TPACK Learning in Improving Teacher Skills in Elementary School: A Systematic Literature Review

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Abstract. The rapid development of technology is a challenge for teachers in Indonesia in the 21st century. Teachers' pedagogical skills must be improved to keep up with current developments. Teachers are required to be able to collaborate with technology in their learning. Overcoming technology challenges in education requires teachers to master competencies in content knowledge, pedagogy, and technology. The learning process with technology integration is currently known as TPACK (Technological Pedagogical Content and Knowledge). However, it was found that teachers' ability to integrate technology into learning still did not reach optimal levels. This study aims to identify TPACK-based learning in elementary schools in terms of teacher ability. This study used a systematic literature review method. One of the procedures in this research method is to analyze and interpret relevant data. Data is collected from Google Scholar. Data was searched using two keywords: "TPACK-based learning" and "primary school teacher skills." 198 data articles were obtained, but only 15 met the analysis criteria in this study. According to the analysis conducted in this study, TPACK (Technological Pedagogical and Content Knowledge) should be an essential component in developing learning models for success in today's learning activities. This is reinforced by the need for teacher training programs to enhance teachers' understanding and skills in integrating TPACK into technology-based learning.

Keywords: TPACK-based Learning; Teacher Skills; Elementary School; SLR.

1. Introduction

The internet has changed the entire education system, especially in the 21st century and in the era of Society 5.0. The change in the era of Revolution 4.0 to the era of Society 5.0 has a difference between the two; the era of 4.0 prioritizes information technology as a new paradigm that causes human roles to begin to be replaced. Meanwhile, in Society 5.0, this is considered a human-centered and technology-based society concept, which in the educational unit is a forum for preparing superior human resources. Education in the Society 5.0 era focuses more on technology, especially technology that can support education. (Susanto, 2023). This situation requires teachers and education personnel to prepare themselves to face these changes so that the education provided to students follows the times' demands. In dealing with this, teachers must have knowledge and skills in integrating technology into the learning process (Drew in (Nursyifa et al., 2020).

Realizing the emergence of technology in education, educators are required to learn not only how to use technology but also "how to effectively integrate technology into teaching practice" because old learning and teaching methods are no longer in accordance with the demands of today's education (O'Connor et al., 2023a).

The use of technology in learning is not only limited to mastering tools and technology but also involves integrating technology with pedagogical knowledge and lesson content in depth. Technology allows teachers to understand how technology can be used appropriately and meaningfully in the context of learning (Hakiki in Ngatminiati et al., 2023). Teachers need to combine their knowledge of material concepts, pedagogy, and the use of technology. This is contained in Technological Pedagogical Content Knowledge (TPACK) developed by Mishra and Matthew J Khoehler (Susana in Idrus & Saleh, 2022) based on the conceptual framework of Lee Shulman. According to Susana in Idrus & Saleh (2022). There are three main components of knowledge that form the basis of TPACK, including: a) Content Knowledge (CK). Content

knowledge is about the subject matter you want to learn or teach. Teachers must know about the content to be taught (Santos & Castro, 2021). This knowledge refers to various subjects that are a teacher's responsibility. This knowledge includes knowledge of concepts, theories, and ideas, as well as practices and approaches to developing that knowledge. b) Pedagogical Knowledge (PK). Pedagogical knowledge refers to teaching methods and processes that include knowledge in classroom management, assessment, lesson plan development and student learning. Teachers' knowledge related to various learning strategies, methods, and practices (Santos & Castro, 2021). c) Technology Knowledge (TK) or technological knowledge. Technological knowledge refers to knowledge of various existing technologies. Teachers' knowledge related to technology, both traditional and modern technology, can be integrated into the learning process.

TPACK describes three main components, namely pedagogy, content, and technology, which are used as the basis for self-development and learning innovation (Suryawati in (Rosmaladewi et al., 2023). This is in accordance with Law No. 11 of 2005 concerning the competence of educators, namely educators must have personality, pedagogical, professional, and social abilities (Mulyani in (Kamaruddin et al., 2022a)). Then in the Regulation of the Minister of Education No. 16 of 2007 it is stated that the mandatory competence of teachers includes proficiency in utilizing information technology to carry out development education. Based on this, currently, teachers are required to be technologically literate and can take advantage of technological developments in learning.

The way to overcome current challenges is the ability of teachers to integrate technology, education, and subject matter into the learning process. By having the ability to apply TPACK-based learning, teachers' abilities do not only focus on pedagogical skills or content knowledge in teaching but can include a deep understanding of technology so that the learning process created can be under current developments (Hanik in Juwandani et al., 2022).

However, many field elementary school teachers still need help integrating technology into learning. The process of modernizing technology-based learning is not running smoothly because there are still obstacles in presenting learning and practice that are not entirely related to technology (Inesha Audia Putri & Harinaredi, 2023).

According to information released by the Ministry of Education and Culture (Kemendikbud), only 40% of teachers can utilize technology in Indonesian education. Therefore, it is necessary to conduct literature review studies on teachers' ability to integrate technology into the learning process.

1.1. Problem Statement

Following the era of society 5.0 and the current 21st century, teachers must have good technological literacy, accompanied by knowledge in terms of pedagogy and mastery of material (Ajizah & Huda, 2020). The era of society 5.0 and the 21st century in the field of education today can be started with the modernization of technology-based learning to make learning effective and efficient. The wise use of technology is a must in every classroom to improve learning and student achievement. (Santos & Castro, 2021). Technological Pedagogical and Content Knowledge (TPACK) is a theory developed to explain the set of knowledge that teachers need to teach effectively using technology (McGraw-Hill in (Santos & Castro, 2021). This theory seeks to identify the knowledge teachers require to integrate technology in teaching and overcome the less diverse nature of teachers' knowledge (Santos & Castro, 2021).

