

**INVESTIGATING TEACHER EDUCATORS AND
PROSPECTIVE TEACHERS' TECHNOLOGICAL
PEDAGOGICAL CONTENT KNOWLEDGE AT THE
UNIVERSITY LEVEL**



Researcher:

Muhammad Saif Ali

Reg: No. 30-FOE/MSEDU/S23

Supervisor

Dr. Azhar Mahmood

**Department of Educational Leadership & Management
Faculty of Education
INTERNATIONAL ISLAMIC UNIVERSITY,
ISLAMABAD
2025**

**INVESTIGATING TEACHER EDUCATORS AND
PROSPECTIVE TEACHERS' TECHNOLOGICAL
PEDAGOGICAL CONTENT KNOWLEDGE AT THE
UNIVERSITY LEVEL**



MUHAMMAD SAIF ALI

30-FOE/MSEDU/S23

A thesis submitted in partial fulfilment of the requirement for the degree of
MS in Educational leaderships and management

**Department of Educational Leadership & Management
Faculty of Education
INTERNATIONAL ISLAMIC UNIVERSITY,
ISLAMABAD**

2025

SUPERVISOR’S CERTIFICATE

The thesis titled “Teacher educators and prospective teachers’ technological pedagogical content knowledge at the university level” submitted by Mr. Muhammad Saif Ali Reg No: 30- FOE/MSEDU/S23 is partial fulfilment of MS degree in Education, has been completed under my guidance and supervision. I am satisfied with the quality of student’s research work and allow him to submit this for further process as per IIUI rules and regulations.

Date: _____

Supervisor: _____

Dr. Azhar Mahmood

APPROVAL SHEET
INVESTIGATING TEACHER EDUCATORS AND
PROSPECTIVE TEACHERS' TECHNOLOGICAL
PEDAGOGICAL CONTENT KNOWLEDGE AT THE
UNIVERSITY LEVEL

By

Muhammad Saif Ali

30-FOE/MSEDU/S23

Accepted by the Department of Educational leaderships and management, Faculty of Education, International Islamic University Islamabad, in the partial fulfilment of the award of the degree of “**MS EDUCATIONAL LEADERSHIPS AND MANAGEMENT**”.

Viva Voce Committee:

Supervisor: _____

(Dr. Azhar Mehmood)

Internal Examiner: _____

External Examiner: _____

Date: _____

Chairperson: _____

Department of Educational Leaderships
and Management, Faculty of Education,
International Islamic University
Islamabad.

Dean: _____

Faculty of Education, International
Islamic University
Islamabad.

AUTHOR’S DECLARATION

I, Muhammad Saif Ali, Reg. No: 30- FOE/MSEDU/S23 as a student of MS in Educational Leaderships and Management at International Islamic University, Islamabad do hereby declare that the thesis entitled “Investigating Teacher Educators And Prospective Teachers’ Technological Pedagogical Content Knowledge At The University Level”, submitted for the partial fulfilment of MS in Educational Leaderships and Management is my original work, except where otherwise acknowledged in the text and has not been submitted or published earlier and shall not in future, be submitted by researchers for obtaining and degree from this or any other university or institutions.

Muhammad Saif Ali

Acknowledgment

In the name of Allah, the Most Gracious, the Most Merciful.

First and foremost, I would like to express my deepest gratitude to my supervisor, **Dr. Azhar Mahmood**, Associate Professor, Chairman of Educational Leadership and Management, and In-Charge of the Faculty of Education programs. His guidance, patience, and unwavering support have been invaluable throughout this journey. His insightful feedback and encouragement pushed me to strive for excellence, and for that, I am truly grateful.

I would also like to acknowledge the late **Pro. DR. Nabi Baksh Jumni**, whose contributions and dedication to the field of education continue to inspire many.

I am also incredibly thankful to **Dr. Sheikh Tariq, Dr. Sufi Amin, and Dr. Asad Abbas Rizvi** from the International Islamic University, Islamabad, whose guidance and expertise have greatly contributed to my research. Their encouragement has been a constant source of motivation.

I owe an immense debt of gratitude to my beloved father, whose financial support, endless motivation, and belief in my abilities have played a crucial role in making this journey possible. His sacrifices and unwavering faith in me have been my greatest strength, and for that, I will always be grateful. To my mother and family members, thank you for your prayers, love, and emotional support, which have been my constant source of comfort and encouragement.

Lastly, I am thankful to my friends and colleagues who stood by me, offered words of encouragement, and shared this journey with me. Your support has meant the world to me.

May Allah bless each and every one of you for your kindness and support.

Muhammad Saif Ali

ABSTRACT

This study aims to evaluate and compare the levels of Technological Pedagogical Content Knowledge (TPACK) among teacher educators and prospective teachers at the university level, with a specific focus on gender-based differences. Conducted at the International Islamic University Islamabad (IIUI) and the University of Swat, the research addresses three key objectives: (1) to evaluate the levels of TPACK among teacher educators, (2) to evaluate the levels of TPACK among prospective teachers, and (3) to compare TPACK competencies between male and female teacher educators and between male and female prospective teachers. A quantitative research design was employed, utilizing universal sampling for teacher educators and stratified random sampling for prospective teachers. Data were collected through a validated TPACK survey tool, along with a structured questionnaire. The major findings of the study reveal that 75% of teacher educators have a high level of content knowledge, with a mean score of 4.38 and a low standard deviation (0.44), indicating strong expertise in their subject areas. However, while 41.7% of teacher educators are highly proficient in technological knowledge, 50% fall into the average range, and 8.3% struggle, highlighting a need for further training in technology integration. Similarly, prospective teachers show moderate proficiency in TPACK, with an average score of 3.92, but 12.4% require significant improvement in integrating technology, pedagogy, and content knowledge. Notably, the study found no significant gender-based differences in TPACK competencies among both teacher educators and prospective teachers, suggesting equal readiness and opportunities for both male and female educators. The major conclusions of the study emphasize the importance of TPACK in preparing educators for 21st-century teaching. While teacher educators excel in content and pedagogical knowledge, there is a clear need for growth in technological integration. Prospective teachers, though moderately proficient, require more structured training to build confidence in using technology effectively. The absence of gender disparities indicates equal opportunities for both male and female educators to refine their skills. The study offers several major recommendations to address these gaps: systematically integrate TPACK frameworks into teacher education programs, create targeted professional development initiatives, including workshops and hands-on training, tackle gender disparities through gender-sensitive training programs, ensure institutional support by providing access to smart classrooms and high-speed internet, and foster collaborative learning communities to share best practices. By implementing these recommendations, teacher education programs can enhance TPACK competencies, ensuring educators are well-prepared to integrate technology effectively into their teaching practices. This study underscores the significance of ongoing professional development and institutional support in equipping educators with the skills needed to navigate the evolving demands of modern education.

Contents

Acknowledgment	v
ABSTRACT	vi
CHAPTER 1	1
INTRODUCTION	1
1.1 Background of the study	2
1.2 Research gap:	3
1.3 Statement of the problem	4
1.4 Objectives of the study.....	5
1.5 Significance of the study.....	5
1.6 Research questions.....	6
1.7 Hypotheses	6
1.8 Delimitation of the study	6
1.9 Operational Definitions.....	6
1.9.1 TPACK levels:	6
1.9.2 Teacher educators:	7
1.9.3 Prospective teachers:	7
1.9.4 Technological knowledge:	7
1.9.5 Pedagogical knowledge:	7
1.9.6 Content knowledge	7
1.9.7 University level	7
1.10 Theoretical framework.....	7
1.10.1 Technology knowledge (TK)	8
1.10.2 Content knowledge (CK)	8

1.10.3 Pedagogical knowledge (PK).....	8
1.10.4 Pedagogical content knowledge (PCK)	9
1.10.5 Technological content knowledge (TCK):.....	9
1.10.6 Technological pedagogical knowledge (TPK):.....	10
1.10.7 Technological Pedagogical Content Knowledge (TPACK):	10
1.11 Conceptual framework	13
CHAPTER 2	14
LITERATURE REVIEW	14
2.1 Introduction.....	14
2.2 The Role of Technology in Education and Learning	15
2.3 Benefits of TPACK.....	16
2.3.1 Enhanced Teaching Effectiveness:	17
2.3.2 Improved Student Engagement:	17
2.3.3 Support for Differentiated Instruction:	18
2.3.4 Promotes Innovation and Creativity	18
2.3.5 Fosters Collaborative Learning.....	19
2.4 Alignment with 21st-Century Skills	19
2.5 Facilitates Continuous Professional Development	20
2.6 Importance of TPACK in Modern Education.....	21
2.6.1 The Significance of TPACK in 21st-Century Teaching	21
2.6.2 TPACK's role in improving teaching effectiveness and student engagement.	22
2.6.3 TPACK for both teacher educators and prospective teachers.....	23
2.7 Technological Pedagogical Content Knowledge among Teacher Educators ...	27
2.7.1 Previous studies on TPACK among teacher educators.....	27
2.7.2 Technological integration in teacher education programs	28
2.8 Technological Pedagogical Content Knowledge among Prospective Teachers	30

2.8.1 Existing research on prospective teachers' TPACK	30
2.8.2 Development of TPACK during teacher education programs	31
2.9 Gender Differences in TPACK Competences	33
2.9.1 Gender and Technology in Education.....	33
2.9.2 TPACK Competencies: Male vs. Female Educators and Trainees.....	33
2.10 Assessing TPACK Among Teacher Educators and Prospective Teachers.....	36
2.11 Challenges and Barriers to TPACK Development	38
2.11.1 Barriers to Effective TPACK Integration	38
2.12 Gender-Related Challenges in Adopting TPACK	41
2.12.1 Confidence and Self-Efficacy	41
2.12.2 Access to Technology and Professional Development	41
2.13.2.1 Perceptions of Technology Use	42
2.13 The teacher education in Pakistan focuses on important concerns and challenges at all levels of teacher education in Pakistan.	42
2.13.1 Challenges in Pakistani Teacher Education.....	42
2.13.1.1 Outdated Curriculum and Pedagogy	43
2.13.1.2 Inadequate Training and Professional Development	43
2.13.1.3 Low Entry Standards and Quality of Teacher Educators.....	43
2.13.1.4 Insufficient Resources and Infrastructure	44
2.13.1.5 Gender Disparities.....	44
2.13.1.6 Political Interference and Weak Policy Implementation	44
2.13.1.7 Low Status and Motivation of Teachers	45
2.13.1.8 Regional Disparities	45
2.13.1.9 Assessment and Evaluation Challenges	46
2.14 Effective Approaches to Fostering TPACK Skills in Teacher Education	46
2.14.1 Role of Teacher Educators and Collaborative Learning	46

2.14.2 Institutional Policies and the Use of Digital Tools and Resources	46
2.14.3 Incorporating TPACK into Curriculum Design.....	47
2.15 Professional Development, Mentorship, and Ongoing Support	48
2.15.1 The Impact of Continuous Professional Development on TPACK Growth..	48
2.15.2 The Role of Mentorship and Peer Collaboration	50
2.15.3 Support Systems for Ongoing TPACK Competency Development	53
CHAPTER 3	55
RESEARCH METHODOLOGY	55
3.1 Research Design.....	55
3.2 Population of the Study.....	55
3.2.1 Characteristics of the population.....	55
3.2.2 Rational of selection of universities.....	56
3.2.3 Sample Selection.....	56
3.2.4 Justification for Sample Selection.....	57
3.3 Instruments for this Study	58
3.4 Validity.....	59
3.5 Pilot Testing	59
3.5.1 Reliability	60
3.6 Data Collection	60
3.7 Data Analysis	61
3.8 Ethical Consideration.....	62
CHAPTER 4	63
DATA ANALYSIS AND INTERPRETATION	63
Table 4.1 <i>Content Knowledge of Teacher Educators</i>	64
Table 4.2 <i>Technological Knowledge of Teacher Educators</i>	64
Table 4.3 <i>Pedagogical Knowledge of Teacher Educators</i>	65

Table 4.4 <i>Technological Content Knowledge of Teacher Educators</i>	66
Table 4.5 <i>Pedagogical Content Knowledge of Teacher Educators</i>	66
Table 4.6 <i>Technological Pedagogical Knowledge of Teacher Educators</i>	67
Table 4.7 <i>Technological Pedagogical Content Knowledge of Teacher Educators</i>	67
Table 4.8 <i>Content Knowledge of Prospective Teachers</i>	68
Table 4.9 <i>Technological Knowledge of Prospective Teachers</i>	69
Table 4.10 <i>Pedagogical Knowledge of Prospective Teachers</i>	69
Table 4.11 <i>Technological Content Knowledge of Prospective Teachers</i>	70
Table 4.12 <i>Pedagogical Content Knowledge of Prospective Teachers</i>	70
Table 4.13 <i>Technological Pedagogical Knowledge of Prospective Teachers</i>	71
Table 4.14 <i>Technological Pedagogical Content Knowledge of Prospective Teachers</i>	72
Table 4.15: TPACK Scores: Gender Comparison Among Teacher Educators	73
Table 4.16: TPACK Scores: Gender Comparison Among Prospective Teachers	75
CHAPTER 5	77
SUMMARY, FINDINGS, DISCUSSION, CONCLUSION AND RECOMMENDATION	77
5.1 SUMMARY	77
5.2 FINDINGS	78
5.3 DISCUSSION	84
5.3.1 TPACK Levels Among Teacher Educators	84
5.3.2 TPACK Levels Among Prospective Teachers	86
5.3.3 TPACK Levels Among Teacher Educators and Prospective Teachers	88
5.3.4 Gender Differences in TPACK Competencies	89
5.3.5 Implications for Teacher Education Programs	89
5.4 Conclusions	90
5.5 Recommendations	92

5.5.1 Embed TPACK Systematically Across Teacher Education Curricula	93
5.5.2 Offer Continuous, Personalized Professional Development for Teacher Educators.....	93
5.5.3 Integrate AI Literacy, Digital Citizenship, and Data Privacy Education.....	93
5.5.4 Establish TPACK-Based Microteaching and Simulation Labs	94
5.5.5 Foster Gender-Inclusive Technology Leadership Initiatives	94
5.5.6 Develop Individualized TPACK Growth Portfolios	94
5.5.7 Implement Dynamic Assessment and Feedback Systems	95
5.5.8 Facilitate Cross-Disciplinary Collaboration and Innovation Projects.....	95
5.5.9 Strengthen Institutional Infrastructure and Support Systems	96
5.5.10 Promote Action Research on TPACK Practices	96
5.6 Limitations and Future Research	97
REFERENCES.....	99

CHAPTER 1

INTRODUCTION

In today's digitally connected world, the integration of Information and Communication Technologies (ICT) in education is not just a trend—it is a necessity. Traditional teacher-centered instruction is increasingly being replaced with student-centered, technology-enhanced learning environments that promote creativity, critical thinking, and collaboration. These shifts are essential for equipping students with the 21st-century skills needed to thrive in a globalized, knowledge-driven economy.

Pakistan's National Education Policy (NEP) 2017 emphasizes the importance of leveraging ICT for improving educational quality, expanding lifelong learning opportunities, and strengthening service delivery. However, the practical implementation of this vision requires systemic reforms in teacher education. Teachers must be adequately prepared to use technology not just as a tool, but as an integral part of their pedagogical practice. This is where the Technological Pedagogical Content Knowledge (TPACK) framework becomes highly relevant.

Mishra and Koehler (2006) extended Shulman's (1987) knowledge domains by introducing TPACK—a model that articulates the complex interplay between technology, pedagogy, and content knowledge. This model has since become a cornerstone for understanding the competencies teachers need to integrate technology meaningfully into teaching and learning. It is not enough to know the subject content or teaching strategies in isolation; teachers must understand how to weave together content, pedagogy, and technology to create effective, context-sensitive learning experiences.

While the theoretical importance of TPACK is widely acknowledged (Chai et al., 2010; Koehler & Mishra, 2009), many challenges persist—particularly in

developing countries like Pakistan. Research indicates that teacher educators and pre-service teachers often lack sufficient training, hands-on experience, and institutional support for using technology effectively (Ertmer & Ottenbreit-Leftwich, 2010; Öztürk & Horzum, 2011). Moreover, existing teacher education programs in Pakistan frequently suffer from outdated curricula, insufficient funding, and socio-cultural barriers—including gender disparities and political interference.

As an education researcher deeply invested in improving Pakistan's teacher education system, the researcher believes that tackling these issues is essential. It is no longer sufficient to equip teachers with generic pedagogical skills; they must be empowered with the digital competencies demanded by today's classrooms. This research is driven by my commitment to exploring how the TPACK model can serve as a practical and strategic framework for enhancing the preparation of future educators in Pakistan.

1.1 Background of the study

Twenty-first century skills have attracted central attention in recent years. Pupils of today and in the future are expected to be able to collaborate, solve problems, think creatively and innovatively, and use information and communication technology (ICT) applications effectively. According to Voogt et al. (2013), teachers must be familiar with a variety of pedagogical techniques in order to effectively use ICT and promote students' development of twenty-first century skills. This implies that twenty-first-century skills should be included in the teacher preparation program. There is an agreement that instructors must provide pupils with learning content that supports their development of twenty-first century abilities (Rotherham and Willingham, 2009).

Hence, the importance of technology in student learning is widely acknowledged, enabling instructors to become technology literate and integrate

technology into their instruction (Chang et al., 2017). The technological pedagogical content knowledge (TPACK) framework is a theoretical approach for researching how instructors utilize ICT in education. Punya Mishra and Matthew Koehler established the concept in 2006 as an approach to handling the complex interplay of technology, pedagogy, and content in educational contexts. TPACK highlights the significance of knowing how these three categories of information overlap and inform one another in order to provide meaningful learning experiences for students.

1.2 Research gap:

The integration of technology in teacher education has progressed globally; however, its adoption within Pakistan remains inconsistent and underexplored—particularly at institutions such as the International Islamic University Islamabad (IIUI) and the University of Swat. These universities serve a vital role in preparing future educators, yet there is limited evidence on how well teacher educators and prospective teachers at these institutions understand or apply Technological Pedagogical Content Knowledge (TPACK).

To date, no comparative studies have been conducted to examine TPACK competencies between these two groups within the mentioned universities. Additionally, there is a lack of focused research on gender-based variations in TPACK knowledge and application, which is a relevant consideration given the socio-cultural dynamics of the country.

This study aims to address these research gaps by:

- Assessing TPACK competencies among teacher educators and prospective teachers,
- Exploring gender-related differences in TPACK understanding and implementation.

By filling these gaps, the research contributes to the broader educational discourse and offers practical insights for policy development, teacher training initiatives, and curriculum design—ultimately supporting Pakistan’s educational goals of inclusivity, innovation, and effectiveness.

1.3 Statement of the problem

The integration of Information and Communication Technologies (ICT) in teaching methods is increasingly seen as essential for developing effective and relevant learning environments. Although the 2017 National Education Policy Draft (NEP) emphasizes the importance of ICT integration, there is still a considerable gap in understanding the levels of Technological Pedagogical Content Knowledge (TPACK) among teacher educators and prospective teachers at the university level. TPACK provides a framework for combining technology, pedagogy, and content knowledge to improve educational practices. However, there is a shortage of empirical research investigating how well educators and prospective teachers in Pakistani universities understand and implement TPACK principles in their teaching methods.

There is a significant gap in current research regarding the evaluation of TPACK levels among teacher educators and prospective teachers in Pakistani universities. Although the 2017 NEP highlights the critical role of ICT in education, there has been limited analysis on the extent to which educators and future teachers grasp and apply TPACK principles. Furthermore, it is essential to explore how teacher education programs incorporate these competencies and whether there is any gender-based differences in TPACK knowledge. This study seeks to address these gaps by providing a comprehensive assessment of TPACK levels and examining potential disparities, thereby laying the groundwork for enhancing teacher preparation and ensuring alignment with modern educational standards.

1.4 Objectives of the study

Following were the objectives of this study

- 1) To evaluate the levels of Technological Pedagogical and Content Knowledge (TPACK) among teacher educators.
- 2) To evaluate the levels of Technological Pedagogical and Content Knowledge (TPACK) among prospective teachers.
- 3) To compare TPACK competencies between male and female teacher educators and between male and female prospective teachers at the university level.

1.5 Significance of the study

This study holds particular significance as it looks closely at how teacher educators and prospective teachers in Pakistani universities understand and apply Technological Pedagogical Content Knowledge (TPACK) in their teaching. By examining their ability to integrate technology effectively into their instructional practices, the research offers important insights into the current state of technology use in teacher education. It also explores possible gender differences in TPACK competencies, which can help us better understand how male and female educators may experience and approach technology integration differently.

The findings of this study will be useful to a range of people connected to education. Teacher educators can use the results to reflect on their teaching approaches and identify areas where they might improve. Prospective teachers will benefit by gaining a clearer picture of the skills they need to develop as they prepare for the classroom. For those involved in designing teacher education programs—such as curriculum planners and training coordinators—this research can help shape more relevant and responsive training that supports meaningful use of technology. Policymakers and education leaders can also draw on the study to inform decisions

about how to support and strengthen teacher preparation in a digital world. Overall, the research aims to support better training, more thoughtful program development, and ultimately, stronger teaching practices that use technology to enhance learning. In doing so, it contributes to the broader goal of creating a more inclusive, capable, and future-ready education system in Pakistan.

1.6 Research questions

Q 1: What are the TPACK levels of teacher educators at the university level?

Q 2: What are the TPACK levels of prospective teachers at the university level?

1.7 Hypotheses

H₀₁: There is no significant difference in the TPACK competencies of male and female teacher educators at the university level.

H₀₂: There is no significant difference in the TPACK competencies of male and female prospective teachers at the university level.

1.8 Delimitation of the study

The study was concentrate only on evaluating the levels of Technological Pedagogical and Content Knowledge (TPACK) among teacher educators and prospective teachers at the International Islamic University Islamabad and the University of Swat, specifically targeting those in their 4th and 5th semesters at both institutions.

1.9 Operational Definitions

1.9.1 TPACK levels:

The level of understanding and competency in integrating technology, pedagogy, and content knowledge in educational settings.

1.9.2 Teacher educators:

Teacher educators are responsible for teaching prospective teachers and offering professional development to present university educators.

1.9.3 Prospective teachers:

Prospective teachers are university students enrolled in teacher education programs who intend to become educators themselves.

1.9.4 Technological knowledge:

Technological knowledge refers to the understanding and implementation of different technological tools, applications, and resources that are important to educational practices.

1.9.5 Pedagogical knowledge:

Pedagogical knowledge includes understanding about teaching methods, instructional tactics, and methodologies for facilitating effective learning experiences.

1.9.6 Content knowledge

Content knowledge refers to skill and comprehension of the subject matter being taught, which includes curricular material and disciplinary principles.

1.9.7 University level

University level concentrates on the context of higher education institutions, where teacher education programs are given and potential teachers are taught.

1.10 Theoretical framework

The theoretical framework for TPACK is based on the work of Lee Shulman, who proposed the idea of pedagogical content knowledge (PCK) in 1986. PCK focuses on the relationship between pedagogical and content knowledge, emphasizing the need to learn how to successfully teach certain subject matter. Mishra (1998) was a pioneer

of the concept of TPACK, In the context of educational software design, briefly address the triad of theory and technology rather than content and pedagogy.

Building on Shulmans' idea of Pedagogical Content Knowledge (PCK), Mishra and Koehler (2006) proposed the Technological Pedagogical Content Knowledge (TPACK) framework to reflect the growing influence of technology in education. They observed that effective teaching in the modern classroom increasingly depends on the integration of digital tools, and that this requires more than just technical know-how. Teachers must develop a combined understanding of content (CK), pedagogy (PK), and technology (TK), and how these areas interact in practice. Specifically, the TPACK framework identifies seven knowledge components that describe how these domains intersect.

1.10.1 Technology knowledge (TK)

Technology knowledge covers a wide range of technologies, from low-tech equipment like pencils and paper to digital technologies such as the Internet, digital video, interactive whiteboards, and software.

1.10.2 Content knowledge (CK)

Mishra and Koehler (2006) define content knowledge as "knowledge about the actual subject matter that is to be learned or taught" (p. 1026). Teachers must grasp both the topic they will teach and how knowledge varies between subject areas.

1.10.3 Pedagogical knowledge (PK)

Pedagogical knowledge refers to the techniques and processes of teaching; this includes knowledge of classroom management, assessment, student learning, and lesson plan preparation.

