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A Meta-Analysis of TPACK Research in Pakistan: Insights from the Last Decade

Salman Ashiq
Senior Lecturer at Institute of Business Management (IoBM). salman.ashiq@iobm.edu.pk
Dr. Zehra Habib
Senior Fellow at Institute of Business Management (IoBM). zehra.habib@iobm.edu.pk

Abstract

The purpose of the study was to explore the research studies conducted on Technological, Pedagogical, and Content Knowledge (TPACK) of teachers in the context of Pakistan in the last decade (2014-2024). TPACK of teachers is important for effective integration of technology in classrooms. The study investigated the major trends, predominated methodologies used to explore TPACK, essential findings and implications, further it examined the strategies researchers have recommended to improve TPACK skills of teachers. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) approach was used to select and analyse articles. 34 articles were selected for the process of meta-analysis. Software NVIVO was used to organize the qualitative data and SPSS 21 was used for descriptive representation of the data. Though there was a trend to measure TPACK levels of teachers. the studies lacked in assessing integration of TPACK in curriculum and textbooks moreover none of the strategy has been given to improve the TPACK level of teachers. The findings of the study showed a positive trend of researchers toward TPACK related research studies. Further the study found that majorly researchers were conducted at tertiary level on pre-service teachers. The meta-analysis also identifies significant gaps in the current TPACK-related literature. One such gap is the need for strategies to address the challenges faced by

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in-service teachers in integrating technology into their classrooms. Designing targeted workshops and professional development programs could help overcome these obstacles. Additionally, there is a critical need to evaluate the curriculum and textbook content to determine whether they have the capacity to effectively support technology integration for students.

Keywords: In-service teachers, Meta-analysis, PRISMA, Pre-service teachers, TPACK

Introduction

In recent years, the pervasive presence of technology in classrooms worldwide has ushered in a new era of teaching and learning. Teachers, recognizing the potential of technology to enhance student learning and academic achievement, have increasingly sought ways to integrate it into their instructional practices (Ashiq & Habib, 2020: Hill & Uribe-Florez, 2020). While the integration of technology in education has been widely studied, there remains a pressing need for research specifically focused on its application in classroom. Technology offers both unique benefits and challenges to the teaching and learning process. Hence to effectively support teachers in harnessing the power of technology, it is essential to understand their technological knowledge, pedagogical approaches, and content expertise – collectively referred to as Technological Pedagogical Content Knowledge (TPACK). Moreover, gaining insight into teachers' methods of technology integration and identifying perceived barriers is crucial for developing targeted support strategies (Ghayyur & Mirza, 2021; Khalil et al., 2017; Rahman et al., 2018)

Purpose of the Study

The primary aim of the current study was to conduct a comprehensive analysis of Technological Pedagogical and Content Knowledge (TPACK) research studies carried out in Pakistan over the past decade for investigating the key outcomes and recommendations presented in these studies, with particular emphasis on the strategies and interventions implemented to enhance the TPACK of Pakistani teachers. Further the study expected to

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identify major implications derived from these research efforts. Moreover, it critically studied the prevailing trends in the methodologies used to assess the TPACK competencies of Pakistani teachers. The current study not only highlighted the progression of TPACK-related research in Pakistan over the last ten years but also sheds light on the pedagogical and technological advancements that have influenced teacher development in the country. By synthesizing the findings, this meta-analysis provides valuable insights into how research has contributed to improving TPACK practices and offers recommendations for future research and teacher development initiatives in Pakistan.

Research Questions

Through a comprehensive review of existing literature, this study seeks to address the following key questions:

1.What are the major findings and implications of research studies conducted on TPACK of teachers in Pakistan over the last 10 years?

2.What significant measures have been implemented to address the reported TPACK issue faced by teachers over the past decade (2014-2024)?

3.What are the predominate methodologies used to explore TPACK among teachers in Pakistani research studies from 2014 to 2024?

By addressing these questions, this study aims to contribute to a deeper understanding of TPACK studies conducted in the context of Pakistan over the last decade form 2014 till 2024 and provide valuable insights for educators, researchers, and policymakers seeking to enhance the integration of technology in education.

Literature Review

The TPACK framework, originated and published by Mishra and Koehler (2006), represents an extension of Shulman's (1986) pedagogical content knowledge framework. Developed through a series of theory-based design experiments aimed at elucidating teachers' progression towards technology integration in educational settings, this framework emerged

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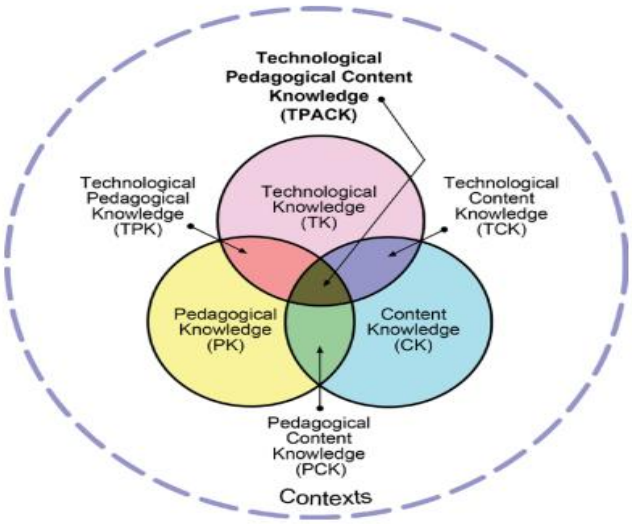
from a synthesis of these experiments. It offers a novel lens through which conceptualizes teachers' proficiency in utilizing technology for informed decision-making (Mishra & Koehler, 2006; Sahin, 2011). This conceptual model delineates a teacher's adaptable expertise across three domains and elucidates how such expertise can effectively inform instructional practices involving technology (Celik, Sahin, Kiray, & Simsek, 2015; Koehler, Mishra, & Cain, 2013).