In the field, many elementary school teachers still need to optimally integrate technology into learning, starting with learning implementation planning (Rosyida et al., 2022). Another study found that many teachers have not used technology-integrated learning resources and media.

Some of the facts found are other supporting things that explain that some of these obstacles can be overcome with TPACK-based learning training that aims to improve teachers' pedagogic competence. For example, research (Mardati et al., 2022) shows the development of teaching materials and learning evaluation through direct training activities such as demonstrations, direct practice, discussions, and mentoring TPACK-based teachers.

1.2. Related Research

Technological Pedagogical And Content Knowledge (TPACK) is known as pedagogic knowledge and content within the framework of the educational curriculum, where teachers in accordance with the learning period and expectations can use technology in pedagogy in a way that supports the teaching of quality materials, such as previous research that discusses TPACK is research entitled The Urgency of Educators' Technological Pedagogical Content Knowledge Personality (Tpack-P) Ability in the Era of the Industrial Revolution 4.0, author Kamaruddin (2021). The study results show that Education 4.0 encourages educators to master technology so that it can be integrated into teaching and learning activities. The ability of educators to understand and master technology in education can be reviewed through the TPaCK "technological pedagogical content knowledge" that exists in educators.

The second research is entitled "Dataset of TPACK in teaching practice: Adversity quotient, attitude computer technology and self-efficacy among Indonesian teachers". Author Prasetiyo, et al. (2022). This research was tested on 901 teachers from 28 provinces in Indonesia by distributing an online survey. The study results show that Datasets can help teachers design effective programs to develop digital competencies in integrating technology into the learning process (Prasetiyo et al., 2022).

Studies on a comprehensive analysis of the application and outcomes of TPACK-based learning in improving teachers' abilities in Indonesia still need to be completed. The study is important because it provides extensive information related to teachers' ability to implement TPACK-based learning. Therefore, this research aims to identify TPACK-based learning in elementary schools and review it in terms of teachers' abilities.

1.3. Research Objectives

This study aims to obtain information related to TPACK-based learning in elementary school, reviewed in terms of teachers' abilities. The description of this study includes:

1. Implementation of the TPACK-based learning process
2. Results of the implementation of the TPACK-based learning process
3. Teachers' Abilities in TPACK-based Learning

2. Theoretical Framework

TPACK is a framework that integrates Technological Knowledge, Pedagogy Knowledge, and Content Knowledge in a learning context (Wibowo in Idrus & Saleh, 2022). Then the TPACK concept involves seven domains of knowledge because there are new slices or synthesis, namely: First, Content Knowledge (CK) is knowledge about concepts, theories, ideas, frameworks, knowledge, as well as practices and approaches to develop this knowledge (Schulman in Kamaruddin et al., 2022b). This knowledge refers to various subjects that are the responsibility of a teacher. A teacher is expected to have the ability to understand and master the subject matter so that he can effectively convey the concepts and content of each discipline of study.

Second, Pedagogical Knowledge (PK) is teachers' knowledge of various implementations, strategies, and methods to support student learning (Koehler in Zakiyah et al., 2022). Third, Technological Knowledge (TK) is knowledge about technology and having this knowledge is useful for using and learning available technologies (Jordan in Wibomo et al., 2023). Teachers' knowledge related to technology, both traditional and modern technology that can be integrated in the learning process. Fourth, Pedagogical Content Knowledge (PCK) is described as the result of combining material knowledge (content knowledge) and learning knowledge

(pedagogical knowledge) in a complete package of a teacher. This aspect encourages the teacher's pedagogical ability to manage learning so that participants can easily understand the content of the field of study, by doing the art of learning that is not monotonous. Fifth, Technological Content Knowledge (TCK) is knowledge about the mutual relationship between technology and content (Koehler in Zakiyah et al., 2022). Sixth, Technological Pedagogical Knowledge (TPK) is knowledge about how various technologies can be used in teaching and the use of these technologies can change the way teachers teach (Schmidt in Wibomo et al., 2023). In this case, TPK facilitates teachers' pedagogical abilities to continue to develop. Seventh, technological pedagogical and content knowledge (TPACK) is the knowledge teachers need to integrate technology into teaching certain materials in a complete package. Teachers must intuitively understand the complex interaction between the three essential components of knowledge, namely CK, PK, and kindergarten, by teaching certain materials using appropriate pedagogic methods and technology (Schmidt in Wibomo et al., 2023).
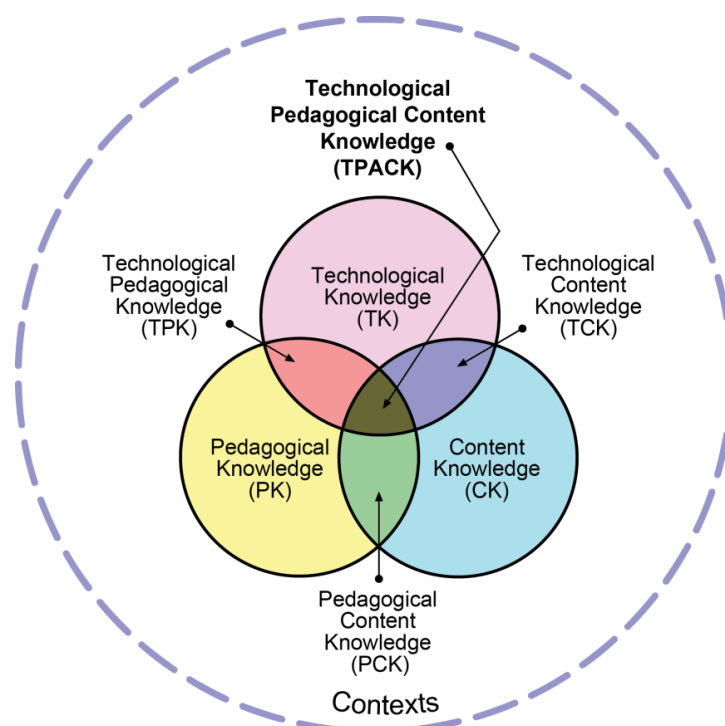

Figure 1. TPACK Components (Source: www.TPACK.org)

Education in the 21st century and the current era of Society 5.0 emphasizes integrating technology into the learning process. Therefore, educators need to continue to improve their skills in utilizing technology to strengthen professionalism in teaching aimed at learning success.

