies in each element of TPACK within the framework of learning, executing, and assessing physical education. The findings of this study are anticipated to inform the development of a curriculum for prospective professional physical education teachers equipped to address the problems of 21st-century education.

2. Theoretical Framework

2.1. ICT and 21st Century Learning

The use of ICT in teaching and learning has increased substantially over recent years in most developed countries (Comi et al., 2017; Falck et al., 2018). Theoretical arguments supporting the positive effects of ICT on educational achievement suggest that they can improve student outcomes by increasing access to information and a more comprehensive range of learning resources (Spiezia, 2011). Additionally, using ICT can promote individualized instruction and better monitoring of student progress (Falck et al., 2018). According to the view supporting ICT, technology will increase students' flexibility and autonomy while improving their attitudes and learning experiences (De Witte & Rogge, 2014). ICT can improve teaching materials and make lessons more complete, engaging, and interactive (Comi et al., 2017). As a result, using ICT will improve students' educational outcomes while reducing educational costs in the long term (De Witte & Rogge, 2014).

Educators' skills in using and integrating ICT can increase educators' confidence to integrate ICT constructively (Lee & Hong, 2022). These skills can be strengthened during teacher education through methodical exposure to ICT training as a pedagogical tool (Mlambo et al., 2020). Curricula that promote social constructivism and incorporate advanced technology can be vital in helping pre-service educators experience constructivist environments early in their careers (Barak, 2014). This is important considering that in the last 20 years, there has been a shift in educational development towards Information and Communication Technology (ICT) as one of the 21st-century education management strategies, which include institutional governance and human resources (Soderstrom et al., 2012). Technology is the driving force behind many developments and innovations in developed and developing countries (Talebian et al., 2014).

The demand for competency to integrate ICT in the learning process requires a comprehensive transformation of education so that the quality of teachers who can advance knowledge, training, student equity and student achievement are developed (Darling-Hammond, 2006; Mullis & Martin, 2019), considering that 21st-century skills consist of; (1) life and career skills, (2) learning and innovation skills, and (3) information media and technology skills (Ataizi & Donmez, 2014; Perdana et al., 2020). This suggests that with the paradigm shift regarding the 21st century, it is hoped that students, especially prospective teachers, will have comprehensive abilities regarding life skills, develop knowledge, and master future technology. Meanwhile, mapping teacher skills in integrating ICT into learning is known as TPACK.

2.2. TPACK Framework

At the conceptual level, TPACK is a type of new strategy or technical knowledge that teachers must control to apply technology well in learning (Koehler & Mishra, 2009; Mishra & Koehler, 2006; Rahmadi, 2019). In its development, TPACK has become a framework that can be used to analyze teacher knowledge related to integrating technology into learning (Koehler & Mishra, 2009). Apart from that, TPACK is the knowledge that can receive knowledge and skills that combine pedagogy and material from current technological

developments (Suyamto et al., 2020). TPACK can be used as an effective tool and a way to explore teachers' abilities in integrating technology into learning (Ersanli, 2016).

TPACK aims to develop basic knowledge when teachers study learning material and how technology can improve the quality of learning, as well as knowing pedagogy that can improve learning content (Koehler et al., 2013). Therefore, TPACK plays a vital role as a framework in compiling learning programs that aim to solve student problems based on learning material through the application of technology (Saputra, 2019). TPACK suggests that the technology used should also work in technical with pedagogical and content-specific knowledge to enhance teaching and match student characteristics and the learning environment (Galindo-Domínguez & Bezanilla, 2021; Su, 2023). A teacher needs to be able to combine TPACK because this greatly influences how the teacher teaches (Koh & Chai, 2011). The TPACK framework is seen in Figure 1.

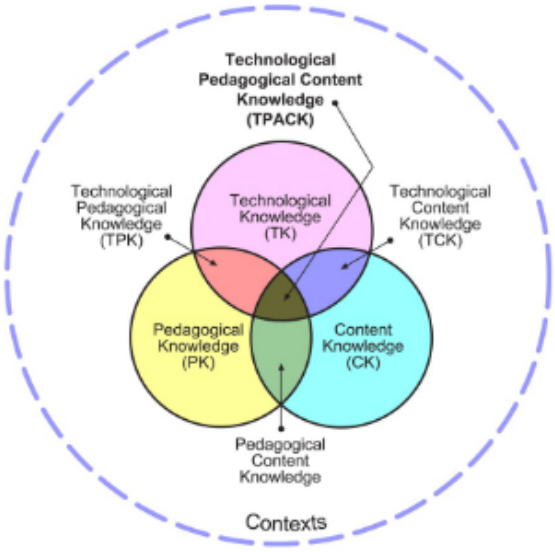

Figure 1. TPACK components (Mishra & Koehler, 2008)

Based on figuere 1 above, this framework shows three main components of knowledge: content, pedagogy, and technology, which are interrelated or interact. From this framework, there can be seven components of knowledge, namely: Technological Knowledge (TK), Pedagogical Knowledge (PK), Content Knowledge (CK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK). Technological Pedagogical and Content Knowledge (TPACK).

2.3. Technological Knowledge (TK)

Teachers need to have a fundamental understanding of simple technologies, such as teaching aids, and the ability to utilize ICT-based tools effectively. Proficiency in using computer programs and applications is essential for designing and delivering technology-based learning experiences. Teachers must also recognize the appropriate moments to integrate information technology to support or achieve specific learning goals (Koehler et al., 2013). This technological competence allows teachers to create engaging and interactive learning environments that cater to students' needs. By mastering these skills, educators can enhance their instructional strategies, making learning more dynamic and accessible for students in various educational contexts.

