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Technological Pedagogical and Content Knowledge (TPACK) in School Education: Analysis of Research Trends

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Abstract

The objective of this systematic literature review was to classify and analyse the findings related to Technological Pedagogical Content Knowledge (TPACK) from 2015 to May 2024, following the PRISMA guidelines. The study focused on the analysis of ten years of empirical research, specifically emphasising TPACK by providing an in-depth understanding of technology integration in school education. Searches in Scopus, Google Scholar, ERIC, JSTOR, and Sage Journal databases resulted in 296 articles, out of which 50 were selected for final analysis. The findings revealed that school teachers demonstrated a high level of TPACK competence with a significant variation in teachers' TPACK level based on factors such as age, gender, and teaching experience. Moreover, a significant and positive relationship was found between teachers' TPACK and their computer self-efficacy, while a significant and negative correlation was identified between teachers' technostress and their integration of technology. Additionally, teachers demonstrated significant and positive attitudes towards the integration of technology in their teaching. This suggests that teachers with positive attitudes also had favourable perceptions of their perceived TPACK.

Keywords*: Technological Pedagogical and Content Knowledge (TPACK), TPACK Competence, Technology Integration, Computer Self-efficacy.*

Introduction

Since the 1990s, the rapid growth of information and communication technologies (ICT) has influenced all professions. The fourth industrial revolution, also known as the "4.0 era," is characterised by substantial advancement in technology that affects all aspects of human life. Education 4.0 is the implementation of technology into the educational process in the sphere of Education. (González-Pérez & Ramírez-Montoya, 2022). The primary feature of this era is the utilisation of technology to improve the teaching and learning of teachers and students (Haderer & Ciolacu, 2022). When learning takes place through technology, new opportunities arise, such as reducing time and effort and making the teaching-learning process easy-going. Digitalisation in the field of education reduces teacher workload and fosters collaboration among colleagues. However, the need for constant acquisition of knowledge and skills in new technologies creates challenges for teachers, including increased workload and time constraints. (Tarafdar et al., 2014). As an innovative tool, technology plays a crucial role in enhancing the teaching-learning process in light of global educational reforms (Kahveci, Sahin, & Genc, 2011). Technological advancements may have transformed the role of teachers from

designers of curriculum to content delivery facilitators, selecting appropriate technology and methodology (Kereluik et al., 2010). Teachers nowadays must be skilled at integrating technology into classroom activities, as it has been shown to enhance learning outcomes. This leads to improvements in teaching methodologies, classroom management, and interventions that utilise technology (Kazu & Erten, 2014). The advancement of ICT has made it essential for teachers to improve their skills and expertise in utilising technology in their instructional methods and to integrate technology into their teaching practices seamlessly (Graham, Tripp & Wentworth, 2009). Teachers in this era are expected to incorporate ICT in planning their teaching process, performing assessments, developing teaching-learning materials, and selecting appropriate technology. Using ICT effectively in the classroom enhances students' learning processes and their performance (Kim & Hannafin, 2011; Vandeyar, 2015). So, teachers must have both technological and pedagogical skills to design and develop instructional materials and activities for their students (Keeler, 2008; Moore, 2006).

The theory of technological pedagogical content knowledge (TPACK), first proposed by Mishra and Koehler (2006), is based on the work of Shulman (1986). It focuses on how educators incorporate various forms of technology, pedagogical approaches, and course content into their classroom instruction. Technological pedagogical content knowledge (TPACK) refers to the framework that combines technology, pedagogy, and content in education. Effective use of technology in education requires the integration of three distinct forms of teacher knowledge: content knowledge, pedagogy, and technology. The combination of various knowledge domains, encompassing both theoretical and practical aspects, generates the flexible knowledge required to successfully integrate technology in education. This framework aims to enhance the efficient integration of technology into instructional practices.

Conceptual Framework of TPACK

Technological Pedagogical and Content Knowledge (TPACK)

Mishra and Koehler (2006) proposed the concept of technological pedagogical and content knowledge (TPACK) in educational research as a theoretical framework for understanding the effective integration of technology into instruction. The TPACK framework is derived from Shulman's (1986) theoretical framework for Pedagogical Content Knowledge (PCK). Shulman (1986) defines pedagogical content knowledge (PCK) as comprising two essential components: Content knowledge (CK) and pedagogical knowledge (PK), which are fundamental domains of teacher knowledge. Additionally, PCK encompasses a specific domain that demonstrates the pedagogical knowledge that is specifically applicable to a particular content area. The TPACK framework incorporates technological knowledge (TK) as a third main domain of knowledge,

resulting in three additional connections between these knowledge domains: technological content knowledge (TCK), technological pedagogical knowledge (TPK), and technological pedagogical content knowledge (TPCK) (Koehler & Mishra, 2005; Mishra & Koehler, 2006). The term Technological Pedagogical Content Knowledge (TPCK), also abbreviated as 'TPACK', highlights the importance of a teacher's understanding of the interaction between technology, pedagogy, and content. This framework illustrates how teachers comprehend technologies for education and the way PCK interacts to offer effective technology-based teaching. It also demonstrates how specific pedagogies can help students use technology and learn more effectively.

