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Integrating technological pedagogical content knowledge in Learning: A systematic review

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Abstract: The use of technology in educational contexts has experienced rapid growth in recent years. This breakthrough offers great potential to improve the quality of learning and teaching at various levels of education. One approach that dominates the conversation is the integration of technological pedagogical content knowledge (TPACK) in learning, which includes the alignment of three main components, namely technology (T), pedagogy (P), and content knowledge (CK). This study uses a systematic literature review approach to collect, select, and determine articles, then analyze and synthesize the latest research findings on the integration of TPACK in learning to improve teacher professionalism. The results showed that the trend of research studies related to TPACK in 2019 to 2023 discussed several components such as self-efficacy, a complete understanding of the dimensions of TPACK, the ability to analyze challenges and obstacles in the use of technology in learning, the ability to collaborate in the digital era, and the ability to build a positive paradigm in integrating technology in the learning process.

Keywords: Integration, learning, professionalism, TPACK

Abstrak: Penggunaan teknologi dalam konteks pendidikan telah mengalami pertumbuhan pesat dalam beberapa tahun terakhir. Terobosan ini menawarkan potensi besar untuk meningkatkan kualitas pembelajaran dan pengajaran di berbagai tingkat pendidikan. Salah satu pendekatan yang mendominasi perbincangan adalah integrasi Technological pedagogical content knowledge (TPACK) dalam pembelajaran, yang mencakup keselarasan tiga komponen utama, yakni teknologi (T), pedagogi (P), dan pengetahuan konten (CK). Penelitian ini menggunakan pendekatan systematic literature review untuk mengumpulkan, memilih, dan menentukan artikel, kemudian menganalisis, dan menyintesis temuan penelitian terkini tentang integrasi TPACK dalam pembelajaran untuk meningkatkan profesionalitas guru. Hasil penelitian menunjukan bahwa tren kajian penelitian terkait TPACK pada tahun 2019 hingga 2023 membahas beberapa komponen seperti rasa percaya diri (self efficacy), pemahaman yang utuh terkait dimensi TPACK, kemampuan dalam menganalisis tantangan dan hambatan dalam pemanfaatan teknologi pada pembelajaran, kemampuan berkolaborasi di era digital, serta kemampuan membangun paradigma yang positif dalam pengintegrasian teknologi pada proses pembelajaran.

Kata kunci: Integrasi, pembelajaran, profesionalisme, TPACK

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INTRODUCTION

Technology in today's digital technology era has become an integral part of human life (Rintaningrum, 2023; van der Straeten & Obertreis, 2022), including in education (Mustofa et al., 2024; Nordlöf et al., 2022). The use of technology in learning can make it easier for students to acquire the knowledge, skills and values needed for growth and development (Bills & Howard, 2019; Grannäs & Stavem, 2021; Rusydiyah, Mumtahanah, et al., 2020; Usher, 2021). The integration of technology in learning is becoming increasingly important as it can improve the quality of learning and prepare students for future success

(Rintaningrum, 2023; Viberg et al., 2023; Yongabo, 2022). One approach that can be used to integrate technology in learning is through the concept of Technological Pedagogical Content Knowledge (TPACK) (Iskandar et al., 2021; Rahayu, 2017; Viberg et al., 2023).

TPACK is a concept that integrates three key elements in learning, namely technological knowledge, pedagogy, and content (Tan et al., 2019; Tanjung et al., 2022). In the TPACK concept, technology is not just a tool, but an integral part of learning that can improve students' understanding and skills (Nilsson, 2022; Rintaningrum, 2023). The rapid development of technology has an impact on the need and process of integrating TPACK in learning which must be relevant (Dewi et al., 2021). The standardized TPACK concept must be accompanied by teachers' capabilities and abilities in integrating TPACK in learning (Ananda et al., 2022; Choi & Young, 2021). Teachers' skills in TPACK integration can be supported by participating in programs in developing teacher competencies, socialization programs, workshops, training (Iskandar et al., 2021; Nuangchalerm, 2020; Tan et al., 2019).

In this era of technological advancement, innovation in learning is essential to maintain the relevance of education quality to technological development (Holopainen et al., 2022; Mu & Wang, 2022; Nisak et al., 2023). Technological developments can help expand the scope of teaching, enrich students' learning experiences, and help students understand knowledge better (Iskandar et al., 2021; Umaña et al., 2020). Learning in the digital era is adapted to accommodate technology in education (Rahayu, 2017), thus teachers must be adaptive to what is needed in teaching (Syahriani & Hasruddin, 2024; Talhah Ajmain, 2020). Adaptive teachers are able to adapt to changes and challenges in the world of education (König et al., 2020; Novitasari et al., 2024). Adaptive teachers must also have a new mindset and the ability to create optimal learning to achieve learning goals (van de Pol et al., 2022). In fact, teachers must also utilize artificial intelligence because artificial intelligence can help teachers and students in various aspects of education, from learning to assessing students' understanding of the material being taught (Karim & Sugianto, 2023).