In the context of physical education, the application of technology can be adapted to suit different learning activities. Teachers are encouraged to incorporate simple technologies

and seamlessly integrate them into their teaching practices to enrich learning experiences (Semiz & Ince, 2012). For instance, using video demonstrations, interactive presentations, or online assessments can enhance students' understanding of physical movements and techniques. Moreover, ICT tools enable teachers to track progress, provide immediate feedback, and foster collaborative learning among students. This integration of technology ensures that physical education remains engaging, innovative, and aligned with modern educational practices, ultimately improving students' overall learning outcomes.

2.4. Pedagogical Knowledge (PK)

Pedagogical Knowledge (PK) refers to a teacher's understanding of teaching processes, methods, and practices, including setting objectives, conducting assessments, and achieving overall learning goals (Maderick et al., 2016). Effective pedagogical knowledge enables teachers to manage classrooms efficiently, plan lessons systematically from start to finish, and evaluate learning outcomes comprehensively. Teachers must continuously deepen their pedagogical knowledge to better understand students' characteristics, learning styles, and developmental stages. This understanding helps teachers design strategies that support students in developing knowledge and acquiring skills aligned with the intended learning objectives (Koehler et al., 2013). Strong pedagogical knowledge is fundamental for creating engaging and meaningful learning experiences.

In the context of physical education, applying pedagogical knowledge means teachers must consider students' developmental needs and abilities throughout the learning process (Spiteri & Chang Rundgren, 2020). Teachers should create inclusive and motivating environments that inspire students to actively participate in lessons and improve their physical and social skills. Effective use of pedagogical knowledge also involves adapting teaching methods to accommodate diverse learning needs and providing constructive feedback to enhance student performance (Semiz & Ince, 2012). Furthermore, physical education teachers should focus on fostering enthusiasm, teamwork, and confidence among students, ensuring that learning experiences are enjoyable, purposeful, and aligned with the principles of holistic education.

2.5. Content Knowledge (CK)

Content Knowledge (CK) refers to a teacher's mastery of topics, concepts, and subject matter that form the foundation of the learning material to be delivered to students. In physical education, CK emphasizes the importance of understanding the curriculum and its components, including movement concepts, physical activities, and sport-related knowledge (Cox & Mann, 2008). Teachers with strong content knowledge are better equipped to present accurate information, design relevant learning activities, and address students' questions effectively. This expertise ensures that lessons are meaningful, well-structured, and aligned with educational standards, ultimately helping students build a solid foundation in physical education.

The application of CK in physical education learning requires teachers to possess in-depth knowledge of movement principles, physical skills, and related theories. Teachers must demonstrate competence in areas such as motor skills, fitness development, and sports techniques, enabling them to guide students in improving their abilities (Semiz & Ince, 2012). Beyond theoretical knowledge, teachers should also model proper techniques and strategies, fostering student engagement and motivation. By integrating CK effectively, teachers not only enhance students' physical capabilities but also promote lifelong health and fitness habits. This comprehensive understanding allows teachers to create learning environments that are both educational and enjoyable.

2.6. Pedagogical Content Knowledge (PCK)

Understanding how teachers integrate pedagogy with subject content forms the foundation of Pedagogical Content Knowledge (PCK). It represents a teacher's ability to effectively combine teaching methods with the material being taught to create structured and meaningful learning experiences (Cengiz, 2015). PCK emphasizes not only mastery of content but also the ability to deliver it in ways that meet students' learning needs. Teachers must carefully plan lessons, ensuring that instructional strategies align with learning goals while addressing students' diverse abilities and backgrounds. This approach allows teachers to transform subject matter into accessible and engaging content that promotes deeper understanding.

In the context of physical education, the application of PCK involves selecting teaching strategies and methods that are appropriate for students' developmental levels and class dynamics (Semiz & Ince, 2012). Teachers must adapt instructional techniques to suit varying skill levels, ensuring lessons are inclusive and motivating. By effectively blending pedagogy and content, teachers can foster active participation, build physical skills, and encourage positive attitudes toward physical activity (Hay et al., 2013).

2.7. Technological Content Knowledge (TCK)

Technological Content Knowledge (TCK) refers to a teacher's understanding of the relationship between technology and subject content, emphasizing how technology can enhance and support learning (Voithofer et al., 2019). It involves the ability to integrate relevant tools and digital resources that complement instructional materials, making learning more dynamic and engaging (Sintawati & Indriani, 2019). Teachers must stay updated with technological advancements and evaluate their applicability to improve content delivery. Effective use of technology not only enriches teaching methods but also helps students grasp concepts more easily through visualizations, simulations, and interactive tools (Agustini et al., 2019).

In the context of physical education, applying TCK means teachers must select appropriate technologies that align with the material being taught (Semiz & Ince, 2012). For instance, video tutorials, fitness-tracking apps, and online assessments can enhance student engagement and understanding (Lengkana et al., 2021). Teachers should integrate tools that support demonstrations of movements and provide real-time feedback, making learning experiences more practical and effective. Such technological integration fosters innovation and motivates students to actively participate in physical activities.