The intersections of these domains generate four additional components in the TPACK model:

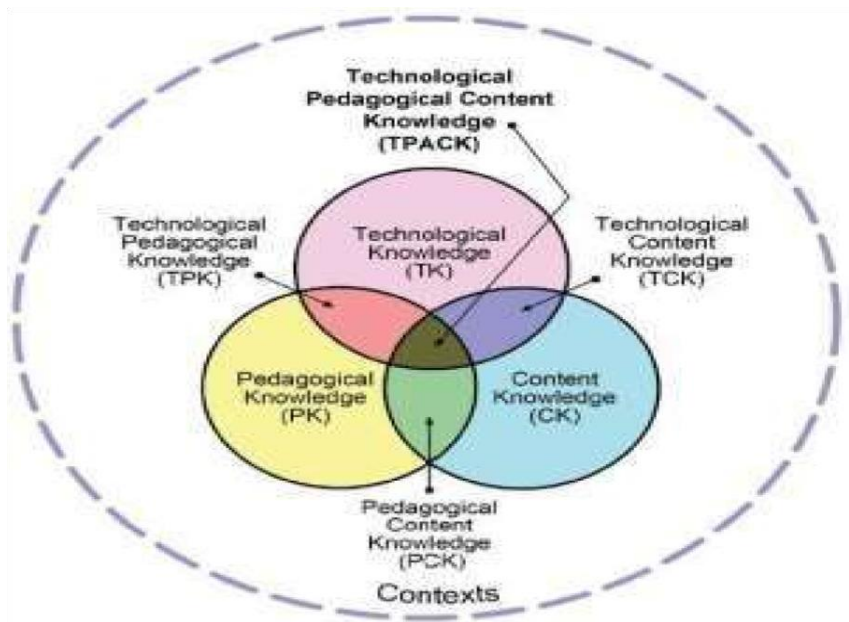


Figure 1. The component of TPACK framework (graphic from <https://taylorinstitute.ucalgary.ca/resources/SAMR-TPACK>)

1.10.4 Pedagogical content knowledge (PCK)

The term pedagogical content knowledge relates to understanding the teaching process (Shulman, 1986). Pedagogical content knowledge differs by topic area since it integrates material and pedagogy with the goal of improving teaching methods in particular areas.

1.10.5 Technological content knowledge (TCK):

Technological content knowledge is the understanding of how technology may provide new representations for certain information. It implies that teachers recognize that by utilizing a certain technology, they may modify the way students practice and understand topics in a given content area.

1.10.6 Technological pedagogical knowledge (TPK):

Technological pedagogical knowledge relates to knowing how numerous technologies may be utilized in teaching, as well as the possibility that employing technology would change the way teachers educate.

1.10.7 Technological Pedagogical Content Knowledge (TPACK):

Teacher knowledge needed to effectively incorporate technology into instruction across various subjects is known as technological pedagogical content knowledge (TPACK). Educators who successfully blend appropriate teaching methods with technology to convey content have a deep understanding of the intricate relationships among the three fundamental components of knowledge (technological knowledge (TK), pedagogical knowledge (PK) and content knowledge (CK)). The true power of TPACK lies in the integration of these elements. Teachers equipped with TPACK can leverage technology to deepen students' exploration and understanding of complex topics in their subject areas while employing teaching strategies that encourage active engagement and critical thinking (Koehler & Mishra, 2008). For instance, a science teacher might use simulations or virtual experiments (TK) to illustrate scientific principles (CK), while implementing inquiry-based methods (PK) to promote student investigation and discovery. An educator with strong TPACK can design interactive lessons that captivate students in meaningful ways, drawing on their subject expertise to ensure that the material is presented effectively and appropriately. TPACK serves as a holistic framework for examining the intricate connections between technology, pedagogy, and content in educational settings. By integrating these three types of knowledge, teachers can craft dynamic and impactful learning experiences that cater to the diverse needs of their students. TPACK represents a comprehensive teaching strategy that acknowledges the complex interactions among technology,

pedagogy, and content knowledge, enabling educators to create transformative learning experiences that equip students for success in a digital age.

Research supports the relevance of TPACK in teacher education. Angeli et al. (2016) emphasized that digital transformation in education requires teachers to acquire not only pedagogical and content knowledge but also technological fluency. They argued that teachers should be prepared to integrate digital media into subject-specific teaching. Mourlam et al. (2021) noted that TCK and TPK are critical subsets of TPACK, as they help pre-service teachers meaningfully apply technology in their future classrooms from the start of their careers. In learning environments such as makerspaces, where trainees develop digital learning tools, TPACK functions both as a prerequisite and an outcome of meaningful engagement with technology (Cross, 2017). However, the development of TPACK among pre-service teachers often depends on the support structures and resources available to them. According to Fernandes et al. (2021), access to digital tools, quality training materials, and expert guidance play a vital role in shaping how effectively pre-service teachers acquire and apply TPACK competencies.

Nilsson (2024) highlights that teacher educators themselves must possess high levels of TPACK in order to model effective practices for their students. When university faculty demonstrate the integration of technology in pedagogically sound and content-rich ways, they provide authentic learning experiences that help pre-service teachers visualize how to use digital tools in their own teaching. This modeling effect is particularly crucial in teacher education programs, where future educators rely heavily on their mentors' practices.

Empirical studies conducted in Pakistan have reinforced the importance of TPACK in teacher preparation. One recent survey of prospective teachers revealed that

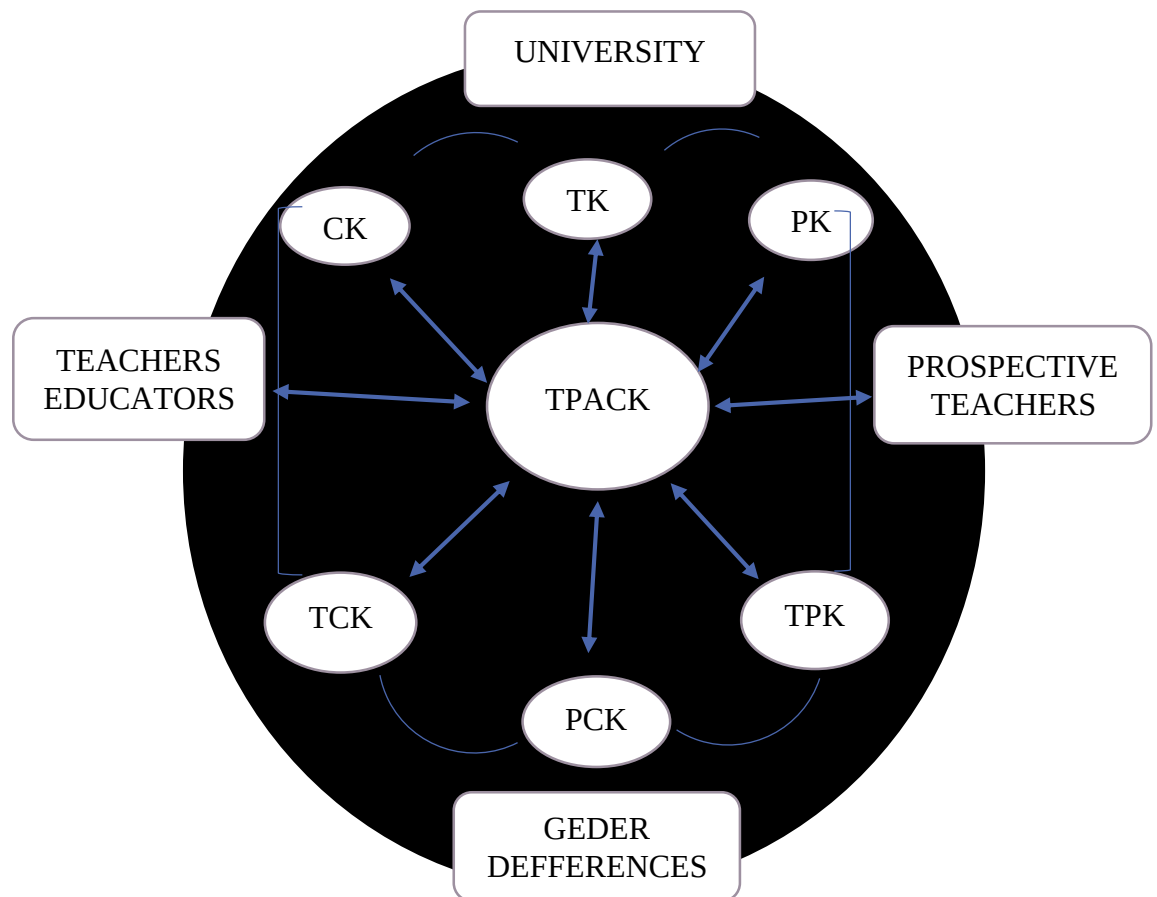
many hold positive attitudes toward the use of Information and Communication Technologies (ICT) in education and acknowledge the value of TPACK (Hussain & Hussain, 2024). However, the same study emphasized the need for systematic training for both pre-service teachers and their instructors in TPACK-related skills and competencies. Similarly, other studies identified challenges such as outdated infrastructure, lack of training, and insufficient technical support that hinder effective TPACK implementation (Ghayyur & Mirza, 2021; Noor et al., 2021). While there is a willingness to engage with educational technologies, these findings suggest that structured support, competent mentorship, and curriculum development are essential for effective and sustainable integration of TPACK in teacher education programs (Ali et al., 2023).

In summary, the TPACK framework serves as a robust theoretical lens for analyzing how teacher educators and prospective teachers in Pakistan approach teaching in the digital age. It offers a comprehensive model for integrating content, pedagogy, and technology, and aligns closely with the goals of 21st-century education. The subsequent section will build on this foundation by presenting the conceptual framework used to assess TPACK competencies among study participants from the International Islamic University Islamabad (IIUI) and the University of Swat.

1.11 Conceptual framework

A conceptual framework serves as the blueprint for a research study, mapping the relationships between key concepts and variables. It operationalizes the theoretical insights into specific constructs that guide the research design, methodology, and analysis. In this study, the Technological Pedagogical Content Knowledge (TPACK) framework underpins the investigation into the competencies of teacher educators and prospective teachers. The conceptual framework is developed based on the theoretical constructs of TPACK, integrating moderating factor such as gender differences.

Figure 1



CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The twenty-first century is marked by rapid technological advancements that have significantly transformed various aspects of life, particularly in education. Technology has become a vital part of contemporary society. In recent years, educational institutions have increasingly incorporated technology into their programs, emphasizing online and digital education, blended learning, digital resources for teaching and learning, e-content creation, online assessments, and professional development for teachers. The National Education Policy Draft (NEP) 2017 aims to turn our nation into a digitally empowered society, leveraging technology to enhance teaching, learning, evaluation processes, teacher training, and educational management. This transition to a digitally empowered nation underscores the crucial role of our educational system and educators. Consequently, both teachers and students must embrace technology. However, effectively integrating technology to maximize its benefits for teaching and learning across all educational levels, from schools to higher education, presents a significant challenge for educators and learners alike (Government of Pakistan, 2017). Teachers must be well-versed in the knowledge, skills, and competencies required for technology integration, as they will impart these skills to students while addressing their diverse needs in an ever-evolving world. It is essential for teachers to grasp the interplay of content, pedagogy, and context (TPACK framework) when utilizing new and emerging technologies, as these technologies can influence both the nature of subject-area learning and the teaching methods they can adopt (Harris, Mishra, & Koehler, 2009).

While numerous studies highlight the value of technology in enhancing learning, there is growing concern about the actual readiness of educators—especially

in developing contexts like Pakistan—to adopt these tools effectively. The present review aims to critically analyze how the TPACK framework can address current gaps and challenges in teacher preparation programs in Pakistani universities.

2.2 The Role of Technology in Education and Learning

Building on the introduction's emphasis on the need for contextualized integration of ICT in education, this section delves into how technology has reshaped teaching and learning environments globally. It sets the groundwork for the subsequent discussion on the TPACK framework by outlining the broader educational shifts driven by digital innovations.

This section sets the stage by outlining how technological innovation has impacted global education, emphasizing its potential to enhance learning outcomes and increase student engagement. Technology has radically transformed education, offering tools like virtual simulations, collaborative platforms, and multimedia content to support active, personalized, and student-centered learning.

Technological innovation has sparked a revolution, particularly in the education sector. It has transformed teaching and learning (Green & Gilbert, 1995; Collins & Halverson, 2018; Kaddoura & Al Husseiny, 2023). From online classes to digital textbooks, technology has expanded students' access to and interaction with educational content (Gustafsson & Ollila, 2003; Bogner & Menz, 2009; Jacob & Furgerson, 2012). According to Green and Gilbert (1995), technology has improved learning abilities and enabled pupils to learn at their own speed. Technology, including podcasts, films, virtual worlds, and audio, enables students to customize their studies based on their needs and timetable (Díaz et al., 2020; Tugtekin, 2023; Vermesan & Friess, 2013). Furthermore, incorporating technology into the educational system facilitates collaborative learning, promotes cooperation, and improves pupil communication skills

(Divjak et al., 2022; Jain et al., 2022). Similarly, digital technologies such as Google Docs and collaborative whiteboards enable students to collaborate on projects and assignments independent of their physical location (Wang et al., 2022; Suki & Suki, 2011; Sánchez & Hueros, 2010). Furthermore, incorporating technology into the educational system results in immersive experiences of learning that are more engaging for students through educational game simulations. Virtual reality platforms provide pupils a novel and participatory approach to studying complicated subjects (Alwaely et al., 2022; Crawford et al., 2020). This method of learning has been shown to boost students' comprehension and retention of material, as well as encourage them to learn (Kaddoura & Al Hussein, 2023; Wang et al., 2022).

However, these innovations often assume an infrastructure and readiness that may not exist in all educational settings. In many parts of Pakistan, resource limitations and varying levels of digital literacy among educators' present significant implementation challenges. The purpose of this study is to examine how contextual factors affect technology integration in local teacher education programs.

2.3 Benefits of TPACK

To understand the practical value of TPACK, it is essential to examine its benefits in real-world teaching contexts. Highlighting these advantages helps clarify why this framework is increasingly promoted in teacher education globally and provides a foundation for evaluating its relevance and applicability in the Pakistani context.

The Technological Pedagogical Content Knowledge (TPACK) framework has emerged as an essential model for contemporary education, offering numerous advantages for both educators and learners. TPACK enables teachers to seamlessly integrate technology into their instructional practices by blending three key areas of

knowledge: content knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK). This integration empowers teachers to design and implement more engaging, effective, and relevant lessons. This section details how TPACK supports instructional improvement, engagement, and inclusion.

2.3.1 Enhanced Teaching Effectiveness:

One of the key advantages of TPACK is its ability to increase teaching effectiveness. Educators may design more engaged and dynamic classes that meet the different needs of their students by incorporating technology in meaningful ways. TPACK enables teachers to speak critically about how technology may assist specific pedagogical practices and curriculum areas, resulting in more focused and effective instruction. For example, Chai et al. (2013) discovered that Singaporean teachers with TPACK abilities had a greater ability to integrate technology into language education, which improved class delivery and engagement. Rodríguez Moreno et al. (2019) define TPACK as integrating content, pedagogy, and technology to enhance teaching and learning. Yet, many teacher educators in Pakistan are still in the early stages of understanding how to leverage TPACK for meaningful outcomes. This review investigates how teacher educators can be supported to transition from awareness to effective implementation of TPACK.

2.3.2 Improved Student Engagement:

The usage of technological tools in educational settings has increased over the last decade (Lewis et al., 2013). They have been implemented in educational settings to enhance learning outcomes and student engagement (Bond et al., 2020). The use of technology, when combined with proper educational practices and material, has the potential to boost student engagement. TPACK enables educators to choose and apply digital resources that promote active learning and collaboration. Interactive technology,

including simulations, instructional games, and multimedia presentations, can help students engage with and relate to their courses.

2.3.3 Support for Differentiated Instruction:

TPACK promotes varied education, allowing teachers to meet the diverse requirements of their students in the classroom. Teachers can give customized materials, activities, and evaluations to students with varied levels of aptitude and learning styles by incorporating technology. For example, educators can employ technology to provide numerous modes of representation (e.g., videos, audio, texts), engagement (e.g., interactive activities, online forums), and expression (e.g., digital projects, presentations). Koh and Chai (2016) underline that teachers who build TPACK competencies are better equipped to construct curriculum activities that educate students for the needs of current workplaces and academic contexts. Furthermore, research has indicated that TPACK integration improves the teaching process (Taopan et al., 2020). In Pakistan, however, differentiated instruction often clashes with overcrowded classrooms and standardized curricula. This review examines how educators in resource-constrained environments adapt TPACK to accommodate diverse learners.

2.3.4 Promotes Innovation and Creativity

The TPACK framework allows teachers to try out novel teaching techniques by using emerging technology. It promotes a continuous learning mentality by requiring instructors to stay current on technological breakthroughs and investigate how these tools might improve pedagogy. Teachers with skilled TPACK competencies are more likely to use innovative approaches in the classroom, such as combining virtual reality for immersive learning experiences or utilizing artificial intelligence (AI) tools for tailored feedback. Joo et al., (2018) discovered that when teachers' TPACK knowledge

grows, so does their confidence in their capacity to use technology effectively, resulting in a more positive attitude toward technology integration. TPACK has long been used to ensure that learning with technology produces equivalent results and balances attention on how we educate with what we teach (Swallow & Olofson, 2017).

2.3.5 Fosters Collaborative Learning

Another key advantage of TPACK is its capacity to encourage collaborative learning. Educators can employ digital tools to encourage students to interact, communicate, and co-create knowledge. Students can collaborate, share ideas, and solve problems together using platforms such as online discussion boards, collaborative document editors, and interactive learning management systems (LMS). As teachers discussed their Collaborative Online International Learning (COIL) practice in various educational settings, academic discussions appeared to shift toward learning outcomes and student satisfaction compared to the cultural learning process in online classes (Vahed & Rodriguez, 2021). Kianinezhad (2023) emphasizes the advantages of online language education, including flexibility, accessibility, and new teaching approaches. The significance of TESOL and technology studies, 17 online communication technologies, collaborative learning, and formative assessment in enabling language instruction and cultural awareness is emphasized.

2.4 Alignment with 21st-Century Skills

Incorporating TPACK into teaching meets the expectations of 21st-century education, which emphasizes technology and digital literacy. As a result, the relevance of technology, as well as digital literacy, has grown to become important in today's educational scene. Thus, blended learning and online education have played critical roles in higher education since the early twenty-first century (Singh & Thurman, 2019). TPACK ensures that instructors do more than just teach information; they also assist

students in building crucial digital skills required for success in today's environment. These abilities include problem-solving, thinking critically, digital communication, and information awareness. Teachers must be familiar with a variety of educational approaches in order to use ICT to help students build twenty-first-century abilities (Voogt et al., 2013). This indicates that twenty-first-century skills should be integrated into teacher education. There is consensus that teachers must provide students with learning content that encourages the development of twenty-first-century abilities (Rotherham & Willingham, 2009). The TPACK framework was also developed for twenty-first-century skills (Mishra et al., 2010), and it is being used to increase the readiness of educators for twenty-first-century capabilities (Figg & Jaipal, 2012) and (Koehler et al., 2011). In the twenty-first century, technology has become significant in educational institutions, allowing teaching and learning to take place at any time and from any location via the Internet (Canbazoglu et al., 2016; Tseng et al., 2016).

2.5 Facilitates Continuous Professional Development

The Technological Pedagogical Content Knowledge (TPACK) paradigm has emerged as a critical component in improving teachers' continual professional development by combining technology, pedagogy, and content into instructional practices. Tondeur et al. (2017) found that professional development activities focusing on TPACK help instructors learn an adaptable skill set that adjusts to new technologies, supporting lifelong learning. Research has demonstrated that equipping educators with additional courses and workshops improves their technical abilities, instructional techniques, and content knowledge (Tütüniş et al., 2022).

Overall, TPACK was demonstrated to improve learning outcomes. According to research, when teachers successfully integrate technology into their instructional methods, students achieve higher levels of accomplishment, improve their grasp of the

subject matter, and boost their critical thinking ability (Schmidt et al. 2009). Educators can create rich learning environments that encourage imagination, creativity, and lifelong learning by leveraging technology to facilitate discovery, collaboration, and solving problems.

The TPACK framework offers a comprehensive method to integrate technology into education, with considerable benefits for both teachers and students. It improves teaching efficacy, increases pupil engagement, promotes differentiated instruction, encourages innovation, fosters collaboration, corresponds with 21st-century skills, and allows for ongoing professional development. As technology advances, the value of TPACK in education will only increase, making it an essential tool for modern teaching.

2.6 Importance of TPACK in Modern Education

Having explored the practical benefits of the TPACK framework, this section now turns to a broader discussion on its significance in equipping educators to meet contemporary educational demands. It connects the earlier insights on instructional improvement and student engagement to the larger goals of 21st-century learning and systemic teacher preparation reforms.

Following the discussion of TPACK benefits, this section shifts toward broader implications of TPACK for modern classrooms and its alignment with 21st-century teaching goals.

2.6.1 The Significance of TPACK in 21st-Century Teaching

The importance of TPACK in contemporary education cannot be emphasized. The modern classroom is distinguished by rapid technological improvements and an increased demand for critical thinking, creativity, teamwork, and communication skills among students. TPACK offers educators a framework for navigating these obstacles, ensuring that technology is not simply present but actively integrated to improve

learning. TPACK has a variety of advantages for boosting the quality of instruction, student engagement, and educational outcomes. TPACK enables educators to build and deliver more engaging and effective teaching. Educators can create interactive learning experiences that appeal to a wide range of learning styles and preferences, increasing student motivation and participation (Angeli & Valanides, 2009).

TPACK also enables teachers to provide tailored feedback, alter instruction, and scaffold learning experiences to meet the particular needs of their students. Another study (Shoukat et al., 2024). This essay investigates how the technological pedagogical content knowledge framework and artificial intelligence might enhance English language proficiency. The study discovered that combining the TPACK model with artificial intelligence applications improves language competency and provides tailored learning by enhancing engagement and feedback. Voogt et al. (2013) found that TPACK is essential for training students to flourish in a technologically advanced world. Teachers with TPACK are better positioned to cultivate the abilities required for students to excel in future professional and academic activities.

Educators may develop learning environments that encourage higher-order thinking and problem-solving in the real world by combining technology with successful pedagogical practices and appropriate material.

2.6.2 TPACK's role in improving teaching effectiveness and student engagement

The incorporation of technology in educational settings has become critical for improving both teaching effectiveness and student engagement. The Technological Pedagogical and Content Knowledge (TPACK) framework provides a strong foundation for this integration, highlighting the interaction of technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK). A recent study shows that educators with a well-developed TPACK can have a considerable impact on

student learning results. Atiqah Shib Khan et al. (2024) investigate how teachers' pedagogic and linguistic quality affects pupil achievement at both private and public universities in Lahore. The study addressed issues regarding how teachers' pedagogical competence influenced students' achievement. The study found a substantial association between teachers' pedagogical quality and student achievement. The regression analysis highlighted the predictive relevance of teachers' pedagogical quality for student achievement.

According to various frameworks, skills such as the teacher's ability to provide students with active engagement, in-class interaction, and technology use competence are common among the skills required for successful and effective online teaching (Bigatel et al., 2012; Martin et al., 2019; Husna et al., 2022). Similarly, Noor et al. (2021) evaluated teacher educators' and prospective teachers' technology pedagogical content understanding, as well as its effect on their bachelor's degree learning in education. The findings demonstrated that the technology knowledge of both teacher educators and prospective teachers has a major effect on the learning process. The study also found that pedagogical expertise enhanced learning. The survey findings also showed that TPACK proficiency improves the teaching-learning process and prepares students for the twenty-first century.

2.6.3 TPACK for both teacher educators and prospective teachers

The significance of TPACK extends to both teacher educators and future educators, as its abilities are critical for effective technology integration in educational contexts. Strong TPACK skills are essential for teacher educators who want to model excellent practices for their pupils, who has future educators. Nilsson, (2024). The purpose of this paper is to observe and comprehend how student teachers incorporate digital technologies into their science instruction. The paper uses Pedagogical Content

Knowledge (PCK) research to enrich the discussion of Technological Pedagogical Content Knowledge (TPACK), which is the incorporation of technology into the teaching of a specific science content. The findings show that the Technological Content Representation (T-CoRe) assisted student instructors in reflecting on their science teaching using digital technologies and highlighted the ways in which technology, content, and purpose are inextricably intertwined in teaching. By exhibiting excellent practices in technology integration, teacher educators prepare future teachers to handle the challenges of modern classroom environments.

Hussain et al. (2024) This study aimed to determine Pakistani prospective teachers' perceptions and attitudes concerning ICT and TPACK. For this reason, 200 future educators pursuing B.Ed., M.Ed., M.Phil., and Ph.D. education from three teacher education educational institutions in South Punjab were chosen as samples and surveyed about their attitudes toward ICT and TPACK. Their perceptions and attitudes towards ICT and TPACK were assessed using a 5-point Likert scale. Prospective teachers' attitudes toward information and communication were found to be positive. Their perceptions and attitudes toward technology knowledge, pedagogical knowledge, subject knowledge, and technological pedagogy were favorable. It is advised that future teachers be trained in ICT and TPACK and that professional trainers who are well-versed in these subjects be engaged.