However, in fact, the use of technology in learning still raises polemics and challenges, including the lack of educators' understanding of technology integration in learning (Hisbullah, 2020), limited training platforms or regular socialization of the TPACK framework (Bueno-Alastuey et al., 2018), lack of teacher awareness about the urgency of developing technological and pedagogical competencies (Choi & Young, 2021). A teacher should have an understanding of technology integration in learning (Hanun, 2021). In addition, teachers must ensure that technology integration in learning does not replace important moral, social and religious values (Ananda et al., 2022). Teachers must also be able to master aspects related to supporting education so that the educational objectives themselves can be conveyed and implemented properly (Khoiriyah et al., 2021).

There have been many studies on TPACK, including research related to the knowledge dimension in the TPACK framework (Dewi et al., 2021; Surjono et al., 2023). The urgency of training and socialization related to TPACK for prospective educators (Iskandar et al., 2021; Nuangchalerm, 2020). TPACK can make it easier for teachers to develop materials (Kristiawan et al., 2022). Teachers' exploration of TPACK integration in learning and the availability of TPACK training platforms. The combination of problem-based learning and TPACK in learning (Tanjung et al., 2022). Upgrading scientific capacity regarding TPACK has an impact on improving teacher competence (Choi & Young, 2021). From the previous

literature, it can be concluded that there is a wide variety of research and studies on TPACK that touch on the concept of knowledge about technology, pedagogy and content as well as studies on integrating TPACK in the learning process. Thus, researchers take a position to examine improving the quality of TPACK-based learning from the results of existing studies from 2015-2022, then take new innovations related to the integration of TPACK in learning from the previous literature as an insight in improving the quality of Islamic religious education learning.

This literature review can provide important significance in the development of learning and education quality. The systematic analysis in this review aims to systematically evaluate the studies that have been conducted from 2015-2023 regarding the integration of TPACK in learning, then identify the results of research and research on TPACK that can provide insight and insight to prospective teachers or teachers in improving the quality of learning, especially learning that is relevant to the development of science and technology. The results of this study are expected to provide a comprehensive overview to teachers regarding the integration of TPACK in learning, as well as assisting decision makers in developing education policies.

METHOD

This research is a qualitative research using Systematic Literature Review (SLR). The literature used was journals/articles relevant to Teacher Competence on TPACK. The literature review was conducted by selecting, identifying and evaluating research to answer the research questions that have been formulated. This research aims to explore the application of the concept of Teacher Competence on TPACK. In this systematic literature review, the research began by identifying articles related to Teacher Competence on TPACK in Eric's database. There are four phases involved in literature mapping, namely identification phase, screening phase, eligibility phase, and inclusion phase.

Phase 1: Identification

Determination of articles that meet the established criteria. First, the database source used for this systematic literature review is Eric. With the criteria of articles published between 2019 and 2023. The Eric database is a free and accessible search engine that covers most peer-reviewed literature across multiple disciplines. Articles were identified through keywords based on the search engine as in the Table 1.

Table 1. Keywords used to search for relevant articles

Database	Keyword
Eric	Teacher Competency on TPACK

The Table 1 shows that the keyword used in finding relevant articles is Teacher Competence on TPACK. The focus determined in this literature leads to an evaluation of the search for research trends related to Teacher Competence on TPACK, there are 1109 literatures from two relevant data sources related to Teacher Competence on TPACK. The next step was to determine the criteria to include and exclude articles from the focused theme according to the framework required for the review as shown in the Table 2.

Table 2. Include and Exclude Criteria

Include Criteria	**Exclude Criteria**
Journal articles	Book chapters, book, proceedings, review
Articles published in 2019-2023	Unpublished articles between 2019-2023
Related articles to teacher competence on TPACK	Unrelated articles to teacher competence on TPACK
English language articles	Unpublished articles in English

The Table 2 illustrates the articles that were selected for follow-up based on the predetermined inclusion and exclusion criteria.