2.8. Technological Pedagogical Knowledge (TPK)

Technological Pedagogical Knowledge (TPK) refers to a teacher's ability to integrate technology effectively with pedagogical strategies to enhance the learning process. It involves selecting and utilizing technological tools that support teaching methods, improve lesson delivery, and facilitate student engagement (Sintawati & Indriani, 2019). Teachers must be able to identify technologies that align with their instructional goals while considering factors such as class level, student readiness, and learning styles. This approach ensures that technology is not only used as a supplementary tool but also as an integral part of the learning experience. In physical education, the application of TPK emphasizes the selection of appropriate technologies that serve as effective learning media, such as videos, online quizzes, and interactive applications. Teachers should design lessons that incorporate these tools to demonstrate movements, track progress, and provide instant feedback, thus making learning more engaging, accessible, and tailored to students' needs (Semiz & Ince, 2012).

2.9. Technological Pedagogical and Content Knowledge (TPACK)

Teachers' understanding of the integration of pedagogy, content, and technology—commonly referred to as Technological Pedagogical Content Knowledge (TPACK)—is an inseparable framework in the learning process (Ajizah & Huda, 2020). This framework emphasizes how educators can effectively combine teaching strategies, subject matter expertise, and technological tools to create meaningful and engaging learning experiences. In physical education, the application of TPACK allows teachers to enhance instruction by utilizing multimedia resources, such as instructional videos, to demonstrate movements or techniques. These resources help visualize complex concepts, making them easier for students to understand and replicate. Furthermore, teachers can reinforce learning by facilitating interactive discussions and providing constructive feedback through question-and-answer sessions (Semiz & Ince, 2012). This approach not only promotes active participation but also fosters critical thinking and problem-solving skills. By integrating TPACK effectively, physical education teachers can create dynamic lessons that support both cognitive and physical development.

3. Method

3.1. Research Design

This research uses a quantitative approach with a cross-sectional survey design. Cross-sectional surveys were chosen because they can examine attitudes, characteristics and opinions without requiring an extended period. In addition, survey research can be helpful as information for evaluating programs in educational practice (Creswell, 2002, p. 376). This is very relevant to the research that will be carried out because this research focuses on pedagogical competence.

3.2. Research Procedures

Eight steps must be taken in the survey research procedures: (1) analyzing the problems. This stage aims to determine that the survey is the proper method to resolve the problems. (2) formulate research questions. (3) Identify the population and sample. This step aims to determine the population and sample involved in the research. (4) determine the survey plan. The goal is to choose the type of survey that suits the problem. (5) create and determine instruments. Aims to select the tools used to collect data. (6) administering instruments. (7) processing data to answer questions. (8) write the final report (Creswell, 2015, p. 801-804).

3.3. Population and Location

The population in this study were all physical education teachers in Sumedang Regency in two sub-districts, namely North Sumedang and South Sumedang sub-districts. This area was chosen based on information from the local education office that there are still many physical education teachers who do not carry out online learning because one of the inhibiting factors is the lack of technological capabilities in learning during the pandemic season. This research uses a convenience sampling technique. This sampling technique was chosen because it only involves respondents who can be a sample and share helpful information to answer the hypothesis (Creswell, 2015, p. 294-295). The sample in this study consisted of physical education teachers in the two sub-districts, with 14 physical education teachers, 11 male and three female.

3.4. Data Collection and Analysis Techniques

Data in the research was collected by distributing questionnaires using Google Forms and an interval scale (Creswell, 2015, p. 331). Responding to the current technological era, Google Forms is one component of the Google Docs service, which has become an online

survey tool that is free and easy to use (Batubara, 2016; Saktiono, 2019). questionnaire using Google Forms was chosen because it can provide information quickly and express a person's opinion regarding problems, either individually or in a group, regarding problems. The data analysis process in this research uses descriptive statistics in the SPSS application (Cresswell, 2015, p. 348-357).

3.5. Validity and Reliability

The instrument consists of 21 statements measured on a Likert scale. These statements encompass seven aspects: Content Knowledge (CK), Pedagogical Knowledge (PK), Technological Knowledge (TK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical and Content Knowledge (TPACK). The instrument was tested on 10 physical education teachers. Validity and reliability tests were conducted using statistical methods, such as item-total correlation for validity and Cronbach's Alpha for reliability. The R table value for N-1 = 9 is 0.6021. The validity test results yielded R count values ranging from 0.661 to 0.995, indicating that the R count values exceed the R table value. Therefore, the instrument is deemed valid. Additionally, the Cronbach's Alpha value of 0.985 indicates high reliability. Thus, the instrument can be declared both valid and reliable.

4. Findings

4.1. Content Knowledge (CK)

The data collection results were based on questionnaires completed by physical education teachers, with 14 as respondents. Data processing based on the Content Knowledge (CK) component is presented in the following Table 1.

Table 1. TPACK Capabilities Based on Content Knowledge Components

Mean	Median	Modus	Min	Max	Standard Deviation
78,57	81,25	68,75	68,75	93,75	6,809

Table 1 shows that the content knowledge (CK) ability of physical education teachers obtained an average ability score of 78.57. The average score is in the interval 66-80 in the good category. The results of data categorization can be seen in the Figure 2 as follows.