TPACK is the result of integrating technology, pedagogy, and materials used in the learning context. A teacher must thoroughly master all three to apply them effectively. Teachers' abilities and skills in mastering technological developments greatly influence the learning (Ni'mah et al., 2023).

Based on the aspect of Pedagogical Content Knowledge (PCK), which consists of content knowledge and pedagogical knowledge that a teacher must possess, has been regulated in Government Regulation No. 74 of 2008 related to teachers' professional competence, which states that a teacher's ability to understand and master various fields of science and technology includes a broad and in-depth understanding of subject matter in accordance with the standards of educational content that have been Set. This includes educational programs, subjects, and learning concepts and methods in science and technology disciplines. Then, according to the Government Regulation Number. 74 of 2008 related to pedagogy, namely the ability to manage student learning, which includes aspects of

educational principles, understanding of students, and implementing learning. In addition, using technology is an integral part of the capability (Juwandani et al., 2022).

3. Method

3.1. Research Design

This study uses a systematic literature method to answer research questions based on PRISMA 2020 (Page in (Lestari & Ilhami, 2022)). This study reviews previous studies on teachers implementing TPACK into learning in elementary schools**.** Search for literature related to relevant articles through the academic database, namely Google Scholar. The reason for choosing this database is the accessibility factor. Google Scholar is a very accessible source of information. The first data search was conducted on October 10, 2023, and the literature was identified and analyzed within one month. This study uses the SLR method to identify, review, and interpret various studies on implementing TPACK in elementary schools. The stages carried out by the researcher in this study include making research questions, determining the data that meets the criteria, finding appropriate literature sources, assessing the reading quality, analyzing data, and summarizing and presenting data (Cabrera, 2023).
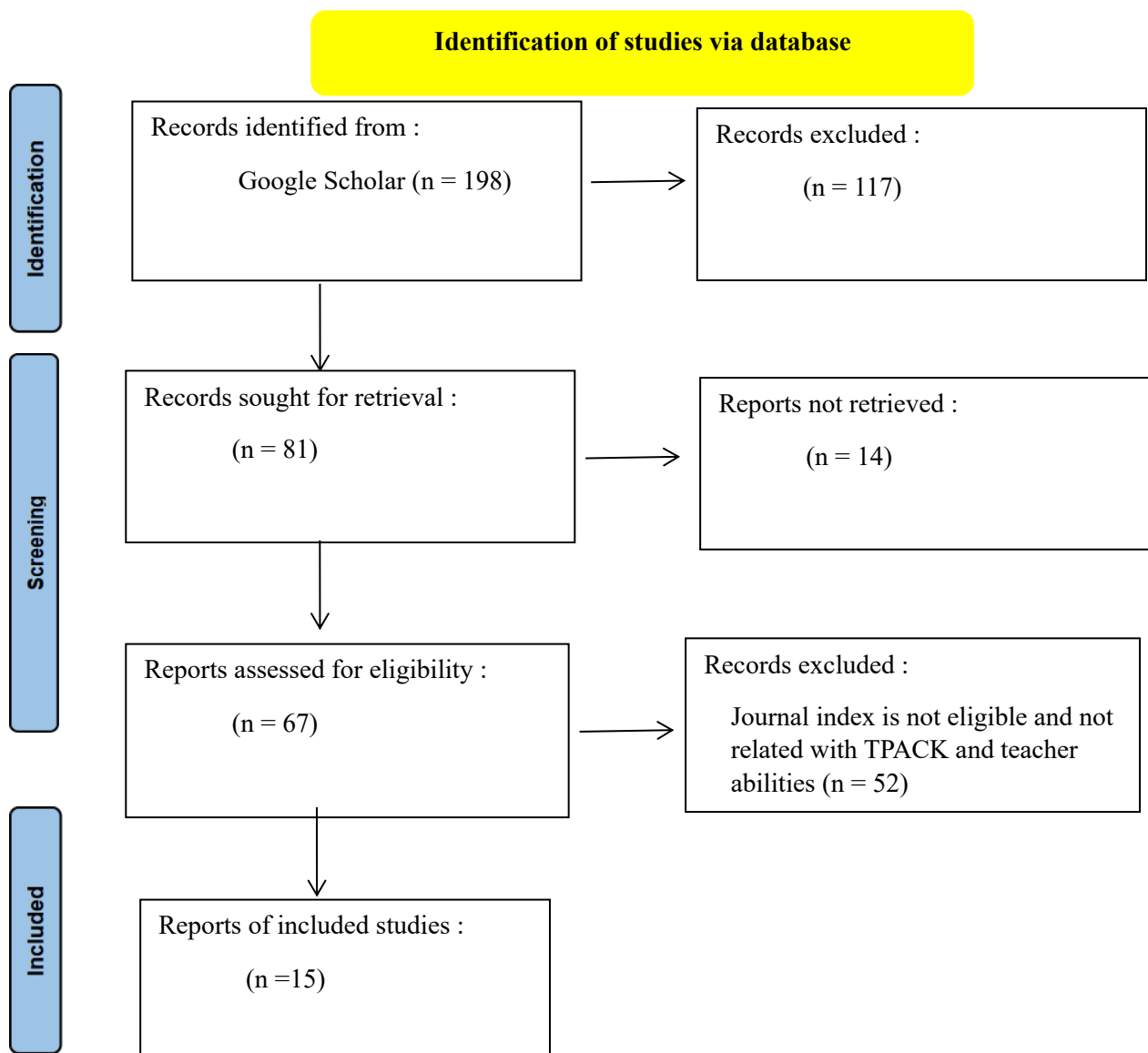
3.2. Data Collection

Data is taken from several relevant and previously tested research results that have been scientifically published on a specific topic and are related to the research question (Kithcenham, 2004). The steps to collect data are obtained using website sources: https://scholar.google.com . The search uses two keywords, namely (1) TPACK-based learning and (2) teacher ability. The search yielded 198 articles. The results displayed by Google Scholar are then filtered according to the provisions of the inclusion criteria in Table 1. Articles are selected by considering the title, abstract, and full-text content concerning the inclusion criteria and excluded by referring to the exclusion criteria determined in Table 1.