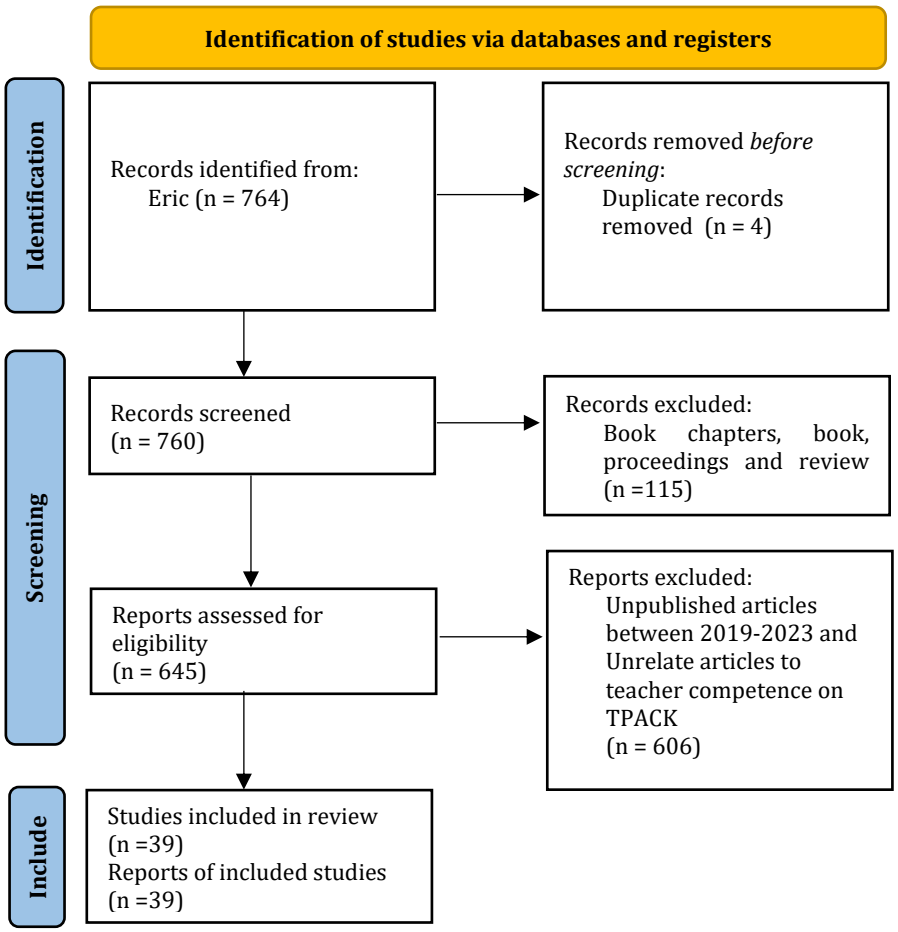

Fig. 1. PRISMA Flowchart

Phase 2: Screening

Literature results from Eric's database were filtered through zotero software to separate articles that were identified as duplicate. Next was the title and abstract screening process, which mapped articles based on titles and abstracts. Titles were screened for relevance and match with the keywords used. Then, the abstracts of each article were screened and scanned according to the predetermined inclusion and exclusion criteria.

Phase 3: Eligibility

At this stage, articles are analyzed and checked for eligibility through Zotero. Once the articles were identified as eligible, it was then possible to download the full text of the articles and separate the articles that fell under the exclusion criteria. In this phase, articles that are determined to be feasible will likely provide answers to the questions in the study.

Phase 4: Inclusion

After checking the eligibility of articles based on inclusion and exclusion criteria. Eligible articles within the inclusion criteria will be extracted and analyzed according to the statements that will be used as guidelines in the review, namely Participant, Intervention, Comparison conditions, Outcomes, Studies (PICOS). The determination of the statement in the extraction process depends on the expected trend in the research question. In the data extraction process using a manual model based on the PICOS statement and continued on the study quality of the extracted literature. The following is the article search process using the PRISMA flowchart:

RESULTS AND DISCUSSION

Based on the mapping of articles included in the inclusion criteria presented in the PRISMA flowchart, research trend articles regarding teacher competence on TPACK in 2019 were 10 articles, in 2020 there were 8 articles, in 2021 there were 13 articles which then became the year with the most research study contributions included in the inclusion criteria. Furthermore, in 2022 with 7 articles and the last is 2023 with 1 article. So that the total articles included in the inclusion criteria from 2019 to 2023 are 39 articles.

Findings from the ERIC database show that there are 764 databases that match the keywords "Teacher's competency on TPACK". After the identification process through Zotero software, 39 articles were found that fit the inclusion criteria with predetermined conditions. The mapping of 39 articles has been parsed based on information on the year of publication, author, title, publication (scopus accredited). Furthermore, it has been mapped on the discussion that refers to teachers need to understand TPACK well, teachers need to have high self-confidence to successfully integrate TPACK, and teachers need to be able to analyze the needs and challenges in the classroom using technology.

Teachers need to understand TPACK well

We have selected 14 articles that fall under the teachers need to understand TPACK well discourse. The screening process began with reviewing the titles and abstracts to assess their relevance to the research questions. Articles that met the initial criteria were then further evaluated by reading the full text. At this stage, strict inclusion and exclusion criteria were applied to ensure only articles that met certain methodological standards were included in the review of 14 articles. After that, we formulated each article by the way to integrate it into TPACK and obtained the data as shown in the Table 3.

Table 3. Articles that belong to the teachers need to understand TPACK well discourse