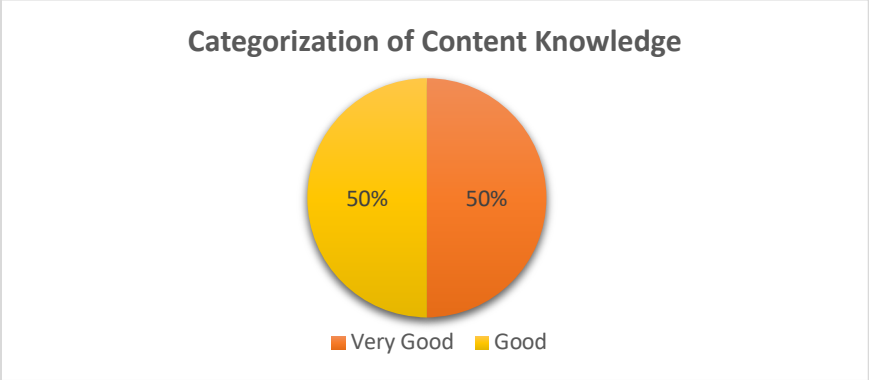

Figure 2. Categorization of Content Knowledge Capabilities

Based on Figure 2 above, the 14 respondents who filled out the questionnaire regarding Content Knowledge (CK) abilities fell into two categories: very good and good. 50% of the respondents involved fall into the very good category, and 50% fall into the good category. It can be concluded that physical education teachers have very good Content Knowledge abilities.

4.2. Pedagogical Knowledge (PK)

Based on the data collection results through questionnaires filled out by physical education teachers, 14 physical education teachers responded based on the Pedagogical Knowledge (PK) component, which is presented in the following Table 2.

Table 2. TPACK Capabilities Based on Pedagogical Knowledge Components

Mean	Median	Modus	Min	Max	Standard Deviation
83,48	81,25	75,00	75,00	93,75	8,704

Table 2 shows that physical education teachers' Pedagogical Knowledge (PK) ability score obtained an average of 83.48. The average score was 81-100 in the very good category. The results of data categorization can be seen in the Figure 3.

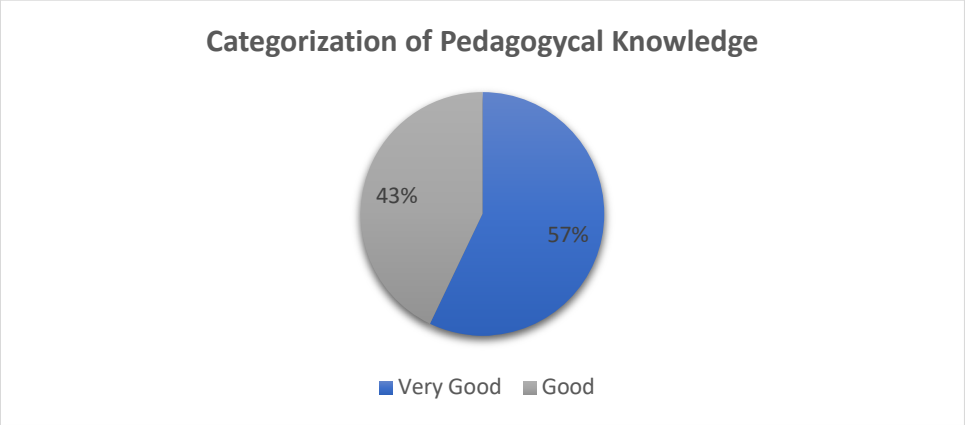

Figure 3. Categorization of Pedagogical Knowledge

Based on Figure 3 above, it can be seen that the 14 respondents who filled out the questionnaire regarding Pedagogical Knowledge (PK) abilities fell into two categories, namely: very good and good. Of which 57% of the respondents involved were in the very good category, and 43% were in the good category. It can be concluded that physical education teachers have good Pedagogical Knowledge (PK) abilities.

4.3. Technological Knowledge (TK)

The results of data collection through questionnaires filled out by physical education teachers with 14 physical education teachers based on the Technological Knowledge (TK) component can be presented in the following Table 3.

Table 3. TPACK Capabilities Based on Technological Knowledge Components

Mean	Median	Modus	Min	Max	Standard Deviation
73,21	71,88	68,75	62.50	87,50	7,527

Table 3 shows that the TPACK ability score based on the Technological Knowledge (TK) component of physical education teachers in the North Sumedang sub-district District obtained an average ability score of 73.21. The average score is 66-80 in the good category. The Figure 4 shows the results of data categorization.

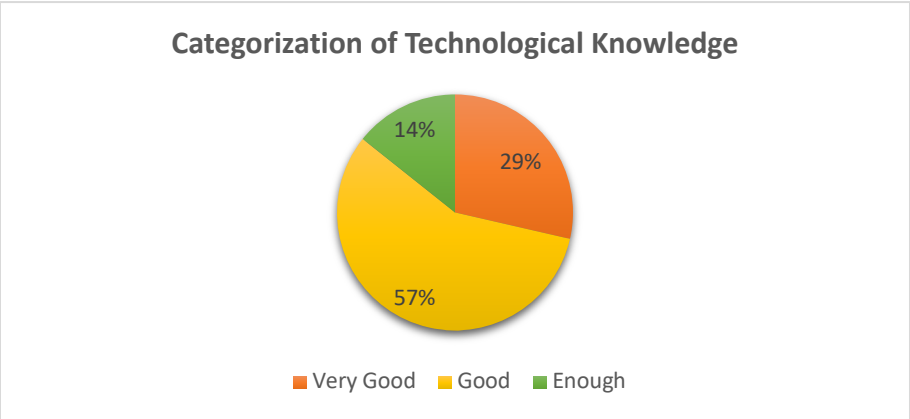

Figure 4. Categorization of Technological Knowledge

Based on Figure 4 above, the 14 respondents who filled out the questionnaire regarding their Pedagogical Knowledge (PK) abilities fall into three categories: very good, good, and enough. Of these, 29% were in the very good category, 57% were in the good category, and 14% fell into the enough category. Physical education teachers have good Technological Knowledge (TK) abilities.