Koehler and Mishra (2006, 2008) explained that TPACK is a framework that focuses on the interplay of content, pedagogy, and technology in the classroom. The TPACK framework's seven components resulted from the combination of three aspects of knowledge: technological, pedagogical, and content. Technological knowledge (TK), pedagogical knowledge (PK), content knowledge (CK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), pedagogical content knowledge (PCK), and technological pedagogical content knowledge (TPACK) are specific terms used to refer to these different types of knowledge.

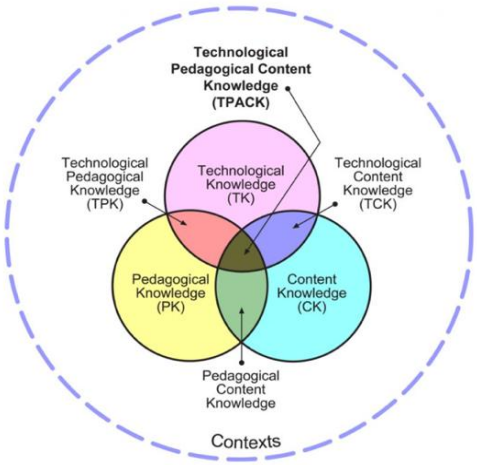


Figure 1: The TPACK Framework and its components
Source: Koehler and Mishra, 2009

Objective

1. To analyse the research findings of TPACK in school education

Research Questions

1. What trends have been identified in studies examining the TPACK of school teachers?
2. What are the research findings of TPACK in school education?

Method and Procedure

The current study focuses on TPACK research performed in school education until May 2024. The method for this research study was designed based on the structure along with suggestions of several studies suggested by Chai et al. (2013b), Bakar, Maat, and Rosli (2018), Greene and Jones (2020) and Joshi (2023) regarding search strategy, inclusion and exclusion criteria, coding, and analysis. This study examines TPACK research conducted in school education up to May 2024.

Search procedures

Information is retrieved via electronic media and hard copies during a literature review (Hart, 1998). The search process is carried out in two stages utilising Hart's (1999) framework:

a. Collect all relevant papers in the initial search;

b. Establish the literature review's inclusion and exclusion criteria.

Key terminology utilised in the literature, including synonyms and alternative spellings, was identified during the initial phase. The following search phrases were utilised to find suitable articles: (“Technological Pedagogical and Content Knowledge” or "TPACK"). The databases utilised for data collection in this study include Google Scholar, Educational Resources Information Centre (ERIC), JSTOR, Sage, and Scopus. These databases are widely used in the field of education (Bano et al., 2018). The search primarily focused on papers published from 2015 to 2024. This search was restricted to research papers published in the English language, excluding conference papers, book chapters, and review articles.

Selection Criteria

This literature review primarily covers research studies pertaining to TPACK and the integration of technology in school education. Subsequent to the initial step of article selection, the most pertinent papers related to the research were identified by applying inclusion criteria.

Inclusion and exclusion criteria

After obtaining all the research studies by utilising search strategy procedures, the following inclusion criteria were employed to assess each research study:

Table 1: Inclusion and Exclusion Criteria

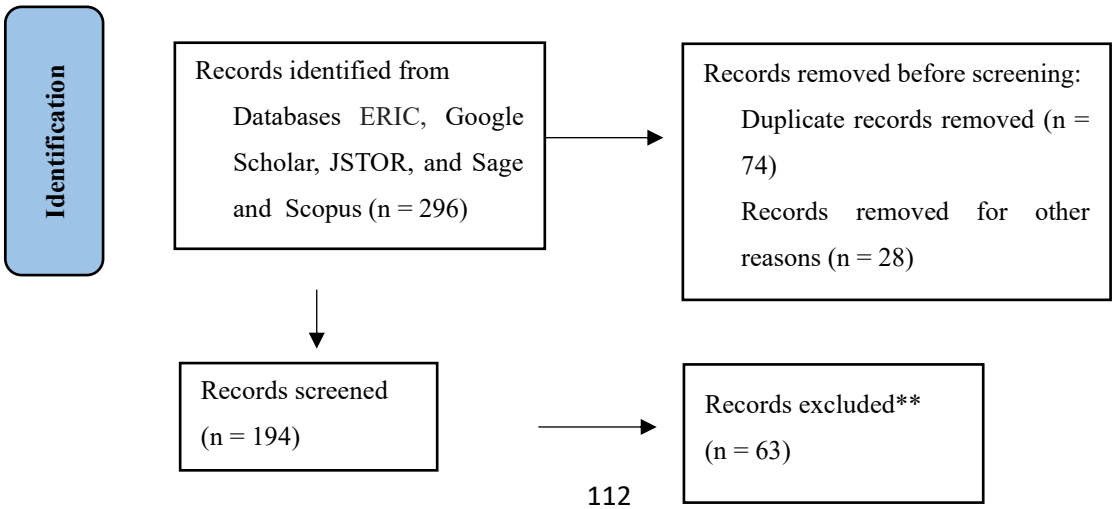
Inclusion criteria	*Exclusion criteria*
1. The research articles written in English 2. The studies related to technology integration in school education 3. The studies are empirically based (Quantitative methods and Mixed methods)	1. The studies which are purely theoretical, such as conceptual papers, meta-analyses, and systematic reviews, were excluded. 2. Research articles whose abstract is only available, not the full text was excluded