No.	Articles	The Way to Integrate
1	Muianga, Barbutiu, Hansson, et al., (2019)	Teachers' perspectives on professional development are vital for enhancing their skills in SCL and ICT approaches. This quantitative case study aims to assess teachers' understanding and application of TPACK, highlighting areas for further development. A solid grasp of TPACK will help teachers create dynamic learning environments that effectively integrate technology and support student-centered learning.
2	Atar et al., (2019)	Pre-service teachers need to evaluate their knowledge of each teaching component separately. They should learn to effectively combine these aspects in English language teaching through structured training. This includes selecting appropriate technologies and implementing effective pedagogical strategies to enhance the learning process. By understanding TPACK, pre-service teachers can better address classroom challenges and improve student learning outcomes.
3	Shafie et al. (2019)	Teachers should identify relevant technologies to support and enhance learning experiences. They must design innovative pedagogical strategies tailored to the content and utilize technology to improve effectiveness. By understanding TPACK, teachers can create interactive learning environments that prepare students for 21st-century challenges and opportunities.
4	Setiawan & Phillipson (2020)	Social media can enhance collaborative learning and enrich science content. Teacher candidates' self-efficacy, belief in their academic ability to use social media, affects TPACK implementation. Teachers with high self-efficacy are more likely to integrate technology creatively. Thus, prospective science teachers in Indonesia should cultivate TPACK and confidence in using social media to foster a dynamic, motivating learning environment.
5	Bakar et al. (2020)	Understanding TPACK helps teachers create effective learning strategies, choose suitable technology, and adapt math content to students' needs. Integrating TPACK with teachers' self-efficacy enhances math teaching quality through technology and boosts their confidence in facilitating meaningful learning for students.
6	Alper Ardıç (2021)	Understanding TPACK allows teachers to view technology as a vital tool integrated with their teaching methods. Shifting negative attitudes to positive ones requires training on technology's benefits for learning outcomes. Increased confidence can be fostered through ongoing practice and professional support.
7	Njiku et al. (2021)	Teachers must grasp how technology enhances mathematics learning and how suitable pedagogical

No.	Articles	The Way to Integrate
		methods can clarify concepts. Collaborative lesson design is a crucial way to develop this knowledge. Teachers can share ideas and create innovative lessons that promote a deeper understanding of mathematics by working together.
8	Adalar (2021)	Prospective teachers must grasp TPACK's components: content knowledge, pedagogy, technology, and how they interact to enhance learning. Strong self-efficacy boosts teacher candidates' confidence in using technology, enabling them to create innovative and responsive teaching strategies.
9	Dewi et al. (2021)	A systematic literature review from 2010 to 2020 reveals a significant rise in TPACK application across education. Understanding TPACK, which integrates content knowledge, pedagogy, and technology, enables teachers to effectively combine these elements, enhancing interactivity and practicality in teaching and learning. This review outlines TPACK research development and serves as a guide for teachers to improve their technology integration in everyday practices.
10	Thohir et al. (2021)	This study explores how pre-service teachers' personality traits, openness, conscientiousness, and emotional stability, affect their mastery of TPACK when using the web as a learning resource. Understanding this relationship can help design training programs that enhance technical skills and supportive personality traits. Teachers who master TPACK will be better equipped to tackle challenges in digital education and create compelling, engaging learning environments.
11	Iskandar et al. (2021)	21st century learning prioritizes critical thinking, collaboration, communication, creativity, and emotional intelligence (EQ). In Indonesia, teacher certification programs should integrate TPACK to effectively incorporate technology in teaching and EQ training to help teachers manage classrooms and connect with students' emotions. This approach ensures that teachers possess both technical skills and the ability to foster meaningful, relevant learning experiences for their students.
12	Shi & Jiang (2022)	Teachers must thoroughly understand technological pedagogical content knowledge (TPACK) to effectively integrate technology into EFL teaching. A solid grasp of TPACK enables them to enhance learning effectiveness and adapt methods to current technological needs.
13	Nikoçeviq-Kurti (2022)	This study examines the evolution and application of TPACK in education from 2010 to 2021, identifying factors that influence teachers' mastery of technology integration. It emphasizes that TPACK encompasses knowledge of technology, content, and pedagogy and

No.	Articles	The Way to Integrate
		their meaningful interaction in teaching. By understanding these trends, teachers can create more effective learning experiences through a holistic approach to content and pedagogy.
14	Eshelman & Hogue (2023)	Teachers should connect micro-instructional design with TPACK elements. By enhancing their TPACK skills, they can improve their teaching methods and increase the effectiveness and relevance of student learning.

Teachers need to have high self-confidence to successfully integrate TPACK

We have selected 15 articles that fall under the teachers need to have high self-confidence to successfully integrate TPACK discourse. The screening process began with reviewing the titles and abstracts to assess their relevance to the research questions. Articles that met the initial criteria were then further evaluated by reading the full text. At this stage, strict inclusion and exclusion criteria were applied to ensure only articles that met certain methodological standards were included in the review of 15 articles. After that, we formulated each article by the way to integrate it into TPACK and obtained the data as shown in the Table 4.

Table 4. Articles that belong to the teachers need to have high self-confidence to integrate TPACK discourse successfully

No.	Articles	The Way to Integrate
1	Altun (2019)	Teachers need to develop skills in various digital tools and understand how technology enhances learning. Training and workshops on integrating technology into the curriculum can boost their confidence. A positive attitude towards technology, supported by the school environment, is crucial. Continuous evaluation and feedback help improve their competencies. Teachers can confidently integrate technology into their teaching by focusing on TPACK components and fostering digital literacy.
2	Nurina et al. (2019)	Improving teachers' confidence in TPACK involves understanding students' perceptions of the learning environment created by biology teachers. Teachers can use surveys or interviews to identify their strengths and areas for improvement, guiding professional development in effective technology use. Collaborating with peers and engaging in self-reflection are also crucial. Enhancing skills in technology and pedagogy allows teachers to create a more engaging learning environment, ultimately boosting educational quality.
3	Sarıçoban et al. (2019)	Integrating Technology Pedagogical Content Knowledge (TPACK) for pre-service English teachers can be achieved through continuous mentoring and practical support.