4.4. Pedagogical Content Knowledge (PCK)

Based on the data collection results through questionnaires filled out by physical education teachers with 14 physical education teachers responding, data processing based on the Pedagogical Content Knowledge (PCK) component is presented in the following Table 4.

Table 4. TPACK Capabilities Based on Pedagogical Content Knowledge Components

Mean	Median	Modus	Min	Max	Standard Deviation
79,64	77,50	75,00	65.00	95.00	8.871

Table 4 shows that education teachers' Pedagogical Content Knowledge (PCK) ability score obtained an average value of 79.64. The average score is 66-80 in the good category. The results of data categorization can be seen in the Figure 5 as follows.

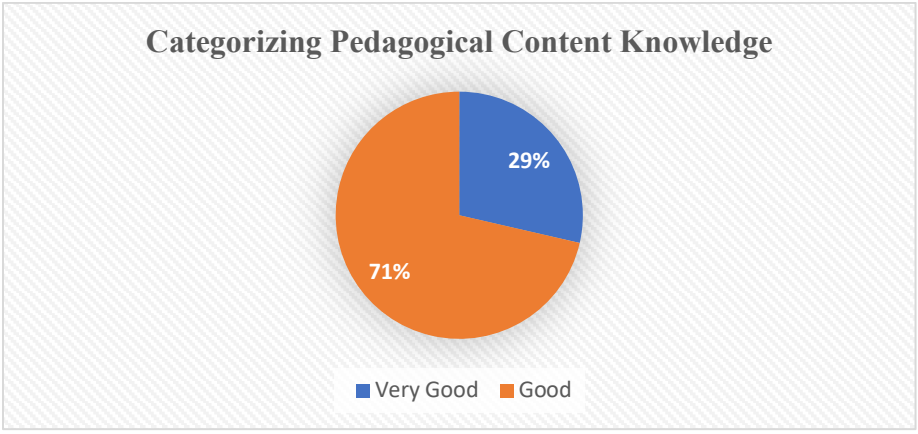

Figure 5. Categorizing Pedagogical Content Knowledge

Based on Figure 5 above, the 14 respondents who filled out the questionnaire regarding Pedagogical Content Knowledge (PCK) abilities fell into two categories: very good and good. Of these, 29% were in the very good category, and 71% were in the good category. Physical education teachers have good Pedagogical Content Knowledge (PCK) abilities.

4.5. Technological Content Knowledge (TCK)

Based on the results of data collection through questionnaires filled out by physical education teachers with a total of 14 physical education teachers responding to data processing based on the Technological Content Knowledge (TCK) component, presented in the following Table 5.

Table 5. TPACK Capabilities Based on Technological Content Knowledge Components

Mean	Median	Modus	Min	Max	Standard Deviation
73,21	72,50	80,00	65,00	80,00	6,079

Table 5 shows that physical education teachers' Technological Content Knowledge (TCK) ability score obtained an average ability score of 73.21. The average score is 66-80 in the good category. The results of data categorization can be seen in the Figure 6 as follows.

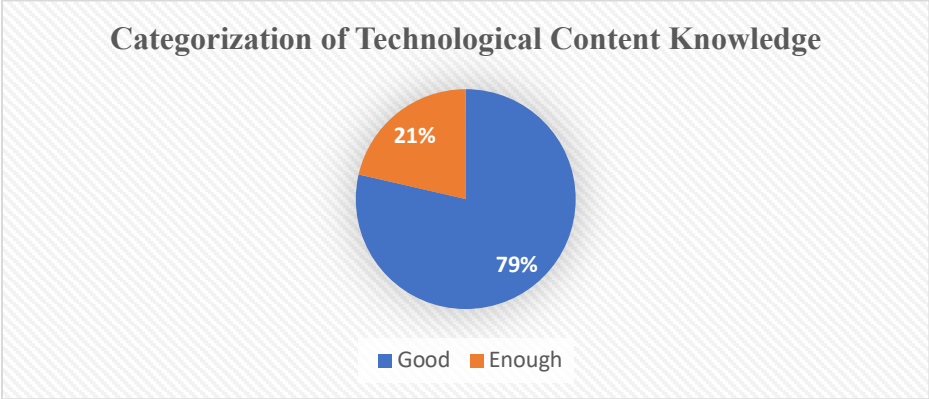

Figure 6. Categorization of Technological Content Knowledge

Based on Figure 6 above, the 14 respondents who filled out the questionnaire regarding Technological Content Knowledge (TCK) abilities fell into two categories: good and enough. Of these, 79% of the respondents fell into the good category and 21%felll into the sufficient category. It can be concluded that physical education teachers have good Technological Content Knowledge (TPK) abilities.