Kocagül & Çoban (2024). The purpose of this study is to identify the elements that influence preservice teachers online teaching practices using the technological pedagogical content knowledge (TPACK) paradigm. This study, which employed a multiple case study technique, featured ten science and nine mathematics preservice teachers who completed the practical and theoretical components of the Teaching Practice 2 course both in person and online. The results show that PSTs confront

significant problems, particularly in the technological and pedagogical knowledge components of TPACK. Both groups have limited awareness of assessment technology because they place minimal importance on it. They normally use standard technologies like presentations or office programs. Their employment of identical technologies to identify and teach the subject demonstrates their insufficient understanding of technological content knowledge (TCK) and technological pedagogical knowledge (TPK). Mastering TPACK abilities is crucial for prospective teachers' professional preparation.

Technological Pedagogical Content Knowledge (TPACK) is essential for preparing instructors to effectively incorporate technology into their teaching practices. TPACK demonstrates that by training educators with the information and abilities to use technology in meaningful ways, they are better prepared to fulfill the demands of 21st-century learners and create enriched learning environments. In this study, we examine twenty-first-century abilities through the lens of technological pedagogical content knowledge (TPACK), with the aim of merging both frameworks. TPACK is a widely used theoretical method among academics studying how (pre-service) teachers use ICT (Voogt et al., 2013).

TPACK enables teacher educators to provide prospective teachers with the skills and strategies they require to seamlessly integrate technology into their instruction. Educators can help teachers-in-training gain a full understanding of how to select, modify, and apply various technologies to support student learning across a wide range of curriculum areas and grade levels (Koehler & Mishra, 2008). A subsequent analysis revealed that both teacher educators' and prospective teachers' technical ability had a significant impact on the learning process. Furthermore, instructional information has been shown to enhance learning. Proficiency in TPACK has been found to enhance

the teaching-learning process and develop skills necessary for 21st-century education. (Noor et al, 2021).

Another study reveals that teacher educators incorporate Project-Based Learning into their TPACK and employ a variety of technologies to improve topic knowledge in both teacher educators and pre-service teachers. Furthermore, blended learning would enable pre-service teachers to immediately witness, grasp, observe, and experience how to study and teach English using technology, pedagogy, and their intersections (Setiawan, 2018). Another study revealed that, when correctly applied and used, the TPACK framework can help both instructors and students enhance their teaching and learning (Alhababi, 2017). The TPACK framework has helped educational technology workers and scholars communicate more accurately and effectively about their work. (Baran et al., 2011). TPACK provides a systematic framework for boosting teachers' ability to use technology by acting as a conceptual bridge between traditional methods to teacher preparation that emphasize pedagogical subject knowledge (Cochran et al. 1991). Teacher preparation programs that stress the convergence of technological, pedagogical, and content knowledge can help future educators navigate the complicated world of educational technology with confidence and competence.

The TPACK framework plays a vital role in contemporary education by enhancing teaching effectiveness and fostering student engagement. Its importance is relevant for both teacher educators and future teachers, making sure that they are equipped to effectively integrate technology into their classrooms. Ongoing research and professional development centered on TPACK will be essential in preparing a new generation of educators to meet the challenges of 21st-century learning environments.

2.7 Technological Pedagogical Content Knowledge among Teacher Educators

2.7.1 Previous studies on TPACK among teacher educators

Numerous research studies have looked into the development and implementation of Technological Pedagogical Content Knowledge (TPACK) among teacher educators. Teacher educators play an important role in promoting effective technology integration in classrooms by modeling and transmitting the TPACK framework to future teachers. Previous studies have mostly examined the extent to which teacher educators hold and implement TPACK in their teaching practices, as well as how their TPACK growth influences prospective teachers. Saubern et al. (2020) said that now is "the time to focus on understanding the knowledge that teachers need to use technology effectively for teaching and learning.". The TPACK framework allows educators to reinvent and realign their teaching approaches with technological improvements (Koehler & Mishra, 2009).

Research on TPACK levels across various groups of teacher educators and prospective teachers has shed light on the effectiveness of teacher education programs in encouraging TPACK improvement. Individual TPACK competency varies greatly, according to research, with factors such as past technology experience, academic background, and pedagogical attitudes influencing TPACK levels (Koehler & Mishra, 2008). Furthermore, research suggests that, while many teacher educators and prospective teachers possess excellent subject knowledge and pedagogical skills, they may lack the confidence or competence to successfully integrate technology into their method of instruction (Mishra and Koehler, 2006).

(Voithofer et al. 2019), the research findings show that TPACK adoption is often low among these teacher educators and that it is influenced by a range of personal and institutional factors. Participants had substantial K-12 and teacher education

experience, as well as a strong understanding of technology. The highest degree awarded by their institution, their self-assessed TPACK score, and their individual acceptance of the International Society for Teaching and Education (ISTE) criteria were all found to influence TPACK adoption. The findings have implications for the professional development of teacher educators as well as program accreditation.

(Ali et al., 2022). The researchers focus on the TPACK framework, which is designed to assess teachers' understanding of how to use technology in the classroom. The study revealed that teachers' technological and pedagogical expertise has a significant positive impact on their TPACK.

2.7.2 Technological integration in teacher education programs

The use of technology into teacher education programs has gained traction over the last decade, spurred by the need to educate educators for increasingly technologically advanced classrooms. Several studies have looked into the methodology and effectiveness of adding TPACK into these programs, specifically how teacher educators can design and implement curriculum that encourage technical, pedagogical, and content knowledge development.

(Ali et al., 2022) The study focuses on teacher educators' assessments of their own efficacy and capacities for integrating technology, pedagogy, and topic knowledge into their courses. To successfully mix knowledge, skills, and technology in the classroom, teachers must have a wide range of experience, which is referred to as TPACK. The study discovered that teachers' TPACK has a significant impact on the instructional strategies they chose to use in their sessions. Based on the findings, it is proposed that the TPACK framework be used to improve teacher education curriculum and construct learning methodologies, strengthen teachers' teaching abilities, and

successfully implement these strategies in their teaching practices in Pakistani programs for teacher education.

(Al Adwan et al., 2024) This study presents a novel integrated technology continuance model (ITCM) that explains instructors' intention to use technology constantly in higher education institutions. Using TAM and UTAUT models for technology adoption, as well as TPACK theory, the study discovered that conducive environments and managerial help improve TPACK, resulting in increased self-efficacy, perceived utility, and perceived simple use. Perceived utility, ease of use, self-efficacy, and social influence all have a substantial impact on instructors' continuous use intention (CUI) for technology in higher education institutions. The findings of research on TPACK assessment have significant significance for teacher education programs. First and foremost, these initiatives must encourage TPACK growth among educators in training. This can be accomplished through specialized classes, hands-on experience, and ongoing professional development opportunities. Furthermore, programs should provide guidance and resources to help bridge gaps in TPACK knowledge and skills.

Furthermore, teacher educators play an important role in showing effective TPACK integration in teaching techniques. They inspire future teachers to use technology in the classroom by serving as role models. Baran et al. (2019) discovered a favorable association between teacher education techniques and preservice teachers' TPACK-practical levels, demonstrating the effectiveness of using TPACK-focused approaches. Furthermore, basic teacher education strategies such as reflecting on ICT's role in education and discussing classroom difficulties and experiences might assist prospective teachers in improving their attitudes toward ICT integration (Kay, 2006; Kaufman, 2015). Measurement of TPACK in teacher educators and future teachers is

crucial for assessing the capacity to successfully integrate technology, pedagogy, and topic knowledge. By examining existing approaches and tools, as well as researching TPACK levels, teacher education programs can identify areas for improvement and propose interventions to increase TPACK development among educators in training.

The increasing focus on TPACK research among teacher educators highlights the importance of professional development and the integration of technology in teacher education programs. These insights indicate that effective TPACK training not only enhances the skills of teacher educators but also significantly boosts the technology readiness of future teachers.

2.8 Technological Pedagogical Content Knowledge among Prospective Teachers

2.8.1 Existing research on prospective teachers' TPACK

In recent years, educational researchers have focused on the development of Technological Pedagogical Content Knowledge (TPACK) among aspiring instructors. Prospective teachers who are still in training need a strong foundation in TPACK to successfully integrate technology into their future classes. Numerous research studies have investigated prospective teachers' TPACK competencies and the elements that influence their development.

(Mohebi and Helder, 2019). The aim of this study is to examine the attitudes of pre-service teachers and their instructors in the United Arab Emirates (UAE) toward pre-service teachers' abilities to employ technology in classroom activities. The Technological Pedagogical and Content Knowledge (TPACK) paradigm served as the foundation for this project. The findings revealed that pre-service teachers are generally confident in their TPACK skills, with the highest mean score ($M = 4.12$) for subject knowledge and the lowest mean score ($M = 3.68$) for TPACK models. The one-way ANOVA results showed that specialization influences pre-service teachers' TPACK.

Furthermore, it was demonstrated that practical experience in schools had the greatest influence on information and communication technology (ICT) integration abilities in the classroom.

Max, et al. (2023, November). This study looks into the extent to which particular digital skills relevant to future educators can be developed through work on projects in a pedagogical maker space, as well as how contextual variables like technological self-efficacy, inspiration, and acceptance of technology influence the development of pre-service teachers' TPACK and intent to use digital media. The findings indicate that the level of TPACK prior to the intervention is an excellent indicator of TPACK following project activity. Moreover, TPACK prior to the intervention increases pre-service teachers' propensity to use digital media in the future. In addition, TPACK has a considerable influence on the perceived usefulness for professional use as well as the inclination to employ information and communication technology. Thus, it appears important to provide a low-threshold entry point at the start of the study in order to lay a solid foundation for more advanced TPACK. Motivation and technological acceptability are highly connected. As a result, teacher preparation should emphasize motivation and acceptance of technology.

2.8.2 Development of TPACK during teacher education programs

Teacher education programs play a critical role in developing prospective teachers' TPACK competencies. According to research, the design and implementation of these programs have a substantial impact on prospective teachers' ability to integrate technology into their teaching methods. Training programs for educators should be improved. In terms of acquiring teaching professional skills and developing pedagogical subject knowledge, using technology is critical to providing training for the construction of technology-oriented teaching materials in all area courses (Ersoy et

al., 2016; Hunter, 2016). This is because teachers' skills to use technology appropriate for their respective disciplines and teaching methods are highly dependent on their education in higher education programs and hence the proficiency of their teacher educators (Tıkman, 2022; Tondeur et al., 2012). Effective utilization of novel educational technology in teacher training programs is crucial for educators (Jaipal-Jamani et al., 2018; Nsouli & Vlachopoulos, 2021; Tıkman, 2022; Uerz et al., 2018). The International Society for Technology in Education has established guidelines for teacher educators. According to these standards, teacher educators should provide genuine educational opportunities for teacher candidates with technology support, facilitate knowledge construction, and continuously improve themselves by following new developments, just as teachers should constantly update their knowledge (ISTE, 2017). Tondeur et al. (2019) noticed that, while many investigations focused on the characteristics of pre-service teachers, little was known about the role of teacher educators in establishing programs for pre-service teachers. They asserted that teacher educators were critical in assisting preservice teachers to "bridge the gap between technology, pedagogy, and content knowledge (TPACK)."

(Thappa; Baliya, 2021) The current study is to explore prospective teachers' comprehension of the Technological Pedagogical and Content Knowledge (TPACK) paradigm during their continuous teacher education program. The statistics showed that students had specialized understanding of technology, pedagogy, and material, but the majority of them were unfamiliar with this framework. Furthermore, teacher educators play an important role in showing effective TPACK integration in teaching techniques. They serve as role models for future teachers, encouraging them to use technology in the classroom. Baran et al. (2019) discovered a favorable association between teacher education techniques and preservice teachers' TPACK-practical levels, demonstrating

the effectiveness of using TPACK-focused approaches. Research on TPACK among future teachers highlights the importance of teacher education programs in fostering these essential skills. The use of structured, hands-on, and collaborative methods in these programs has been shown to significantly enhance prospective teachers' capacity to incorporate technology into their upcoming classrooms.

2.9 Gender Differences in TPACK Competences

2.9.1 Gender and Technology in Education

The incorporation of technology into classrooms is critical for 21st-century education, but gender stereotypes, cultural norms, and access to professional growth can still influence how male and female educators use technology. Females frequently show lower trust in their technology skills than their male counterparts, which can affect how well they integrate technology into their teaching methods (Scherer et al., 2021). Addressing these hurdles through focused professional development and support is critical to eliminating disparities and ensuring that all educators can effectively use technology.

2.9.2 TPACK Competencies: Male vs. Female Educators and Trainees

The incorporation of technology in education is increasingly prevalent, opening up new opportunities for creative teaching and learning. However, studies indicate that gender can affect how teachers perceive and adopt technology. Even with initiatives aimed at achieving gender equality in STEM fields, disparities remain in the digital skills and technical pedagogical content knowledge (TPACK) of male and female educators. This literature review investigates existing studies on gender disparities in technology integration, emphasizing aspects such as self-efficacy, resource availability, and perceptions of technology use. With the rise of efforts aiming at fostering gender

equity in STEM and technology disciplines, female instructors are increasingly encouraged to use new technologies in the classroom.

Nonetheless, they continue to face difficulties in balancing pedagogical and technological expertise. Guillén-Gámez et al. (2021). Gomez et al. (2021) The primary purpose of this study is to determine whether there are any gender disparities in the Digital Competence of Teachers (DCT), in both training and in service. At the same time, the project aims to investigate the approaches, including technological ones, utilized in university classrooms and to assess potential new interventions to overcome the digital gender gap. The findings demonstrate that, when it comes to the teaching task, female participants had a much lower self-perception of their digital teaching competence than men, as well as a lower propensity toward technologies. Despite the benefits of modern technologies, some students may be unable to take advantage of them. Women generally have less access to computers and the internet (ITU, 2019). Furthermore, regardless of their real abilities, women frequently see themselves as less adept in the use of technology than males.

While Brata et al. (2022) revealed no gender difference in male and female students' digital skills, Intel (2013) discovered that half of the interviewed women are unfamiliar or uncomfortable with technology. This low self-efficacy level has a negative impact on females' willingness to use new technologies. Women are also more reflective when using the internet, whereas boys rely on trial and error (Azzolini & Schizzerotto, 2017). The Technological Pedagogical Content Knowledge (TPACK) model is a helpful tool for analyzing these dynamics since it assesses educators' use of technology in content and pedagogy. There has been some research on the association between gender and TPACK. According to Koh et al. (2010), male pre-service teachers in Singapore had more technological and topic expertise than female pre-service

teachers. Lin et al. (2013) examined age, gender, teaching experience, and TPACK among pre- and in-service teachers in Singapore. The results revealed that females have much higher PK (pedagogical knowledge). Females exhibited lower technological knowledge (TK) than males.

On the other side, Koh and Chai (2011) investigate how pre-service teachers' age and gender relate to TPACK domains. The findings indicated that gender had no significant influence on TPACK components. Similarly, Bakar et al. (2020) suggested that there is no gender difference in teachers' self-efficacy for TPACK and technology integration. Similarly, Castéra et al. (2020) discovered no difference in participants' perceptions of TPACK based on their gender. Prasojo et al. (2020) sought to investigate the viewpoints of Indonesian EFL in-service teachers on their TPACK. 573 teachers completed the survey. The findings indicate that teachers are inadequate in TK, despite believing they have an appropriate PK level. The study also found that female participants had greater perceptions of all areas of TPACK than male participants. There were no significant differences in CK, PK, or PCK levels among age groups. However, there were significant differences in TK, TPK, TCK, and TPACK.

Sepriyanti et al. (2024). The study's goal is to compare the TPACK skills of mathematics teachers in Sumatra by gender. The findings show that mathematics teachers in Sumatra have a high level of TPACK abilities, with gender influencing both pedagogical and subject knowledge areas. Male teachers, in particular, do better in these fields than their female counterparts. Furthermore, men teachers use technology in the classroom more frequently and integrate TPACK with greater flexibility than female teachers.

2.10 Assessing TPACK Among Teacher Educators and Prospective Teachers

Mishra and Koehler (2006) developed the TPACK framework, which has become a standard technique to analyzing how teachers incorporate technology, pedagogy, and topic knowledge. TPACK has been measured using a variety of evaluation instruments, each with its own set of approaches and issues. These instruments, frequently in the form of self-assessment questionnaires, observation procedures, or performance-based activities, seek to capture how teachers mix and apply these domains in practice. However, developing psychometrically sound measures for such complex and linked characteristics remains a considerable issue (Chai, Koh, & Tsai, 2016).

Schmidt et al. (2009) developed the Survey of Preservice Teachers' Knowledge of Teaching and Technology (SPTKTT), which measures seven TPACK domains. Despite its popularity, the SPTKTT has received criticism, particularly for its validation procedure, which involved performing principal component analysis (PCA) independently for each area rather than holistically (Chai et al., 2011). Furthermore, when applied to various content areas at the same time, its approach to content-related constructs causes interpretation challenges, prompting some researchers to question its effectiveness for cross-disciplinary evaluation (Chai et al., 2016).

Following the SPTKTT, a number of tailored instruments evolved to meet specific technological and educational approaches. For example, Koh, Chai, and Tsai's (2014) C-TPACK questionnaire focuses on constructivist pedagogy, whereas Lee and Tsai's (2010) TPCK-W examines self-perceptions of TPACK in web-based contexts. These instruments apply the TPACK model to specialized contexts, although they also face psychometric issues in distinguishing all seven components. Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) studies frequently show that

some TPACK elements, such as TCK and PCK, do not load as distinct factors (Chai et al., 2011; Archambault & Barnett, 2010), implying persistent overlap and challenges in empirical validation.

The TPACK-21 instrument, developed by Valtonen et al. (2017), is a recent addition to the TPACK assessment instruments that combines the TPACK framework with 21st-century abilities like teamwork, problem-solving, and digital literacy. This tool is an essential step toward meeting the changing demands of modern education, acknowledging that effective technology use in classrooms requires more than just fundamental technological expertise. By integrating abilities required for 21st-century learning, the TPACK-21 instrument attempts to give a more thorough assessment of teachers' competence to incorporate technology in ways that promote these skills. However, as with previous TPACK instruments, the TPACK-21 questionnaire confronts issues in maintaining a different factor structure across TPACK domains, particularly when incorporating extra constructs that may overlap with TPACK's fundamental components.

Schmid et al. (2020) used a self-report questionnaire to assess pre-service teachers' perceived TPACK competencies across all seven domains, alongside an analysis of 173 lesson plans to examine actual technology integration. They applied statistical methods like t-tests, ANOVAs, cluster analyses, and regression analyses to explore the relationship between self-reported TPACK and real-world teaching practices. Their findings revealed a disconnect between teachers' perceived technological abilities and their actual application in lesson planning, suggesting that self-assessments alone may not provide an accurate measure of teachers' ability to integrate technology effectively.

Some research has successfully validated TPACK tools that align with the theoretical framework of the model. For instance, Koh et al. (2013) used CFA and path modeling to support a seven-factor structure, although their results raised concerns about the TPACK construct's indirect effects on itself. Likewise, Chai et al. (2013) and Valtonen et al. (2015) reported positive outcomes in aligning TPACK factors with two categories of subject knowledge, indicating progress in overcoming structural challenges identified in earlier assessments. In summary, while many TPACK evaluation tools offer valuable insights into teachers' technological and pedagogical skills, they still encounter psychometric challenges, especially in differentiating factors and ensuring cross-cultural relevance. As the field evolves, integrating new competencies, such as those found in the TPACK-21 assessment, could lead to a more comprehensive understanding of teachers' readiness to implement technology in various skill-based educational contexts.

2.11 Challenges and Barriers to TPACK Development

Integrating Technological Pedagogical Content Knowledge (TPACK) into teacher education programs is critical for educating educators to use technology effectively in the classroom. However, several problems and barriers impede the development of TPACK among teacher educators and potential teachers. These barriers include general concerns with technology acceptance, gender challenges, and institutional limits, all of which must be addressed in order for TPACK integration to be successful.

2.11.1 Barriers to Effective TPACK Integration

The Technological Pedagogical Content Knowledge (TPACK) framework highlights the relevance of using technology in teaching and learning. However, various impediments prevent effective implementation among teacher educators and potential

teachers. Ertmer (1999) distinguished between two categories of obstacles: the first-order and the second-order barriers. First-order hurdles include external factors such as availability of technological devices, time, support, and training for professional development, whereas second-order barriers include internal factors such as instructors' confidence in utilizing technology and belief in its effectiveness in education.

Dinc, E. (2019) The study investigated preservice teachers' attitudes on technology integration and identified potential barriers to its implementation in education. The study revealed that future teachers hold important views on integrating technology into education. They believe it's crucial to use technology effectively, include it in the curriculum, boost student engagement, and make course content more visual. They also see the value in working with school leaders to implement technology and in learning to teach with tools that can't be taught in advance. However, they face both external and internal challenges. Key obstacles include limited funding, insufficient equipment, a lack of skills, and time constraints. As Makawawa (2021) points out, one of the biggest issues is the shortage of technology resources and infrastructure needed to support offline, online, and blended learning approaches.

The lack of necessary technological resources creates a significant barrier to the seamless implementation of distance learning projects. Muliani et al. (2024). the goal of this study is to conduct qualitative studies using semi-structured interviews and examine teachers' daily notebooks about the technologies employed in their teaching and learning processes, as well as the challenges they confront while integrating these technologies. The study found that following the epidemic, the 10 teachers used a variety of technologies, including Google Meet, Google Classroom, and WhatsApp Groups. It also identified several common challenges that teachers face when using these technologies, including hardware and software issues, connectivity problems,

financial constraints, concerns about personal information security, a lack of technical support, decreased face-to-face interaction, psychological challenges, and language barriers.

Hechter and Vermette (2013), the biggest challenges teachers face when trying to integrate technology into their classrooms are a lack of resources, time, training opportunities, and financial or administrative support. Keengwe, Onchwari, and Wachira (2008) point out that the main obstacles include not having enough training, inadequate equipment, limited time, insufficient support from school leaders, and technical difficulties. Nikolopoulou and Gialamas (2015) found that teacher's ability to use technology is often limited by issues like insufficient funding, lack of technical and administrative support, inadequate training, and limited access to the necessary tools and equipment.

Hur et al. (2016) highlighted several challenges that hinder the effective integration of technology in classrooms, such as a shortage of technical equipment, limited computer labs, and unreliable internet connections. Kilinc et al. (2018) found that teachers identified key barriers, including insufficient access to technology, lack of resources, and inadequate administrative and technical support. Blocher et al. (2011) emphasized the importance of professional development, showing that it significantly enhances teachers' ability to use technology effectively. Wong (2015) and Miranda and Russell (2012) discovered that teacher's willingness to adopt technology in their teaching largely depends on their belief in its potential to help achieve specific educational goals.

Many teachers wish to integrate technology into their classroom instruction (Aslan & Zhu, 2015; Kimmons & Hall, 2016) but lack the compulsory understanding to do so effectively. According to Alkhawaldeh and Menchaca (2014), variables

influencing technology incorporation in education include a lack of capacity and confidence.

Accordingly, Kim et al. (2013) found that teachers' technology integration strategies influence their opinions about effective teaching methods. Teachers' use of technology rises when they have technology integration experiences in education (Kim et al., 2013). They feel more at ease, which influences their success in incorporating technology. Yanis and Yuruk (2021) discuss the relevance of teacher willingness to embrace technology and incorporate it into the educational landscape. Teachers' motivation and commitment play an important part in deciding how effectively technological tools are used to enhance the learning experience, influencing the overall effectiveness of distance learning programs.

2.12 Gender-Related Challenges in Adopting TPACK

2.12.1 Confidence and Self-Efficacy

Male and female educators may embrace TPACK differently because of differences in self-confidence and self-efficacy. Male educators frequently report feeling more competent in utilizing technology, which is affected by societal attitudes that traditionally link technical skills with men. Female educators may lack confidence, which can limit their readiness to employ technology in the classroom. Providing supportive training can boost female educators' confidence levels. Bakar et al. (2020) suggested that there is no gender difference in teachers' self-efficacy for TPACK and technology integration.

2.12.2 Access to Technology and Professional Development

Access to technology and chances for professional development might be inconsistent, with female educators possibly facing difficulties due to institutional biases or personal responsibilities. Professional development programs are frequently

more accessible to individuals who are already comfortable with technology, which may disadvantage certain female educators. Providing flexible and accessible training can assist in overcoming these issues.