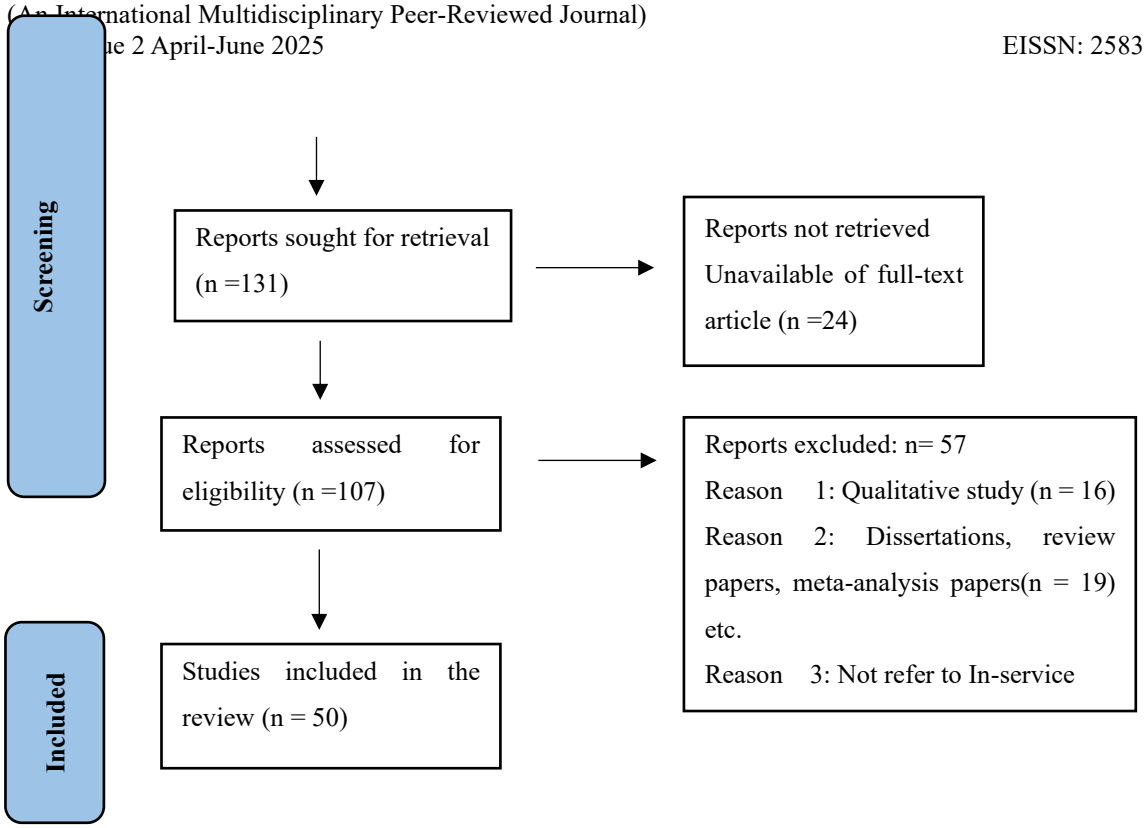
4. The research papers published between 2015–2024 5. Full texts of studies are included. 6. "Technology integration," and "Technological Pedagogical and Content knowledge," "TPACK" included in the title, search terms, or abstract 7. The studies focused on the context of technology integration in school education 8. The participants involved are in-service primary and secondary school teachers.	3. Research studies based on qualitative methods are excluded 4. Participants involved other than primary and secondary school teachers are excluded. 5. "Technology integration," and "TPACK" if not mentioned in the abstract, search terms, or title, studies are removed.

Study selection

Figure 2 presents the PRISMA flow diagram, highlighting the sequential data progression during the systematic review process. Articles were gathered in the initial stage using a search strategy. After getting the results, all duplicates were removed. The inclusion and exclusion criteria were used to evaluate all research papers. The screening procedure emphasises the evaluation of technological pedagogical and content knowledge (TPACK) as shown in the paper's title, keywords, or abstract. If the word was not explicitly defined, the research study was chosen for a thorough review in the subsequent screening phase. Research studies meeting the defined inclusion and exclusion criteria have been gathered into a comprehensive master list. A total of 296 articles were identified from searches conducted across multiple databases, including the Educational Resources Information Centre (ERIC), JSTOR, Google Scholar, Scopus, and Sage. These publications focused on technological pedagogical content knowledge (TPACK). Furthermore, 57 records were excluded from the review of titles and abstracts due to not meeting the inclusion criteria. Upon completion of the final evaluation, the aggregate number of studies that met the predetermined inclusion and exclusion criteria was 50.