No.	Articles	The Way to Integrate
		Providing relevant technological resources and guidance enhances their ability to use technology effectively in language teaching. Constructive feedback from experts and peers boosts their confidence in TPACK integration. This structured approach helps pre-service teachers build competence and confidence, leading to an effective learning environment.
4	Young et al. (2019)	Intensive training and mentoring for teachers can enhance their understanding of TPACK (Technological et al. Knowledge) by focusing on content, pedagogy, and technology. An evaluation using confidence intervals assessed the training's effectiveness, identifying strengths and weaknesses in TPACK implementation. This data enables a targeted follow-up plan for improvement. Ongoing support through professional learning communities and constructive feedback will further boost teachers' confidence, leading to better integration of TPACK in the classroom and improved mathematics education in urban areas.
5	Kewalramani & Havu-Nuutinen (2019)	Teachers can learn from each other about innovative technology tools for scientific investigations. Interactive apps, learning videos, and digital experimentation can enhance children's engagement and understanding. Collaboration with fellow teachers and resource access are crucial for building confidence in technology integration. This approach helps preschool teachers effectively use technology to enrich children's learning experiences and foster curiosity and critical thinking in scientific inquiry.
6	Bagheri (2020)	Developing a TPACK validation instrument is crucial for accurately measuring teachers' knowledge and skills in technology, pedagogy, and content. Ongoing training, such as workshops and seminars, should be provided to enhance teachers' application of technology in English language teaching. Adequate resources, including access to the latest technology and collaboration platforms, will boost teachers' confidence. Additionally, fostering a supportive environment for sharing experiences can promote professional growth. By integrating TPACK effectively, English teachers in Iran can enhance their teaching practices and create more engaging learning experiences for students.
7	Inpeng & Nomnian (2020)	Using Facebook as a platform for Teaching English as a Foreign Language (TEFL) enables teachers to enhance their methods through various technological features. The group and page functions support class discussions, material sharing, and real-time feedback, fostering better student engagement. Additionally, Facebook encourages teacher collaboration, allowing access to a broader

No.	Articles	The Way to Integrate
		professional community for support and idea exchange. This boosts teachers' confidence in implementing TPACK by providing them with tools and resources that promote innovative teaching practices.
8	Nuangchalerm (2020)	Continued support from schools and the government for pre-service teachers in Thailand, including technology resources and opportunities to share best practices, is essential. A supportive environment fosters teacher confidence through hands-on experience and collaboration. Mentoring programs and professional learning communities further prepare teachers to integrate TPACK effectively. Thus, a holistic approach combining training, support, and collaboration is crucial for the successful integration of TPACK by pre-service teachers in Thailand.
9	Uluçinar (2021)	Teachers with a positive view of the teaching-learning process are more likely to integrate technology effectively in their practice. To boost their confidence in using TPACK, training should focus on technology and enhance their understanding of teaching concepts. Practice-based training can help teachers experience how technology supports their strategies, fostering critical reflection on their experiences. This approach will enhance their confidence and skills in integrating TPACK, ultimately improving classroom learning quality.
10	Gonzales & Gonzales (2021)	Through ongoing training on the Interactive Whiteboard (IWB), math teachers can see how this technology enhances effective teaching strategies and enriches content. Using the TPACK framework for evaluation enables reflection and constructive feedback, helping teachers identify areas for improvement. This boosts their confidence and skills in integrating TPACK, ultimately enhancing student learning outcomes.
11	Chieng & Tan (2021)	Teachers' insights from the survey highlight barriers and enablers in implementing TPACK. Understanding these perspectives allows for targeted training to enhance technological, pedagogical, and content skills, along with practical examples for classroom use. Additionally, fostering learning communities among science teachers can facilitate the sharing of practical strategies for integrating technology, equipping them with the knowledge, skills, support, and confidence needed for successful TPACK implementation.
12	Bostan & Sener (2021)	Providing adequate resources and technical support is crucial for teachers to address challenges in the learning process. Collaboration and sharing best practices can enhance their confidence and skills. Access to a supportive learning community allows continuous improvement in using technology effectively. Ongoing