Figure 1: TPACK Model (2013)



Note: Illustrates a Venn diagram delineating the three core elements of TPACK as individual circles, along with the overlapping segments that give rise to novel categories of knowledge.

As articulated by Koehler et al. (2013), technological knowledge (TK) pertains to a teacher's acumen in utilizing information technology for communication, information processing, and problem-solving purposes. Pedagogical knowledge (PK) encompasses a teacher's grasp of instructional methods, strategies, and processes. Content knowledge (CK) refers to a teacher's comprehensive understanding of the subject matter to be conveyed. Technological pedagogical knowledge (TPK) delineates a teacher's proficiency in employing technology to facilitate teaching and learning processes. Technological content knowledge (TCK) signifies a teacher's command over technology specific to the subject matter being taught. Pedagogical content knowledge (PCK) denotes a teacher's comprehension of pedagogical strategies as they pertain to the subject matter. Finally, technological pedagogical and content knowledge (TPACK)

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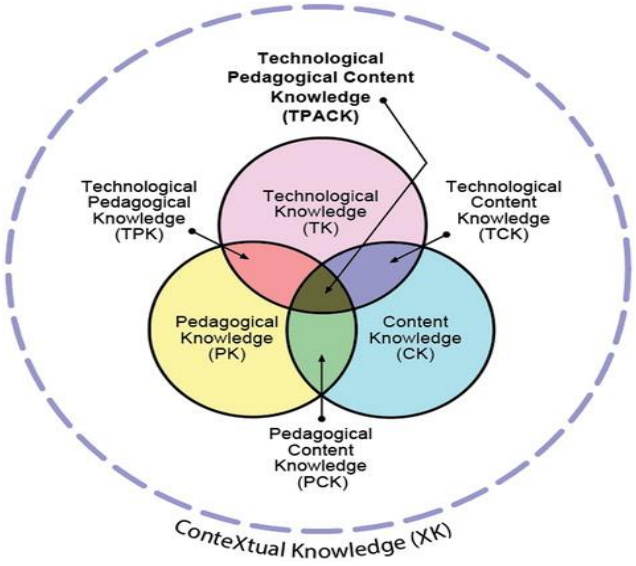
encapsulates a teacher's understanding of the interplay among these three components. TPACK shows the relation among all the three skill sets, pedagogy, content and technology which facilitate teachers in designing context specific technology-based lessons, and enables them to use technology efficiently (Koehler & Mishra, 2006; Koehler et al., 2014).

Figure 2: TPACKX Model (2019)



Note: Shows TPACKX (Technological, pedagogical and content Knowledge) Framework model further updated by Mishra in 2019, in this model Mishra introduced contextual knowledge (Mishra, 2019).

In 2019, Mishra enhanced the TPACK model by introducing an additional element, which he termed Contextual Knowledge (XK). Previously referred to simply as context, XK encompasses a teacher's understanding of the specific educational environment in which they operate (Mishra, 2019). This upgrade to the model acknowledges the critical role that contextual factors play in the effective integration of technology in teaching. XK includes various dimensions such as the socio-cultural, institutional, and situational aspects that influence teaching and learning (Mishra, 2019). It recognizes that factors like school policies, student demographics, available technological infrastructure, and community values can significantly impact how teachers apply their technological, pedagogical, and content knowledge in practice

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(Brianza et al., 2022). By explicitly incorporating XK into the TPACK framework, Mishra underscored the necessity for teachers to adapt their strategies to fit their unique teaching

The inclusion of Contextual Knowledge (XK) in the TPACK model encourages a more personalized approach to teacher education. It prompts educators and policymakers to consider the diverse settings in which teachers work and to tailor support mechanisms accordingly. This ensures that the integration of technology is not only theoretically sound but also practically feasible and contextually relevant.

Methodology

A systematic Meta analysis was conducted to investigate the scholarly literature available on studies related to TPACK conducted in the Pakistani educational context in the last decade (2014 till June 2024). Selecting appropriate methodology in meta-analysis research is very crucial as its validity and reliability impacts the findings of the study. A well-defined Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol by page et al. (2020) was adopted to guide the article selection and review process. The details of the process are given as flows.

Article Search Process

To search articles, Google scholar platform was utilized and different keywords were used to search articles like TPACK in Pakistan, Technological, Pedagogical and Content knowledge in mathematics, and TPACK 2024. Pakistani studies on TPACK 2014. The purpose of using different keywords is to search for all related articles published in the context of Pakistan.

Article Selection process

The articles selection process was directed by PRISMA guidelines, the criteria for selecting articles included publication in peer reviewed journals, focusing on studies related to the Technological Pedagogical Content Knowledge (TPACK). The scope of the study was limited to articles published between June 2014 and June 2024. Initially, articles were identified using the Google Scholar search engine. Subsequently, Scopus and Web of Science databases were utilized to verify the authenticity of the journals in which these articles were published.

The critical process of selecting quality articles from existing literature was done via four step filtration process mentioned in PRISMA (figure no 4). The process includes identification, screening, eligibility and inclusion. These steps helped in exploring articles in depth.

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Identification: From the articles searched through keywords, only 51 were selected after checking the validity of journals in which they are published via Scopus and Web of Science.