2.13.2.1 Perceptions of Technology Use

Perceptions of technology use vary, with male educators frequently perceiving it as a beneficial teaching tool, whereas female educators may perceive it as an additional challenge. Earlier experiences and a lack of female role models in tech-integrated education could explain this disparity. Highlighting successful female instructors who use technology well can foster a more positive attitude toward its utilization. Castéra et al. (2020) discovered that the participants' views of TPACK did not differ based on gender.

2.12.2.2 Strategies for Developing TPACK

The development of Technological Pedagogical Content Knowledge (TPACK) in teacher education is becoming more crucial in the digital age. Effective TPACK techniques involve a combination of institutional support, educator engagement, and intentional technology incorporation into curricula. This section covers modern methods of TPACK development, with an emphasis on teacher educators, institutional policy, and curricular design.

2.13 The teacher education in Pakistan focuses on important concerns and challenges at all levels of teacher education in Pakistan.

2.13.1 Challenges in Pakistani Teacher Education

Teacher education in Pakistan plays a vital role in shaping the country's educational landscape, as it significantly affects the quality of teaching and learning in schools. However, it encounters a variety of challenges that impede its effectiveness and restrict its capacity to develop well-trained, competent, and motivated teachers.

These challenges are complex, stemming from systemic issues and practical limitations, and are further intensified by persistent underfunding. Together, these factors adversely affect the overall quality of education in the nation. Below is a comprehensive discussion of the challenges confronting teacher education in Pakistan.

2.13.1.1 Outdated Curriculum and Pedagogy

The curriculum in teacher education programs in Pakistan often falls behind current educational practices. Many institutions still depend on traditional rote-learning techniques instead of promoting critical thinking, creativity, and problem-solving abilities (UNESCO, 2019). There is a noticeable lack of focus on innovative teaching methods, the integration of technology, and student-centered learning approaches, all of which are crucial for equipping teachers to address the challenges of the 21st century. This stagnation can be attributed in part to inadequate funding for curriculum development and the implementation of modern teaching practices (Ali, 2021).

2.13.1.2 Inadequate Training and Professional Development

The entry requirements for teacher education programs are often low, attracting candidates who may not have the necessary academic background or passion for teaching. This results in a pool of teachers who may lack the subject knowledge, pedagogical skills, and motivation required to effectively educate students. Additionally, many teacher training institutions suffer from a shortage of qualified and experienced faculty. Teacher educators themselves often lack training in modern pedagogical techniques, which limits their ability to model effective teaching practices for their students.

2.13.1.3 Low Entry Standards and Quality of Teacher Educators

Teacher education in Pakistan frequently suffers from political interference, resulting in the appointment of unqualified individuals to important roles within

educational institutions (Khan, 2020). Furthermore, although there are policies and reforms designed to enhance teacher education, their execution is often weak or inconsistent, creating a disconnect between policy and practice. This issue is partly attributed to insufficient financial resources dedicated to monitoring and evaluation mechanisms (World Bank, 2018).

2.13.1.4 Insufficient Resources and Infrastructure

Many teacher training institutions in Pakistan struggle with limited resources, such as insufficient libraries, outdated technology, and poorly equipped classrooms (Ali, 2021). The absence of modern teaching tools and resources significantly hampers teacher educators' ability to provide high-quality training. These infrastructure challenges stem from chronic underfunding, with the education sector receiving less than 2-3% of Pakistan's GDP, which is well below the recommended global standard of 4-6% (World Bank, 2018).

2.13.1.5 Gender Disparities

Gender differences in teacher education present a major challenge, especially in rural regions. Female educators frequently encounter cultural and societal obstacles that hinder their ability to pursue or complete their education and training (Government of Pakistan, 2017). This gender imbalance within the teaching workforce can adversely affect girls' education, as female teachers tend to be more adept at meeting the needs of female students. Additionally, funding limitations exacerbate this problem, as there is often a shortage of resources for gender-sensitive programs and initiatives (UNESCO, 2019).

2.13.1.6 Political Interference and Weak Policy Implementation

Teacher education in Pakistan frequently suffers from political interference, resulting in the appointment of unqualified individuals to important roles within

educational institutions (Khan, 2020). Furthermore, although there are policies and reforms designed to enhance teacher education, their execution is often weak or inconsistent, creating a disconnect between policy and practice. This issue is partly attributed to insufficient financial resources dedicated to monitoring and evaluation mechanisms (World Bank, 2018).

2.13.1.7 Low Status and Motivation of Teachers

The teaching profession in Pakistan is frequently seen as undervalued, characterized by low salaries and few opportunities for career advancement (Ali, 2021). This situation negatively impacts teachers' motivation and morale, resulting in high turnover rates and a lack of dedication to their work. Additionally, the low regard for teachers deters talented individuals from entering the field, which further deteriorates the quality of the teaching workforce. Funding shortages significantly contribute to this problem, as insufficient budgets restrict the ability to offer competitive salaries and incentives for educators (Government of Pakistan, 2017).

2.13.1.8 Regional Disparities

There are notable differences in the quality of teacher education between urban and rural regions. Teacher training institutions in rural areas frequently struggle with limited resources, inadequate infrastructure, and a shortage of qualified faculty compared to those in urban centers (UNESCO, 2019). This gap leads to unequal educational outcomes, with students in rural areas often receiving a lower quality of education than their urban peers. Additionally, the uneven distribution of funding exacerbates this issue, as rural institutions typically receive much less financial support (World Bank, 2018).

2.13.1.9 Assessment and Evaluation Challenges

The assessment methods employed in teacher education programs frequently fall short, emphasizing memorization instead of the practical application of knowledge and skills (Khan, 2020). Additionally, there is a notable absence of thorough evaluation mechanisms to guarantee that these programs are achieving their goals and producing capable teachers. Financial limitations hinder the development and implementation of effective assessment tools and systems (Ali, 2021).

2.14 Effective Approaches to Fostering TPACK Skills in Teacher Education

2.14.1 Role of Teacher Educators and Collaborative Learning

Teacher educators play an important role in creating collaborative learning environments that encourage the development of Technological Pedagogical Content Knowledge (TPACK) among pre-service teachers. Teacher educators enhance prospective teachers' TPACK competencies by demonstrating the integration of technology, pedagogy, and content knowledge through collaborative methods such as peer mentorship, co-teaching, and professional learning communities. These collaborative settings also promote critical thinking, problem-solving, and the exchange of best practices, all of which are essential for adapting to the changing needs of digital-age education (Koehler et al., 2013; Tondeur et al., 2012).

2.14.2 Institutional Policies and the Use of Digital Tools and Resources

The institution's involvement is a key contextual aspect in determining how learners build digital literacies and other technology-assisted practices necessary for success in the digital age. To enhance digital learning, institutions need to implement comprehensive strategies and regulations that operate at the system level. This approach should stimulate bottom-up innovation processes that have a broad impact across the

entire institution (SURF, 2022). Higher education is observing the emergence of three distinct types of provision: degree education, continuing education and professional development, and open education. Educational technology plays a significant role in all three areas. As off-campus students seek greater flexibility to enhance access and scalability through learning that is independent of location and time, the impact on continuing education is expected to be more pronounced.

Most countries have not yet fully developed continuing education and open education, despite the fact that these areas should be included in every higher education system (Hub, B., 2022). Higher education institutions are looking for policies and strategies to establish their profile in these areas, which can complement and overlap to some extent (Haywood et al. 2015). The European Maturity Model for Blended Education (EMBED) maturity model defines institutional policies as leadership, strategies, and conditions relating to the structure and support of digital learning. Several essential actors, teams, or agencies participate in the decision-making process, including program coordinators, deans, and central and decentralized educational and ICT support services (Dijkstra and Goeman, 2021).

2.14.3 Incorporating TPACK into Curriculum Design

The Technological Pedagogical Content Knowledge (TPACK) model (Mishra & Koehler, 2006) is one of the most commonly used in educational settings. Niess et al. (2009) adapted the generic TPACK model for mathematics education objectives, developing TPACK mathematics standards as well as a model that describes the evolution of this content-specific construct toward satisfying the standards. The success and impact of these techniques are strongly dependent on how well technology is integrated into teacher education programs. Kay's (2006) review of strategies for incorporating technology into preservice education identified several effective

practices, including offering mini workshops, embedding technology across all courses, demonstrating its use, encouraging collaboration among preservice teachers, mentor teachers, and faculty, providing hands-on experience with technology in real-world settings, and ensuring better access to software, hardware, and support. Earlier methods frequently depended on independent educational technology courses, which have proven to be ineffective at teaching practical skills (Saad, 2013; Voithofer et al., 2019). More recent research indicates that integrating technology across the curriculum greatly enhances learning opportunities for future educators (Yigit, 2014; Foulger et al., 2017). However, teacher education programs continue to face the difficulty of instructional technology being considered as an add-on (Voithofer & Nelson, 2020).

2.15 Professional Development, Mentorship, and Ongoing Support

2.15.1 The Impact of Continuous Professional Development on TPACK Growth

Continuing Professional Development (CPD) is a process of continuous learning to maintain and improve professional skills, knowledge, and competences throughout one's career. CPD is intended to help professionals keep current in their fields and enhance their work. It can involve activities such as attending workshops, training sessions, and engaging in mentoring or reflective practices. CPD aims to promote lifelong learning and continual progress, allowing professionals to adapt to industry changes while maintaining high standards of practice. Nessaei et al. (2024). This study aimed to explore the connection between Iranian EFL (English as a Foreign Language) instructor's understanding of technical pedagogical content knowledge (TPCK) and their readiness to participate in continuous professional development (CPD) courses. The results show a significant link between instructor's grip of TPCK and their willingness to engage in CPD programs. Regression analysis indicates that various aspects of technological pedagogical content knowledge strongly influenced

Iranian EFL teacher's interest in attending CPD courses. The study concluded that ongoing professional development, combined with a solid understanding of TPACK, plays a crucial role in fostering essential qualities for effective teaching, such as language proficiency, positive student-teacher relationships, stress-free learning environments, and other personal attributes vital for successful foreign language education.

Bunane and Karegeya (2022) found that chemistry teachers value CPD programs for enhancing their pedagogical and content knowledge, which subsequently improves the quality of teaching and learning in chemistry. Sibomana et al. (2022) suggest that educational stakeholders should prioritize developing CPD initiatives to equip chemistry teachers with the skills needed to effectively communicate complex concepts. Mugiraneza (2021) noted that Rwandan teachers in biology, chemistry, physics, and mathematics emphasize the importance of regular training and workshops to strengthen their subject knowledge, ICT skills, and ability to use teaching tools effectively. CPD can assist teachers in enhancing their curriculum, pedagogy, and ICT capabilities; in most cases, teacher professional development consists of updating or introducing new tools or abilities. It is seen as an essential component of education (Essien et al., 2016). As a result, increasing teacher's efficiency and effectiveness, as well as the quality of education, is vital (Ndiokubwayo, 2017). Effective educator professional development leads to improved instruction and learning. Professional development is a continual requirement for instructors, particularly in science and mathematics, which are areas covered in rigorous state programs.

Rokhyati (2015) emphasizes the importance of continual professional development courses for EFL teachers. Without this training, teachers struggle to comprehend how to design successful and suitable teaching approaches. Teachers that

engage in continual professional development appear to employ more appropriate and efficient teaching strategies, and their students appear to be more proficient with them. Professional development courses may help instructors identify and apply appropriate solutions to demanding and complex classroom situations. Smith and Benavot (2019) state that allowing instructors to engage in continuing professional development courses will lead to long-term success in educational programs. This is essential because, in some fields, such as driving, professional growth may come to an end when a person reaches a specific age. However, the teaching profession is marked by long-term and continual lifelong professional growth.

2.15.2 The Role of Mentorship and Peer Collaboration

Mentoring and peer collaboration are critical components of personal and professional development in many disciplines. They offer individuals leadership, support, and opportunity for advancement, creating a climate conducive to learning and innovation.

2.15.2.1 Mentorship

Mentorship is a relationship in which a more experienced person (the mentor) guides, advises, and supports a less experienced individual (the mentee). This relationship can have a tremendous impact on the mentee's career path and personal growth. Mentoring, when combined with other strategies, could be regarded as an effective way to support and address the requirements of instructors in small groups or individually during the technology integration process (Baran, 2016). Belt and Lowenthal (2020) found that mentorship was an effective technique for developing educators' teaching skills with technology after reviewing relevant papers from 2013 to 2018. Although the literature does not provide a clear definition of mentoring, it can be considered an exchange of experiences between a professional and a novice. Mentoring,

as defined by Gabriel and Kaufield (2008), is "a nurturing process, a relationship, and, occasionally, a role reversal." Gökoğlu and Çakıroğlu (2017) found that mentoring improves instructors' digital literacy, instructional skills, ethics and policies, professional growth, and organizational and managerial abilities. Mentoring has been found to help faculty members learn current instructional technologies and create courses that include new technology practices (Baran, 2016). Mourlam (2017) introduced TPACK to 5 teacher education faculty members and advised them on how to implement technology-based instruction. The participants appreciated the faculty developer's assistance in accomplishing their goals. Furthermore, the mixed-method study discovered that both faculty and pre-service teachers who participated in the courses improved their TPACK.

Koh's (2020) study found that one-on-one mentorship for faculty in technology-enhanced education significantly supports the development of their TPACK (Technological Pedagogical Content Knowledge). She recommended that mentoring programs should concentrate on three main areas: demonstrating technology use, adjusting teaching methods to be more student-centered, and enhancing practical skills. By demonstrating technology, faculty establish a solid foundation in technological knowledge (TK) and technological pedagogical knowledge (TPK), which are crucial for TPACK development. Pedagogical adjustment aids educators in transitioning to student-centered approaches, thereby improving their pedagogical content knowledge (PCK). At the same time, enhancing practice enables faculty to bolster their TK, TPK, PCK, technological content knowledge (TCK), and overall TPACK. In a study by Yu and Karakaya (2018), paired teacher educators with graduate students to investigate the effects of a one-on-one TPACK mentorship program. The educators involved reported that the mentorship experience significantly enhanced their technological knowledge

(TK), technological content knowledge (TCK), and technological pedagogical knowledge (TPK). These results underscore the importance of personalized mentorship in assisting educators to effectively integrate technology into their teaching practices.

2.15.2.2 Peer Collaboration

Peer collaboration, on the other hand, entails individuals working at the same level to achieve common objectives. This collaborative method promotes community and shared accountability, which can improve learning results. When group members share common interests, they build bonds and mutual trust, which boosts their self-efficacy and enthusiasm for teaching. Collaboration also assists teachers in identifying knowledge gaps and developing collective knowledge (Donnelly & Hume, 2015). According to research on TPACK, online collaborative learning is significant in assisting participants in co-constructing their knowledge (Saito & Atencio, 2016; Zhang et al., 2019) via learning by design (Yeh et al., 2021).

Collaborative learning opportunities are available through a variety of formats, including e-classrooms (Kurth et al., 2022), blended learning (Al-Samarraie & Saeed, 2018; Papanikolaou et al., 2017), flipped classrooms (Herrera-Pavo, 2021), and interactive simulations (Cummings et al.). Online collaborative learning has been used successfully to better understand pre- and in-service teachers' knowledge and TPACK growth. Such learning strengthens connections among teacher trainees in a learning community (Chong & Kong, 2012; Saito & Atencio, 2016). In practice, instructors' online collaborative learning may involve a combination of face-to-face engagement and online collaboration (asynchronous Facebook conversations and email, or synchronous web-conferencing meetings) (Yeh et al., 2021). Although the aforementioned benefits have been offered, the literature suggests that there is currently a lack of attention paid to the possible growth of collective TPACK aided by a

collaborative learning environment that incorporates learning by design (Yeh et al., 2021).

In summary, mentorship and collaboration with peers play a vital role in both personal and professional growth. They provide individuals with the support, knowledge, and skills necessary for success in their careers. By fostering these relationships, organizations and educational institutions can cultivate environments that promote continuous learning and innovation.

2.15.3 Support Systems for Ongoing TPACK Competency Development

For educators looking to effectively integrate technology into their teaching, having robust support systems to develop and sustain their Technological Pedagogical Content Knowledge (TPACK) is crucial. TPACK is a framework that emphasizes the relationship between technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK), which is vital for improving both teaching and learning outcomes (Mishra & Koehler, 2006). One of the most beneficial support systems is professional development opportunities, such as ongoing workshops and online courses designed to help educators incorporate technology into specific subjects. These programs assist teachers in enhancing their TPACK skills (Harris & Hofer, 2011; Voogt et al., 2013). Collaborative environments, such as Professional Learning Communities (PLCs) and mentorship programs, also play a significant role in the growth of TPACK. These settings enable educators to share ideas, strategies, and resources while receiving tailored support from colleagues and mentors (Trust et al., 2016; Koehler et al., 2014). Furthermore, access to technological tools and resources—like tech-enhanced classrooms and Open Educational Resources (OERs)—provides teachers with opportunities to experiment and apply their TPACK knowledge in practical, real-world contexts (Archambault & Crippen, 2009; Cox & Graham, 2009). Reflective practices,

such as maintaining teaching portfolios or participating in action research, further aid in TPACK development. These approaches encourage educators to assess their technology-integrated lessons and investigate how technology influences student learning (Niess, 2011; Schmidt et al., 2009). Institutional support is equally important, as administrative backing and clear policies ensure that educators have the time, funding, and resources necessary for professional growth and innovation (Mishra & Koehler, 2006; Voogt et al., 2013). In addition to formal structures, online communities—like Twitter chats, educational blogs, and forums—offer spaces for educators to exchange ideas, share resources, and keep up with the latest trends in TPACK (Trust et al., 2016). By utilizing these various support systems, educators can consistently enhance their TPACK skills, resulting in a more effective and meaningful use of technology in the classroom.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Research Design

This quantitative study used a survey research design to measure the levels of Technological Pedagogical Content Knowledge (TPACK) among teacher educators and prospective teachers at the university level. Quantitative methods were employed to facilitate the methodical collection and analysis of numerical data, while a descriptive approach was used to characterize and summarize the data. The study was quantitative and used a survey research strategy, which involved collecting and analyzing numerical data relating to TPACK scores using validated survey instruments.

3.2 Population of the Study

The population of this study consisted of teacher educators and prospective teachers from the International Islamic University Islamabad and the University of Swat, both of which have education departments. The total number of teacher educators was 14, and the number of prospective teachers was 263. Specifically, the Department of Educational Leadership and Management at the International Islamic University Islamabad was included, with 8 teacher educators and 210 prospective teachers from the 4th and 5th semesters. At the University of Swat, the study included 6 teacher educators and 53 prospective teachers from the 4th and 5th semesters. These universities were selected to encompass teacher educators and prospective teachers from both institutions.

3.2.1 Characteristics of the population

The characteristics of the population included the professional experience and academic qualifications of the teacher educators, as well as the educational background and academic progress of the prospective teachers. These universities were selected to

encompass a diverse group of teacher educators and prospective teachers, providing a comprehensive overview of both institutions.

3.2.2 Rational of selection of universities

The rationale for selecting these universities was based on their well-established education departments, which provided a representative sample of teacher educators and prospective teachers. The diversity in academic programs and the educational environments at these institutions offered a comprehensive perspective on the subject matter, enhancing the generalizability of the study's findings. These universities were selected to encompass a diverse group of teacher educators and prospective teachers, providing a comprehensive overview of both institutions.

Table 1

Population of the study

S.NO	Name of universities	Number Teachers Educators	Number prospective teachers
1	International Islamic University Islamabad	8	210
2	University of swat	6	53
TOTAL		14	

3.2.3 Sample Selection

The sample of the study consisted of 14 teacher educators and 100 prospective teachers. The Universal Sampling Technique was used for the selection of teacher educators, and the Stratified Random Sampling Technique was used for the selection of prospective teachers, with 50 students selected from each university. This approach ensured a diverse representation within the selected institutions.

Table 2 *Sample of the Study*

S.NO	Name of Universities	Selected Number Teachers Educators	Selected Number Prospective Teachers
1	International Islamic University Islamabad	8	50
2	University of swat	6	50
TOTAL		14	100

3.2.4 Justification for Sample Selection

In response to the concern regarding the sample selection—specifically, the selection of 50 prospective teachers (PTs) from each university despite population differences—the following justification is provided:

The total sample of the study consisted of 14 teacher educators and 100 prospective teachers. For teacher educators, a Universal Sampling Technique was applied, as their population was limited and manageable across both institutions. For prospective teachers, a Stratified Random Sampling Technique was used, selecting 50 students from each university to ensure balanced institutional representation.

It is important to note that:

- The University of Swat, which follows a co-education system, had a total population of 53 final-year prospective teachers (combined 4th and 5th semesters). Hence, selecting 50 from this population represents a near-census approach, covering 94% of the population.
- International Islamic University Islamabad (IIUI) maintains separate campuses for male and female students, which naturally results in a larger overall population of final-year prospective teachers. However, to maintain comparability and equal representation from both institutions, 50 students were randomly selected using stratified sampling from the male and female campuses.

This sampling strategy was purposefully chosen to:

1. Ensure equity and balance in institutional representation.
2. Reflect gender diversity, particularly relevant due to the gender-segregated structure at IIUI.
3. Keep the study methodologically consistent and manageable, considering logistical and analytical constraints.

This approach is commonly accepted in comparative research where equal sample sizes are used to enable fair and valid comparisons between groups, especially when institutional contexts differ.

3.3 Instruments for this Study

This study utilized a well-established TPACK survey instrument and a structured questionnaire to collect data, drawing upon previous research in the field. Both instruments employed a five-point Likert scale, ranging from 'strongly disagree' to 'strongly agree,' to ensure precise measurement of participants' responses. The TPACK framework, which consists of seven distinct components, served as the basis for the questionnaire. Five statements were developed for each component, resulting in a total of 35 items.

To address the specific perspectives of the two participant groups, separate questionnaires were constructed for teacher educators and prospective teachers. The majority of the items were adapted from validated tools developed by Schmidt et al. (2009) and Schmid et al. (2020). In addition, several items were incorporated from the TPACK-21 instrument created by Valtonen et al. (2017), which integrates the TPACK framework with 21st-century competencies such as collaboration, critical thinking, and digital literacy. Further enrichment of the questionnaire was achieved by including

selected items from the studies conducted by Nguyen Van Loi (2021) and Fuad et al. (2020).

3.4 Validity

Validity is about how accurately something is measured (Clark, 2014). To ensure the tools used in the study were valid, experts in the field reviewed them and confirmed their accuracy. Based on their feedback and suggestions, the tools were adjusted and improved to enhance their clarity, relevance, and alignment with the research objectives. Although the questionnaire was adopted, it was necessary to re-check its validity because tools developed in one context may not fully suit a different population or setting. Reassessing validity ensures the instrument remains appropriate, understandable, and relevant to the new participants.

During the validation process, some items were revised for better clarity, cultural relevance, and alignment with the study objectives. This process involved careful review by subject matter experts who provided written and verbal suggestions. Items that were found to be ambiguous, redundant, or less relevant were either modified, reworded, or replaced based on the recommendations received.

To establish content validity, the researcher reviewed relevant literature and consulted with experienced professionals in the field. Certificates of validity were also obtained from these experts to confirm the accuracy and appropriateness of the research instruments.

3.5 Pilot Testing

Pilot testing is like a trial run for a test or survey, where a small group of people take it and provide feedback on how it works. They help identify any issues, such as unclear instructions, confusing questions, formatting errors, or typos. The goal is to

ensure that everyone taking the test understands the questions in the same way and that there are no misunderstandings.

After the questionnaires were reviewed and refined with input from experts, they were shared with 20 participants who were not part of the main study. Once these participants completed the questionnaires, their feedback was used to make further improvements and adjustments to ensure the questions were clear and effective

3.5.1 Reliability

Reliability is all about how consistent and dependable a measurement tool is in producing similar results when used under the same conditions Taherdoost, (2022). In simpler terms, it tells us how stable and error-free a test is over time. If there are too many errors, the results become less trustworthy Creswell & Creswell, (2017). To check the reliability of the survey questionnaire, the researchers used Cronbach's alpha, a statistical method that measures internal consistency. The overall reliability score was 0.87, which shows that the questionnaire is highly consistent and reliable.

3.6 Data Collection

The data collection process was carefully planned to ensure everything ran smoothly, participation was maximized, and the results would be as reliable as possible. To keep things organized, Google Sheets was used to manage and track incoming responses. Surveys were shared electronically through email and WhatsApp, along with clear instructions to help participants complete them without difficulty. Participants were given plenty of time to respond, and gentle reminders were sent out to encourage participation and reduce the chances of missing responses.

Data collection unfolded in three main phases. In the first phase, the questionnaires were shared with teacher educators and prospective teachers at the

International Islamic University Islamabad (IIUI) and the University of Swat, using email and WhatsApp as the primary channels.