Table 1. Inclusion and Exclusion Criteria

Criteria for Artifact Selected (Inclusion Criteria)	Criteria for Articles Not Selected (Exclusion criteria)
Published between 2020 and 2023	Published before 2020
Journals at least indexed by Sinta	Sinta's unindexed journal
Speaking Indonesian or English	Not Indonesian or English
Related to TPACK-based learning	Not related to TPACK-based learning
Related to the competence of elementary school teachers	Not related to the competence of elementary school teachers
Article is a peer-reviewed journal	Non-peer-reviewed journal article

The Google Scholar database was chosen because it provides reliable and high-quality data, makes it easy to extract data, and is relevant to the research topic. Then, the complete process related to identifying article selection via the Google Scholar database is presented in Figure 2 below.

Identification of studies via database

Records identified from : Google Scholar (n = 198)	Records excluded : (n = 117)

Identification

Records sought for retrieval : (n = 81)	Reports not retrieved : (n = 14)

Screening

Reports assessed for eligibility : (n = 67)	Records excluded : Journal index is not eligible and not related with TPACK and teacher abilities (n = 52)

Reports of included studies : (n =15)

Included

3.3 Data Analysis

The researcher analyzed the results by making a spreadsheet that elaborated on the author's name, the year of publication, implementation or application, and research results. Then, the researcher synthesizes and presents the results in the form of analysis and synthesis of findings and ends with the implications of the results of the Systematic Literature Review to answer research questions. This is in line with the methodology proposed by Evan & Person (2001), which states that there are six stages of SLR data analysis, namely: Identification of research focus, identification of relevant research, selection of research that meets the criteria, assessment of selected data, data extraction, and data synthesis.

This method identifies and selects relevant materials by following predetermined procedures to make the results obtained more objective and accountable. (Anggraini et al., 2023). The advantage of a Systematic Literature Review is that it can strengthen the evidence from previous research and describe information from the various research questions available in the study. Meanwhile, the weakness of the Systematic Literature Review method is that it takes a long time to meet the requirements of the research question. In addition, to find the literature as a whole, several points of discussion are missed so that they affect the final result of a research conclusion.

4. Findings

This study determined 15 articles for further analysis based on the selection process results. This is a summary of the results of the analysis of articles regarding the implementation of TPACK-based learning related to the competence of educators, both teachers and prospective teachers.

Table 2. TPACK Application

Author and Year	Application
(Idrus, Baharullah & Saleh, 2022)	Teachers' teaching experience is divided into teachers with five years or more of experience (experienced teachers) and teachers with less than five years of teaching experience (beginner teachers).
(Maharani, Ristiani & Yasa, 2022).	Developing a TPACK knowledge test instrument for prospective elementary school teachers.
(Zainuddin, Untari, Nahdiyah & Waluyo, 2021).	TPACK learning guidance based on HOTS, social studies subject matter.
(Rosmaladewi, Hastuti & Rahayo, 2023).	The mastery of TPACK for prospective teaching students in compiling learning tools consisting of lesson plans, LKPD and learning media to the ability to use technology.
(Indriani, Hidayah & Yayuk, 2021).	Development of TPACK-based thematic pedagogical specific subjects for elementary school teachers as well as service activities such as questions and answers and work demonstrations.
(Kismiati, Hutasoit & Rahayu, 2022).	Survey to determine the satisfaction and usefulness of the BASF Virtual Lab virtual learning media introduction training.
(Ajizah & Huda, 2020).	Literature on the integration of kindergarten, PK and CK into PAI learning.
(Bungai, Rahmawati & Femmy, 2022)	Creating a HOTS-based Participant Worksheet in maximizing teachers' pedagogic competence.
(Wibowo, Herliani & Limbong, 2023).	Observations related to the experience of implementing TPACK in online learning during the Covid-19 pandemic of PPG student alumni in office.
(Kamaruddin, Latuconsina, Pramono, dkk, 2022).	Literature related to the knowledge and skills of teachers in the field of technology in the learning process.
(Aeni, Djuanda, Maulana, dkk, 2022).	Application of the Technological Pedagogical Content Knowledge wordwall educational games application .
(Yurinda & Widyasari, 2022).	Knowing the difference between certified teachers and non-certified teachers for 3 components related to technology, namely kindergarten, TCK, and TPACK.
(Iskandar, 2022).	Literature in obtaining concepts and understandings related to the integration of TPACK into the management

	of the learning system and its impact on improving the competence of educators.
(Putri & Harinaredi, 2023)	Modernization of learning in the 4.0 era of higher classes through TPACK-based social studies learning design.
(Mardati, Sukma & Saifudin, 2021).	Develop teaching materials and learning evaluation through direct training activities such as demonstrations, hands-on practice, discussions and teacher mentoring.