Figure 2: The Diagram illustration of the Findings Article





Search results

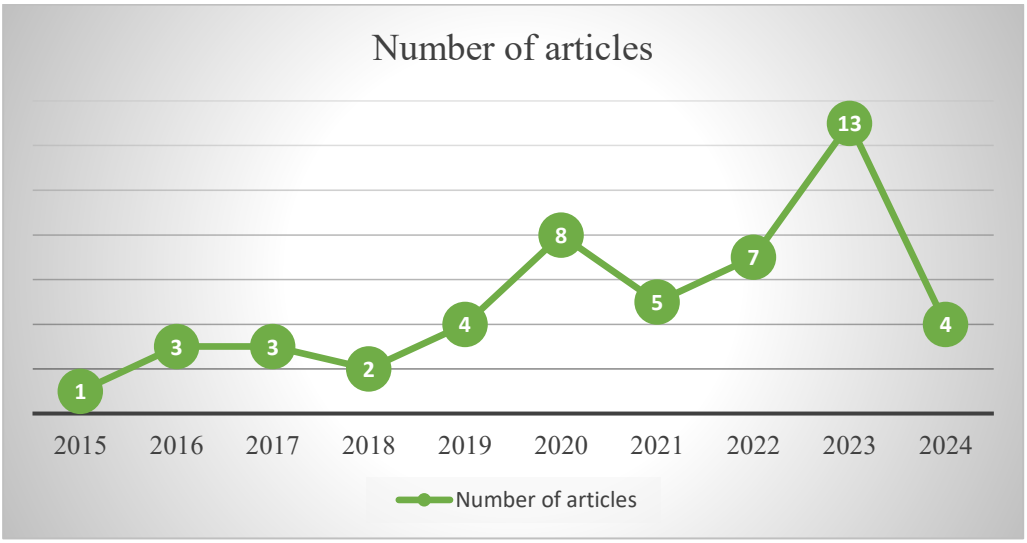
The results of the review are used to answer each research question. The descriptions of the review of studies are summarised, synthesised, and critiqued in the following manner.

Year-wise trends of TPACK

Research articles that focused on TPACK analysis were published periodically from 2015 to 2024, as shown in Figure 3. The majority of the publications used in this analysis were found in 2023, with 13 in total. Between 2015 and 2023, there was an ongoing increase in the quantity of articles. As 2024 is the current year, research on TPACK is ongoing. So, less number of studies, i.e., four, are considered in this paper.

Table 2: Year-wise Distribution of the Number of Articles

Sr. No.	Year	Number of articles	Percentage
1.	2015	01	2%
2.	2016	03	6%
3.	2017	03	6%
4.	2018	02	4%
5.	2019	04	8%
6.	2020	08	16%
7.	2021	05	10%
8.	2022	07	14%
9.	2023	13	26%
10	2024	04	8%
Total		50	100