No.	Articles	The Way to Integrate
		evaluation and feedback are also vital for measuring success. This holistic approach can boost teachers' confidence in integrating TPACK into English language learning, promoting greater acceptance and engagement with mobile tools.
13	Dikmen & Demirer (2022)	TPACK is a framework that helps teachers effectively integrate content, pedagogy, and technology. Key social cognitive variables include self-efficacy, motivation, and perceptions of technology. To enhance teachers' confidence in using TPACK, it is crucial to provide training that balances technical and pedagogical skills, including practical simulations and opportunities for exploration. Additionally, fostering a collaborative environment for sharing experiences can further boost confidence. As a result, effective TPACK integration can significantly improve teaching quality by empowering teachers to use technology in their classrooms.
14	Widyasari et al. (2022)	Through flipped learning, teachers can leverage technology to provide materials outside the classroom, allowing for deeper discussions and application of concepts during class. By designing subject-specific activities, they make learning more relevant and practical. Ongoing training can help teachers implement these strategies effectively, offering best practice demonstrations, peer collaboration, and constructive feedback. This support boosts teachers' confidence in integrating TPACK, encouraging them to innovate and improve their teaching practices.
15	Kristiawan et al. (2022)	Professional development should offer ongoing training, technical support, and collaboration to boost teachers' confidence in integrating TPACK. A supportive school environment is essential to helping teachers navigate technological challenges. This approach will deepen their knowledge of content, teaching methods, and technology, ultimately enhancing student engagement and learning outcomes.

Teachers need to be able to analyze the needs and challenges in the classroom using technology

We have selected 10 articles that fall under the teachers need to be able to analyze the needs and challenges in the classroom using technology discourse. The screening process began with reviewing the titles and abstracts to assess their relevance to the research questions. Articles that met the initial criteria were then further evaluated by reading the full text. At this stage, strict inclusion and exclusion criteria were applied to ensure only articles that met certain methodological standards were included in the review of 10 articles. After that, we formulated each article by the way to integrate it into TPACK and obtained the data as shown in the Table 5.

Table 5. Articles that belong to the teachers need to be able to analyze the needs and challenges in the classroom using technology discourse

No.	Articles	The Way to Integrate
1	Ebersole (2019)	Pre-service teacher education programs should offer practical sessions for candidates to explore relevant technology tools. They should also critically reflect on their use of technology in the classroom, focusing on student needs and challenges. This will help them integrate technology effectively to enhance learning. Additionally, mentors should provide constructive feedback and support. This approach will prepare pre-service teachers to address classroom challenges with technology, improving the quality of education they offer.
2	de Freitas & Spangenberg (2019)	Teachers analyze classroom needs and challenges to address barriers to ICT integration, including technical issues like insufficient infrastructure and skills and pedagogical challenges in adopting new teaching methods. Continuous reflection allows teachers to identify effective strategies, such as professional training, collaboration with colleagues, and using available resources. This approach helps create dynamic learning environments that leverage technology to enhance students' mathematics learning.
3	Peng (2020)	The practice-based technology teaching assistant program aims to equip teachers with practical skills for effectively using technology in the classroom. It includes intensive training on TPACK concepts, helping teachers understand how technology supports pedagogical goals and content delivery. This approach enables them to analyze classroom needs, identify relevant technology tools, and develop innovative teaching strategies. Additionally, the program offers a collaborative platform for sharing experiences and best practices, fostering continuous improvement. Ultimately, it prepares teachers for 21st-century challenges and enhances the learning environment for students' holistic development.
4	Ormancı et al. (2020)	Contemporary educational approaches, such as active, collaborative, and project-based learning, help aspiring teachers develop critical analysis and problem-solving skills for the classroom. Using TPACK, teachers can identify classroom needs and effectively utilize technology to enhance learning. TPACK integrates technology, pedagogy, and content knowledge, enabling teachers to master their subjects and innovate teaching methods. Focused training in TPACK boosts their confidence in using technology, empowering them to address student needs and challenges better.
5	Bergeson & Beschorner (2020)	Pre-service teachers begin by observing case studies that illustrate the use of technology in supporting learning.

No.	Articles	The Way to Integrate
		They then follow a systematic technology integration planning cycle, which includes planning, implementation, evaluation, and reflection. This helps teachers identify student needs, address challenges, and develop effective technology-based strategies. Continuous reflection and evaluation enable teachers to refine their methods, ensuring technology enhances student learning outcomes.
6	Ajloni & O'Toole (2021)	Adopting TPACK enables teachers in Jordan to analyze classroom needs and challenges effectively. Video technology enhances interactivity and engagement in learning. With TPACK, teachers can choose suitable video tools for their content and teaching methods, using demonstration videos for complex concepts or discussion videos to foster critical thinking. It also helps identify challenges like limited tech access or varying digital literacy levels and guides teachers in finding solutions. Integrating TPACK with video technology supports teachers in meeting students' learning needs and addressing classroom challenges.
7	Casler-Failing (2021)	Developing the 'T' in Technological Pedagogical Content Knowledge (TPACK) is crucial for teachers to address classroom challenges through technology. Robots can serve as innovative tools for teaching math concepts. Educators need to understand how robotics can enhance instructional strategies and materials. This knowledge enables them to create engaging learning experiences, meet diverse student needs, and tackle issues like time constraints and attention spans. Teachers can evaluate and refine their methods by integrating robots into math education, fostering an adaptive and enjoyable learning environment.
8	Kartal & Dilek (2021)	Pre-service teachers learn the basics of TPACK by exploring the interaction between technology, pedagogy, and content. In a technology-enhanced science teaching course, they identify student needs and challenges and are encouraged to design innovative teaching strategies using educational technology tools like science simulation software and online platforms. This hands-on approach helps them develop analytical skills to effectively address teaching challenges and make science learning more engaging and meaningful for students.
9	Habibi et al. (2022)	TPACK provides a comprehensive framework that combines content, pedagogy, and technology, helping teachers create effective learning strategies. Pre-service science teachers can identify their technology needs by considering technology access, school support, and technical skills and attitudes. For instance, they might use simulation software for complex concepts or e-learning