The first filtration process in PRISMA is duplication, in this process duplicate articles were eliminated by checking their references in different databases. Three articles were found duplicate with little modification, hence eliminated. Only 45 articles went in the screening process.

Screening: In screening process title and abstract of the selected articles were reviewed according to the PRISMA abstract checklist (Appendix A). After screening 6 articles were excluded which were not relevant like studies on South-Asia, other countries, comparison of different countries etc. Total 39 articles were found appropriate.

Eligibility: In this process all articles were downloaded to get full access, the articles were read critically and irrelevant articles were omitted. Total articles were excluded out of which 4 articles were not available in full text pdf, and 1 on special education. 34 articles were selected for systematic review and meta-analysis process, all numeric details of the PRISMA are mentioned in figure no 3, below

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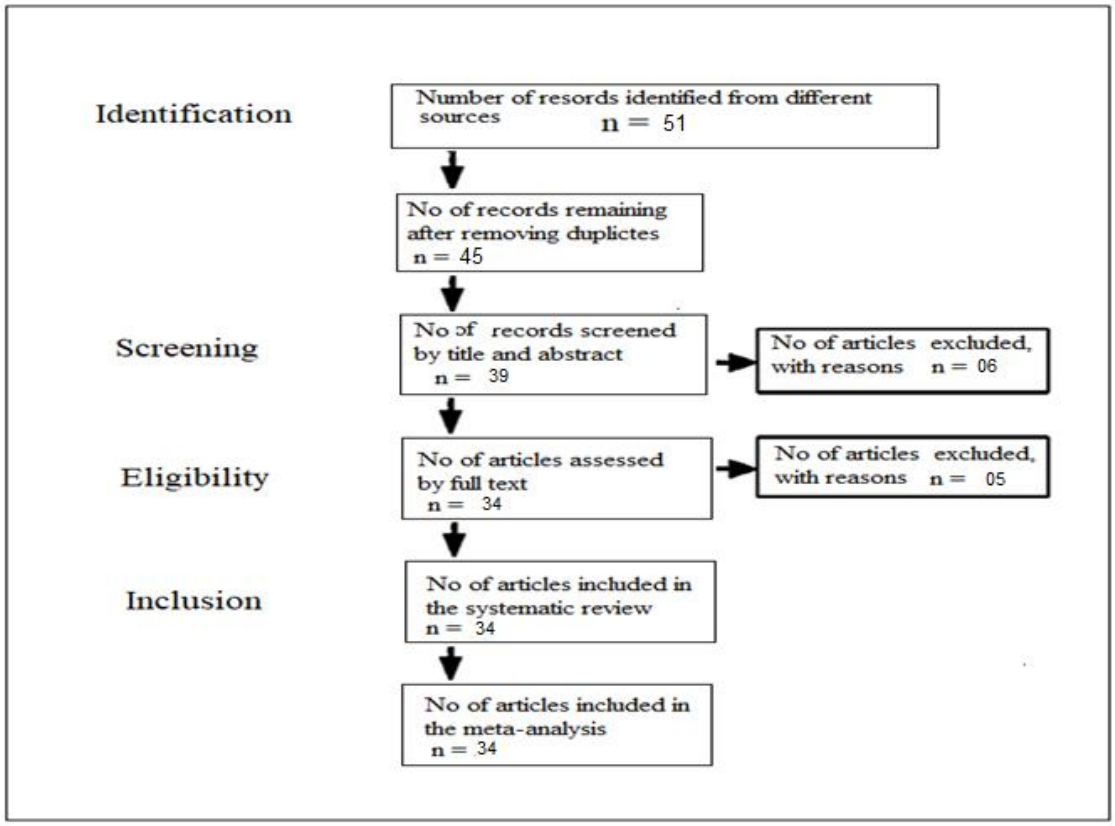
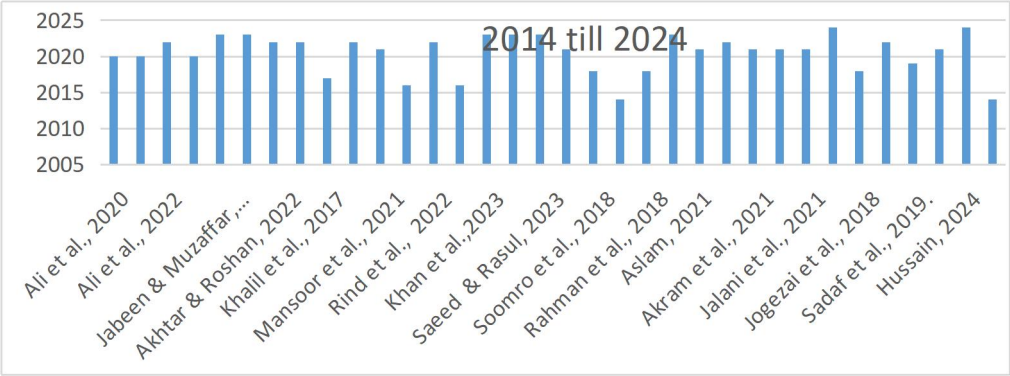
Figure 3: Flow Chart of Article Selection Process



Note: Flow chart of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Page et al., 2021)

Table 1 below highlights the pictorial representation of published articles selected for meta-analysis study after the PRISMA process. The articles are mentioned with last name of Authors in APA style. The graph represents the year of publication on y-axis and authors on x-axis.