When the initial response rate turned out to be lower than expected, the second phase involved visiting both institutions in person. At IIUI, the researcher met with teacher educators from the Male Campus and distributed questionnaires directly to students who were on-site. To broaden the reach, the survey links were also shared in student WhatsApp groups. For the Female Campus, with respect to institutional protocols, departmental staff helped in distributing the survey among female students.

In the third phase, the researcher visited the University of Swat again to collect more responses in person. Teacher educators were engaged directly, and students who were available at the time were asked to complete the survey. WhatsApp was once again used to circulate the link and ensure better accessibility.

Throughout all phases, the researcher personally oversaw every step of the process—from designing the instruments to sharing the surveys and keeping track of responses. Because the instruments were self-administered and standardized, participants had a consistent experience, which helped support the reliability of the data.

By the end of the process, responses had been successfully collected from 12 out of 14 teacher educators and 97 out of 100 prospective teachers—a strong response rate that reflected both careful planning and a well-executed data collection strategy.

3.7 Data Analysis

To summarize the participant's TPACK scores and survey responses, descriptive statistics such as Means, Standard Deviations, and Frequency Distributions were calculated. The overall TPACK scores, which were measured on a Likert scale from 1 to 5, were then grouped into three levels of proficiency:

1 to 2.99: Low TPACK: This category indicated lower proficiency in TPACK, suggesting potential challenges with technology integration and a need for targeted professional development to enhance skills.

3 to 3.99: Average TPACK: This category reflected moderate proficiency, demonstrating general competency in TPACK with identifiable areas for improvement.

4 to 5: High TPACK: This category signified advanced proficiency, indicating confidence in integrating technology into teaching practices and the potential to take on leadership roles in technology-enhanced education.

Inferential Statistics

To examine potential differences in TPACK scores between male and female participants, an independent samples t-test was conducted. This analysis compared the mean TPACK scores of the two groups to determine if any statistically significant differences existed. All statistical analyses were performed using SPSS (version 26), ensuring robust and reliable results.

3.8 Ethical Consideration

Before starting the study, we received ethical approval from the appropriate institutional review board to ensure the research followed all necessary ethical guidelines and standards. Every participant provided informed consent, clearly understanding that their involvement was completely voluntary and that they could withdraw from the study at any point without any consequences. To protect their privacy, we kept all participant information confidential and anonymous. Data was collected and reported in a way that focused on group-level findings, ensuring no individual could be identified.

CHAPTER 4

DATA ANALYSIS AND INTERPRETATION

This chapter presents the outcomes of the data analysis conducted as part of this research. The data collection and processing were directly aligned with the research goals established in Chapter 1 of this dissertation. The main focus of the study was to evaluate the Technological Pedagogical and Content Knowledge (TPACK) levels among both teacher educators and prospective teachers, while also exploring whether there were any gender-based differences in these competencies. Specifically, the research aimed to compare the TPACK scores of male and female teacher educators, as well as male and female prospective teachers at the university level. In this chapter, the data collected through the research instruments are described in detail, followed by a thorough statistical analysis and interpretation of the findings. Descriptive statistics, such as means, frequency distributions, and standard deviations were used to summarize the participant's TPACK scores. The total TPACK scores were also grouped into three categories—low, average, and high proficiency—based on predefined score ranges. To further analyze the data, an independent t-test was employed to compare the average TPACK scores between male and female participants. All statistical analyses were performed using SPSS (version 26), and the results are presented in tables to make them clear and easy to understand. The study was structured to test two null hypotheses related to gender differences in TPACK competencies, as outlined in Chapter 1. These hypotheses were examined using appropriate statistical methods to determine whether there were any significant differences in TPACK scores between male and female teacher educators and prospective teachers.

Objective no.1 To evaluate the levels of Technological Pedagogical and Content Knowledge (TPACK) among teacher educators.

Table 4.1 *Content Knowledge of Teacher Educators*

Dimension	Proficiency Level	Frequency	Percentage	Mean	Std. Deviation
CK	Low				
	Average	3	25.0		0.43866
	High	9	75.0	4.3833	
	Total	12	100		

Table 4.1 shows that 75% of teacher educators achieved a high level of content knowledge proficiency, while 25% were at an average level. The mean Content Knowledge (CK) score is 4.38, indicating strong overall competency. The standard deviation is low (0.44), meaning most scores were very close to the average. The results suggest that teacher educators have strong content knowledge, with most (75%) demonstrating high proficiency. This reflects their confidence and expertise in their subject areas.

Table 4.2 *Technological Knowledge of Teacher Educators*

Dimension	Proficiency Level	Frequency	Percentage	Mean	Std. Deviation
Tk	Low	1	8.3		
	Average	6	50.0		0.68997
	High	5	41.7	4.2167	
	Total	12	100		

Table 4.2 reveals that 50% of teacher educators demonstrated an average level of technological knowledge, 41.7% achieved a high level, and 8.3% scored low. The

mean Technological Knowledge (TK) score is 4.22, indicating a generally strong level of competency. However, the standard deviation of 0.69 suggests moderate variation in the scores. Most teacher educators possess adequate technological knowledge, with nearly 42% performing at a high level. However, the presence of a small group (8.3%) with low scores highlights a need for targeted professional development to improve technological skills.

Table 4.3 *Pedagogical Knowledge of Teacher Educators*

Dimension	Proficiency Level	Frequency	Percentage	Mean	Std. Deviation
PK	Low				
	Average	6	50.0		0.55350
	High	6	50.0	4.2500	
	Total	12	100		

Table 4.3 shows that 50% of teacher educators achieved a high level of pedagogical knowledge, while the other 50% were at an average level. The mean Pedagogical Knowledge (PK) score is 4.25, reflecting strong overall proficiency. The standard deviation of 0.55 indicates moderate consistency in the scores. Teacher educators demonstrate well-developed pedagogical knowledge, with no participants scoring in the "Low" category. This highlights their solid teaching expertise.

Table 4.4 *Technological Content Knowledge of Teacher Educators*

Dimension	Proficiency Level	Frequency	Percentage	Mean	Std. Deviation
TCK	Low				
	Average	7	58.3		0.48866
	High	5	41.7	4.2333	
	Total	12	100		

Table 4.4 shows that 58.3% of teacher educators demonstrated an average level of Technological Content Knowledge (TCK), while 41.7% achieved high proficiency. The mean TCK score is 4.23, reflecting a generally strong understanding. The standard deviation of 0.49 indicates moderate consistency among the scores. Most teacher educators are proficient in TCK, with a significant proportion achieving high proficiency. However, the nearly even split between "Average" and "High" levels suggests there is room for improvement in effectively integrating technology with content knowledge.

Table 4.5 *Pedagogical Content Knowledge of Teacher Educators*

Dimension	Proficiency Level	Frequency	Percentage	Mean	Std. Deviation
PCK	Low				
	Average	4	33.3		0.40113
	High	8	66.7	4.3500	
	Total	12	100		

Table 4.5 shows that 66.7% of teacher educators achieved a high level of Pedagogical Content Knowledge (PCK), while 33.3% scored at an average level. The mean PCK score is 4.35, indicating strong overall competency in combining pedagogy with content. The standard deviation of 0.40 suggests low variability, meaning most

scores were close to the mean. Teacher educators demonstrate a strong hold of PCK, with the majority (66.7%) achieving high proficiency. This highlights their ability to effectively integrate pedagogical strategies with subject content.

Table 4.6 *Technological Pedagogical Knowledge of Teacher Educators*

Dimension	Proficiency Level	Frequency	Percentage	Mean	Std. Deviation
TPK	Low	1	8.3		
	Average	5	41.7		0.52194
	High	6	50.0	4.1167	
	Total	12	100		

Table 4.6 reveals that 50% of teacher educators achieved a high level of Technological Pedagogical Knowledge (TPK), 41.7% scored at an average level, and 8.3% fell into the low category. The mean TPK score is 4.12, indicating strong overall proficiency. The standard deviation of 0.52 suggests moderate variability in the scores. Most teacher educators demonstrate proficiency in TPK, with half achieving high scores. However, the presence of a small group (8.3%) in the low category underscores the importance of targeted training to enhance their ability to integrate technology with pedagogy effectively.

Table 4.7 *Technological Pedagogical Content Knowledge of Teacher Educators*

Dimension	Proficiency Level	Frequency	Percentage	Mean	Std. Deviation
TPACK	Low	1	8.3		
	Average	7	58.3		0.55569
	High	4	33.3	4.1167	
	Total	12	100		

Table 4.7 shows that 58.3% of teacher educators scored at an average level of Technological Pedagogical Content Knowledge (TPACK), 33.3% achieved high proficiency, and 8.3% fell into the low category. The mean TPACK score is 4.12, indicating strong overall competency. The standard deviation of 0.56 reflects moderate variability among the scores. Teacher educators generally demonstrate strong TPACK competencies, with a significant portion achieving high proficiency. However, the presence of a small group (8.3%) in the low category highlights areas where further development and support are needed to enhance their ability to integrate technology, pedagogy, and content effectively.

Objective no.2 To evaluate the levels of Technological Pedagogical and Content Knowledge (TPACK) among prospective teachers.

Table 4.8 *Content Knowledge of Prospective Teachers*

Dimension	Proficiency Level	Frequency	Percentage	Mean	Std. Deviation
CK	Low	11	11.3	3.9052	0.72806
	Average	42	43.3		
	High	44	45.4		
	Total	97	100		

Table 4.8 indicates that 45.4% of prospective teachers achieved a high level of Content Knowledge (CK), 43.3% scored at an average level, and 11.3% fell into the low category. The mean CK score is 3.91, reflecting moderate overall competency. The standard deviation of 0.73 suggests moderate variability in the scores. Prospective teachers display moderate content knowledge, with nearly half demonstrating high proficiency. However, the presence of 11.3% scoring low highlights the need for targeted interventions to strengthen their understanding of subject content.

Table 4.9 *Technological Knowledge of Prospective Teachers*

Dimension	Proficiency Level	Frequency	Percentage	Mean	Std. Deviation
Tk	Low	14	14.4	3.7959	0.78368
	Average	47	48.5		
	High	36	37.1		
	Total	97	100		

Table 4.9 shows that 37.1% of prospective teachers achieved a high level of Technological Knowledge (TK), 48.5% scored at an average level, and 14.4% fell into the low category. The mean TK score 3.80, reflecting moderate overall proficiency. The standard deviation of 0.78 indicates moderate variability among the scores. While some prospective teachers show high technological knowledge, nearly half are at an average level, and 14.4% scored low. This highlights the need for additional training and support to enhance technological competencies across the group.

Table 4.10 *Pedagogical Knowledge of Prospective Teachers*

Dimension	Proficiency Level	Frequency	Percentage	Mean	Std. Deviation
PK	Low	13	13.4	3.9402	0.79904
	Average	40	41.2		
	High	44	45.4		
	Total	97	100		

Table 4.10 shows that 45.4% of prospective teachers achieved a high level of Pedagogical Knowledge (PK), 41.2% scored at an average level, and 13.4% fell into the low category. The mean PK score is 3.94, reflecting strong overall pedagogical knowledge. The standard deviation of 0.80 indicates moderate variability among the scores. Prospective teachers demonstrate strong pedagogical knowledge, with nearly

half scoring at a high level. However, the 13.4% who scored low suggest that further support and development are necessary to ensure more consistent proficiency.

Table 4.11 *Technological Content Knowledge of Prospective Teachers*

Dimension	Proficiency Level	Frequency	Percentage	Mean	Std. Deviation
TCK	Low	13	13.4	3.7918	0.79839
	Average	49	50.5		
	High	35	36.1		
	Total	97	100		

Table 4.11 shows that 36.1% of prospective teachers achieved a high level of Technological Content Knowledge (TCK), 50.5% scored at an average level, and 13.4% fell into the low category. The mean TCK score is 3.79, reflecting moderate overall competency. The standard deviation of 0.80 indicates moderate variability among the scores. While most prospective teachers have average TCK, the 13.4% who scored low highlight the need for targeted improvement in integrating technology with content knowledge.

Table 4.12 *Pedagogical Content Knowledge of Prospective Teachers*

Dimension	Proficiency Level	Frequency	Percentage	Mean	Std. Deviation
PCK	Low	16	16.5	3.8412	0.74830
	Average	45	46.4		
	High	36	37.1		
	Total	97	100		

Table 4.12 shows that 37.1% of prospective teachers achieved a high level of Pedagogical Content Knowledge (PCK), 46.4% scored at an average level, and 16.5% fell into the low category. The mean PCK score is 3.84, reflecting moderate overall

proficiency. The standard deviation of 0.75 indicates moderate variability in the scores. While some prospective teachers show high proficiency in combining pedagogy with content, the presence of 16.5% scoring low suggests a need for additional training to improve their ability to integrate pedagogical and content knowledge effectively.

Table 4.13 *Technological Pedagogical Knowledge of Prospective Teachers*

Dimension	Proficiency Level	Frequency	Percentage	Mean	Std. Deviation
TPK	Low	11	11.3	3.9629	0.70612
	Average	40	41.2		
	High	46	47.4		
	Total	97	100		

Table 4.13 shows that 47.4% of prospective teachers achieved a high level of Technological Pedagogical Knowledge (TPK), 41.2% scored at an average level, and 11.3% fell into the low category. The mean TPK score is 3.96, indicating strong overall proficiency. The standard deviation of 0.71 suggests moderate consistency in the scores. Prospective teachers demonstrate strong proficiency in TPK, with nearly half achieving high scores. However, the 11.3% who scored low highlight areas where further development and support are needed to enhance their integration of technology with pedagogy.

Table 4.14 *Technological Pedagogical Content Knowledge of Prospective Teachers*

Dimension	Proficiency Level	Frequency	Percentage	Mean	Std. Deviation
TPACK	Low	12	12.4	3.9237	0.71789
	Average	46	47.4		
	High	39	40.2		
	Total	97	100		

Table 4.14 shows that 40.2% of prospective teachers achieved a high level of Technological Pedagogical Content Knowledge (TPACK), 47.4% scored at an average level, and 12.4% fell into the low category. The mean TPACK score is 3.92, reflecting moderate overall competency. The standard deviation of 0.72 indicates moderate variability in the scores. Prospective teachers show strong overall TPACK proficiency, with nearly half achieving high scores. However, the 12.4% who scored low indicate that there are areas requiring targeted support to enhance their ability to integrate technology, pedagogy, and content effectively.

Objective 3: To compare TPACK competencies between male and female teacher educators and between male and female prospective teachers at the university level.

Table 4.15: TPACK Scores: Gender Comparison Among Teacher Educators

Dimension	Gender	N (Simple size)	Mean TPACK score	Standard Deviation (SD)	t-value	p-value	Significance (p < 0.05)
CK	MALE	9	4.3778	0.47376	0.072	0.944	0.00
	Female	3	4.4000	0.40000			
TK	MALE	9	4.2000	0.77460	0.138	0.893	0.00
	Female	3	4.2667	0.46188			
PK	MALE	9	4.2222	0.59535	0.288	0.779	0.00
	Female	3	4.3333	0.50332			
TCK	MALE	9	4.2667	0.56569	0.393	0.702	0.00
	Female	3	4.1333	0.11547			
PCK	MALE	9	4.3111	0.41366	0.563	0.586	0.00
	Female	3	4.4667	0.41633			
TPK	MALE	9	4.0889	0.60093	0.306	0.766	0.00
	Female	3	4.2000	0.20000			
TPCK	MALE	9	4.0667	0.62450	0.522	0.613	0.00
	Female	3	4.2667	0.30551			

Table 4.15 shows that analysis of TPACK scores among male and female teacher educators reveal no statistically significant differences across the dimensions of Content Knowledge (CK), Technological Knowledge (TK), Pedagogical Knowledge (PK), Technological Content Knowledge (TCK), Pedagogical Content Knowledge

(PCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical Content Knowledge (TPCK).

Regarding CK, male teacher educators mean score of 4.3778 (SD = 0.47376), while females scored 4.4000 (SD = 0.40000), with a t-value = 0.072 and p-value = 0.944. In TK, males scored 4.2000 (SD = 0.77460) compared to females at 4.2667 (SD = 0.46188), with a t-value = 0.138 and p-value = 0.893. For PK, male teacher educators mean of 4.2222 (SD = 0.59535), while females scored 4.3333 (SD = 0.50332), with a t-value = 0.288 and p-value = 0.779.

In the dimension of TCK, male teacher educators achieved a mean score of 4.2667 (SD = 0.56569), and females scored 4.1333 (SD = 0.11547), resulting in a t-value = 0.393 and p-value = 0.702. For PCK, males scored 4.3111 (SD = 0.41366) compared to females at 4.4667 (SD = 0.41633), with a t-value = 0.563 and p-value = 0.586. In TPK, males scored 4.0889 (SD = 0.60093), while females scored 4.2000 (SD = 0.20000), with a t-value = 0.306 and p-value = 0.766. Lastly, for TPCK, male teacher educators mean of 4.0667 (SD = 0.62450), and females scored 4.2667 (SD = 0.30551), with a t-value = 0.522 and p-value = 0.613.

The p-values across all dimensions exceed the significance level of 0.05, indicating no statistically significant differences in TPACK scores between male and female teacher educators. the null hypothesis, "There is no significant difference in the TPACK competencies of teacher educators at the university level," is supported by these findings. The results demonstrate that male and female teacher educators exhibit comparable TPACK competencies, with any observed variations likely due to random chance.

Table 4.16: TPACK Scores: Gender Comparison Among Prospective Teachers

Dimension	Gender	N (Simple size)	Mean TPACK score	Standard Deviation (SD)	t-value	p-value	Significance (p < 0.05)
CK	MALE	53	3.9509	0.78339	0.678	0.499	0.00
	Female	44	3.8500	0.65999			
TK	MALE	53	3.8302	0.82499	0.471	0.638	0.00
	Female	44	3.7545	0.73815			
PK	MALE	53	3.9170	0.87128	0.313	0.755	0.00
	Female	44	3.9682	0.71130			
TCK	MALE	53	3.8830	0.85344	1.239	0.218	0.00
	Female	44	3.6818	0.72088			
PCK	MALE	53	3.8226	0.77028	0.267	0.790	0.00
	Female	44	3.8636	0.72916			
TPK	MALE	53	3.9736	0.80100	0.163	0.871	0.00
	Female	44	3.9500	0.58050			
TPCK	MALE	53	3.9132	0.82323	0.157	0.875	0.00
	Female	44	3.9364	0.57510			

Table 4.16 shows that analysis of TPACK scores among male and female prospective teachers at the university level reveals no statistically significant differences across all dimensions, including Content Knowledge (CK), Technological Knowledge (TK), Pedagogical Knowledge (PK), Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical Content Knowledge (TPCK).

Regarding CK, male prospective teachers mean score of 3.9509 (SD = 0.78339), while females scored 3.8500 (SD = 0.65999), with a t-value = 0.678 and p-value = 0.499. In TK, males scored 3.8302 (SD = 0.82499) compared to females at 3.7545 (SD = 0.73815), with a t-value = 0.471 and p-value = 0.638. For PK, male prospective teachers scored 3.9170 (SD = 0.87128), while females scored 3.9682 (SD = 0.71130), with a t-value = 0.313 and p-value = 0.755.

In TCK, male prospective teachers achieved a mean score of 3.8830 (SD = 0.85344), while females scored 3.6818 (SD = 0.72088), resulting in a t-value = 1.239 and p-value = 0.218. For PCK, males scored 3.8226 (SD = 0.77028) compared to females at 3.8636 (SD = 0.72916), with a t-value = 0.267 and p-value = 0.790. In TPK, males scored 3.9736 (SD = 0.80100), while females scored 3.9500 (SD = 0.58050), with a t-value = 0.163 and p-value = 0.871. Lastly, for TPCK, male prospective teachers mean score of 3.9132 (SD = 0.82323), and females scored 3.9364 (SD = 0.57510), with a t-value = 0.157 and p-value = 0.875.

The p-values across all dimensions exceed the significance level of 0.05, indicating no statistically significant differences in TPACK scores between male and female prospective teachers. The null hypothesis, "There is no significant difference in the TPACK competencies of prospective teachers at the university level," is supported by these findings. The results suggest that male and female prospective teachers demonstrate comparable TPACK competencies, and any observed variations are likely due to random chance rather than gender-based factors.

CHAPTER 5

SUMMARY, FINDINGS, DISCUSSION, CONCLUSION AND RECOMMENDATION

5.1 SUMMARY

This study explored and compared the Technological Pedagogical Content Knowledge (TPACK) levels of university-level teacher educators and prospective teachers, with a particular focus on whether gender played a role in these competencies. The research was carried out at the International Islamic University Islamabad (IIUI) and the University of Swat, using a quantitative approach. Validated TPACK surveys and demographic questionnaires were administered to collect data. The participants included 14 teacher educators and 100 prospective teachers, selected through universal and stratified random sampling methods, respectively. The findings revealed that teacher educators have strong TPACK skills, especially in Content Knowledge (CK) and Pedagogical Content Knowledge (PCK), with an overall mean TPACK score of 4.12. However, they showed some gaps in Technological Knowledge (TK) and Technological Pedagogical Knowledge (TPK), suggesting a need for additional training to better integrate technology into their teaching practices. On the other hand, prospective teachers displayed moderate TPACK proficiency, with mean scores ranging from 3.79 to 3.96. While they performed well in CK and Pedagogical Knowledge (PK), they struggled with TK and Technological Content Knowledge (TCK), indicating areas for improvement. Interestingly, the study found no significant differences in TPACK competencies based on gender for either group, meaning that gender did not appear to influence proficiency levels. These results underscore the importance of providing targeted professional development opportunities to strengthen

technology integration skills, ensuring that both current and future educators are well-prepared to meet the demands of 21st-century teaching.

5.2 FINDINGS

1. Table 4.1 highlights that 75% of teacher educators have a high level of content knowledge, while 25% fall into the average range. With a mean score of 4.38 and a low standard deviation (0.44), the results show that most educators are confident and skilled in their subject areas. This strong performance reflects their expertise and readiness to teach their disciplines effectively.
2. Table 4.2 reveals that 50% of teacher educators have an average level of technological knowledge, 41.7% are highly proficient, and 8.3% score low. The mean TK score is 4.22, suggesting generally solid competency. However, the moderate standard deviation (0.69) indicates some variability in skills. While most educators are comfortable with technology, the small group struggling with it points to a need for focused training to bridge this gap.
3. Table 4.3 shows that 50% of teacher educators achieved a high level of pedagogical knowledge, while the other 50% were at an average level. The mean Pedagogical Knowledge (PK) score is 4.25, reflecting strong overall proficiency. The standard deviation of 0.55 indicates moderate consistency in the scores. Teacher educators demonstrate well-developed pedagogical knowledge, with no participants scoring in the "Low" category. This highlights their solid teaching expertise.
4. Table 4.4 shows that 58.3% of teacher educators demonstrated an average level of Technological Content Knowledge (TCK), while 41.7% achieved high proficiency. The mean TCK score is 4.23, reflecting a generally strong understanding. The standard deviation of 0.49 indicates moderate consistency among the scores. Most teacher

educators are proficient in TCK, with a significant proportion achieving high proficiency. However, the nearly even split between "Average" and "High" levels suggests there is room for improvement in effectively integrating technology with content knowledge.

5. Table 4.5 shows that 66.7% of teacher educators achieved a high level of Pedagogical Content Knowledge (PCK), while 33.3% scored at an average level. The mean PCK score is 4.35, indicating strong overall competency in combining pedagogy with content. The standard deviation of 0.40 suggests low variability, meaning most scores were close to the mean. Teacher educators demonstrate a strong hold of PCK, with the majority (66.7%) achieving high proficiency. This highlights their ability to effectively integrate pedagogical strategies with subject content.
6. Table 4.6 reveals that 50% of teacher educators achieved a high level of Technological Pedagogical Knowledge (TPK), 41.7% scored at an average level, and 8.3% fell into the low category. The mean TPK score is 4.12, indicating strong overall proficiency. The standard deviation of 0.52 suggests moderate variability in the scores. Most teacher educators demonstrate proficiency in TPK, with half achieving high scores. However, the presence of a small group (8.3%) in the low category underscores the importance of targeted training to enhance their ability to integrate technology with pedagogy effectively.
7. Table 4.7 shows that 58.3% of teacher educators scored at an average level of Technological Pedagogical Content Knowledge (TPACK), 33.3% achieved high proficiency, and 8.3% fell into the low category. The mean TPACK score is 4.12, indicating strong overall competency. The standard deviation of 0.56 reflects moderate variability among the scores. Teacher educators generally demonstrate strong TPACK competencies, with a significant portion achieving high proficiency. However, the

presence of a small group (8.3%) in the low category highlights areas where further development and support are needed to enhance their ability to integrate technology, pedagogy, and content effectively.