Table 3. Implementation Results

Author and Year	Implementation Results
(Idrus, Baharullah & Saleh, 2022)	1) The technological knowledge (kindergarten) ability of beginner teachers and experienced teachers is classified as good in using and utilizing technology. 2) Content knowledge (CK) ability of beginner teachers and experienced teachers to master the material well. 3) Pedagogical knowledge (PK) ability of experienced teachers is much more varied using student-centered learning methods, while monotonous beginner teachers use student-centered lecture and question and answer methods. 4) Technological Pedagogical Knowledge (TPK) Beginner teachers and experienced teachers have a good mastery of Technological Pedagogical Knowledge (TPK) in using computer applications in learning, using the Learning Management System (LMS), and communicating with students related to learning using social media. 5) Teachers' technological content knowledge (TCK) ability in presenting subject matter has the same good ability in utilizing technology in presenting subject matter. 6) Pedagogical Content Knowledge (PCK) ability of beginner teachers and experienced teachers using Microsoft Word and Microsoft PowerPoint computer applications have the same ability. 7) Ability Technological Pedagogical Content Knowledge (TPACK) for beginner teachers and experienced teachers has differences in the application of learning methods, as well as PK and CK skills. Beginner teachers are monotonous using teacher-centered lecture and question and answer learning methods, while experienced teachers use several variations of teacher-centered and student-centered learning methods such as quiz game methods, playing with ice breaking, and group methods.
(Maharani, Ristiani & Yasa, 2022).	TPACK-Test is a complete measuring tool in estimating the three mandatory elements of learning activities, namely technology, pedagogy and content. 1) Technology: Development of learning models in learning activities in which there is technology 2) Pedagogy: Teachers' insight in integrating technology in learning activities 3) Content: Contains material with the situation of learning activities within the scope of elementary schools.

(Zainuddin, Untari, Nahdiyah & Waluyo, 2021).	The change in the mindset of teachers in the application of learning in the classroom, so that learning will be interesting and innovative which combines technology and science.
(Rosmaladewi, Hastuti & Rahayo, 2023).	The mastery of TPACK for prospective teachers is seen from the ability to compile lesson plans and innovative learning media in digital learning.
(Indriani, Hidayah & Yayuk, 2021).	The development of thematic pedagogical specific subjects based on TPACK makes a collaboration between technology, pedagogy and material. In the thematic pedagogical specific subject based on TPACK, the learning tools are made more comprehensive so that there is a suitability of pedagogical specific components in the form of syllabi, lesson plans, student worksheets, and assessment sheets. Then the thematic pedagogical specific subject based on TPACK has applied the principles of ephemeral, efficient and referring to student needs.
(Kismiati, Hutasoit & Rahayu, 2022).	The BASF Virtual Lab introduction training as a learning medium in the TPACK training for elementary school teachers received many positive responses. The use of this virtual media is able to stimulate students' thoughts, willingness, attention, and feelings in a fun learning atmosphere so that the material presented becomes clearer.
(Ajizah & Huda, 2020).	With the ability of teachers to master TPACK, they can present innovative and creative learning, and be effective as a solution in balancing the characteristics of students in accordance with the demands of the times.
(Bungai, Rahmawati & Femmy, 2022)	The use of HOTS-oriented LKPD that is adapted to the student's environment is very feasible and practical for grade IV elementary school students. As well as being able to improve students' critical thinking skills and improve technological skills in it.

(Wibowo, Herliani & Limbong, 2023)	1. Participating in KKG, discussing with peers and learning independently related to the understanding of Content Knowledge (CK) in Mathematics, Science, Social Studies and SBdP lesson content. 2. The use of online learning technology such as Whatsapp groups, google forms , and Project Based Learning related to mastery of Pedgogic Knowledge (PK). 3. Using internet-based technology such as various applications as a tool to help create learning media related to the understanding of Technological Knowledge (TK) 4. Using internet-based technology such as various applications as a tool to help create learning media related to the understanding of Technological Knowledge (TK) 5. Using an online-based online learning application, equipped with learning videos, related to the understanding of Pedagogical Content Knowledge (PCK). 6. Using and elaborating various online learning media more than one media, such as Whatsapp groups, zoom meetings, google meet, google classroom, and youtube, this is related to mastering Technological Content Knowledge (TCK). 7. Using technology that is adjusted by students, related to the understanding of Technological Pedagogical Knowledge (TPK). 8. Using the right pedagogical materials, methods and technologies in accordance with the understanding of Technological Pedagogical And Content Knowledge (TPACK).
(Kamaruddin, Latuconsina, Pramono, dkk, 2022).	TPACK is something that has an impact on educators with the relationship between educators, content and inherent technology. On the other hand, educators also face a number of challenges in shifting or changing technology, subject matter, pedagogy and classroom context in the current era which can be done with a number of learning approaches, including learning technology by activity types and technology by design. The development of TPACK began with a number of simple technologies that were already known, and then continuously improved to better and more sophisticated media.
(Aeni, Djuanda, Maulana, dkk, 2022).	Teachers can conduct innovative learning and improve IT capabilities by using technology-based media such as wordwalls accompanied by learning videos that function as teaching materials.
(Yurinda & Widyasari, 2022).	Technological Knowledge (TK) is in the form of teachers' knowledge on how to use technology in the learning process, certified teachers who have participated in the Teacher Professional Program (PPG) have better knowledge than teachers who have not been certified. There is a difference between certified teachers and teachers who have not certified student learning outcomes, namely certified

	teachers have a better understanding of pedagogical skills. In mastery of technology, teachers who are not certified are better than certified teachers, because the majority of teachers who are not certified are young, so in terms of knowledge they tend to be better than teachers who are already certified related to technology.
(Iskandar, 2022).	The relationship between TPACK and the management of the learning system is related and mutually influencing. TPACK not only focuses on the use of the learning system from offline to online but also becomes a means of developing competencies and abilities of both educators and students. Currently, the teaching and learning process does not only focus on providing theory, but also a collaboration between theory and practice.
(Putri & Harinaredi, 2023)	Teachers use technology as a teaching tool, learning media, and digital-based learning resources that have been in accordance with the demands of learning in the 4.0 era, such as integrating materials, technology, and strategies in social studies lessons. High-grade social studies learning in the implementation of TPACK helps teachers and students to understand the material easily where in social studies learning is often associated with real life so that learning becomes more difficult. The implementation of TPACK helps students become more active in understanding social studies material with images of objects and innovations provided in each lesson.
(Mardati, Sukma & Saifudin, 2021).	Strengthening teacher competence in developing IT-based learning tools is in line with the basic competencies that must be possessed as professional teachers. This self-development activity is useful in supporting innovative, varied, and effective online learning in the pandemic era.