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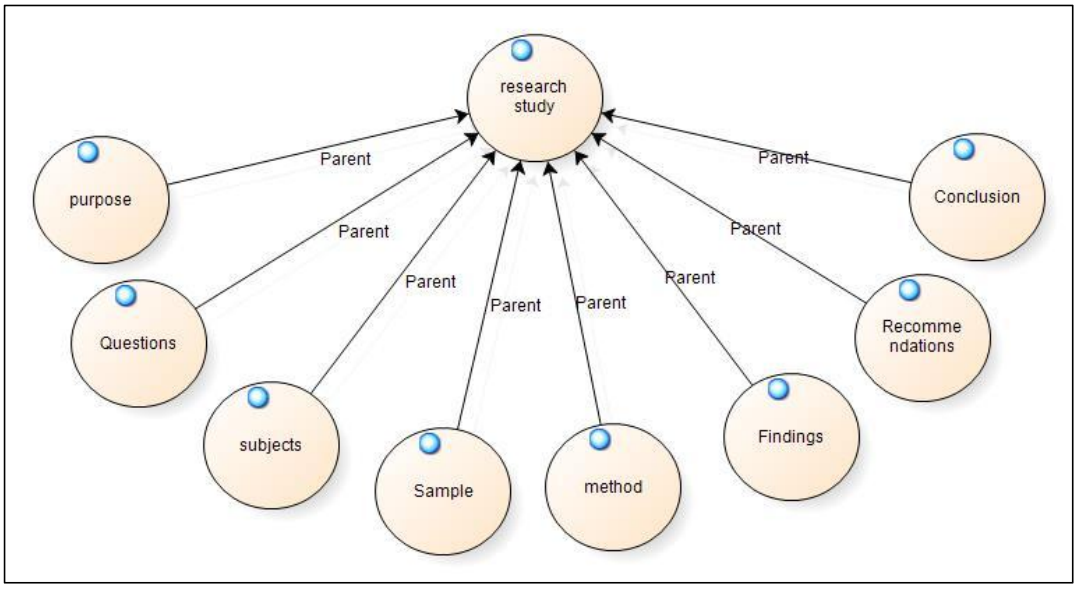
Data Analysis

The selected articles were systematically summarized and analyzed using the PRISMA approach. NVivo 11 software was employed to organize the data, ensuring a structured and systematic process. It was further utilized to explore the articles in relation to the research questions, facilitating the creation of codes, the generation of themes, and the development of models from the qualitative data. Additionally, the Statistical Package for Social Sciences (SPSS) was used to analyze the descriptive information of the selected articles.

Findings and Discussion

To analyse the major findings and implications of research studies conducted on teachers' TPACK in Pakistan over the past 10 years, the PRISMA approach was employed to address the first research question. Figure 4 provides a pictorial representation of the various domains explored in the research to identify the key findings and implications of these studies on TPACK.



The findings from this meta-analysis revealed a positive attitude among teachers towards the integration of technology in education. Akhtar et al. (2016) indicated that educators generally expressed satisfaction with their TPACK at the "Consensus" level, a result that aligns with the study by Chai et al. (2013). The analysis further identified the most critical domains of TPACK, reporting that TCK and TPK are significant predictors of teachers' TPACK, with TPK exerting the strongest influence. Similarly, Özgür (2020) found that TCK

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was the highest-rated factor for technology integration. These results align with Cubeles and Riu (2018), who discovered that teachers with more classroom experience using technology reported higher levels of self-efficacy. This suggests that student learning improves and teachers gain greater confidence in their teaching abilities when provided with opportunities for professional development to enhance their TPACK. Moreover, the study highlights that teacher educators with sound technological, pedagogical, and content knowledge has a significant and positive impact on their knowledge, skills, and teaching practices as indicated in the study conducted by Irum et al, (2021). These findings are consistent with research from various global studies, using different methodologies, which confirm that educators' TPACK level profoundly influences their teaching effectiveness.

Ali et al. (2020) examined pre-service teachers' perceptions of TPACK and their use of technology in teaching. They conducted a cross-sectional survey of 290 teachers across three institutions, it included a 46-item questionnaire and a pilot study with 50 participants. Findings showed that while teachers had a general understanding of TPACK, differences in knowledge levels were not statistically significant. Content knowledge was assessed in subjects like Mathematics, Social Studies, Science, and Literature, with science scoring highest in pedagogical content knowledge and mathematics the lowest. The overall TPACK scores ranged from 3.52 to 3.75, reflecting low confidence in technology integration, especially among female teachers. In a study by Hassan (2024), both ICT and TPACK were well-regarded by prospective educators, though ICT received a higher mean rating. Teachers' attitudes were significantly influenced by Technological Knowledge (TK), which had a positive impact on Pedagogical Knowledge (PK), Content Knowledge (CK), Technological Pedagogical Knowledge (TPK), Pedagogical Content Knowledge (PCK), and Technological Content Knowledge (TCK). Overall, prospective teachers recognized the importance of both ICT and TPACK.

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The study recommended incorporating TPACK into teacher education programs to enhance technology integration in teaching and improve student learning outcomes (Saeed & Rasul, 2023). Their research emphasizes the urgent need to equip teachers with the necessary skills to navigate the rapidly changing educational landscape in the digital age (Jimoyiannis, 2010). By integrating pedagogical knowledge, content knowledge, and technological proficiency, higher education institutions can advance more effective pedagogy and content delivery (Polly et al., 2010). This research lays the groundwork for further studies and initiatives to address the critical issue of technology integration in education, ensuring that educators are adequately prepared to meet the demands of the 21st century (Chai et al., 2013). Additionally, a study by Soomro et al. (2018) found that faculty members in higher education are already incorporating technology into their teaching practices despite limited technological resources. The faculty demonstrated collaboration in teaching and openness to technology. This study reports on the adaptation of the TPACK framework among higher education faculty members and provides insights into their intrapersonal beliefs regarding the integration of technology with pedagogical and content knowledge.