8. Table 4.8 indicates that 45.4% of prospective teachers achieved a high level of Content Knowledge (CK), 43.3% scored at an average level, and 11.3% fell into the low category. The mean CK score is 3.91, reflecting moderate overall competency. The standard deviation of 0.73 suggests moderate variability in the scores. Prospective teachers display moderate content knowledge, with nearly half demonstrating high proficiency. However, the presence of 11.3% scoring low highlights the need for targeted interventions to strengthen their understanding of subject content.
9. Table 4.9 shows that 37.1% of prospective teachers achieved a high level of Technological Knowledge (TK), 48.5% scored at an average level, and 14.4% fell into the low category. The mean TK score 3.80, reflecting moderate overall proficiency. The standard deviation of 0.78 indicates moderate variability among the scores. While some prospective teachers show high technological knowledge, nearly half are at an average level, and 14.4% scored low. This highlights the need for additional training and support to enhance technological competencies across the group.
10. Table 4.10 shows that 45.4% of prospective teachers achieved a high level of Pedagogical Knowledge (PK), 41.2% scored at an average level, and 13.4% fell into the low category. The mean PK score is 3.94, reflecting strong overall pedagogical knowledge. The standard deviation of 0.80 indicates moderate variability among the scores. Prospective teachers demonstrate strong pedagogical knowledge, with nearly half scoring at a high level. However, the 13.4% who scored low suggest that further support and development are necessary to ensure more consistent proficiency.

11. Table 4.11 shows that 36.1% of prospective teachers achieved a high level of Technological Content Knowledge (TCK), 50.5% scored at an average level, and 13.4% fell into the low category. The mean TCK score is 3.79, reflecting moderate overall competency. The standard deviation of 0.80 indicates moderate variability among the scores. While most prospective teachers have average TCK, the 13.4% who scored low highlight the need for targeted improvement in integrating technology with content knowledge.
12. Table 4.12 shows that 37.1% of prospective teachers achieved a high level of Pedagogical Content Knowledge (PCK), 46.4% scored at an average level, and 16.5% fell into the low category. The mean PCK score is 3.84, reflecting moderate overall proficiency. The standard deviation of 0.75 indicates moderate variability in the scores. While some prospective teachers show high proficiency in combining pedagogy with content, the presence of 16.5% scoring low suggests a need for additional training to improve their ability to integrate pedagogical and content knowledge effectively.
13. Table 4.13 shows that 47.4% of prospective teachers achieved a high level of Technological Pedagogical Knowledge (TPK), 41.2% scored at an average level, and 11.3% fell into the low category. The mean TPK score is 3.96, indicating strong overall proficiency. The standard deviation of 0.71 suggests moderate consistency in the scores. Prospective teachers demonstrate strong proficiency in TPK, with nearly half achieving high scores. However, the 11.3% who scored low highlight areas where further development and support are needed to enhance their integration of technology with pedagogy.
14. Table 4.14 shows that 40.2% of prospective teachers achieved a high level of Technological Pedagogical Content Knowledge (TPACK), 47.4% scored at an average level, and 12.4% fell into the low category. The mean TPACK score is 3.92, reflecting

moderate overall competency. The standard deviation of 0.72 indicates moderate variability in the scores. Prospective teachers show strong overall TPACK proficiency, with nearly half achieving high scores. However, the 12.4% who scored low indicate that there are areas requiring targeted support to enhance their ability to integrate technology, pedagogy, and content effectively.

15. The analysis of TPACK scores among male and female teacher educators reveals no statistically significant differences across the dimensions of Content Knowledge (CK), Technological Knowledge (TK), Pedagogical Knowledge (PK), Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical Content Knowledge (TPCK). For CK, male teacher educators mean score of 4.3778 (SD = 0.47376), while females scored 4.4000 (SD = 0.40000), with a t-value = 0.072 and p-value = 0.944. In TK, males scored 4.2000 (SD = 0.77460) compared to females at 4.2667 (SD = 0.46188), with a t-value = 0.138 and p-value = 0.893. For PK, male teacher educators mean of 4.2222 (SD = 0.59535), while females scored 4.3333 (SD = 0.50332), with a t-value = 0.288 and p-value = 0.779. In the dimension of TCK, male teacher educators achieved a mean score of 4.2667 (SD = 0.56569), and females scored 4.1333 (SD = 0.11547), resulting in a t-value = 0.393 and p-value = 0.702. For PCK, males scored 4.3111 (SD = 0.41366) compared to females at 4.4667 (SD = 0.41633), with a t-value = 0.563 and p-value = 0.586. In TPK, males scored 4.0889 (SD = 0.60093), while females scored 4.2000 (SD = 0.20000), with a t-value = 0.306 and p-value = 0.766. Lastly, for TPCK, male teacher educators mean of 4.0667 (SD = 0.62450), and females scored 4.2667 (SD = 0.30551), with a t-value = 0.522 and p-value = 0.613.

The p-values across all dimensions exceed the significance level of 0.05, suggesting that there are no statistically significant differences in TPACK scores between male and female teacher educators. These results support the null hypothesis stating that “There is no significant difference in the TPACK competencies of teacher educators at the university level.” The findings indicate that male and female teacher educators have similar TPACK competencies, with any differences likely attributable to random chance.

16. The analysis of TPACK scores among male and female prospective teachers at the university level reveals no statistically significant differences across all dimensions, including Content Knowledge (CK), Technological Knowledge (TK), Pedagogical Knowledge (PK), Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical Content Knowledge (TPCK). For CK, male prospective teachers mean score of 3.9509 (SD = 0.78339), while females scored 3.8500 (SD = 0.65999), with a t-value = 0.678 and p-value = 0.499. In TK, males scored 3.8302 (SD = 0.82499) compared to females at 3.7545 (SD = 0.73815), with a t-value = 0.471 and p-value = 0.638. For PK, male prospective teachers scored 3.9170 (SD = 0.87128), while females scored 3.9682 (SD = 0.71130), with a t-value = 0.313 and p-value = 0.755. In TCK, male prospective teachers achieved a mean score of 3.8830 (SD = 0.85344), while females scored 3.6818 (SD = 0.72088), resulting in a t-value = 1.239 and p-value = 0.218. For PCK, males scored 3.8226 (SD = 0.77028) compared to females at 3.8636 (SD = 0.72916), with a t-value = 0.267 and p-value = 0.790. In TPK, males scored 3.9736 (SD = 0.80100), while females scored 3.9500 (SD = 0.58050), with a t-value = 0.163 and p-value = 0.871. Lastly, for TPCK, male prospective teachers mean score of 3.9132 (SD = 0.82323), and females scored 3.9364 (SD = 0.57510), with a t-value =

0.157 and $p\text{-value} = 0.875$. The $p\text{-values}$ across all dimensions exceed the significance level of 0.05, which shows that there are no statistically significant differences in TPACK scores between male and female prospective teachers. This supports the null hypothesis stating that “There is no significant difference in the TPACK competencies of prospective teachers at the university level.” The results indicate that both male and female prospective teachers exhibit similar TPACK competencies, and any differences noted are probably due to random chance rather than gender-related factors.

5.3 DISCUSSION

The present study aimed to assess the levels of Technological Pedagogical Content Knowledge (TPACK) among teacher educators and prospective teachers, compare TPACK competencies between male and female educators, and evaluate gender differences in TPACK competencies. This section discusses the study's key findings in relation to existing literature, implications for teacher education programs, and potential areas for further research.

5.3.1 TPACK Levels Among Teacher Educators

The first objective of the study was to evaluate the levels of Technological Pedagogical Content Knowledge (TPACK) among teacher educators. the results show that teacher educators are highly skilled in certain areas but could improve in others, particularly when it comes to using technology effectively in teaching.

When it comes to their subject knowledge (Content Knowledge or CK), teacher educators excelled, with 75% scoring at a high level of competency and an average score of 4.38. This reflects their strong confidence and expertise in their specific fields. They also performed well in teaching strategies (Pedagogical Knowledge or PK) and combining teaching methods with subject content (Pedagogical Content Knowledge or PCK). Half of the educators achieved high proficiency in PK, while 66.7% did so in

PCK, with mean scores of 4.25 and 4.35, respectively. These results highlight their ability to effectively connect teaching practices with the material they teach. However, the study revealed some gaps, especially in the use of technology. While 41.7% of educators showed high proficiency in Technological Knowledge (TK), half were only at an average level, and 8.3% scored low. This suggests that many educators need more training to improve their tech skills. Similarly, integrating technology with subject content (Technological Content Knowledge or TCK) and teaching methods (Technological Pedagogical Knowledge or TPK) showed mixed results. About 58.3% of educators were average in TCK, and 41.7% were average in TPK. Although the mean scores for these areas (4.23 for TCK and 4.12 for TPK) indicate solid overall ability, the varying performance levels point to a need for more support in blending technology with teaching and content.

In the broader TPACK dimension, which combines technology, teaching methods, and content, 58.3% of educators scored at an average level, while 33.3% achieved high proficiency. The mean score of 4.12 shows strong overall competence, but the fact that 8.3% scored low highlights the need for additional training. These findings suggest that while teacher educators are confident in their subject knowledge and teaching strategies, they could benefit from more support to effectively incorporate technology into their classrooms.

These results align with recent research by Al-Adwan et al. (2024), who reported that although teacher educators possess deep pedagogical and content expertise, they often experience challenges with dynamic technology integration due to insufficient professional training. Similarly, Uerz, Volman, and Kral (2018) emphasized that teacher educators frequently rely on basic technologies rather than leveraging transformative digital pedagogies. Tondeur et al. (2020) emphasized that the

lack of systematic support structures hampers educators' ability to transition from basic to complex technology integration. The current study reflects this reality, suggesting that Pakistani teacher education institutions need stronger ongoing support for authentic technology use.

Koh, Chai, and Tsai (2014) found that teacher educators engaged in technology-driven innovations displayed higher TPACK competencies. Compared to their findings, this study reveals relative gaps, indicating the need for structured, practical technology integration training for teacher educators. Tondeur, van Braak, Sang, Voogt, Fisser, and Ottenbreit-Leftwich (2012) also highlighted that authentic, real-world experiences are essential for developing high-level TPACK skills, which aligns with the need for experiential learning in the Pakistani context.

5.3.2 TPACK Levels Among Prospective Teachers

The second objective of the study was to evaluate the levels of Technological Pedagogical and Content Knowledge (TPACK) among prospective teachers. The results show that while these prospective teachers have a strong hold of TPACK overall, there are areas where they could improve, pointing to the need for focused training and support.

Future teachers showed solid skills in teaching strategies (Pedagogical Knowledge or PK), with 45.4% scoring at a high level and a mean score of 3.94. They also did well in combining technology with teaching methods (Technological Pedagogical Knowledge or TPK), with 47.4% achieving high proficiency and a mean score of 3.96. These results suggest they're capable of using teaching techniques effectively and blending technology with their instructional approaches. However, the fact that 13.4% scored low in PK and 11.3% in TPK indicates that some need extra help in these areas.

When it comes to their subject knowledge (Content Knowledge or CK), 45.4% of future teachers scored high, with a mean score of 3.91. While this shows moderate competence overall, 11.3% scored low, suggesting that some need more support to strengthen their understanding of the subjects they'll teach. Similarly, their ability to connect teaching methods with subject content (Pedagogical Content Knowledge or PCK) was moderate, with 37.1% achieving high proficiency and a mean score of 3.84. However, 16.5% scored low, highlighting the need for more training to help them better integrate teaching strategies with their subject knowledge.

The findings were less encouraging in areas involving technology. For Technological Knowledge (TK), 37.1% of future teachers scored high, but nearly half (48.5%) were only at an average level, and 14.4% scored low, with a mean score of 3.80. Similarly, in Technological Content Knowledge (TCK), which combines technology with subject content, 36.1% scored high, while 50.5% were average, and 13.4% scored low, with an average score of 3.79. These results suggest that many future teachers need more training to improve their tech skills and learn how to use technology effectively in teaching their subjects.

Finally, in the broader TPACK dimension—which combines technology, teaching methods, and content—40.2% of future teachers scored high, while 47.4% were average, and 12.4% scored low. The overall TPACK mean score of 3.92 reflects moderate overall ability, but the range of scores shows that some need more development to effectively merge technology, teaching strategies, and subject content.

These findings align with recent studies by Nilsson (2024) who noted that while pre-service teachers are digitally literate, they often lack the ability to apply technology meaningfully within subject-specific pedagogy. Similarly, Muliani, Wibowo, and Triyono (2024) reported that digital familiarity does not automatically translate to

strong TPACK skills. Basilotta-Gómez-Pablos, Martín del Pozo, and García-Valcárcel (2022) further emphasized that structured, reflective technology engagement is key to boosting pre-service teachers' capabilities—a point reinforced by the present study's findings. Chai, Koh, and Tsai (2016) found that hands-on TPACK experiences significantly raised competence levels, suggesting that Pakistani teacher education programs would benefit from embedding more experiential digital teaching activities. In addition, Cetin and Kazan (2023) highlighted that mobile technologies, gamification, and adaptive learning platforms can significantly improve prospective teachers' TPACK levels, pointing to a potential innovation path for Pakistani universities.

5.3.3 TPACK Levels Among Teacher Educators and Prospective Teachers

The results indicate that both teacher educators and prospective teachers possess varying levels of TPACK competencies. While teacher educators generally demonstrated a higher level of TPACK, prospective teachers exhibited moderate competencies, highlighting the ongoing need for enhanced technology integration in teacher education programs. These results align with prior studies suggesting that teacher educators, due to their experience and exposure, tend to have stronger pedagogical and technological competencies compared to prospective teachers (Koehler & Mishra, 2009).

The study further highlights the importance of structured training in improving TPACK competencies. Research has consistently shown that prospective teachers benefit significantly from hands-on experiences and professional development programs focused on technology integration (Chai et al., 2013). Consequently, teacher preparation programs should incorporate more practical applications of technology to enhance prospective teachers' digital fluency.

5.3.4 Gender Differences in TPACK Competencies

The study found no statistically significant gender-based differences in TPACK competencies among both teacher educators and prospective teachers. This is an important finding, as it suggests that gender does not play a significant role in determining TPACK proficiency levels. Both male and female educators and prospective teachers demonstrated comparable levels of knowledge and skills in integrating technology, pedagogy, and content.

This finding contrasts with some previous studies that have suggested gender differences in technology use and confidence (Goswami & Dutta, 2015; Scherer et al., 2021). However, the results of this study align with other research that found no significant gender differences in TPACK competencies (Bakar et al., 2020; Castéra et al., 2020). The lack of gender-based differences in this study may be attributed to the increasing emphasis on technology integration in education and the growing recognition of the importance of digital literacy for all educators, regardless of gender.

5.3.5 Implications for Teacher Education Programs

The findings of this study have significant implications for teacher education programs in Pakistan and beyond, emphasizing the need for comprehensive policies to enhance technological, pedagogical, and content knowledge (TPACK) among educators. Teacher education programs should prioritize targeted professional development initiatives, such as workshops, online courses, and hands-on training sessions, to improve the technological skills of both teacher educators and prospective teachers. Additionally, curricula should be redesigned to incorporate TPACK-focused content, emphasizing the intersection of technology, pedagogy, and content knowledge through practical experiences like digital tools, simulations, and collaborative learning platforms. The lack of gender-based differences in TPACK competencies suggests that

programs should adopt a gender-neutral approach to technology training, ensuring equal opportunities for all educators to develop their skills and confidence. Furthermore, institutions should integrate more practical, hands-on experiences with technology into teacher training, addressing specific gender-related challenges through gender-sensitive training programs. Establishing mentorship programs and providing ongoing support can help prospective teachers refine their TPACK skills, while universities must invest in the necessary technological infrastructure and continuous professional development opportunities to support both current and future educators. By implementing these strategies, teacher education programs can better equip educators to effectively integrate technology into their teaching. This not only improves how they deliver lessons but also enhances the overall learning experience for students, leading to better educational outcomes.

5.4 Conclusions

5.4.1 Conclusions regarding TPACK Levels Among Teacher Educators

Teacher educators generally show a strong command of their subject areas and effective teaching practices. Their understanding of what they teach and how to teach it is quite solid, and there's a sense of consistency in how they apply this knowledge across different situations. This suggests they are well-equipped to support student learning.

When it comes to technology, many teacher educators are comfortable using digital tools and incorporating them into their teaching. However, combining technology meaningfully with both content and pedagogy seems to be more challenging. Some educators appear to face barriers such as limited training opportunities, hesitation to adopt new methods, or a lack of support from their

institutions. These factors can make it harder for them to fully integrate technology into their teaching in a seamless way.

Even though many have made progress in blending their knowledge of technology, pedagogy, and content, it's clear that others are still finding their way. Transitioning to tech-enhanced teaching brings real challenges—like staying current with digital tools, balancing traditional teaching with new approaches, and managing additional demands on their time. With the right kind of professional development and support, these challenges can be addressed, helping educators feel more confident and capable in modern classrooms.

5.4.2 Conclusions regarding TPACK Levels Among Prospective Teacher

Prospective teachers seem to have a solid starting point when it comes to understanding their subjects, knowing how to teach, and using technology as part of instruction. At the same time, not all of them are at the same level. Some appear to need more support, possibly due to differences in their background experiences, access to technology, or the kind of training they've received during their studies.

In general, they're fairly comfortable with using technology, but when it comes to combining it effectively with their subject matter and teaching methods, many are still developing these skills. Some prospective teachers may feel unsure about using new tools or may not have had enough hands-on practice during their training. More practical, well-guided experiences can help build their confidence and ease their transition into the teaching profession.

Bringing together knowledge of technology, pedagogy, and content is no small task, especially for those who are still gaining classroom experience. While some manage it well, others need time and support to grow. Mentorship from experienced educators, opportunities to work with peers, and timely feedback can go a long way in helping them become well-rounded, tech-savvy teachers.

5.4.3 Conclusions regarding Gender Differences in TPACK Competencies

When comparing male and female teacher educators, there's no significant difference in their ability to combine technology, teaching methods, and subject knowledge. The data shows that both groups are equally skilled across all areas, with any small differences likely due to chance. This is a positive finding, as it shows that both men and women are equally prepared to use these skills in their teaching.

Similarly, there's no significant difference between male and female prospective teachers in their ability to integrate technology, teaching methods, and subject knowledge. Both groups perform equally well, with any minor variations likely due to random factors. This suggests that both men and women entering the teaching profession are equally ready to use these skills effectively in their future classrooms.

The findings highlight that while teacher educators excel in content and pedagogy, there is room for growth in technological integration. Prospective teachers, though moderately proficient, need more structured training to develop confidence in using technology effectively. The absence of gender disparities suggests equal opportunities for both male and female educators to refine their skills. Investing in ongoing professional development will be key to strengthening TPACK competencies and ensuring educators are fully prepared for 21st-century teaching.

5.5 Recommendations

Based on the findings of this study and informed by current educational research, it is recommended that the following measures be undertaken to strengthen Technological Pedagogical Content Knowledge (TPACK) among teacher educators and prospective teachers:

5.5.1 Embed TPACK Systematically Across Teacher Education Curricula

It is strongly recommended that teacher education programs integrate the TPACK framework systematically across all aspects of the curriculum. Instead of confining technological knowledge to isolated technology courses, the integration of content knowledge, pedagogical strategies, and technological tools must occur simultaneously within all subjects. Every method course and content-specific course should include assignments and projects requiring students to demonstrate how technology can meaningfully enhance learning outcomes. This will ensure that both teacher educators and prospective teachers develop a holistic, interconnected understanding of TPACK that becomes an organic part of their instructional planning and teaching practice.

5.5.2 Offer Continuous, Personalized Professional Development for Teacher Educators

To address existing gaps in technological competencies, universities implement continuous and personalized professional development programs. These programs remain flexible and responsive to individual educator needs, covering tools such as Artificial Intelligence in Education (AIED), Learning Analytics, Virtual Reality (VR), and Augmented Reality (AR). The professional development process includes certifications, workshops, webinars, and mentoring sessions that systematically strengthen technological pedagogical expertise over time.

5.5.3 Integrate AI Literacy, Digital Citizenship, and Data Privacy Education

AI literacy, digital ethics, and data privacy form core components of teacher education. Teacher educators and prospective teachers engage with the responsible use of digital tools, understand implications of AI integration, ensure student data protection, and promote digital citizenship. Training modules include applications of

AI in personalized learning, ethical considerations, and compliance with data protection regulations such as GDPR.

5.5.4 Establish TPACK-Based Microteaching and Simulation Labs

Institutions create microteaching and simulation labs that enable prospective teachers to practice using smart boards, learning management systems (LMS), virtual classrooms, and educational apps. These labs replicate classroom settings and provide opportunities to plan, deliver, and reflect on lessons incorporating technology. Regular participation in simulations builds both competence and confidence in digital instruction.

5.5.5 Foster Gender-Inclusive Technology Leadership Initiatives

Although the study found no statistically significant gender differences in TPACK competencies, it remains crucial to continue promoting gender inclusivity in technology leadership. Institutions should implement programs that actively encourage both male and female educators to take on leadership roles in educational technology initiatives. Opportunities such as Educational Technology (EdTech) ambassador programs, leadership workshops, and mentorship pairings with experienced technology integrators should be offered equitably. Highlighting role models from diverse backgrounds will further strengthen confidence among all genders, ensuring that leadership in educational technology is inclusive, representative, and forward-thinking.

5.5.6 Develop Individualized TPACK Growth Portfolios

Both teacher educators and prospective teachers should be encouraged to develop personalized TPACK portfolios as part of their professional growth. These digital portfolios would track their evolving competencies by documenting lesson plans, technology-enhanced teaching artifacts, reflections on technology integration, feedback received, and self-assessments. Portfolios would serve as dynamic tools for

self-monitoring progress and identifying areas for improvement. Furthermore, institutions can use these portfolios as assessment tools to measure the effectiveness of their teacher preparation programs in developing comprehensive TPACK skills.

5.5.7 Implement Dynamic Assessment and Feedback Systems

To accurately monitor the development of TPACK competencies, dynamic assessment systems must be established. Traditional testing methods are insufficient for evaluating integrated skills like TPACK. Instead, institutions should implement authentic assessment strategies such as peer-reviewed teaching demonstrations, video-taped digital lessons, classroom observations with detailed TPACK rubrics, and student feedback. Regular, constructive feedback must be provided to teacher educators and prospective teachers to guide their improvement. Formative assessments conducted periodically during teacher education programs will ensure continuous professional growth rather than last-minute evaluations.

5.5.8 Facilitate Cross-Disciplinary Collaboration and Innovation Projects

To foster a richer understanding of technology integration, teacher education programs should actively collaborate with faculties of computer science, instructional technology, media studies, and design thinking. Interdisciplinary innovation projects where future teachers co-develop educational apps, gamified learning platforms, multimedia teaching materials, or AI-driven assessments will broaden their technological horizons. Such collaborations will expose educators to cutting-edge technological applications and inspire creative approaches to technology-enhanced pedagogy, ensuring that they are not just users but innovators in educational technology.

5.5.9 Strengthen Institutional Infrastructure and Support Systems

Modern technology integration is impossible without proper institutional support. Universities must invest substantially in upgrading their technological infrastructure by equipping classrooms with smart boards, interactive projectors, fast internet access, digital libraries, and collaborative learning spaces. Alongside physical upgrades, institutions should establish support units where teachers can receive technical assistance, training, and mentoring regarding educational technologies. Ensuring that teacher educators and prospective teachers have consistent access to well-maintained digital tools will empower them to practice and model best practices in technology integration.

5.5.10 Promote Action Research on TPACK Practices

Finally, it is recommended that both teacher educators and prospective teachers engage in action research projects that explore innovative uses of technology in education. By systematically investigating the impact of technology-enhanced lessons on student learning outcomes, classroom engagement, or inclusivity, educators will deepen their understanding of effective technology integration. Action research findings may be encouraged for presentation at seminars, conferences, and publication in educational journals, fostering a culture of inquiry, reflection, and evidence-based teaching within institutions.

By following these recommendations, teacher education programs can improve the technological pedagogical content knowledge of both current educators and future teachers, making sure they are prepared to effectively incorporate technology into their teaching methods.

5.6 Limitations and Future Research

5.6.1 Limitations

This study offers important insights into the TPACK levels of teacher educators and prospective teachers; however, there are some limitations to consider. The research was carried out at two universities in Pakistan, which may restrict the applicability of the findings to other regions and educational contexts. Future research should aim to broaden the sample to include a more varied group of educators and prospective teachers from different geographical and institutional backgrounds. Another limitation is the dependence on self-reported data gathered through surveys. These self-reported answers can be affected by biases like social desirability and individual interpretations of TPACK competencies. To address this limitation, future studies could incorporate qualitative methods, such as classroom observations and interviews, to provide a more thorough understanding of how TPACK is utilized in real teaching scenarios.