4.6. Technological Pedagogical Knowledge (TPK)

Based on the results of data collection through questionnaires filled out by physical education teachers with a total of 14 physical education teachers as respondents, data processing based on the Technological Pedagogical Knowledge (TPK) component is presented in the following Table 6.

Table 6. TPACK Capabilities Based on Technological Pedagogical Knowledge Components

Mean	Median	Modus	Min	Max	Standard Deviation
74,55	75,00	75,00	62,50	87,50	6,233

Table 6 shows the Technological Pedagogical Knowledge (TPK) ability score of physical education teachers in the North Sumedang sub-district, who obtained an average ability score of 66-80 in the good category. The results of data categorization can be seen in the chart 7:

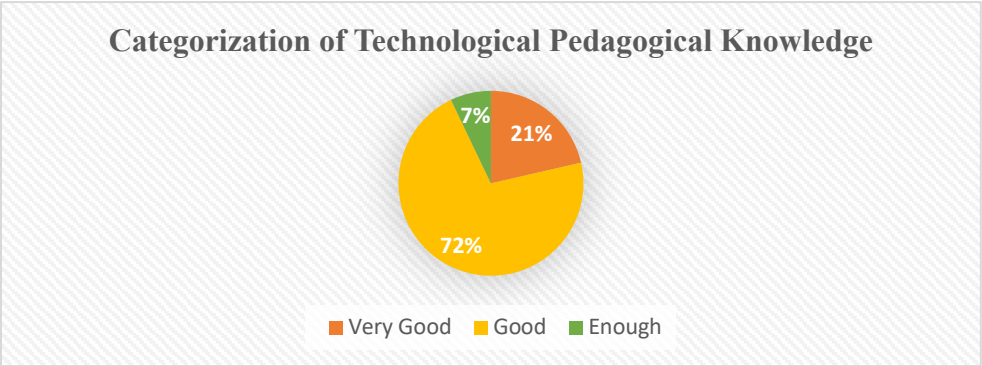

Figure 7. Frequency Distribution of Technological Pedagogycal Knowledge

Based on Figure 7 above, the 14 respondents who filled out the questionnaire regarding their Technological Pedagogical Knowledge (TPK) abilities fell into three categories: very good, good, and enough. Of which 21% of the respondents involved were in the very good category, 72% of the respondents were in the good category. Moreover, 7% of respondents fall into enough category. It can be concluded that physical education teachers have good Technological Pedagogical Knowledge (TPK) abilities.

4.7. Technological Pedagogical and Content Knowledge (TPACK)

Based on the results of data collection through questionnaires filled out by physical education teachers with a total of 14 physical education teachers responding, data processing based on the Technological Pedagogical and Content Knowledge (TPACK) component is presented in the following Table 7.

Table 7. TPACK Capabilities Based on Technological Pedagogical and Content Knowledge Components

Mean	Median	Modus	Min	Max	Standard Deviation
79,17	75,00	75,00	66,67	91,67	7,124

Table 7 shows that the TPACK physical education ability score in the North Sumedang sub-district District obtained an average ability score of 79.17. The average score is 66-80 in the good category. The results of data categorization can be seen in the Figure 8 as follows:

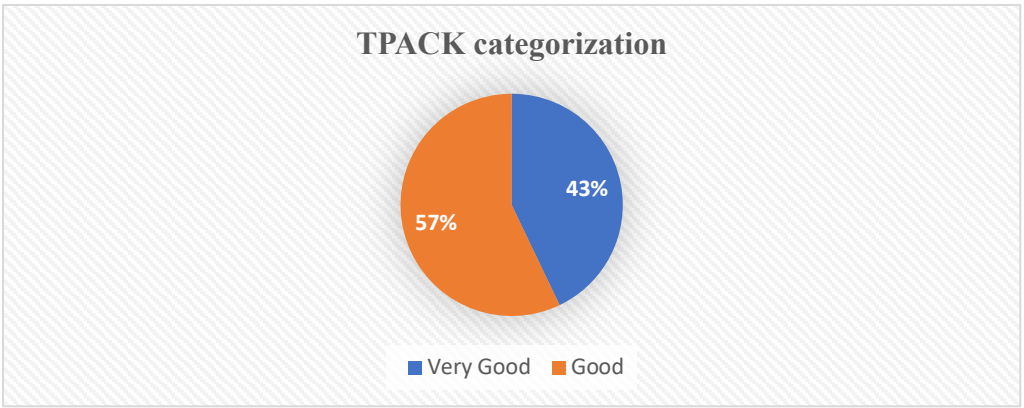

Figure 8. Technological Pedagogical and Content Knowledge

Based on Figure 8 above, the 14 respondents who filled out the questionnaire regarding Technological Pedagogical and Content Knowledge (TPACK) abilities fell into two categories: Very Good and Good. Of which 43% of the respondents involved fell into the

very good category, and 57% of respondents fell into the good category. It can be concluded that physical education teachers have good Technological Pedagogical Content Knowledge (TPACK) abilities.

4.8. Physical Education Teachers' TPACK Ability in Learning Planning

Figure 9 illustrates data related to teachers' TPACK abilities in learning planning. The chart highlights the proportion of teachers who have mastered this competency and those who have not. It shows that most teachers demonstrate proficiency in planning lessons using TPACK principles. Meanwhile, a smaller percentage of teachers still require further development in this area.