The meta-analysis reveals that teachers' Technological Pedagogical Content Knowledge (TPACK) is instrumental in promoting digital citizenship and responsibility among students, while simultaneously motivating teachers to engage in professional development programs. The integration of TPACK into teaching practices significantly enhances teachers' technological proficiency. However, the findings also indicate that many teachers still predominantly rely on traditional lecture-based methods, as evidenced by Inamullah's (2014) ; Jogezai et al. (2018) and Rehman et al. (2021) studies, which found a widespread dependence on one-way communication in the classroom. While modern teaching strategies that promote student engagement and active participation can substantially improve educational quality, there is a notable inconsistency in the adoption of diverse teaching methods. This suggests a lack of confidence among educators in

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implementing contemporary pedagogical approaches. Therefore, the analysis underscores a critical need for targeted professional development programs aimed at equipping teachers with the necessary skills to apply innovative teaching techniques and interactive methodologies effectively. Addressing these gaps is essential for improving the overall quality of education and ensuring that teachers are well-prepared to meet the demands of 21st-century learning environments.

Strategies Employed To Improve The Tpack Of Pakistani Teachers

The second question of metanalysis was to find out the significant measures that have been implemented to address the reported TPACK issue faced by teachers. The study found that most of the studies conducted have checked the TPACK level of pre-service and in-service teachers at different levels. The studies used quantitative, qualitative and mixed method approach to assess the TPACK level of teachers. These studies have highlight Technological Content Knowledge and Technological Pedagogical Knowledge as the weak areas of teachers for which recommended TPACK should be included in the basics of the teacher's education programs. Curriculum should have a positive approach of teaching with technology of the subject (Ali et al., 2023)

The TPACK (Technological et al. Knowledge) framework is valuable for eff ectively integrating technology in higher education institutes. Here are some recommendations for using the TPACK framework in higher education: Professional Development: Provide faculty members professional development opportunities to familiarize themselves with the TPACK framework. Offer workshops, seminars, or online courses to help educators understand how to integrate technology, pedagogy, and content knowledge in their teaching practices. Collaborative Learning: Encourage collaboration among faculty members to share their experiences and best practices related to technology integration. Create communities of practice or online forums where educators can exchange ideas, resources, and challenges. Curriculum Redesign: Use the TPACK framework to guide redesigning courses and curricula.

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Identify opportunities to integrate technology in meaningful ways to enhance content delivery, student engagement, and learning outcomes. Technology Infrastructure: Ensure the institution has the necessary technology infrastructure and support to facilitate effective technology integration. It includes access to reliable internet, appropriate software, and technical support for faculty and students. Ongoing Assessment: Continuously assess the impact of technology integration on teaching and learning outcomes. Use formative and summative assessments to evaluate the effectiveness of technology use and make data-informed decisions for improvement. Digital Literacy Training: Offer students digital literacy training and resources to ensure they are equipped to navigate and use technology effectively for learning purposes. It will empower students to take ownership of their learning and engage actively in technology-rich environments. Faculty Support: Provide ongoing support and mentorship for faculty members as they implement the TPACK framework. Offer resources, peer coaching, and opportunities for sharing success stories to build confidence in using technology for teaching. Continuous Improvement: Emphasize a culture of continuous improvement, where faculty and administrators are open to experimentation, learning from failures, and evolving their practices based on evidence and best practices. By implementing the TPACK framework in higher education institutes, educators can create more meaningful and compelling learning experiences that leverage the potential of technology to enhance pedagogy and content delivery.

The meta-analysis concludes that while textbooks remain the most common teaching aid, there is a significant gap in research analyzing curricula and textbooks through the lens of the TPACK framework. This gap highlights the need to investigate these educational materials to assess their alignment with TPACK principles and ensure that technology integration in schools is effective.

The analysis also emphasizes the importance of updating the ICT curriculum in teacher education programs. Hussain et al. (2024) recommend that B.Ed. students be taught

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in a constructive manner that leverages appropriate technologies. They advocate for the inclusion of TPACK components in teacher education curricula and stress the importance of training prospective teachers in technology-rich environments to build their comfort and competence in using technology.

Similarly, Jalani et al. (2021) recommends the integration of TCK and TPACK-related courses in the B.Ed. (Hons) program, specifically suggesting courses like "ICTs for Teaching Mathematics" and "ICTs for Teaching English." These recommendations underline the urgent need to incorporate TPACK into teacher education programs to better prepare future educators for the technological demands of modern classrooms. Mostly, studies have recommended to have a Professional development session on weak TPACK areas of teachers, like Khan et al., 2023 recommended 'Create, implement, assess, and institutionalize standards for teacher professional development.'

There is a pressing need to assess the TPACK levels of teachers and subsequently design targeted workshops to address any identified areas of weakness. However, it is concerning that no studies over the past decade have focused on the actual development of teachers' TPACK. Most research has been limited to assessing the current TPACK levels of educators and offering recommendations, without implementing or evaluating specific interventions. Therefore, there is a significant gap in the literature, highlighting the necessity of conducting experimental studies, particularly for in-service teachers, aimed at enhancing their TPACK competencies. These studies would not only provide valuable insights into the effectiveness of professional development programs but also contribute to the overall improvement of teaching practices in the context of integrating technology into education.

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Predominate Methodologies (2014 to 2024)

The study explored research conducted on TPACK of teachers in the context of Pakistan from 2014 till 2024. The findings and discussion of the current study are reported in the order of research questions.