Graph 1: Distribution of the Number of Articles by Year

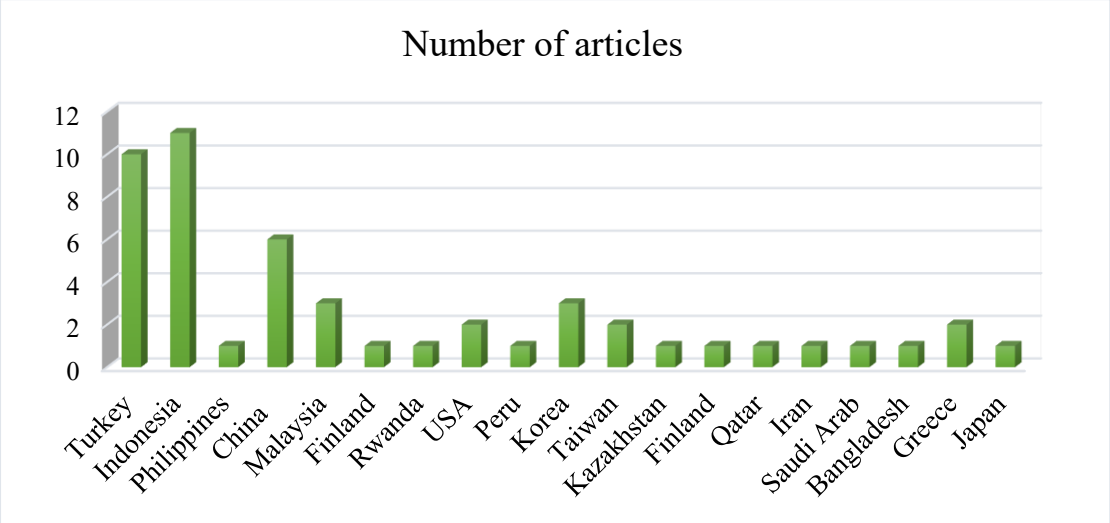
Locations that studied on TPACK

Articles indicate that the majority of the study was conducted in Asia, followed by Europe in second place. Out of the 50 papers, Asian studies comprised 74%, while European countries constituted 14%. Table 2 presents comprehensive statistics and discusses countries that have examined TPACK. Indonesia was the leading nation in Asia, followed by China. Concurrently, Turkey exerted dominance across Europe. All research in America was conducted within the United States. In Australia and Africa, there was a paucity of research articles pertaining to TPACK. Indonesia was the leading nation in TPACK research, followed by Turkey.

Table 3: Distribution of the Number of Articles by Country

Sr. No.	Country	Number of articles	Percentage
1.	Turkey	10	20%
2.	Indonesia	11	22%
3.	Philippines	01	2%
4.	China	06	12%
5.	Malaysia	03	6%
6.	Finland	01	2%
7.	Rwanda	01	2%
8.	USA	02	4%
9.	Peru	01	2%
10	Korea	03	6%
11.	Taiwan	02	4%
12.	Kazakhstan	01	2%
13.	Finland	01	2%
14.	Qatar	01	2%
15.	Iran	01	2%
16.	Saudi Arab	01	2%

17.	Bangladesh	01	2%
18.	Greece	02	4%
19.	Japan	01	2%
Total		**50**	**100**



Graph 2: Distribution of the Number of Articles by Country

Results and Discussion

Teachers' TPACK competence

One way to measure a teacher's TPACK is by investigating how efficiently and seamlessly they incorporate subject matter, pedagogy, and technology in the classroom. Teacher's TPACK level is not necessarily a separate scale but rather a range because teachers may have various levels of experience in each area. The level of language teachers' TPACK was studied, and it was found that language teachers had an average level of TPACK confidence, and CK, TK, and TPK were relatively low (Cheng 2017, 702). In similar studies, the primary school teachers' TPACK competencies were studied and found at a medium level (Zhakiyanova et al., 2023; Bingimlas, 2018). Further, in the majority of the studies, the TPACK competence of the school teachers was found at a high level (Naing & Wiedarti, 2023; Agustin, Aridah, & Iswari, 2023; COŞKUN & ZEYBEK, 2023; Azhar & Hashim, 2022; Destiani, Setyarini, & Rodliyah, 2022; Maknun, 2022; Li, Liu & Su 2022; Erdoğan & Akbaba, 2022; KAŞCI & Selçuk, 2021; Gökbulut, 2021; Giannakos et al., 2015).

Comparing the TPACK level of teachers according to gender, age, and experience, TPACK competencies varied considerably based on gender, age, and professional seniority characteristics and statistically significant differences were observed in the TPACK competencies when considering characteristics such as gender, age, and professional seniority.

Few studies revealed a significant difference existed among the teacher's TPACK competencies based on their gender, teaching subjects, and teaching experience (Gökbulut, 2021; Bingimlas, 2018). Male teachers demonstrated much greater technological knowledge abilities compared to their female teachers. Again, the teachers with high professional seniority demonstrated very low technology knowledge (TK) (Zhakiyanova et al., 2023; Mansour, Said & Abu-Tineh, 2024). In contrast, the male teachers who were older had a higher level of confidence in their content knowledge (CK), whereas the older female teachers tended to possess less confidence in their technology knowledge (TK). (Cheng, 2017, 701). However, some studies revealed no significant difference in TPACK mastery between male and female teachers (Naing & Wiedarti, 2023; Li, 2023; KAŞCI & Selçuk, 2021). Similarly, teaching experience and school level did not show any significant difference between science and mathematics teachers' self-efficacy in integrating technology (Mansour, Said & Abu-Tineh 2024). Personal characteristics, including teachers' value beliefs, also have a role in shaping their TPACK competencies. Among personal characteristics, the one predictor of TPACK is value beliefs (Cheng and Xie, 2018).

Constructs of TPACK

TPACK constructs such as content knowledge, pedagogical knowledge, and technological knowledge are strongly interconnected and significantly affect teachers' TPACK and their professional development (Hsu & Chen, 2023; Mailizar, Hidayat & Al-Manthari, 2021; Roussinos & Jimoyiannis, 2019). The majority of teachers exhibited a significant level of confidence in their content knowledge (CK), pedagogical knowledge (PK) and technological knowledge (TK). However, their expertise in technological pedagogical knowledge (TPK), technological content knowledge (TCK) and technological pedagogical content knowledge (TPACK) were found to be at moderate levels; as a result, it was hard for them to mingle technology into their teaching practices (Muslimin, Mukminatien & Ivone, 2023; Thy, Im & Iwayama, 2023; Haryati, Yuliasri, Nurkamto & Fitriati, 2022). Further, it was found that teachers' pedagogical knowledge (PK) has a significant positive effect on TPACK, whereas technological knowledge (TK) and content knowledge (CK) do not affect TPACK. Rather, TK and PK have significant positive effects on TPK, and TPK positively influences the TPACK of teachers (Absari, Priyanto & Muslikhin 2020). In a study, teachers' content knowledge was found to be at a high level, whereas technological knowledge was found to be at a low level (Maknun, 2022). Content Knowledge (CK), Pedagogical Knowledge (PK), Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), and Technological Pedagogical Content Knowledge (TPACK) of teachers differ significantly at various