No.	Articles	The Way to Integrate
		platforms for collaborative discussions. Teachers can seek additional resources or professional development by understanding challenges such as limited access or lack of training. This integration allows them to effectively address classroom needs and enhance student learning outcomes.
10	Rakes et al. (2022)	Teachers use interactive software, math apps, and e-learning platforms to enhance student learning. These tools help visualize abstract concepts and provide real-time assignments and feedback. By integrating technology, teachers can identify students' challenges, such as difficulties in understanding concepts or motivation issues. This data-driven approach allows for tailored teaching methods, ultimately improving effectiveness and responsiveness in the classroom.

The mapping of articles included in the inclusion criteria can then be identified that in 2019, the trend of research studies centered on the discussion of teacher professional competence (Atar et al., 2019; Ebersole, 2019; Nurina et al., 2019). A teacher who has high professional competence is able to master and deliver subject matter clearly and precisely, manage the classroom effectively, apply innovative learning methods, and provide adequate guidance to students (Arifuddin & Karim, 2021). The 2019 research study illustrates that teachers' professional competence can be supported by confidence in utilizing technology during the learning process, not limited to integrating technology in learning, but being able to invite students to explore technology-based learning. In addition, teachers' professional competence can be nurtured through a comprehensive understanding of the dimensions and framework of TPACK knowledge (Muianga, Barbutiu, & Hansson, 2019).

Research trends on TPACK in 2019 align with 21st-century digital competencies. In our digitally connected era, strong digital skills are crucial for adapting to technology in education (Shafie et al., 2019). It's important to recognize barriers to technology use in learning, such as limited access to devices and the internet, insufficient skills among teachers and students, and misalignment with curricula. By understanding these challenges, educators can adopt strategies to integrate technology effectively into their teaching (Altun, 2019).

Research in 2020 highlights social media as an alternative for developing TPACK in learning, focusing on enhancing Teacher Professionalism in the education system (Rusydiyah, 2020). Through social media, teachers can enhance student interactions, collaboration, and learning content. It allows for resource sharing, immediate feedback, and interactive discussions. However, attention to privacy, security, and responsible use is essential. Social media can boost learning effectiveness and prepare students for the digital age (Inpeng & Nomnian, 2020; Surahman et al., 2020). Teacher self-efficacy in 2020 highlights how confidence in using technology positively influences student engagement and enthusiasm (Bakar et al., 2020). There is an ongoing discussion about teacher competence in estimating obstacles when integrating TPACK into learning (Dhurumraj et al., 2020).

Research trends in 2021, similar to the previous year, emphasize self-confidence and positive thinking as essential for integrating TPACK into learning (Mohammad-Salehi et al., 2021). Self-confidence enables teachers to use technology effectively, while positive thinking fosters innovation. When creating TPACK-based lesson plans, confidence is essential for selecting and integrating technologies, and a positive mindset promotes creativity and collaboration (Li, 2021). Evaluating TPACK-based learning necessitates confidence and positive thinking to recognize the benefits of technology. These elements foster a harmonious learning environment, leading to relevant competencies. (Uluçinar, 2021). Integrating TPACK in learning does not need sophisticated technology. Creative teachers can use simple tools like videos, interactive PowerPoint slides, and social media to enhance student understanding (Iskandar et al., 2021). Teachers can engage students using videos and interactive PowerPoint slides, which present learning materials through visual, audio, and interactive elements (Alper Ardıç, 2021). Through creativity and active learning design skills, teachers can create engaging learning experiences using simple yet effective media (Bostan & Sener, 2021).

The 2022 research review highlights the importance of enhancing teacher capacity and implementing TPACK in learning through the Plan, Do, Study, and Action (PDSA) approach (Vanek, 2022). In the Plan stage, teachers learn content and strategies for using technology. In the Do stage, they actively integrate TPACK. The Study stage analyzes learning outcomes and evaluates technology effectiveness. Finally, the Action stage allows teachers to adjust to enhance TPACK-based learning. This PDSA cycle ensures systematic and sustainable TPACK implementation (Adelabu et al., 2022). Research from the same year highlights that a teacher's TPACK knowledge significantly affects learning effectiveness (Habibi et al., 2022). A teacher who effectively integrates technology, pedagogy, and content can create a more engaging and interactive learning experience for students (Widyasari et al., 2022). Teachers with TPACK knowledge can choose suitable technological tools to enhance learning, integrate effective strategies, and foster student collaboration and engagement. This knowledge ultimately improves learning outcomes and empowers students (Kristiawan et al., 2022).