Trends of TPACK Research in last decade 2014 till 2024

Table 1: Frequency Table of number of studies with respect to year

Year	Frequency	Percent	Valid Percent	Cumulative Percent
Valid2014	1	2.9	2.9	2.9
2016	2	5.9	5.9	8.8
2017	1	2.9	2.9	11.8
2018	3	8.8	8.8	20.6
2019	1	2.9	2.9	23.5
2020	3	8.8	8.8	32.4
2021	7	20.6	20.6	52.9
2022	7	20.6	20.6	73.5
2023	6	17.6	17.6	91.2
2024	3	8.8	8.8	100.0
Total	34	100.0	100.0	

The above table depicts that the trend of conducting research on TPACK have marginally increased with the passage of time, especially after covid-19 (2020).

Table 2: Frequency Table of number of studies with respect to Provinces

Province		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Sindh	12	35.3	35.3	35.3
	Punjab	18	52.9	52.9	88.2
	KPK	1	2.9	2.9	91.2

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	Gilgit-Baltistan	3	8.8	8.8	100.0
	Total	34	100.0	100.0	

The above table shows the trend of research studies in Pakistan with respect to the provinces. According to data the highest number of studies were conducted and published in Punjab, which covers approximately 53% of the total studies. Sindh comes at the second place which covers 35% of the total studies conducted on TPACK. Gilgit-Baltistan appears at the 3rd place with approximately 9% of the total studies, whereas Khyber Pakhtunkhwa province is on the 4th place. Unfortunately, no study on TPACK was published from the province of Balochistan.

Table 3: Frequency Table of number of studies conducted on type of teachers

Type Of Teachers

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Pre-service Teachers	21	60.0	61.8	61.8
	In-service Teachers	13	37.1	38.2	100.0
	Total	34	97.1	100.0	
Missing	System	1	2.9		
Total		35	100.0		

Most of the studies were conducted on pre-service teachers approximately 62 %, the data of these studies were collected from ungraduated B.Ed and M.Ed students. Whereas the studies conducted on in-service teachers comprises of 38% of total studies, which mostly includes university teachers. The trend of TPACK studies have become more common in universities and specifically to teacher education institutes. Table 4 below shows the trend of TPACK research studies in different levels of education systems.

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Table 4 : *Frequency Table of number of studies conducted in different level of Education sectors*

Level of Education					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	University Level	27	77.1	79.4	79.4
	College Level	2	5.7	5.9	85.3
	School	5	14.3	14.7	100.0
	Total	34	97.1	100.0	
Missing	System	1	2.9		
Total		35	100.0		

The data in table 4 shows that most of the studies on TPACK were conducted at university level which is approximately 80%. Whereas 15% of the total studies were conducted at school level on in-service teachers. Only 6% of the total studies were conducted at intermediate college level.

Predominate Methodologies used during 2014 to 2024

Table 5 : *Frequency Table of number of studies with respect to type of Methodology*

Type Of Method					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Quantitative	28	80.0	82.4	82.4
	Qualitative	2	5.7	5.9	88.2
	Mixed Method	4	11.4	11.8	100.0
	Total	34	97.1	100.0	
Missing	System	1	2.9		

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Type Of Method

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Quantitative	28	80.0	82.4	82.4
	Qualitative	2	5.7	5.9	88.2
	Mixed Method	4	11.4	11.8	100.0
	Total	34	97.1	100.0	
Missing	System	1	2.9		
Total		35	100.0		

More than 80% of the research studies conducted on TPACK used quantitative research approach most commonly referred as survey method. These studies have used different research instruments to investigate the TPACK level of teachers. Most of the studies adopted already designed TPACK survey but one of the studies constructed its own survey form. The construct validity of the scale was determined by 'Exploratory Factor Analysis' (EFA) and 'Confirmatory Factor Analysis' (CFA).

Approximately 12% of the studies used mixed method approach. These studies used both quantitative and qualitative approach in order to explore the technological, pedagogical and content knowledge of teachers. Most of the studies have already adopted the designed TPACK survey and have used semi structure interviews to explore the perception of mathematics teachers. 6% of the studies were found purely qualitative and used interviews, Focus Group Discussion (FGD) and observations to examine the TPACK level of teachers.

The adoption of a mixed methods approaches for investigating the TPACK (Technological Pedagogical Content Knowledge) levels of the teachers provides enhanced opportunities to thoroughly examine teachers' capabilities and experiences (Sepriyanti et al., 2024). This approach allows for a comprehensive understanding of teachers' perceptions, ultimately presenting a broader and more detailed picture of the data. Consequently, it aids