instructional stages (Li, Liu & Su, 2022). In a study, the majority of the teachers were found to have a very good knowledge of TPACK constructs, i.e., TK, PK and CK (Roussinos & Jimoyiannis, 2019). Moreover, it was found that Technological Pedagogical Content Knowledge (TPACK) has a significant and positive impact on the integration of technology (Agustin, Aridah & Iswari, 2023). So, teachers with good knowledge of technology, pedagogy and content can effectively integrate technology into their teaching practice (Sangka, Indriayu, Mackenzie & Santika, 2022; Roussinos & Jimoyiannis, 2019).

However, computer science teachers admit that there is room for improvement in their expertise in technology and the integration of their knowledge of content, pedagogy, and technology. Furthermore, teachers acknowledge the necessity for additional guidance in incorporating technology into their teaching methods and effectively explaining algorithms. These areas of focus are connected to their pedagogical content knowledge and Technological Pedagogical Content Knowledge (TPACK) (Giannakos et al., 2015). The variable representing the type of school revealed differences in the four categories of technology-related knowledge of TPACK. The correlation analysis revealed a negative association between both age and teaching experience, particularly with the four technology-related knowledge domains (Thy, Im & Iwayama, 2023).

TPACK as a Predictor of Computer Self-efficacy

Research has examined the correlation between Technological Pedagogical Content Knowledge (TPACK) and computer self-efficacy. Teachers who possess higher levels of Technological Pedagogical Content Knowledge (TPACK) are more likely to feel confident in using technology in the classroom, leading to an improvement in their computer self-efficacy. This association makes intuitive sense because TPACK emphasises integrating technology, pedagogy, and content knowledge that can enhance teachers' ability to use computers in educational contexts effectively. After examining the levels of computer self-efficacy among teachers, it was found that teachers had a high level of self-efficacy when it comes to utilising technology in their teaching (Zhakiyanova et al., 2023; COŞKUN & ZEYBEK, 2023; KAŞCI & Selçuk, 2021; Islam, 2020**)**. However, in a single study, a moderate level of computer self-efficacy among teachers was found in integrating technology into their teaching (Njiku, Mutarutinya & Maniraho, 2020). Based on the findings, it can be determined that teachers possess a high level of confidence in utilising technology in their teaching practices. The primary factors contributing to computer self-efficacy are prior experience in information and communication technology (ICT), technological pedagogical content knowledge (TPACK), capacity-building programmes, and support from educational institutions (Islam, 2020).

Additionally, while analysing the relationship between computer self-efficacy and TPACK, a significant and positive association was discovered between the computer self-efficacy and TPACK competence of teachers in schools (Zhakiyanova et al., 2023; Yildiz Durak, Atman Uslu, Canbazoğlu Bilici & Güler 2023; Njiku, Mutarutinya & Maniraho, 2020; Lopez-Vargas, Duarte-Suárez & Ibáñez-Ibáñez, 2017). It can be said that teachers have a positive belief in using computers and technology for their teaching (Helppolainen & Aksela, 2020). This finding is similar to some other findings, i.e., a positive and moderate level of correlation was found between teacher's technological, pedagogical and content knowledge and their perceived self-efficacy (COŞKUN & ZEYBEK, 2023) and mathematics teachers' technology integration self-efficacy was strongly associated with their self-efficacy beliefs (Bakar, Maat & Rosli, 2020). Teacher training in technology use has increased their technology self-efficacy beliefs (Helppolainen & Aksela, 2020). The teachers' self-efficacy in using technology has a chain-mediating impact on how their Technological Pedagogical Content Knowledge (TPACK) influences their intentions to utilise technology (Bai, Guo & Gu 2024).

Computer self-efficacy of teachers differs among different subjects. Comparing the TPACK self-efficacy of vocational and technical teachers with the science and mathematics teachers, it was found that compared to science and math teachers, vocational and technical teachers had substantially better TPACK self-efficacy (Şimşek and Sarsar 2019, 204). However, no significant difference was found among mathematics teachers' technology self-efficacy based on gender and teaching experience (KAŞCI & Selçuk, 2021; Bakar, Maat & Rosli, 2020). Still, the self-efficacy of classroom teachers varied significantly depending on their professional seniority as well as the duration they had been using computers and mobile devices. (KAŞCI & Selçuk, 2021).