The study in 2023 goes so far as to discuss how prospective teachers' positive paradigms and perceptions towards the use of TPACK in learning have a strong impact on their self-confidence. If prospective teachers have a positive view of technology and believe that TPACK integration can improve learning effectiveness, they will be more motivated to try and explore various technological tools and methods in the classroom. Conversely, negative perceptions or less supportive paradigms may lead to a sense of self-confidence in adopting technology in learning. Therefore, building teachers' positive paradigms and perceptions related to TPACK is an important key in increasing their confidence to integrate technology creatively and effectively in the learning process (Eshelman & Hogue, 2023).

Furthermore, a teacher's professional competence is an important pillar in creating quality education that has a positive impact on students. Professionally competent teachers are able to deliver subject matter clearly and enjoyably, deal with challenges in the classroom, and create an inclusive and inspiring learning environment (Karim, 2020). With expertise in developing lesson plans, understanding students' individual needs and implementing innovative teaching methods, these teachers can be a key driver for students' intellectual and social development.

Research studies from year to year from 2019 to 2023 related to TPACK have their own uniqueness and characteristics. in 2019 it can be mapped that the integration of TPACK to improve teacher professionalism can be supported through high confidence in the implementation of technology in learning. In this case, the utilization of simple learning media such as power point slides, interactive whiteboards and videos can be used to facilitate students in receiving material. This is in line with the findings listed in Nisak et al's research which discusses the success of innovative microteaching learning in improving the TPACK competencies of prospective teachers (Nisak et al., 2023). With the selection of appropriate media can create innovative learning.

The integration of TPACK in social media-based learning has great potential to improve the effectiveness and relevance of the learning process. TPACK refers to a holistic understanding of how technology can be used appropriately to teach content that meets students' needs. In the context of social media-based learning, teachers need to integrate knowledge of lesson content, effective teaching strategies and the ability to utilize social media technology productively. Through the use of relevant social media, such as e-learning platforms, social networks, or the use of online discussion groups, students can actively participate, collaborate, and share knowledge with others in a comfortable and familiar context. Indirectly, social media and technology-based learning can stimulate students to be digitally literate, as in Rusydiyah's research which outlines literacy indicators in four categories, among which are basic information and communication technology (ICT) skills, information skills, media awareness, and computational thinking (Rusydiyah, Purwati, et al., 2020).

In the 2021 research review literature, there are several things that become the substance of the discussion, such as integrating TPACK in learning which becomes more effective when supported by collaboration and synergy between teachers, students, and other related parties. TPACK refers to the knowledge of how to use technology in the context of teaching and learning that is appropriate to the subject matter being taught. Collaboration between teachers and students allows them to share knowledge and experiences with each other, thus improving the understanding of how technology can be integrated well in the learning process. In addition, synergy with related parties such as technology developers, school administrators and parents is also important to create an optimal learning environment. Through this collaboration and synergy, the integration of TPACK can provide maximum benefits in improving the quality of learning and preparing students to face the demands of the ever-evolving digital world.

Teacher capacity building through a structured and systematic approach such as one of the research findings in 2022 (plan, do, study, act) has great potential to create effective learning. Through comprehensively designed training programs, teachers can develop pedagogical skills, subject knowledge and an understanding of students' individual needs. With a structured approach, teachers can learn innovative and effective teaching methods, such as the use of technology in learning, differentiation strategies and formative evaluation. Being systematic in its development means teachers have the opportunity to apply the new knowledge gained in the classroom context on a consistent and ongoing basis. The education curriculum must be designed systematically and consider many things, such as Rusydiyah's explanation in her research which examines the need for a learning

environment approach that can support good teaching, in order to realize quality learning (Rusydiyah et al., 2021).

On the other hand, an important thing to note in the integration of TPACK in learning to realize professional educators is that educators or prospective educators must be able to build a paradigm and perception that positive thinking plays a crucial role in increasing their capacity in learning. Having a positive paradigm means seeing themselves as influential agents of change in students' lives. With an optimistic and confident attitude, prospective teachers will be more motivated to continue learning and developing their pedagogical skills and knowledge. A positive paradigm also opens the door for acceptance and adaptation to changes in education, such as the use of new technologies and learning methods. When prospective teachers have the belief that they are capable of facing challenges and influencing student success, they will be more open to seeking meaningful learning opportunities and continuously strive to improve themselves.

CONCLUSION

During 2019-2023, research trends on the integration of TPACK in learning emphasized several important points to note, that are the teachers need to have high self-confidence to successfully integrate TPACK. They must believe that they are capable of using technology in learning and facing the challenges that may arise. Then, the teachers need to be able to analyze the needs and challenges in the classroom, which will help them design good and relevant lessons using technology. Furthermore, the teachers need to understand TPACK well. They should understand the lesson content, effective teaching strategies and how to use technology appropriately. Social media such as facebook or Instagram can also be used by teachers to share knowledge and resources related to TPACK. The results and implications of the integration of technology in learning to create professional educators can be supported by several competencies such as self-confidence, comprehensive understanding, utilization of social media to create innovative learning, the ability to analyze obstacles in the use of technology, and the ability to build a positive paradigm in using technology in learning.

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