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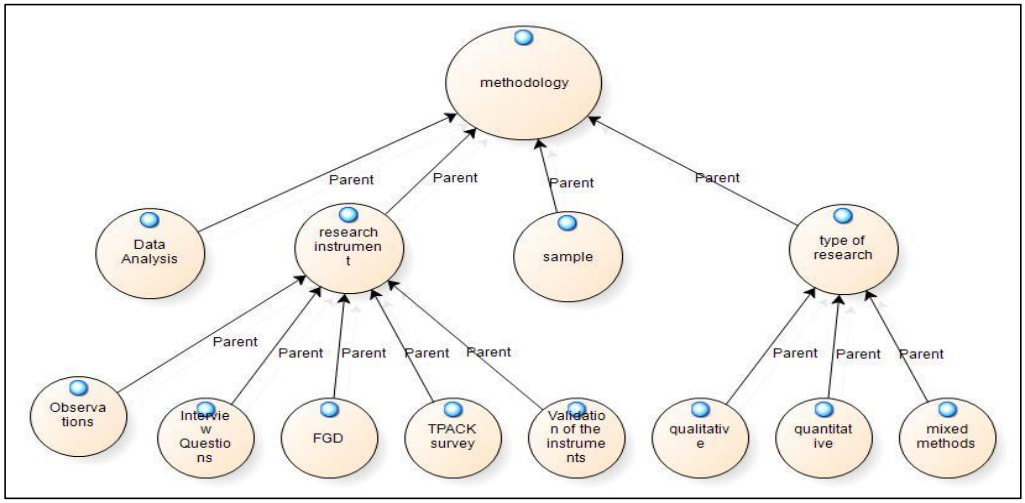
researchers in gaining a more profound comprehension of the findings. Furthermore, this methodology offers a variety of avenues to assess the current TPACK levels of teachers and identify their areas of weakness (Yanuarto et al., 2021). This, in turn, facilitates the design of targeted professional development workshops aimed at enhancing teachers' TPACK levels, thereby contributing to more effective teaching practices.

Figure 2: *Model of coding details of the theme*



Note: The model is created by NVIVO to show the Coding details of the theme "methodologies used to explore TPACK among secondary-level mathematics teachers".

Methodologies of the articles were explored by investigating the details of the research methodologies like; type of research method used qual, quant or mixed, nature of participants, sample size, research instruments and the techniques used to analyze data.

Conclusion

This meta-analysis study examined research articles published between 2014 and 2024, exploring how research trends have evolved over time and how Pakistani researchers have increasingly recognized the importance of investigating teachers' levels of Technological, Pedagogical, and Content Knowledge (TPACK) and publishing their findings. The results of these studies revealed positive correlations between teachers' willingness to adopt technology and their TPACK scores. Additionally, the studies highlighted the specific areas

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where Pakistani teachers, particularly in Technological Content Knowledge and Pedagogical Content Knowledge, need improvement. Notably, several studies indicated that mathematics teachers face significant challenges in mastering Pedagogical Content Knowledge and Technological Pedagogical Knowledge.

Most of these studies were conducted within the higher education sector, underscoring a critical need for research at the school level to support in-service teachers in addressing their areas of weakness. However, merely improving teachers' TPACK levels is insufficient if the curriculum is not aligned with TPACK principles. Therefore, it is imperative to analyze and update the current curriculum to effectively integrate technology into classrooms.

Recommendations

1. **Design and Implement Professional Development Workshops**: Focus on creating workshops that equip in-service teachers with practical strategies and skills to overcome the barriers to technology integration in classrooms.
2. **Evaluate and Update Curriculum and Textbooks**: Conduct a thorough analysis of current curriculum and textbook content to assess their alignment with TPACK principles and ensure they are capable of supporting technology integration in education.

These steps are essential for advancing the effective use of technology in education and enhancing the overall quality of teaching and learning.

Reference

A gyei, D. D., & Voogt, J. M. (2015). Pre-service teachers' TPACK competencies for spreadsheet integration: Insights from a mathematics-specific instructional technology course. Technology, Pedagogy and Education, 24(5), 605-625

Ali, M. S., Lodhi, M. E., Aslam, S., Amir, M., Chughtai, A. N., Qurashi, K. S. A., ... & Mahmood, A. (2014). Impact of Information Technology on Higher Education in

Pakistan (A Study on People of Faisalabad, Pakistan). International Journal of Business and Management Invention ISSN (Online), 3(2), 44-53.

Ali, Z., Ahmad, N., Rehman, H. U., Ullah, N., & Zahra, T. (2023). Investigating Teacher Educators' Perceptions on Technology Integration in Teacher Preparation Programs. *Journal of Social Sciences Review*, *3*(2), 341-355

Ali, Z., Rehman, H. U., & Ullah, N. (2022). Measuring University Teacher Educators' Knowledge and Skills Using TPACK in Teachers Education Programs. Research Journal of Social Sciences and Economics Review, 3(3), 83-91.\

Ali, Z., Thomas, M., Ahmed, N., Ahmed, I., & Ahmed, I. (2020). Assessment of Pre Service Teacher's Perceptions on Technological Pedagogical and Content Knowledge (TPACK) in Karachi Pakistan. International Journal of Scientific & Engineering Research, 11(3), 1402-1407

Ashiq, S., & Habib, Z. (2020). Impact of Computer Integrated Technique in Science Education at Elementary Level: A Study in Karachi. *Journal of Education and Educational Development*, *7*(2), 328-350.

Aslam, R., Khan, N., Asad, M. M., & Ahmed, U. (2021). Impact of technological pedagogical content knowledge on teachers' digital proficiency at classroom in higher education institution of Pakistan. Interactive Technology and Smart Education, 18(1), 119-130

Başaran, B. (2020). Investigating science and mathematics teacher candidate's perceptions of TPACK-21 based on 21st century skills. Ilkogretim Online, 19(4).

Brianza, E., Schmid, M., Tondeur, J., & Petko, D. (2022). Investigating contextual knowledge within TPACK: How has it been done empirically so far?. In *Society for Information Technology & Teacher Education International Conference* (pp. 2204-2212). Association for the Advancement of Computing in Education (AACE).

Journal of Social Signs Review
Print ISSN: 3006-4651
Online ISSN: 3006-466X

Bueno, R. W. D. S., Lieban, D., & Ballejo, C. C. (2021). Mathematics teachers' TPACK development based on an online course with GeoGebra. Open Education Studies, 3(1), 110-119.