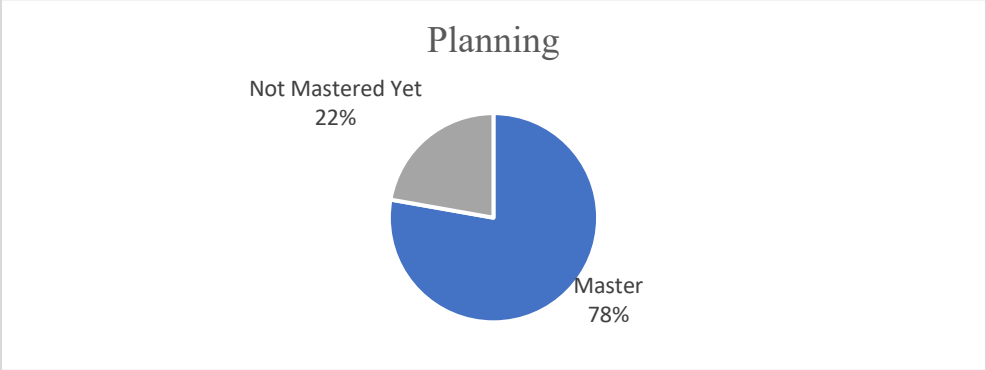

Figure 9. TPACK Capability Percentage Diagram in Learning Planning

Based on Figure 9 above shows that 78% of physical education teachers have mastered TPACK skills in planning physical education lessons in terms of analyzing statement items included in the planning component. Understanding the contents of the syllabus and making a learning implementation plan before carrying out learning is part of the TPACK skill. In planning learning, teachers use ICT, such as looking for reference material using the YouTube application, and physical education teachers already understand technology as a support for learning.

4.9. Physical Education Teachers' TPACK Ability in Implementing Learning

The following data on Figure 10 presents an analysis of Physical Education teachers' TPACK (Technological Pedagogical Content Knowledge) abilities in implementing learning. It highlights the extent to which teachers can effectively integrate technology, pedagogy, and content knowledge into their instructional practices. The results provide insights into their preparedness and competency in designing and delivering lessons that align with 21st-century teaching standards. Additionally, the data identifies areas where further training or professional development may be required to enhance their implementation skills.

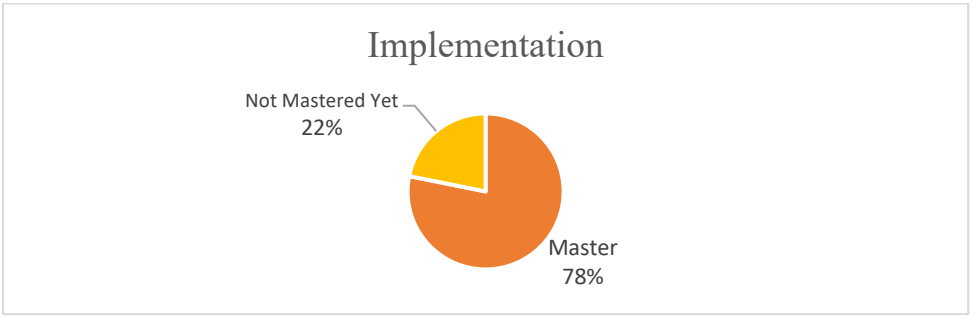

Figure 10. TPACK Capability Percentage Diagram in Implementing Learning

Based on Figure 10 above shows that 78% of physical education teachers have mastered TPACK skills in implementing physical education learning in terms of analysis of statement items included in the implementation components. In learning, teachers have used approaches, methods, and strategies that can improve students' skills. Teachers have also used technology as a learning medium; one example is learning videos to attract students' attention to learning. To carry out online learning, teachers use teleconference features such as Zoom and Google Meet to communicate with students.

4.10. Physical Education Teachers' TPACK Ability in Learning Evaluation

The data presented on Figure 11 highlights Physical Education teachers' TPACK (Technological Pedagogical Content Knowledge) abilities in conducting learning evaluations. It examines their capacity to integrate technology, pedagogy, and content knowledge to design and implement effective assessment strategies. This analysis provides valuable insights into how well teachers utilize digital tools and pedagogical approaches to evaluate student performance and learning outcomes. Furthermore, the findings identify areas where additional training or professional development may be needed to enhance their evaluation practices.