5.6.2 Future Researches

Building upon the findings of this study, future research could explore the following areas:

1. Investigating how TPACK competencies change over time with continuous professional development, providing insights into the long-term effectiveness of training programs.
2. Conducting in-depth qualitative analyses to explore educator's perceptions, challenges, and experiences in implementing TPACK-based teaching strategies.
3. Examining TPACK competencies across different educational systems and cultural contexts to identify best practices and strategies for global implementation.

4. Analyzing how advancements in artificial intelligence, virtual reality, and other emerging technologies influence TPACK development and integration in teaching.

Future study can help us obtain a deeper understanding of TPACK and its practical application in a wide range of educational settings.

REFERENCES

- Akturk, A. O., & Ozturk, H. S. (2019). Teachers' TPACK Levels and Students' Self-Efficacy as Predictors of Students' Academic Achievement. *International Journal of research in education and science*, 5(1), 283-294.
- Al-Adwan, A. S., Meet, R. K., Anand, S., Shukla, G. P., Alsharif, R., & Dabbaghia, M. (2024). Understanding continuous use intention of technology among higher education teachers in emerging economy: evidence from integrated TAM, TPACK, and UTAUT model. *Studies in Higher Education*, 1-20.
- Ali, Z., Azam, R., & Saba, F. (2023). Technological Pedagogical and Content Knowledge of Pre-Service Elementary School Teachers in Karachi, Pakistan: A Quantitative Study. *Journal of Social Sciences Review*, 3(1), 678-688.
- Alhababi, H. H. (2017). Technological pedagogical content knowledge (TPACK) effectiveness on English teachers and students in Saudi Arabia. University of Northern Colorado. An explanatory study among selected United Arab Emirates (UAE) universities. Available at SSRN 3421436.
- 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. <https://doi.org/10.54183/jssr.v3i2.272>
- 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.
- Alkhawaldeh, N. I. & Menchaca, M. (2014). Barriers to utilizing ICT in education in Jordan. *International Journal on e-Learning*, 13(2), 127-155.
- Al-Samarraie, H., & Saeed, N. (2018). A systematic review of cloud computing tools for collaborative learning: Opportunities and challenges to the blended-learning environment. *Computers & Education*, 124, 77–91.
- Alwaely, S. A., Lahiani, H., Aljarrah, H., & Alqudah, H. (2022, November). The Effects of Information Technology on the Educational Sector in the United Arab

Emirate. In 2022 *International Arab Conference on Information Technology (ACIT)* (pp. 1-10). IEEE.

Angeli, C., & Valanides, N. (2009). Epistemological and methodological issues for the conceptualization, development, and assessment of ICT–TPCK: Advances in technological pedagogical content knowledge (TPCK). *Computers & Education*, 52(1), 154–168.

Archambault, L., & Crippen, K. (2009). Examining TPACK among K-12 online distance educators in the United States. *Contemporary issues in technology and teacher education*, 9(1), 71-88.

Archambault, L.M. & Barnett, J.H. (2010). Revisiting technological pedagogical content knowledge: 16–31). Hershey, PA: Information Science Reference.

Aslan, A. & Zhu, C. (2015). Pre-service teachers' perceptions of ICT integration in teacher education in Turkey. *The Turkish Online Journal of Educational Technology*, 14(3), 97- 110.

Atiqa Shib Khan, Irfana Rasul, Saima Malik, Mahwish Mumtaz Niazi. (2024-09-28). The Impact of Teachers' Pedagogic Quality under the TPACK Framework on Student Success at Public and Private Universities in Lahore. *Remittances Review*, September 2024.

Ay, Y., Karadağ, E., & Acat, M. B. (2015). The Technological Pedagogical Content Knowledge-practical (TPACK-Practical) model: Examination of its validity in the Turkish culture via structural equation modeling. *Computers & Education*, 88, 97-108.

Azzolini, D., & Schizzerotto, A. (2017). The second digital divide in Europe. A cross-national study on students' digital reading and navigation skills. Research Institute for the Evaluation of Public Policies, 2, 1–17. <https://irvapp.fbk.eu/wpcontent/uploads/2017/09/FBK-IRVAPP-Working-Paper-No.-2017-02.pdf>

Bakar, N. S. A., Maat, S. M., & Rosli, R. (2020). Mathematics Teacher's Self-Efficacy of Technology Integration and Technological Pedagogical Content

- Knowledge. *Journal on Mathematics Education*, 11(2), 259-276.
<http://doi.org/10.22342/jme.11.2.10818.259-276>
- Baran, E. (2016). Investigating faculty technology mentoring as a university-wide professional development model. *Journal of Computing in Higher Education*, 28, 45–71. <https://doi.org/10.1007/s12528-015-9104-7>
- Baran, E., Canbazoglu-Bilici, S., Albayrak-Sari, A., & Tondeur, J. (2019). Investigating the impact of teacher education strategies on preservice teachers' TPACK. *British Journal of Educational Technology*, 50(1), 357–370.
<https://doi.org/10.1111/bjet.12565>
- Baran, E., Chuang, H. H., & Thompson, A. (2011). TPACK: An emerging research and development tool for teacher educators. *Turkish Online Journal of Educational Technology-TOJET*, 10(4), 370-377.
- Baran, E.; Correia, A.P.; Thompson, A. Transforming online teaching practice: Critical analysis of the literature on the roles and competencies of online teachers. *Distance Educ.* 2011, 32, 421–439.
- Bigatel, P. M., Ragan, L. C., Kennan, S., May, J., & Redmond, B. F. (2012). The identification of competencies for online teaching success. *Journal of Asynchronous Learning Networks*, 16(1), 59–78.
- Blocher, J. M., Armfield, S. W., Sujo-Montes, L., Tucker, G., & Willis, E. (2011). Contextually based professional development. *Computers in the Schools*, 28, 158-169.
- Bogner, A., & Menz, W. (2009). The theory-generating expert interview: epistemological interest, forms of knowledge, interaction. *Interviewing experts*, 43-80.
- Bond, M., Buntins, K., Bedenlier, S., Zawacki-Richter, O., & Kerres, M. (2020). Mapping research in student engagement and educational technology in higher education: A systematic evidence map. *International journal of educational technology in higher education*, 17, 1-30.
- Brata, W., Padang, R., Suriani, C., Prasetya, E., & Pratiwi, N. (2022). Student's digital literacy based on students' interest in digital technology, internet costs, gender,

- and learning outcomes. *International Journal of Emerging Technologies in Learning*, 17(3), 138–151. <https://www.learntechlib.org/p/220512/>
- Bunane, J. B., Kampire, E., & Karegeya, C. (2022). Teachers' perceptions on the impact of continuous professional development to promote quality teaching and learning of chemistry: a case of Rwamagana secondary schools, Rwanda. *African Journal of Chemical Education*, 12(2), 96-111.
- Burns, N., & Grove, S. K. (2001). *The practice of nursing research: Conduct, critique, and utilization* (4th ed.). Philadelphia, PA: W.B. Saunders.
- Canbazoglu Bilici, S., Guzey, S. S., & Yamak, H. (2016). Assessing pre-service science teachers' technological pedagogical content knowledge (TPACK) through observations and lesson plans. *Research in Science & Technological Education*, 34(2), 237-251.
- Castéra, J., Marre, C. C., Yok, K., Sherab, K., Impedovo, M. A., Sarapuu, T., & Armand, H. (2020). Self-reported TPACK of teacher educators across six countries in Asia and Europe. *Education and Information Technologies*, 25(4), 3003– 3019. <https://doi.org/10.1007/s10639-020-10106-6>
- Chai CS, Koh JHL & Tsai CC (2010). Facilitating preservice teachers' development of technological, pedagogical, and content knowledge (TPACK). *Educational Technology and Society*, 13(4):63–73.
- Chai, C. S., Koh, J. H. L., & Tsai, C.-C. (2011a). Exploring the factor structure of the constructs of technological, pedagogical, content knowledge (TPACK). *The Asia- Pacific Education Researcher*, 20(3), 595–603.
- Chai, C. S., Koh, J. H. L., & Tsai, C.-C. (2013). A review of technological pedagogical content knowledge. *Educational Technology & Society*, 16(2), 31-51.
- Chai, C. S., Koh, J. H. L., Tsai, C. C., & Tan, L. L. W. (2011). Modeling primary school pre-service teachers' Technological Pedagogical Content Knowledge (TPACK) for meaningful learning with information and communication technology (ICT). 57(1), 1184-1193.
- Chai, C. S., Koh, J. H. L., Tsai, C.-C., & Tan, L. L. W. (2011b). Modeling primary school pre-service teachers' technological pedagogical content knowledge (TPACK) for meaningful learning with information and communication

- technology (ICT). *Computers & Education*, 57(1), 1184–1193.
<https://doi.org/10.1016/j.compedu.2011.01.007>.
- Chai, C. S., Koh, J. H., & Tsai, C.-C. (2016). Review of the quantitative measures of technological pedagogical content knowledge (TPACK). In M. C. Herring, M. J. Koehler & P. Mishra, (Eds.), *Handbook of technological pedagogical content knowledge (TPACK) for educators* (2nd ed). New York, NY: Taylor & Francis.
- Chang, Y., Hsu, C., & Ciou, P. (2017). Examining the use of learning communities to improve pre-service teachers' technological pedagogical content knowledge. *International. Journal of Learning and Teaching*.3 (2), 136-143.
- Chong, W., & Kong, C. (2012). Teacher collaborative learning and teacher self-efficacy: The case of lesson study. *The Journal of Experimental Education*, **80**(3), 263–283.
- Cochran, K. F., King, R. A., & DeRuiter, J. A. (1991). *Pedagogical content knowledge: A tentative model for teacher preparation*. Paper presented at the annual meeting of the American Educational Research Association, Chicago, IL.
- Collins, A., & Halverson, R. (2018). Rethinking education in the age of technology: The digital revolution and schooling in America. Teachers College Press.
- Continuing Professional Development (CPD)*. (n.d.). Retrieved from THE INSTITUTION OF ENGINEERING AND TECHNOLOGY(IET):
<https://www.theiet.org/career/professional-development/continuing-professional-development>.
- Cox, S., & Graham, C. R. (2009). Diagramming TPACK in practice: Using an elaborated model of the TPACK framework to analyze and depict teacher knowledge. *TechTrends: Linking Research & Practice to Improve Learning*, 53(5).
- Crawford, J., Butler-Henderson, K., Rudolph, J., Malkawi, B., Glowatz, M., Burton, R., ... & Lam, S. (2020). COVID-19: 20 countries' higher education intra-period digital pedagogy responses. *Journal of Applied Learning & Teaching*, 3(1), 1-20.
- Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.

- Cummings, C., Mason, D., Shelton, K., & Baur, K. (2017). Active learning strategies for online and blended learning environments. In *Flipped instruction: Breakthroughs in research and practice* (pp. 88–114). IGI Global.
- Díaz, J., Saldaña, C., & Avila, C. (2020). Virtual world as a resource for hybrid education. *International Journal of Emerging Technologies in Learning (iJET)*, 15(15), 94-109.
- Dijkstra, W. and Goeman, K., European Maturity Model for Blended Education. Implementation Guidelines. EMBED. Project, funded by the European Commission.
<https://embed.eadtu.eu/download/2517/EMBED%20implementation%20guidelines.pdf?inline=1>
- Dinc, E. (2019). Prospective teachers' perceptions of barriers to technology integration in education. *Contemporary Educational Technology*, 10(4), 381-398.
- Divjak, B., Rienties, B., Iniesto, F., Vondra, P., & Žižak, M. (2022). Flipped classrooms in higher education during the COVID-19 pandemic: Findings and future research recommendations. *International Journal of Educational Technology in Higher Education*, 19(1), 1-24.
- Donnelly, D. F., & Hume, A. (2015). Using collaborative technology to enhance student teachers' pedagogical content knowledge in science. *Research in Science & Technological Education*, 33(1), 61–87.
- Ersoy M., Kabakçı Yurdakul I., Ceylan B. (2016). Investigating preservice teachers' TPACK competencies through the lenses of ICT skills: An experimental study. *Education and Science*, 41(186), 119–135. <https://doi.org/10.15390/EB.2016.6345>
- Ertmer, P. A. (1999). Addressing first- and second-order barriers to change: Strategies for technology integration. *Educational Technology Research and Development*, 47(4), 47- 61.
- Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher technology change: How knowledge, confidence, beliefs, and culture intersect. 42(3), 255-284.
- Essien, E. E., Akpan, O. E., & Obot, I. M. (2016). The Influence of In-Service Training, Seminars and Workshops Attendance by Social Studies Teachers on Academic

- Performance of Students in Junior Secondary Schools In Cross River State, Nigeria. *Journal of Education and Practice*, 7(22), 31–35.
- Fernández-Miravete, Á. D., & Prendes-Espinosa, M. P. (2021). Analysis of the digitization process of a Secondary School from the DigCompOrg model. *RELATEC—Revista Latinoamericana de Tecnología Educativa*, 20, 9-25.
- Fuad, M., Ariyani, F., Suyanto, E., & Shidiq, A. S. (2020). Exploring teachers ' TPACK : Are Indonesian language teachers ready for online learning during the COVID-19 outbreak ? 8(4), 6091–6102. <https://doi.org/10.13189/ujer.2020.082245>
- Figg, C., & Jaipal, K. (2012). TPACK-in-Practice: Developing 21st century teacher knowledge. *Proceedings of Society for Information Technology & Teacher Education International Conference*, Austin, Texas, 4683-4689.
- Foulger, T. S., Graziano, K. J., Schmidt-Crawford, D., & Slykhuis, D. A. (2017). Teacher educator technology competencies. *Journal of Technology and Teacher Education*, 25(4), 413–448.
- Gabriel, M. A., & Kaufield, K. J. (2008). Reciprocal mentorship: An effective support for online instructors. *Mentoring & Tutoring: Partnership in Learning*, 16(3), 311-327.
- Ghayyur, T. S., & Mirza, N. A. (2021). Exploring TPACK skills of prospective teachers and challenges faced in digital technology integration in Pakistan. *Journal of Development and Social Sciences*, 2(4), 226-241.
- Gökoğlu, S., & Çakıroğlu, Ü. (2017). Determining the roles of mentors in the teachers' use of technology: Implementation of systems-based mentoring model. *Educational Sciences: Theory & Practice*, 17(1).
- Gómez-Trigueros, I. M., & Yáñez de Aldecoa, C. (2021). The digital gender gap in teacher education: The TPACK framework for the 21st century. *European Journal of Investigation in Health, Psychology and Education*, 11(4), 1333-1349.
- Goswami, A., & Dutta, S. (2015). Gender differences in technology usage—A literature review. *Open Journal of Business and Management*, 4(1), 51-59.

- Government of Pakistan. (2017). *National education policy 2017*. Ministry of Federal Education and Professional Training. <https://www.mofept.gov.pk/Policies>
- Green, K. C., & Gilbert, S. W. (1995). Great expectations: Content, communications, productivity, and the role of information technology in higher education. *Change: The magazine of higher learning*, 27(2), 8-18.
- Guillén-Gámez, F. D., Mayorga-Fernández, M. J., Bravo-Agapito, J., & Escribano-Ortiz, D. (2021). Analysis of teachers' pedagogical digital competence: Identification of factors predicting their acquisition. *Technology, Knowledge and Learning*, 26(3), 481-498.
- Gustafsson, T., & Ollila, M. (2003). Expert consultation in the preparation of a national technology programme. Systems Analysis Laboratory. Helsinki: Helsinki University of Technology, 31.
- Harris, J. B., & Hofer, M. J. (2011). Technological pedagogical content knowledge (TPACK) in action: A descriptive study of secondary teachers' curriculum-based, technology-related instructional planning. *Journal of Research on Technology in Education*, 43(3), 211-229.
- Haywood, J., Connelly, L., Henderikx, P., Weller, M. & Williams, K. (2015). The changing pedagogical landscape. New ways of teaching and learning and their implications for higher education policy, European Commission, Education and Culture, 2015. Publications Office. <http://www.changingpedagogicallandscapes.eu/publications/>
- Hechter, R. P., & Vermette, L. A. (2013). Technology integration in K-12 science classrooms: an analysis of barriers and implications. *Themes in science and technology education*, 6(2), 73-90.
- Harris, J., Mishra, P., & Koehler, M. (2009). Teachers' technological pedagogical content knowledge and learning activity types: Curriculum-based technology integration reframed. *Journal of research on technology in education*, 41(4), 393-416.
- Hub, B. (2022, November 10). *Institutional policies for digital higher education*. Retrieved from BLOOM Hub: <https://bloomhub.eu/2022/11/10/devel-digitech-learn-hied-institutional-policies-for-digital-higher-education>.

- Hunter M. A. (2016). Innovative approaches to faculty development for technology integration: Evaluation of a three-tiered model. (Unpublished Doctoral Dissertation). *Fielding Graduate University*. Retrieved from <http://research.fielding.edu/2016/01/innovative-approaches-tofaculty.html>
- Hur, J. W., Shannon, D., & Wolf, S. (2016). An investigation of relationships between internal and external factors affecting technology integration in classrooms. *Journal of Digital Learning in Teacher Education*, 32(3), 105-114.
- Husna, S. H., Shahrinaz, I., Siti, H. S. A., Ummul, F. A. R. (2022). Conceptual framework of factors affecting online teaching. *International Journal of Innovative Research and Scientific Studies*, 5(4), 354-362. <https://doi.org/10.53894/ijirss.v5i4.874>
- 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.
- Hussain, S. (2024). Analysis of the opinion of prospective teachers regarding TPACK and ICT: a glimmer of light for Pakistan's education system. *International Research Journal of Education and Innovation*, 5(1), 28-38.
- INTEGRATION. In Society for Information Technology & Teacher Education International Conference (pp. 1671-1676). Association for the Advancement of Computing in Education (AACE).
- Intel. (2013). Women and the Web. Bridging the Internet gap and creating new global opportunities in low and middle-income countries. <https://www.intel.la/content/dam/www/public/us/en/documents/pdf/women-and-the-web.pdf>
- ISTE. (2017). *Essential Conditions. Necessary conditions to effectively learning*. Retrieved from https://my.iste.org/s/store?_ga=2.204168595.201517631.16765699501368183152.1676569950#/store/browse/detail/a1w1U000004LpF0QAK

- ITU. (2019). The ICT Development Index (IDI). <https://www.itu.int/en/ITU-D/Statistics/Pages/IDI/default.aspx>
- Jacob, S. A., & Furgerson, S. P. (2012). Writing interview protocols and conducting interviews: Tips for students new to the field of qualitative research. *Qualitative Report*, 17, 6.
- Jain, V., Mogaji, E., Sharma, H., & Babbili, A. S. (2022). A multi-stakeholder perspective of relationship marketing in higher education institutions. *Journal of Marketing for Higher Education*, 1-19.
- Jaipal-Jamani K., Figg C., Collier D., Gallagher T., Winters K. L., Ciampa K. (2018). Developing TPACK of university faculty through technology leadership roles. *Italian Journal of Educational Technology*, 26(1), 39–55. <https://www.learntechlib.org/p/184086>
- Jen, T. H., Yeh, Y. F., Hsu, Y. S., Wu, H. K., & Chen, K. M. (2016). Science teachers' TPACK- Practical: Standard-setting using an evidence-based approach. *Computers & Education*, 95, 45-62.
- Jin, Y., & Schmidt-Crawford, D. (2022). Preservice teacher cluster memberships in an edtech course: A study of their TPACK development. *Computers and Education Open*, 3, 100089.
- Joo, Y. J., Park, S., & Lim, E. (2018). Factors influencing preservice teachers' intention to use technology: TPACK, teacher self-efficacy, and technology acceptance model. *Journal of Educational Technology & Society*, 21(3), 48-59.
- Kabakci Yurdakul, I. Ş. I. L., & Çoklar, A. N. (2014). Modeling preservice teachers' TPACK competencies based on ICT usage. *Journal of Computer Assisted Learning*, 30(4), 363- 376.
- Kaddoura, S., & Al Hussein, F. (2023). The rising trend of Metaverse in education: Challenges, opportunities, and ethical considerations. *PeerJ Computer Science*, 9, e1252.
- Kauffman, H. (2015). A review of predictive factors of student success in and satisfaction with online learning. *Research in Learning Technology*, 23.

- Kaufman, K. (2015). Information communication technology: challenges & some prospects from preservice education to the classroom. *Mid-Atlantic Education Review*, 2, 1–11.
- Kay, R. (2006). Evaluating strategies used to incorporate technology into pre-service education: a review of the literature. *Journal of Research on Technology in Education*, 38, 383–408.
- Keengwe, J., Onchwari, G., & Wachira, P. (2008). Computer technology integration and student learning: Barriers and promise. *Journal of science education and technology*, 17, 560-565.
- Kianinezhad, N. (2023). Effective methods of teaching foreign languages online: A global view. *TESOL and Technology Studies*, 4(1), 45-59.
- Kilinc, E., Tarman, B., & Aydin, H. (2018). Examining Turkish social studies teachers' beliefs about barriers to technology integration. *TechTrends*, 62, 221-223.
- Kim, C., Kim, M. K., Lee, C., Spector, J. M., & DeMeester, K. (2013). Teacher beliefs and technology integration. *Teaching & Teacher Education*, 29, 76-85.
- Kimmons, R. & Hall, C. (2016). Toward a broader understanding of teacher technology integration beliefs and values. *Journal of Technology and Teacher Education*, 24(3), 309- 335.
- Kocagül, M., & Çoban, G. Ü. (2024). Evaluation of pre-service science and Math teachers' online teaching experiences within the TPACK framework. *Journal of Educational Technology and Online Learning*, 7(2), 149-167.
- Koehler, M. J., & Mishra, P. (2008). Introducing TPCK. In AACTE Committee on Innovation and Technology (Eds.), *Handbook of Technological Pedagogical Content Knowledge (TPCK) for Educators* (pp. 3–29). Routledge.
- Koehler, M. J., Shin, T. S., & Mishra, P. (2012). How do we measure TPACK? Let me count the ways. In *Educational technology, teacher knowledge, and classroom impact: A research handbook on frameworks and approaches* (pp. 16-31). IGI Global.
- Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge? *Contemporary Issues in Technology and Teacher Education*, 9(1), 60–70.

- Koehler, M. J., Mishra, P., & Cain, W. (2013). What is technological pedagogical content (TPACK)? *Journal of Education*, 193(3), 13–19.
- Koehler, M. J., Mishra, P., Kereluik, K., Shin, T. S., & Graham, C. R. (2014). The technological pedagogical content knowledge framework. *Handbook of research on educational communications and technology*, 101-111.
- Koh& Chai (2011). Modeling Pre-service Teachers' Technological Pedagogical Content Knowledge (TPACK) Perceptions: The Influence of Demographic Factors and TPACK Constructs. Proceedings ascilite 2011 Hobart, 735-746.
- Koh, J. H. L., & Chai, C. S. (2016). Seven design frames that teachers use when considering technological pedagogical content knowledge (TPACK). *Computers & Education*, 102, 244–257. <https://doi.org/10.1016/j.compedu.2016.09.003>.
- Koh, J. H. L., Chai, C. S., & Tsai, C. C. (2010). Examining the technological pedagogical content knowledge of Singapore pre-service teachers with a large-scale survey. *Journal of Computer Assisted Learning*, 26(6), 563-573.
- Koh, J. H. L., Chai, C. S., & Tsai, C. C. (2014). Demographic factors, TPACK constructs, and teachers' perceptions of constructivist-oriented TPACK. *Journal of Educational Technology & Society*, 17(1), 185–196.
- Koh, J. H. L., Chai, C. S., & Tsai, C.-C. (2013). Examining practicing teachers' perceptions of technological pedagogical content knowledge (TPACK) pathways: A structural equation modeling approach. *Instructional Science*, 41(4), 793–809. <https://doi.org/10.1007/s11251-012-9249-y>.
- Koh, J. H., & Chai, C. S. (2011). Modeling pre-service teachers' technological pedagogical content knowledge (TPACK) perceptions: The influence of demographic factors and TPACK constructs. In G. Williams, P. Statham, N. Brown, & B. Cleland (Eds.), *changing demands, changing directions*. (pp. 735-746). Hobart: ascilite
- Kurth, A., Kaufmann, H. R., & Schäffner, L. (2022, February 17). *Inclusive online collaborative learning environments*. Creation of a Collaborative Environment in e-classrooms. https://reacteclass.eu/wp-content/uploads/REACTLiteratureReview_final.pdf

- Lee, M. H., & Tsai, C. C. (2010). Exploring teachers' perceived self-efficacy and technological pedagogical content knowledge with respect to educational use of the worldwide web. *Instructional Science: An International Journal of the Learning Sciences*, 38(1), 1–21.
- Lewis, C. C., Fretwell, C. E., Ryan, J., & Parham, J. B. (2013). Faculty use of established and emerging technologies in higher education: A unified theory of acceptance and use of technology perspective. *International Journal of Higher Education*, 2(2), 22–34.
- Lin, T. C., Tsai, C. C., Chai, C. S. and Lee, M. H. (2013). Identifying Science Teachers' Perceptions of Technological Pedagogical and Content Knowledge (TPACK). *Journal of Science Education and Technology*, 22(3), 325-336.
- Makawawa, J. C., Mustadi, A., Septriwanto, J. V., Sampouw, F., & Najoran, R. A. O. (2021). Primary school teachers' perception of technological pedagogical content knowledge in online learning due to Covid 19. *Journal Prima Edukasia*, 9(1), 86-96.
- Margerum-Leys, J., & Marx, R. (2002). Teacher knowledge of educational technology: A study of student teacher/mentor teacher pairs. *Journal of Educational Computing Research*, 26(4), 427-462.
- Martin, F., Budhrani, K. & Wang, C. (2019). Examining faculty perception of their readiness to teach online. *Online Learning*, 23(3), 97–119. <https://doi.org/10.24059/olj.v23i3.1555>
- Max, A. L., Weitzel, H., & Lukas, S. (2023, November). Factors influencing the development of pre-service science teachers' technological pedagogical content knowledge in a pedagogical makerspace. In *Frontiers in Education* (Vol. 8, p. 1166018). Frontiers Media SA.
- McCrary, R. (2004). A framework for understanding teaching with the Internet. *American Educational Research journal* 41(2), 447-488.
- Miranda. H. P. & Russell, M. (2012). Understanding factors associated with teacher-directed student use of technology in elementary classrooms: A structural equation modeling approach. *British Journal of Educational Technology*, 43(4), 652-666.