Cubeles, A., & Riu, D. (2018). The effective integration of ICTs in universities: the role of knowledge and academic experience of professors. *Technology, Pedagogy and Education*, *27*(3), 339-349

Ghayyur, T. S., & Mirza, N. A. (2021). Exploring TPACK skills of prospective teachers and challeges faced in digital technology integration in Pakistan. Journal of Development and Social Sciences, 2(4), 226-241.

Hill, J. E., & Uribe-Florez, L. (2020). Understanding Secondary School Teachers' TPACK and Technology Implementation in Mathematics Classrooms. International Journal of Technology in Education, 3(1), 1-13…..

Hill, J.E. & Uribe-Florez, L. (2020). Understanding secondary school teachers' TPACK and technology implementation in mathematics classrooms. International Journal of Technology in Education (IJTE), 3(1), 1-13.

Huang, Z. (2018). Theoretical analysis of TPACK knowledge structure of mathematics teachers based on T-TPACK mode. Kuram ve Uygulamada Egitim Bilimleri, 18(5), 2044-2053…

Hussain, S., Fakhar-Ul-Zaman, D. B. K., Kanwal, M., Hussain, T., Nawaz, I., & Thaheem, M. I. (2024). TPACK and ICT, the new hope for Pakistan's education system: analysis of the perception of prospective teachers. Remittances Review, 9(2), 743-754

Jafri, M. (2020). Teaching mathematics with digital content resources (DCR) in Pakistan. A review of emerging frameworks in mathematics education research. Bahria University, Karachi Campus

Kim, S. (2018). Technological, Pedagogical, and Content Knowledge (TPACK) and beliefs of preservice secondary mathematics teachers: Examining the relationships. EURASIA Journal of Mathematics, Science and Technology Education, 14(10), em1590…..

Önal, N. (2016). Development, Validity and Reliability of TPACK Scale with Pre-Service Mathematics Teachers. International Online Journal of Educational Sciences…

Ozudogru, M., & Ozudogru, F. (2019). Technological pedagogical content knowledge of mathematics teachers and the effect of demographic variables. Contemporary educational technology, 10(1), 1-24…

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., ... & Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *Bmj*, *372*.

Rahman, F. U., Hussain, M. A., & Khalid, S. (2018). Technological pedagogical content knowledge (TPACK) and preparedness of tutors in open and distance learning (ODL) for new teacher education programs. *Journal of Educational Research*, *21*(2), 147-161

Rakes, C. R., Stites, M. L., Ronau, R. N., Bush, S. B., Fisher, M. H., Safi, F., ... & Viera, J. (2022). Teaching mathematics with technology: TPACK and effective teaching practices. Education Sciences, 12(2), 134

Saeed, S., & Rasul, I. (2023). Technological Pedagogical Content Knowledge (TPACK) in Practice: Measuring Teachers' Proficiency at Public and Private Universities of Lahore, Pakistan. Journal of Asian Development Studies, 12(3), 325-336

Sepriyanti, N., Aniswita, A., & Wahida, D. (2024). An analysis of Technological, Pedagogical, and Content Knowledge (TPACK) competencies of mathematics teachers in Sumatra in terms of gender. Indonesian Journal of Science and Mathematics Education, 7(1), 94-104

Soomro, S., Soomro, A. B., Ali, N. I., Bhatti, T., Basir, N., & Gill, N. P. (2018). TPACK adaptation among faculty members of education and ICT departments in University of

Journal of Social Signs Review
Print ISSN: 3006-4651
Online ISSN: 3006-466X

Sindh, Pakistan. International Journal of Advanced Computer Science and Applications, 9(5), 203-209.

Tiengyoo, K., Sotaro, S., & Thaithae, S. Second-Order Confirmatory Factor Analysis of 21st Century Mathematics Teaching Predicament among Secondary Mathematics Teachers in Secondary Educational Service Area Office Lopburi

Yanuarto, W. N., Maat, S. M., & Husnin, H. (2021, February). TPACK in mathematics teacher education: Are teachers ready to teach for ICT literacy?. In Journal of Physics: Conference Series (Vol. 1778, No. 1, p. 012012). IOP Publishing

Journal of Social Signs Review
Print ISSN: 3006-4651
Online ISSN: 3006-466X

Appendix A

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

	Item #	Checklist item	Reported (Yes/No)
TITLE			
Title	1	Identify the report as a systematic review.	
BACKGROUND			
Objectives	2	Provide an explicit statement of the main objective(s) or question(s) the review addresses.	
METHODS			
Eligibility criteria	3	Specify the inclusion and exclusion criteria for the review.	
Information sources	4	Specify the information sources (e.g. databases, registers) used to identify studies and the date when each was last searched.	
Risk of bias	5	Specify the methods used to assess risk of bias in the included studies.	
Synthesis of	6	Specify the methods used to present and synthesise results.	

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results			
RESULTS			
Included studies	7	Give the total number of included studies and participants and summarise relevant characteristics of studies.	
Synthesis of results	8	Present results for main outcomes, preferably indicating the number of included studies and participants for each. If meta-analysis was done, report the summary estimate and confidence/credible interval. If comparing groups, indicate the direction of the effect (i.e. which group is favoured).	
DISCUSSION			
Limitations of evidence	9	Provide a brief summary of the limitations of the evidence included in the review (e.g. study risk of bias, inconsistency and imprecision).	
Interpretation	10	Provide a general interpretation of the results and important implications.	
OTHER			
Funding	11	Specify the primary source of funding for the review.	
Registration	12	Provide the register name and registration number.	