TPACK and Technostress

Technostress refers to the unpleasant psychological and physiological responses that persons may have as a result of their involvement with technology. The TPACK framework can assist teachers in reducing technostress by integrating technology into their teaching practices. With the integration of TPACK into teachers' teaching practice, it was found that teachers had a moderate technostress level (Gökbulut, 2021). With the highest path coefficients (−.45), TPACK has a significant impact on teachers' technostress, which suggests that TPACK plays an important role in helping teachers cope with the psychological stress caused by technology (Dong, Xu, Chai & Zhai, 2020). The most significant factors that were shown to influence technostress strongly were ICT competency, the alignment of educational ICT use with the teaching style, support from the school, job satisfaction, and attitudes towards educational

ICT use (Erdoğan & Akbaba, 2022; Syvänen et al., 2016). A strong and negative relationship was found between the technostress level experienced by teachers and their Technological Pedagogical Content Knowledge (TPACK), digital literacy competency, job satisfaction, and school support (Muslimin, Mukminatien & Ivone, 2023; Erdoğan & Akbaba, 2022; Gökbulut, 2021). High level of TPACK, high level of educational support, high level of computer self-efficacy, and use of technology in teaching have had significant positive effects on technostress by suggesting some techniques for reducing teacher stress when using technology in the classroom (Dong, Xu, Chai & Zhai, 2020; Eom, Lee & Lee 2020; Joo, Lim & Kim, 2016; Syvänen et al., 2016).

Comparing the technostress level among the school teachers, it was found that teachers working in leading schools observed higher levels of technological overload and complexity than those in ordinary schools (Eom, Lee & Lee, 2020). The variables such as gender, age, and teaching experience in the classroom were associated with significantly different levels of technostress among teachers. More specifically, technostress was higher among the subject teachers compared to class teachers. Female teachers had higher technostress levels than male teachers. Additionally, teachers with 16-30 years of working experience had a higher level of technostress compared to those with 0-15 years of experience (Özgür, 2020; Syvänen et al., 2016). However, in a study, it was found no statistically significant difference in the levels of technostress experienced by male and female teachers (Gökbulut, 2021)

Teacher's Perception towards Integration of Technology

The majority of teachers expressed favourable opinions on the utilisation of the TPACK framework for teaching English at high school levels (Prasetya, Putra & Budasi 2019). Primary science teachers consider their technological knowledge to be lower than their non-technological knowledge, specifically in terms of pedagogical and subject knowledge. They perceive high confidence in pedagogical knowledge (Muhaimin et al., 2019; Mai & Hamzah, 2017). However, in some studies, the difference in the perceptions of school teachers towards using the TPACK framework was found among the teachers. There are no changes in science teachers' perceptions based on gender. Still, there are differences in their perceptions of pedagogical knowledge (PK), content knowledge (CK), and pedagogical content knowledge (PCK) based on age (Mai & Hamzah, 2017). Similarly, elementary school teachers' perceptions of TPACK, teacher efficacy, and school environment support differed depending on their career and school (Eom, Lee & Lee, 2020).

Attitudes of Teachers towards ICT Integration

There are several factors that influence teachers' attitudes towards integrating Information and Communication Technology (ICT) into their teaching. These factors encompass the teachers' level of comfort with technology, belief in their own capacity to incorporate technology, their perception of how technology is utilised in the classroom, the support they receive, and the resources available to them. The attitudes of teachers towards technology have a chain-mediated effect on the influence of their Technological Pedagogical Content Knowledge (TPACK) on how they intend to utilise technology (Bai, Guo & Gu, 2024). The reviews identified a strong and positive relationship between teachers' attitudes and the incorporation of technology in their teaching methods. This implies that teachers with favourable attitudes also had positive perceptions of their Technological Pedagogical Content Knowledge (TPACK) (Ramirez-Asis et al., 2024; Alhamid & Mohammad-Salehi, 2024; Wang & Zhao, 2023; Aridah & Iswari, 2023; Azhar & Hashim, 2022). Similarly, the attitudes of teachers towards the integration of technology, school support and support from peers have a positive influence on their TPACK (Agustin, Aridah & Iswari, 2023; Davaasuren, So & RYOO 2021**).** The majority of the teachers lacked technology-related knowledge, but after experiencing large-scale online education, they were willing to integrate technology into their teaching. (Li, 2023). Further, a significant difference was found among the teachers with respect to age. Compared to younger teachers, older teachers aged more than 45 have a negative attitude towards technology use and are affected by techno insecurity (Wang & Zhao, 2023).

Gender seems to play a role in determining perspectives on computer-assisted education (CAE). Competencies related to technological content knowledge (TCK) and technological knowledge (TK) have significant differences based on gender. A weak positive correlation exists between their attitudes towards computer-assisted education (CAE) and their TPACK competencies. The correlation between teachers' competence in Technological Knowledge (TK) and Technological Pedagogical Knowledge (TPK) and their attitude towards computer-assisted education (CAE) is significantly stronger compared to other abilities (Baturay, Gökçearslan & Sahin, 2017). Value beliefs are individual characteristics that have an impact on teachers' TPACK competencies. Only the variable of value beliefs had a significant positive effect on teacher's TPACK competencies (Cheng & Xie, 2018). Moreover, teachers' attitudes towards the incorporation of technology in the classroom are greatly influenced in a negative way by feelings of insecurity and the complexity associated with technology. Still, techno-invasion and overload have considerable positive effects on teachers' attitudes towards ICT (Wang & Zhao, 2023).