Table 4. Teacher's Ability

Author and Year	Teacher's Ability
(Idrus, Baharullah & Saleh, 2022)	TPACK's ability in the pedagogical content knowledge domain between experienced teachers and novice teachers has differences in the application of learning methods.
(Maharani, Ristiani & Yasa, 2022).	Teachers' abilities related to TPACK are categorized as good in the knowledge component.
(Zainuddin, Untari, Nahdiyah & Waluyo, 2021).	Teachers' ability to integrate kindergarten, PK and CK with high-level thinking skills in learning.
(Rosmaladewi, Hastuti & Rahayo, 2023).	The ability of prospective teachers to master the TPACK concept shows misconception behavior, supported by the use of technology-based learning resources that are still low in the availability of tools.

(Indriani, Hidayah & Yayuk, 2021).	The ability of teachers to develop and implement TPACK still has obstacles, namely the need for TPACK skill assistance on thematic pedagogical specific subjects.
(Kismiati, Hutasoit & Rahayu, 2022).	The ability to use virtual media and teaching references during the Covid-19 pandemic.
(Ajizah & Huda, 2020).	Teachers' ability to be creative in preparing the right learning model in PAI subjects through the integration of kindergarten, PK and CK.
(Bungai, Rahmawati & Femmy, 2022)	Teachers' ability to facilitate learning through the Participant Worksheet (LKPD) in the aspect of pedagogical competence.
(Wibowo, Herliani & Limbong, 2023).	The pedagogical ability of teachers in delivering learning materials during the Covid-19 pandemic can be seen from the strategy of developing an understanding of lesson content, creative and innovative in using internet-based technology.
(Kamaruddin, Latuconsina, Pramono, dkk, 2022).	Teachers' ability in learning technology by acitivity types and technology by design in optimizing kindergarten integrated with PK, PCK, and PK in the learning process.
(Aeni, Djuanda, Maulana, dkk, 2022).	Teachers' ability to innovate in technology-based learning through the application of the Technological Pedagogical Content Knowledge (TPACK) wordwall educational games application.
(Yurinda & Widyasari, 2022).	The ability of certified and non-certified teachers is seen well in using technology in the form of learning methods and strategies.
(Iskandar, 2022).	The TPACK method is a method that has the potential to improve teachers' ability to operate technology.
(Putri & Harinaredi, 2023)	The ability of teachers to consider technology that is adapted to the material and learning process in terms of learning resources and media.
(Mardati, Sukma & Saifudin, 2021).	Teachers' competence in improving online learning by utilizing learning technology applications.

5. Discussion

Effective technology in the classroom requires teachers to have three domains of knowledge, namely technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK). These domains form the basis of the TPACK model, which guides the successful integration of technology into the classroom. Based on this knowledge, teachers need to balance adequately covering the curriculum and meeting the individual needs of their students (Abubakir & Alshaboul, 2023).

In addition to technology, there is a pedagogical aspect. Pedagogy refers to the interaction between teachers, students, the learning environment, and learning tasks. Learning depends on teachers' pedagogical approach in the classroom (UNESCO, 2018). Effective pedagogy depends on teachers' strategies in developing the learning process, students' abilities, and the availability of resources (Santos & Castro, 2021).

Based on Table 2 above, the implementation of TPACK-based learning is based on the principle of integrating technology into the learning process. Teachers' proficiency in the use

of technology, which is then incorporated into learning, is adapted to the 21st century in the current Society 5.0 era. Many previous researchers have proposed integrating technology, pedagogy, and content in the same way that has been done as a correlation of technology, pedagogy, and content knowledge (Mishra & Koehler, 2006; Niess, 2005 in Rasilah, 2021). This integration aligns with the learning principles in Permendikbud no. 22 of 2016 in the process standards, namely that educators must be able to utilize and use communication and information technology to increase the effectiveness and efficiency of learning activities.

Teachers must continue to update pedagogic knowledge, including content, teaching practices, and technological advancements. TPACK refers to the incorporation of teaching knowledge frameworks and technologies that improve the usability of teaching in the classroom (Su, 2023). In general, TPACK-based learning was widely used during COVID-19 and online learning. Teachers apply technology in the digital era because it aims to integrate various aspects of knowledge, resource mastery, and technology and is considered the right choice (O'Connor et al., 2023a).

Based on Table 3 above, the results of the implementation in the context of TPAPEK-based learning begin with a change in the mindset of teachers in the importance of combining technology and science into the learning process and starting from the teacher's ability to compile lesson plans and learning media that are integrated with technology. (Rosmaladewi et al., 2023). Then, presenting innovative and creative learning through better and awkward learning media (Kamaruddin et al., 2022a). Several studies discuss TPACK training in elementary schools, which can then improve teachers' abilities in the field of IT and become a means of developing teacher competencies in collaboration between theory and practice. (Inesha Audia Putri & Harinaredi, 2023).