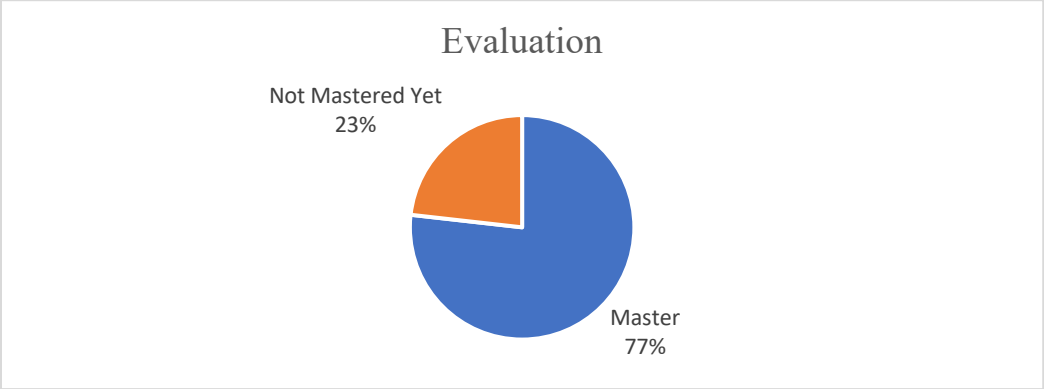

Figure 11. TPACK Ability Percentage Diagram in Learning Evaluation

Figure 11 above illustrates that 77% of Physical Education teachers have demonstrated mastery of TPACK (Technological Pedagogical Content Knowledge) skills in implementing physical education learning, particularly in the context of evaluating student progress. This data reflects their ability to integrate technology effectively into the learning process, enhancing both instruction and assessment. Teachers utilized Google Forms as a tool for conducting evaluations at the end of each lesson, enabling them to gather and analyze student responses efficiently. This approach not only streamlined the assessment process but also encouraged the use of digital platforms to support learning objectives. Additionally, teachers leveraged WhatsApp as a communication medium to facilitate discussions with students, allowing them to address questions, clarify concepts, and provide feedback outside the classroom. The use of these digital tools highlights the adaptability of teachers in incorporating technology to enhance learning evaluations, fostering interactive and accessible learning environments for students.

5. Discussion

Based on the descriptive results of this research, in general, the TPACK abilities of physical education teachers are going well. This shows that teachers can integrate technology appropriate to the material and methods used during learning. The results of this research are supported by Brantley-Dias & Ertmer, (2013); Voogt et al., (2013) stated that the understanding that teachers have in integrating technology that is appropriate to the

material and learning methods will have a positive impact on improving students' skills in understanding the learning material provided.

Their ability to master technology, pedagogy, and content separately, such as subject matter components (CK), pedagogical knowledge (PK), and technological knowledge (TK), lies in good criteria. So, physical education teachers already have the three essential skills of technology, pedagogy, and content in learning. The results of this research are supported by Fauziyah & Suwarno (2021) and Roth (2014) which stated that before physical education teachers combine technology, pedagogy and content components, they must first understand the basic concepts of TPACK so that teachers can create an optimal and efficient learning environment. In line with this, the findings show the ability of physical education teachers to master technology, pedagogy, and content in a unified manner, such as components of content pedagogy knowledge (PCK), content technology knowledge (TCK), pedagogy technology knowledge (TPK), and content pedagogy technology knowledge (TPACK) on good criteria. This shows that physical education teachers throughout North Sumedang sub-district have a good understanding of integrating the three basic knowledge of TPACK without any difficulties. The results of this research are supported Koehler et al. (2013) and Niess, (2011) which stated that technology, pedagogy and content should be implemented as an inseparable whole. Therefore, it can be concluded that physical education teachers have applied TPACK in the learning process, this can be seen from the findings that on average teachers have mastered TPACK in planning, implementing and evaluating physical education learning.

Physical education teachers need to think creatively and innovatively and also can integrate technology into learning; therefore, measuring teachers' ability to integrate technology into learning requires the TPACK work system. Therefore, teachers must implement TPACK to enrich technology-based teaching experiences (Pyle & Esslinger, 2014). Adapting to new technology is very important because technology continues to develop rapidly from time to time. This encourages physical education teachers to continue learning so they can adapt to the latest technology (Koehler & Mishra, 2009; Mishra & Koehler, 2006).

6. Conclusion

This research concludes that the TPACK ability of physical education teachers in elementary schools in terms of 7 TPACK components includes content knowledge (CK) of 78.57 in the good category, pedagogical knowledge (PK) of 83.48 in the very good criteria, technological knowledge (TK) of 73.21 on good criteria, pedagogical content knowledge (PCK) of 79.64 on good criteria, Technological Content Knowledge (TCK) of 79.64 on good criteria, Technological Pedagogical Knowledge (TPK) of 74.55 on good criteria, and Technological Pedagogical and Content Knowledge (TPACK) of 74.55. Apart from that, TPACK's ability in the learning process, as viewed from the statement item analysis, showed that TPACK's ability in learning planning was 78%, TPACK's ability in implementing learning was 78%, and TPACK's ability in learning evaluation was 77%. Thus, the Sumedang district's teachers can already implement technology, pedagogy, and content in every physical education lesson. However, this ability needs to be followed up in the form of real action at the implementation level in the learning process.

Limitation

This study has several limitations that should be acknowledged. Firstly, the sample size was limited to only 14 physical education teachers in North Sumedang, which may not be representative of the broader population of physical education teachers in other regions. Additionally, the use of convenience sampling may introduce selection bias, affecting the generalizability of the findings. Furthermore, the study relied on self-reported data, which can

be influenced by subjective perceptions and may not accurately reflect actual TPACK competencies. Lastly, the cross-sectional design captures a snapshot of TPACK abilities at a single point in time, limiting the ability to assess changes or trends over time.

Recommendation

Based on the findings of this study, several recommendations can be made for future research. Firstly, it is suggested to expand the sample size and include a more diverse range of physical education teachers from different regions to enhance the generalizability of the results. Additionally, employing a longitudinal study design could provide insights into changes in TPACK competencies over time. Future research could also explore the impact of specific training programs on improving TPACK skills among physical education teachers. Finally, qualitative methods, such as interviews or focus groups, could be incorporated to gain deeper insights into the challenges and successes teachers face in integrating technology into their instruction.

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Conflict of Interest

The Author(s) declare(s) that there is no conflict of interest.

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