Conclusion

This study reviews the research carried out on Technological Pedagogical Content Knowledge (TPACK) in the field of school education. It especially focuses on studies published between 2015 to 2024. This study investigated the current research trends and findings in the domain of technological pedagogical and content knowledge (TPACK). The search revealed findings indicating that a total of 50 studies have been identified, with the highest number of publications in 2023. The majority of these studies were done in the continent of Asia. The 50 articles were categorised into six categories: (a) investigating TPACK competencies, (b) evaluating TPACK components, (c) examining the relationship between TPACK and computer self-efficacy, (d) exploring the association between TPACK and technostress, (e) analysing teachers' perception of technology integration, and (f) studying teachers' attitude towards TPACK. Research findings show that teachers have various levels of TPACK proficiency. The TPACK competence of school teachers was found to be at a high level. More specifically, research on TPACK competencies revealed that teachers exhibited varying levels of confidence in their TPACK competency. However, their TPACK mostly involved the utilisation of technology in the instructional process. While some teachers excel at pedagogy, others are proficient with technology. The levels of Technological Pedagogical Content Knowledge (TPACK) among teachers vary according to factors such as their status, gender, and training. Implementing technology into instruction considerably improves teachers' TPACK abilities. In the context of English language education, teachers display excellent TPACK competence, with gender and school status having no major impact on their ability. In addition, teachers' TPACK competency, pedagogical skills, and attitudes towards internet use all play a role in their preparedness for online instruction.

The computer self-efficacy of teachers is an essential factor in incorporating technology into instruction. Technological Pedagogical Content Knowledge (TPACK) is positively and significantly correlated with teachers' perceptions of their own ability to incorporate information technology (IT) into the classroom. Moreover, enhancing teachers' computer self-efficacy may improve their motivation to utilise technology efficiently within the classroom setting. In addition, research suggests that teachers have high self-efficacy in TPACK, especially in topic understanding, and a desire to improve their technology skills for future blended learning contexts. These findings highlight the necessity of improving teachers' TPACK and computer self-efficacy in order to promote effective technology integration in education. School and collegial support have been shown to predict teachers' TPACK and computer self-efficacy, hence reducing technostress among educators. Research on the

correlation between TPACK and technostress shows that TPACK (Technological Pedagogical Content Knowledge) significantly impacts technostress among teachers. Teachers with greater TPACK levels report lower levels of technostress because they are better suited to integrate technology into their teaching practices. Moreover, the levels of technostress experienced by teachers can be significantly predicted by factors such as organisational support, TPACK (Technological Pedagogical Content Knowledge), support from the school, and job satisfaction. As a result, increasing educators' TPACK and providing proper support can help reduce technostress and improve teaching performance in the digital age. It has been noticed that teachers may require further training and workshops to improve their TPACK comprehension and implementation, particularly in terms of lesson planning, teaching strategies, and assessment methodologies. In summary, it is crucial to implement professional development programmes that specifically target the integration of Technological Pedagogical Content Knowledge (TPACK) in order to improve teachers' preparedness to employ technology in the classroom effectively.

Limitations

This review has many shortcomings despite the fact that it highlights some significant trends and research findings for TPACK research in school education. Only articles published between 2015 and May 2024 were included in this research study, which was confined to some databases such as Scopus, Google Scholar, JSTOR and Eric. Research studies that were peer-reviewed and used quantitative methodologies were the only papers that were considered for this review. In order to enable researchers to get further into TPACK, future research should incorporate a broader range of resources, such as conference proceedings, editorials, dissertations, and doctoral theses.

Recommendation and Further Research

The study's conclusions highlighted the essential need for further investigations utilising innovative technological tools and techniques to support previous findings about TPACK. By extending the research with more variables, new TPACK dimensions might be investigated. Professional development programmes that focus on teacher proficiency, teaching strategies, and assessment techniques would help teachers achieve a better understanding of the TPACK domains. Different locations and methodologies used for qualitative and mixed methods research can allow participants and investigators to view the framework from a new perspective. Studies can be done employing both quantitative and qualitative research methods to provide a comprehensive analysis of TPACK. Validating the present findings at different schools, colleges, and higher educational institutions will be one of the main areas for future

investigation. More research can be done on the teacher's leadership in different educational institutions and how it affects the way the professional development process is carried out. Future research can investigate the long-term impact of TPACK on teachers' 21st-century competencies. The effect of various technology-based models on teachers' TPACK can be further investigated through experimental studies. Further studies can be done on students' perspectives.

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