The results of the application mentioned above are under the demands of teachers in the 21st century who must have solid and qualified technological literacy, which includes, of course, pedagogical knowledge and mastery of the material (Ajizah & Huda, 2020). Then, the pedagogical competence of educators in the 21st century has a distinctive characteristic, namely utilizing information technology that supports learning activities in the classroom (Anshori in Maharani et al., 2022). These learning activities can be measured using the TPACK-Test which can estimate the three mandatory elements of learning activities between teachers' insights about content, pedagogy, and technology (Unaida in Maharani et al., 2022). Then, one of the subject matters, such as science, has a laboratory platform, namely BASF Virtual Lab, designed to make science learning interactive and fun (Kismiati et al., 2022). In addition, social studies learning in implementing TPACK helps students become more active with object image innovations in each lesson designed by the teacher (Inesha Audia Putri & Harinaredi, 2023).

Quality education is an essential aspect of educational development. Therefore, to achieve quality education, effective teachers must be present to ensure the development of the young generation's potential (Lupag-padam et al., in Santos & Castro, 2021). To develop this potential, teacher education institutions prepare teachers' knowledge in depth.

Based on Table 4 above, teachers' abilities in TPACK-based learning start from research that describes the abilities that prospective elementary school teachers must possess, teachers' abilities in implementing TPACK-based learning, as well as the differences in the skills of experienced teachers, and novice teachers, certified teachers and non-certified teachers. Then, teachers' ability to use technology is often applied in learning during the Covid-19 pandemic. In integrating the three main components of TPACK, namely kindergarten, PK, and CK, there are learning innovations carried out by teachers in supporting technology-based learning, such as making LKPD through the TPACK approach, selecting and using learning methods and models, and the support of various TPACK-based trainings to prepare teacher skills.

Teachers' ability to master subject matter is common, but it will be more optimal if these skills are supported by the ability to apply technology in the learning process (Rosmaladewi et al.,

2023). Teachers' abilities in the seven components of TPACK proposed by Mishra and Koehler in Hanum et al., 2021) include the following:

Table 5. TPACK Components

No.	Component	Definition
1.	Technological Knowledge (TK)	Teachers' ability to understand and use technology broadly.
2.	Pedagogical Knowledge (PK)	Teachers' ability to implement the learning process.
3.	Content Knowledge (CK)	The teacher's ability to master the content of the learning material.
4.	Technological Content Knowledge (TCK)	Teachers' ability to use technology to deliver learning materials.
5.	Technological Pedagogical Knowledge (TPK)	The ability of teachers to have skills in utilizing technology when teaching to achieve predetermined learning goals.
6.	Pedagogical Content Knowledge (PCK)	The teacher's ability to teach with an approach that helps students understand the subject matter.
7.	Technological Pedagogical Content Knowledge (TPACK)	The ability of teachers to use technology in teaching and learning activities to teach the material they master.

Source: Johar and Hanum, 2021.

Seven frameworks of insight are interconnected with each other (content), pedagogy, and technology (technology). Material insight or content knowledge is the mastery of learning materials or fields of study. The learning materials are adjusted to students' learning activities, from compiling lesson plans and digital learning media (Indriani et al., 2023). Based on the analysis results, modern learning tools are integrated with technology in this aspect of content knowledge. In this case, it includes using learning software or online learning platforms. Then, it was found that efforts were made for teachers to participate in teacher competency activities (KKG), discuss with peers, and learn independently related to understanding Content Knowledge (CK).

Second, pedagogical insight or knowledge is insight into the strategy and process of learning activities. Integrating pedagogic skills based on the findings identified in this case is called TPACK-based thematic pedagogy, which uses learning tools that refer to students' needs. Then, innovative and creative learning is presented while still considering students' characteristics in accordance with the demands of the times.

Pedagogy involves understanding the various teaching methods used to deliver subject matter most effectively, such as collaborative project-based learning supported by the WhatsApp app group and Google Forms. Teachers can be trained to use technology or synchronized communication tools such as Google Meet or Google Forms in teaching activities. Then, when using technology tools/applications, the school organizes training so that teachers can use these tools/technology appropriately and effectively. Teachers can take advantage of the available tools/applications well if they know their use and how to use them (O'Connor et al., 2023a).

Third, technological insight or knowledge is an insight into the use of digital technology; in this case, it can use internet-based technology in learning activities. This also differentiates experienced teachers from inexperienced teachers. The results highlight the impact of years of experience on teachers' knowledge and practice. For example, teachers with 1-5 years of

experience show higher Technological Knowledge skills than teachers with extended teaching periods. This is also in line with the research results (Abubakir & Alshaboul, 2023), which show that teachers' technological knowledge (TK) in 1-5 years is better than that of teachers whose teaching period is more extended or more than six years.

Furthermore, the fourth aspect, namely, pedagogical insight and material or pedagogical content knowledge, is a combination of insights about learning materials or fields of study along with learning strategies and processes; in this case, the mastery of pedagogical knowledge is the basis of teaching teachers. This knowledge includes learning strategies, classroom management, and classroom assessments. In this case, teachers combine content and pedagogy to develop better teaching practices in the content field, such as teaching or learning media that use Microsoft Word, Microsoft PowerPoint, and learning videos.

Fifth, technological and material insight or technological content knowledge is an insight into digital technology under the learning material and field of study. In this case, it can be through the learning approach, technology by activity types, and technology by design. Starting with simple technology that is already known, then continuously upgraded to better and more sophisticated media (Kamaruddin et al., 2022a). Technology content knowledge refers to how technology can create new representations for a particular content (Santos & Castro, 2021). Content or learning materials, in this case, can be shared through WhatsApp groups, zoom, Google Meet, Google Classroom, and YouTube. These various applications can change how students practice and understand concepts excitingly.

Sixth, insight into technology and pedagogy or technological pedagogical knowledge is an insight into digital technology for learning processes and strategies. In this case, teachers can use technology tailored to the student's needs, such as innovations in the form of Student Worksheets (LKPD) that are oriented to High Order Thinking Skills (HOTS) (Rahmawati et al., 2022). In this case, the technology is adjusted to the student; it can be done using the Learning Management System (LMS). This aligns with a recent study that provides examples of educational technologies that can improve higher education through LMS interactive technology. The platform is used in the United States and Qatar (Abubakir & Alshaboul, 2023).