- Mishra, P. (1998). Flexible learning in the periodic system with multiple representations: The design of a hypertext for learning complex concepts in chemistry. (Doctoral dissertation, University of Illinois at Urbana-Champaign). *Dissertation Abstracts International* 59 (11), 4057. (MT 9912322).
- Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A new framework for teacher knowledge. *Teachers College Record*, 108(6), 1017–1054. <https://doi.org/10.1111/j.1467-9620.2006.00684.x>
- Mishra, P., Koehler, M. J., & Henriksen, D. (2010). The 7 transdisciplinary habits of mind: Extending the TPACK framework towards 21st century learning. *Educational Technology*, 51(2), 22-28.
- Mohebi, L., & Helder, M. (2019). A quantitative approach to assess the perceptions of pre- service teachers and their instructors about TPACK capabilities of pre-service teachers:
- Mourlam, D. (2017). Preparing for infusion: Emergence of a model for faculty TPACK development. *Journal of Technology and Teacher Education*, 25(3), 301–325.
- Mugiraneza, J. P. (2021). Digitalization in Teaching and Education in Rwanda. In International Labour Office • Geneva. <https://www.ilo.org.publication.wcsm-783668>
- Muliani, M., Sukarni, S., & Jumadil, J. (2024). English Teachers' Tecnological Knowledge and Some Barriers on It: The Basis for Developing TPACK Teaching Model. *Journal of Languages and Language Teaching*, 12(1), 499-510.
- Ndihokubwayo, K. (2017). Investigating the status and barriers of science laboratory activities in Rwandan teacher training colleges towards improvisation practice. *Rwandan Journal of Education*, 4(1), 47-54.
- Nessaei, H., & Kazemi, S. (2024). On the Relationship between Iranian EFL Teachers' Technological Pedagogical Content Knowledge (TPCK) and their Willingness to Attend Continuing Professional Development (CPD) Courses. *Teaching and learning*, 4(1).

- Niess M. L. (2011). Investigating TPACK: Knowledge growth in teaching with technology. *Journal of Educational Computing Research*, 44(3), 299–317. <https://doi.org/10.2190/ec.44.3.c>
- Niess, M. L. (2011). Investigating TPACK: Knowledge growth in teaching with technology. *Journal of Educational Computing Research*, 44(3), 299-317.
- Niess, M. L., Ronau, R. N., Shafer, K. G., Driskell, S. O., Harper S. R., Johnston, C., Browning, C., Özgün-Koca, S. A., & Kersaint, G. (2009). Mathematics teacher TPACK standards and development model. *Contemporary Issues in Technology and Teacher Education*, 9(1): 4-24.
- Nikolopoulou, K., & Gialamas, V. (2016). Barriers to ICT use in high schools: Greek teachers' perceptions. *Journal of Computers in Education*, 3, 59-75.
- Nilsson, P. (2024). From PCK to TPACK-Supporting student teachers' reflections and use of digital technologies in science teaching. *Research in Science & Technological Education*, 42(3), 553-577.
- Noor, M., Rashid, S., Shakoor, A., & Ullah, H. (2021). Investigating Teachers' Educators and Prospective Teachers' Technological Pedagogical Content Knowledge and its Impact on their Learning at Bachelor Level in Education. *Elementary Education Online*, 20(2), 1239-1239.
- Nsouli R., Vlachopoulos D. (2021). Attitudes of nursing faculty members toward technology and e-learning in Lebanon. *BMC Nursing*, 20(1), 1–15. <https://doi.org/10.1186/s12912-021-00638-8>
- Öztürk, E., & Horzum, M. B. (2011). Adaptation of technological pedagogical content knowledge scale into Turkish. *Ahi Evran University Education Faculty Journal*, 12(3), 255-278.
- Otrell-Cass, K., Cowie, B., & Maguire, M. (2010). Taking video cameras into the classroom.
- Papanikolaou, K., Makri, K., & Roussos, P. (2017). Learning design as a vehicle for developing TPACK in blended teacher training on technology-enhanced learning. *International Journal of Educational Technology in Higher Education*, 14, 1–14.

- Prasojo, L. D., Habibi, A., Mukminin, A., & Yaakob, M. F. M. (2020). Domains of Technological Pedagogical and Content Knowledge: Factor Analysis of Indonesian In-Service EFL Teachers. *International Journal of Instruction*, 13(4), 593-608. DOI: [10.29333/iji.2020.13437a](https://doi.org/10.29333/iji.2020.13437a)
- Retrieved from DRAFT NATIONAL EDUCATION POLICY 2017: <https://mofept.gov.pk/Policies>
- Rokhyati, U. (2015). English teachers' professional development and self-confidence in performing their profession. *International Journal on Studies in English Language and Literature (IJSELL)*, 3 (2), 78-82. DOI: <https://www.arcjournals.org/pdfs/ijSELL/v3-i2/8>
- Rotherham, A. J., & Willingham, D. (2009). 21st century. Educational leadership, 67(1), 16- 21.
- Saad, M. M. (2013). Information and communication technology in building prospective teachers' knowledge base: cohort of secondary mathematics pre-service teachers in Lebanon (doctoral dissertation). Saint Joseph University.
- Saito, E., & Atencio, M. (2016). Pedagogical content knowledge in action: Its impromptu development by an expert practitioner. *Pedagogy, Culture & Society*, 24(1), 101–121.
- Sánchez, R. A., & Hueros, A. D. (2010). Motivational factors that influence the acceptance of Moodle using TAM. *Computers in human behavior*, 26(6), 1632-1640.
- Saubern, R., Henderson, M., Heinrich, E., & Redmond, P. (2020). TPACK–time to reboot? *Australasian Journal of Educational Technology*, 36(3), 1-9.
- Scherer, R., Howard, S. K., Tondeur, J., & Siddiq, F. (2021). Profiling teachers' readiness for online teaching and learning in higher education: Who's ready? *Computers in human behavior*, 118, 106675.
- Schmidt, D. A., Baran, E., Thompson, A. D., Mishra, P., Koehler, M. J., & Shin, T. S. (2009). Technological pedagogical content knowledge (TPACK): The development and validation of an assessment instrument for preservice teachers. *Journal of Research on Technology in Education*, 42(2), 123–149. <https://doi.org/10.1080/15391523.2009.10782544>.

- Schmid, M., Brianza, E., & Petko, D. (2020). Developing a short assessment instrument for Technological Pedagogical Content Knowledge (TPACK. xs) and comparing the factor structure of an integrative and a transformative model. *Computers & Education*, 157, 103967.
- 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.
- Setiawan, I. (2018). Exploring a teacher educator's experiences in modeling TPACK to create English language multimedia in technology courses (Doctoral dissertation, Universitas Negeri Makassar).
- Shoukat, S., Mamoon, R., & Arif, M. F. (2024). Enhancing Language Proficiency through TPACK Model and AI Applications A Study on Effective Integration Strategies in English Language Instruction. *Pakistan Languages and Humanities Review*, 8(2), 540- 554.
- Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15(2), 4-14.
- Sibomana, A., Karegeya, C., & Sentongo, J. (2022). Cooperative learning on students' knowledge retention and attitude in Chemistry. *BOOK OF PROCEEDINGS—LONG PAPERS*, 298.
- Singh, V., & Thurman, A. (2019). How many ways can we define online learning? A systematic literature review of definitions of online learning (1988-2018). *American Journal of Distance Education*, 33(4), 289-306.
- Smith, W. C. & Benavot, A. (2019). Improving Accountability in Education: Importance of Structured Democratic Voice. *Asia Pacific Education Review*, 20 (2), 193- 205. DOI: <https://link.springer.com/article/10.1007/s12564-019-09599-9>
- Suki, N. M., & Suki, N. M. (2011). Exploring the relationship between perceived usefulness, perceived ease of use, perceived enjoyment, attitude, and subscribers' intention towards using 3G mobile services. *Journal of Information Technology Management*, 22(1), 1-7.

- SURF (2022), Guiding in synchronous online education (only available in Dutch). <https://www.surf.nl/begeleiden-in-synchroon-online-onderwijs-bison>
- Swallow, M. J. C., & Olofson, M. W. (2017). Contextual understandings in the TPACK framework. *Journal of Research on Technology in Education*, 49(3–4), 228–244. <https://doi.org/10.1080/15391523.2017.1347537>
- Taopan, L. L., Drajiati, N. A., & Sumardi, S. (2020). TPACK Framework: Challenges and Opportunities in EFL classrooms. *Research and innovation in language learning*, 3(1), 1-22.
- Taherdoost, H. (2016). Measurement and scaling techniques in research methodology; survey/questionnaire development. *International Journal of Academic Research in Management (IJARM)*, 6.
- Thappa, S. R., & Baliya, J. N. (2021). Exploring awareness for technological pedagogical and content knowledge (TPAC) in pre-service teacher education programme. *MIER Journal of Educational Studies Trends and Practices*, 1-14.
- Tikman F. (2022). Assessment of digital material design experiences of preservice social studies teachers in terms of various variables: a mixed design research. (Unpublished Doctoral dissertation). Anadolu University Graduate School of Educational Sciences, Eskişehir.
- Tondeur J., van Braak J., Sang G., Voogt J., Fisser P., Ottenbreit-Leftwich A. (2012). Preparing pre-service teachers to integrate technology in education: A synthesis of qualitative evidence. *Computers & Education*, 59(1), 134–144. <https://doi.org/10.1016/j.compedu.2011.10.009>
- Tondeur, J., Scherer, R., Baran, E., Siddiq, F., Valtonen, T., & Sointu, E. (2019). Teacher educators as gatekeepers: Preparing the next generation of teachers for technology integration in education. *British Journal of Educational Technology*, 50(3), 1189-1209.
- Tondeur, J., Van Braak, J., Ertmer, P. A., & Ottenbreit-Leftwich, A. (2017). Understanding the relationship between teachers' pedagogical beliefs and technology use in education: A systematic review of qualitative evidence. *Educational technology research and development*, 65, 555-575.

- Trust, T., Krutka, D. G., & Carpenter, J. P. (2016). "Together we are better": Professional learning networks for teachers. *Computers & education*, 102, 15-34.
- Tseng, J. J., Lien, Y. J., & Chen, H. J. (2016). Using a teacher support group to develop teacher knowledge of Mandarin teaching via web conferencing technology. *Computer Assisted Language Learning*, 29(1), 127-147.
- Tugtekin, U. (2023). The Dark Side of Metaverse Learning Environments: Potential Threats and Risk Factors. In *Shaping the Future of Online Learning: Education in the Metaverse* (pp. 57-67). IGI Global.
- Tütüniş, B., Ünal, K., & Babanoğlu, P. (2022). ICT (web tools) for English language teaching in primary schools: TPACK framework and usage. *International Journal of Education, Technology and Science*, 2(1), 95-107.
- Uerz D., Volman M., Kral M. (2018). Teacher educators' competences in fostering student teachers' proficiency in teaching and learning with technology: An overview of relevant research literature. *Teaching and Teacher Education*, 70, 12–23. <https://doi.org/10.1016/j.tate.2017.11.005>
- Vahed, A., & Rodriguez, K. (2021). Enriching students' engaged learning experiences through the collaborative online international learning project. *Innovations in Education and Teaching International*, 58(5), 596–605. <https://doi.org/10.1080/14703297.2020.1792331>
- Valtonen, T., Sointu, E., Kukkonen, J., Kontkanen, S., Lambert, M. C., & M€akitalo-Siegl, K. (2017). TPACK updated to measure pre-service teachers' twenty-first century skills. *Australasian Journal of Educational Technology*, 33(3), 15–31. <https://doi.org/10.1111/j.1365-2729.2012.00487.x>.
- Valtonen, T., Sointu, E., M€akitalo-Siegl, K., & Kukkonen, J. (2015). Developing a TPACK measurement instrument for 21st century pre-service teachers. *Seminar.Net*, 11(2), 87–100.
- Van Loi, N. (2021). VIETNAMESE HIGH-SCHOOL TEACHERS' PERCEPTIONS OF TPACK IN TEACHING ENGLISH AS A FOREIGN LANGUAGE. *European journal of education studies*, 8(4).

- Vermesan, O., & Friess, P. (Eds.). (2013). Internet of things: converging technologies for smart environments and integrated ecosystems. River publishers
- Voithofer, R., Nelson, M. J., Han, G., & Caines, A. (2019). Factors that influence TPACK adoption by teacher educators in the US. *Educational Technology Research and Development*, 67(6), 1427–1453. <https://doi.org/10.1007/s11423-019-09652-9>
- Voogt, J., Fisser, P., Pareja Roblin, N., Tondeur, J., & van Braak, J. (2013). Technological pedagogical content knowledge – a review of the literature. *Journal of Computer Assisted Learning*, 29, 109–121. <https://doi.org/10.1111/j.1365-2729.2012.00487.x>.
- Wang, M., Yu, H., Bell, Z., & Chu, X. (2022). Constructing an Edu-metaverse ecosystem: a new and innovative framework. *IEEE Transactions on Learning Technologies*, 15(6), 685-696.
- Wong, G. K. W. (2015). Understanding technology acceptance in pre-service teachers of primary mathematics in Hong Kong. *Australasian Journal of Educational Technology*, 31(6), 713-735
- Yalley, C. E. (2016). Investigating the technological pedagogical content knowledge of social studies teachers in the senior high schools in the Kumasi Metropolis (Doctoral dissertation, University of Cape Coast).
- Yanış, H., & Yürük, N. (2021). Development, validity, and reliability of an educational robotics based technological pedagogical content knowledge self-efficacy scale. *Journal of Research on Technology in Education*, 53(4), 375–403. <https://doi.org/10.1080/15391523.2020.1784065>
- Yeh, Y. F., Chan, K. K. H., & Hsu, Y. S. (2021). Toward a framework that connects individual TPACK and collective TPACK: A systematic review of TPACK studies investigating teacher collaborative discourse in the learning by design process. *Computers & Education*, 171, 104238.
- Yeh, Y. F., Hsu, Y. S., Wu, H. K., Hwang, F. K., & Lin, T. C. (2014). Developing and validating technological pedagogical content knowledge-practical (TPACK-practical) through the Delphi survey technique. *British Journal of Educational Technology*, 45(4), 707-722.

- Yigit, M. (2014). A review of the literature: How pre-service mathematics teachers develop their technological, pedagogical, and content knowledge. *International Journal of Education in Mathematics, Science and Technology*, 2(1), 26–35. <https://doi.org/10.18404/ijemst.96390>
- Yu, J., & Karakaya, O. (2018, March). Examination of the impact of a one-on-one technology mentoring program: Multiple case studies on the mentees' perspectives. In *Society for Information Technology & Teacher Education International Conference* (pp. 594-599). Association for the Advancement of Computing in Education (AACE).
- Zhang, S., Liu, Q., & Cai, Z. (2019). Exploring primary school teachers' technological pedagogical content knowledge (TPACK) in online collaborative discourse: An epistemic network analysis. *British Journal of Educational Technology*, 50(6), 3437–3455.

APPENDIX-A

Teacher's survey

Dear teachers,

I am a student pursuing an MS in Educational Leadership and Management, conducting research on **"Investigating Teacher Educators' and Prospective Teachers' Technological Pedagogical Content Knowledge at the University Level."** Your participation is highly valued, and I kindly request that you fill out this questionnaire. Please be assured that your responses will remain confidential and will only be used for research purposes.

Researcher: Muhammad Saif Ali

Education: MS Scholar, Educational Leadership and Management Department

University: International Islamic University Islamabad.

NAME (Optional) _____ **GENDER: Male** ☐ **Female** ☐

UNIVERSITY NAME: _____

PROGRAMME OF STUDY YOU TEACH IN: _____

SEMESTER(S) YOU TEACH: _____

SUBJECT(S) YOU TEACH: _____

YEARS OF TEACHING EXPERIENCE:

1. Less than 5 year
2. 6 to 10 year
3. 11 to 15 year
4. 16 to 20
5. More than 20 year

Instructions: Please tick (✓) the option that best reflects your opinion according to the scale below.

Scale:

1 = Strongly Disagree (SD), 2 = Disagree (D), 3 = Neutral (N), 4 = Agree (A)
5 = Strongly Agree (SA)

Objective no.2: To evaluate the levels of technological pedagogical and content knowledge (TPACK) among teacher educators.

Level 1: Content Knowledge (CK)

CK1	I have sufficient knowledge about my teaching subject.	SD	D	N	A	SA
CK2	I can use a subject-specific way of thinking in my teaching subject.					
CK3	I know the basic theories and concepts of my teaching subject.					
CK4	I am familiar with recent research in my teaching subject.					
CK5	I know the history and development of important theories in my teaching subject.					

Level 2: Technological Knowledge (TK)

TK1	I keep up with important new technologies.					
TK2	I know how to solve my own technical problems					
TK3	I know about a lot of different technologies.					
TK4	I know how to use Microsoft Word and PowerPoint.					
TK5	I have sufficient opportunities to work with different technologies.					

Level 3: Pedagogical Knowledge (PK)

PK1	I can adapt my teaching style to different learners.					
PK2	I use a wide range of teaching approaches in a classroom setting.					
PK3	I know how to assess student performance in multiple ways.					
PK4	I am familiar with common student misconceptions in my subject.					
PK5	I can organize and maintain classroom management effectively.					

Level 4: Technological Content Knowledge (TCK)

TCK1	I know how technological developments have changed the field of my subject.					
TCK2	I can explain which technologies have been used in research in my field.					
TCK3	I know technologies that help me understand my subject better.					
TCK4	I know how to use essential technologies specific to my subject to enhance learning.					
TCK5	I use technology to illustrate difficult content in my subject.					

Level 5: Pedagogical Content Knowledge (PCK)

PCK1	I know how to select effective teaching approaches to guide student thinking and learning in my teaching subject.					
PCK2	I know how to develop appropriate tasks to promote students' complex thinking in my teaching subject.					
PCK3	I can assess students' learning using a variety of methods.					
PCK4	I can explain essential content in ways that students can easily understand.					
PCK5	I can adjust my teaching methods based on what students currently understand.					

Level 6: Technological Pedagogical Knowledge (TPK)

TPK1	I can choose technologies that enhance the teaching approaches for a lesson.					
TPK2	I can adapt technology to different teaching activities to improve student engagement.					
TPK3	I think critically about how to use technology effectively in my classroom.					

TPK4	I can select suitable technologies to enhance the learning experience of my students.					
TPK5	I effectively engage students in using technology to solve real-world problems.					

Level 7: Technological Pedagogical and Content Knowledge (TPACK)

TPACK1	I can integrate content, pedagogy, and technology in my teaching to enhance student learning.					
TPACK2	I can choose technologies that enhance the content for a lesson.					
TPACK3	I can select technologies to use in my classroom that enhance what I teach, how I teach, and what students learn.					
TPACK4	I can help others coordinate the use of content, technologies, and teaching approaches in my school.					
TPACK5	I can teach lessons that appropriately combine my teaching subject, technologies, and teaching approaches.					

Thank you for your participation!

Contact Information

If you have any questions regarding the survey, feel free to contact me at:

Email: [muhammadsaifaliswt@gmail.com]

APPENDIX-B

Student's survey

I am a student pursuing an MS in Educational Leadership and Management, conducting research on **"Investigating Teacher Educators' and Prospective Teachers' Technological Pedagogical Content Knowledge at the University Level."** Your participation is highly valued, and I kindly request that you fill out this questionnaire. Please be assured that your responses will remain confidential and will only be used for research purposes.

Researcher: Muhammad Saif Ali

Education: MS Scholar, Educational Leadership and Management Department

University: International Islamic University Islamabad.

NAME (Optional): _____ **GENDER: Male** ☐ **Female** ☐

UNIVERSITY NAME: _____

PROGRAMME OF STUDY: _____ **SEMESTER** _____

Instructions: Please tick (✓) the option that best reflects your opinion according to the scale below.

Scale:

1 = Strongly Disagree (SD), 2 = Disagree (D), 3 = Neutral (N), 4 = Agree (A)
5 = Strongly Agree (SA)

Objective no.1: To evaluate the levels of technological pedagogical and content knowledge (TPACK) among prospective teachers.

Level 1: Content Knowledge (CK)

CK1	I understand the core concepts of the subject I plan to teach.	SD	D	N	A	SA
CK2	I can explain subject-specific ways of thinking to future students.					
CK3	I am aware of the basic theories and frameworks within my teaching subject.					
CK4	I am familiar with the major trends and developments in my teaching subject.					
CK5	I can explore various strategies to enhance my understanding of subject content.					

Level 2: Technological Knowledge (TK)

TK1	I am familiar with emerging technologies relevant to education.					
TK2	I can use technology tools effectively to complete academic and teaching-related tasks.					
TK3	I can troubleshoot common issues with technology used for teaching purposes.					
TK4	I use software like Microsoft Word, PowerPoint, and other tools during my studies.					
TK5	I have opportunities to experiment with various technologies in my teacher education program.					

Level 3: Pedagogical Knowledge (PK)

PK1	I understand how to modify my teaching approaches for different learners.					
PK2	I am aware of a range of instructional strategies that can be used in a classroom.					
PK3	I know how to assess students' learning using different methods.					
PK4	I understand the common misconceptions students might have in my subject area.					
PK5	I have learned how to manage a classroom effectively through my teacher education courses.					

Level 4: Technological Content Knowledge (TCK)

TCK1	I understand how technological advancements impact my subject field.					
TCK2	I know which technologies are commonly used for research in my subject area.					
TCK3	I can identify the most appropriate technology tools to teach specific content in my subject.					
TCK4	I can explain how technology can be used to demonstrate key concepts in my subject.					

TCK5	I know how to use technology to clarify difficult concepts in my teaching subject.					
-------------	--	--	--	--	--	--

Level 5: Pedagogical Content Knowledge (PCK)

PCK1	I can choose teaching approaches that align with the learning objectives of my subject.					
PCK2	I am capable of designing learning activities that encourage critical thinking in my subject.					
PCK3	I understand how to assess students' mastery of subject-specific content.					
PCK4	I can explain difficult subject matter in a way that is understandable for students.					
PCK5	I can adapt my instructional approach depending on students' understanding of the content.					

Level 6: Technological Pedagogical Knowledge (TPK)

TPK1	I can identify which technologies will enhance my teaching methods during lessons.					
TPK2	I can adapt technology to make learning activities more engaging for students.					
TPK3	I consider how to use technology strategically when planning lessons.					
TPK4	I can select technology tools that improve the overall learning experience.					
TPK5	I can integrate technology to make teaching strategies more effective.					

Level 7: Technological Pedagogical and Content Knowledge (TPACK)

TPACK1	I feel confident in integrating technology, pedagogy, and content in my teaching.					
TPACK2	I can design lessons that effectively combine content, teaching strategies, and technology.					
TPACK3	I can adapt technological tools to teach various topics in my subject area.					

TPACK4	I understand how to use technology to support student learning across different content areas.					
TPACK5	I feel prepared to help future students learn using a combination of technology, pedagogy, and content.					

Thank you for your participation!

Contact Information

If you have any questions regarding the survey, feel free to contact me at:

Email: [muhammadsaifaliswt@gmail.com]