Seventh, insight into technology, pedagogy, and materials or technological, pedagogical, and content knowledge, which is an integrated insight into digital technology relevant to learning activity processes and strategies, as well as learning materials or fields of study (Nugraheni in Maharani et al., 2022). Technology as a teaching tool, learning media and digital-based learning resources (Putri & Harinaredi, 2023).

In addition to the 7 TPACK frameworks above, teachers can develop TPACK-based learning through various trainings to improve understanding and skills related to the integration of content, pedagogy, and technology in the learning process, namely through various self-development trainings for teachers, starting from utilizing technology applications in making learning tools application-based, developing technology-based teaching materials and developing innovations in terms of learning evaluation. This is done through workshops/seminars with group quizzes and demonstrations to illustrate the application of TPACK in the context of learning.

Teachers intuitively understand the complex interaction between the three essential knowledge components (CK, PK, TK) by teaching content using the correct pedagogical methods and technologies. (Santos & Castro, 2021). TPACK refers to the incorporation of teaching knowledge frameworks and technologies that improve the effectiveness of teaching in the classroom. Then, a teacher's competence is determined based on his ability to handle subject content and choose the correct and relevant learning strategies that students can access.

Referring to the concept of Pedagogical Content Knowledge, it was explained that integrating technology, content, and knowledge makes learning more meaningful (Aslaner in Mardati et al., 2022). Other innovations that can be done by using the Learning Management System (LMS) in improving the aspect of technological pedagogical knowledge (TPK) and

using the BASF Virtual Lab which is a website-type platform that uses various science learning features in elementary school, for other subject content such as Mathematics, Social Studies, PKn, and Cultural Arts can be integrated with technology through learning activities that using learning models such as Project Based Learning which is carried out by various techniques and supported by digital learning resources and media using computer technology and internet networks.

Presentations related to the content components in TPACK involve knowledge of learning content. Teachers must understand the content of learning and concepts and frameworks in a subject (Iskandar, 2022). Teachers are agents and support targets of technological changes and implement them in various classes (Kamaruddin et al., 2022b) . However, based on several findings, beginner teachers could be more varied using teacher-centered lectures and question-and-answer learning methods. In contrast, experienced teachers use several variations of teacher-centered and student-centered learning methods, such as the quiz game, playing with ice breaking, and group methods.

Then, from some of the research results mentioned earlier, several weaknesses can be identified, namely the focus on the teacher's ability. The research emphasizes teachers' ability to integrate TPACK as a whole, not specific and in-depth. It is recommended that the results of this study be developed by adding other variables such as TPACK-based learning evaluation, specific subjects in terms of content, and various teacher training innovations related to TPACK.

TPACK is essential for prospective teachers because they are the future educators shaping the new generation. Several studies show that implementing TPACK in the classroom still needs to be focused to improve learning delivery. Very little attention is paid explicitly to teachers' knowledge requirements regarding the use of technology, and many teachers still have difficulty using technology (Santos & Castro, 2021).

TPACK theory has challenges in its application in the classroom. Not all teachers can effectively deliver learning with technology integration. Continuous training for prospective teachers or teachers during the pre-service and in-service PPGs is highly recommended, as are various other supporting trainings.

6. Conclusion

Based on the analysis results, TPACK marks a new era and a process of progress in the world of education. TPACK summarizes the various skill needs of educators in the modernization era. Technology, pedagogy, and content mastery are the main elements in TPACK and seven domains of knowledge as new synthetics are interconnected. TPACK-based learning highlights the paradigm shift of teachers in integrating technology into the learning process, which aligns with the demands of the current Society 5.0 era. Teachers must update their pedagogical knowledge, content, and technology to create an effective and efficient learning experience. Implementing TPACK has helped teachers compile lesson plans and learning media that are integrated with technology, as well as present innovative and creative learning through sophisticated learning media. TPACK training has been shown to improve teachers' technological abilities, aiding in developing competencies by incorporating theory and practice into learning. Teachers in the 21st century must have solid technological literacy, and pedagogical competencies must include information technology to support learning activities in the classroom. The TPACK-Test estimates teachers' understanding of content, pedagogy, and technology and can measure learning activities. In addition to impacting education, TPACK also impacts educators by improving professionalism through various measurements and training related to TPACK. This allows for effective technology integration in learning, improved teaching quality, and advanced student learning outcomes. However, some areas for improvement were also identified, such as a focus on teachers' abilities in general without in-depth analysis and a need for more emphasis on TPACK-based learning evaluation and TPACK-related teacher training innovations.

Limitation

It is undeniable that in this study, there are limitations that need to be considered by readers, especially future researchers. The limitations of this study are related to the use of a new database limited to Google Scholar. In addition, the scope of the analyzed articles is limited to the last three years (2020-2023). These two limitations certainly affect the depth of the analysis carried out. Therefore, to obtain more in-depth facts, additional database sources can be added, and the scope of the year analyzed can be expanded.

Recommendation

Based on this study's limitations, findings, and results, some recommendations can be expanded in implementing the TPACK-based learning process and teacher capabilities, namely, the development of an effective teacher training model. Further research can identify the most effective training strategies to improve teachers' abilities in implementing TPACK-based learning. Second, evaluation in measuring the achievement of the implementation of TPACK-based learning can be carried out by measuring student achievement after the implementation of TPACK-based learning. In addition to measuring cognitive outcomes, it can also explore how the application of TPACK-based learning affects the quality of the learning process, such as student involvement, teacher-student interaction, and the atmosphere of the learning process.

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Conflict of Interest

The researcher stated that there was no conflict of interest.

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