

**TECHNOLOGICAL, PEDAGOGICAL AND CONTENT
KNOWLEDGE OF HIGHER SECONDARY SCHOOL
TEACHERS AND TEACHING EFFECTIVENESS: A CRITICAL
STUDY**

**A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF DOCTOR OF
PHILOSOPHY**

H. LALBIAKZUALI

MZU REGISTRATION NO: 4717 of 2011

PH.D. REGISTRATION NO: MZU/Ph.D./1630 OF 21.10.2020



**DEPARTMENT OF EDUCATION
SCHOOL OF EDUCATION
NOVEMBER, 2025**

**TECHNOLOGICAL, PEDAGOGICAL AND CONTENT KNOWLEDGE OF
HIGHER SECONDARY SCHOOL TEACHERS AND TEACHING
EFFECTIVENESS: A CRITICAL STUDY**

BY

H. LALBIAKZUALI

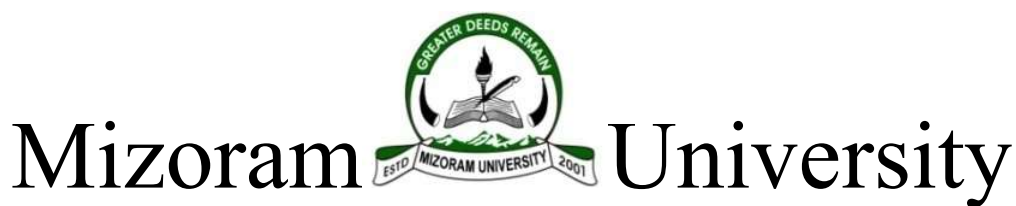
DEPARTMENT OF EDUCATION

SUPERVISOR

PROF. LOKANATH MISHRA

Submitted

**In partial fulfillment of the requirement of the Degree of Doctor of Philosophy in
Education of Mizoram University, Aizawl**



TANHRIL: MIZORAM – 796004

(A Central University Accredited 'A' Grade by NACC in 2019)

Prof. Lokanath Mishra

M.Sc. (Math), M.A(Eco), M.Ed., Ph.D. D.Litt *Email-mishra.lokanath70@gmail.com*

Dean School of Education

Mobile-+919457115093

CERTIFICATE

This is to certify that the thesis entitled “Technological Pedagogical and Content Knowledge of Higher Secondary School Teachers and Teaching Effectiveness: A Critical Study” submitted by H. Lalbiakzuali, Regn. No. MZU/Ph.D./1630 of 21.10.2020 for the Degree of Doctor of Philosophy in Education of the Mizoram University, Aizawl, India embodies the record of original investigation carried out by her under my supervision. She has been duly registered and the thesis presented is worthy of being considered for the award of Ph.D. degree. This research work has not been submitted for any degree of any other university.

(PROF LOKANATH MISHRA)

Supervisor

DECLARATION

Mizoram University

November, 2025

I, H. Lalbiakzuali, hereby declare that the subject matter of this thesis is the record of work done by me, that the contents of this thesis did not form basis of the award of any previous degree to me or to do the best of my knowledge to anybody else, and that the thesis has not been submitted by me for any research degree in any other University/Institute.

This is being submitted to the Mizoram University for the degree of Doctor of Philosophy in Education.

(H. LALBIAKZUALI)

Candidate

(Prof. LALBIAKDIKI HNAME)

Head of Department

(Prof. LOKANATH MISHRA)

Supervisor

ACKNOWLEDGEMENTS

My profound and sincere gratitude is extended to my supervisor, Prof. Lokanath Mishra, whose constant, warm, and sincere guidance was instrumental in the successful completion of this thesis. His unwavering support and expertise were invaluable. Without his constant encouragement, inspiration, understanding, patience and dedication to the work, this thesis would not be able to come out in its present form.

I also wish to express my earnest and sincere appreciation to all the experts at the Education Department, MZU, for providing their insightful advice and professional inputs, which significantly enriched this research.

My thanks are extended to the Principals, teachers, and students whose cooperation and participation in the data collection process were essential to this study.

On a personal note, I offer my deepest gratitude to my husband, Isaac Vanlalpeka, and to my entire family for their unwavering cooperation and support, both mental and physical. I must acknowledge my mother, Mrs. Lallawmpuii, who provided consistent encouragement and selfless care for my newborn and toddler, which allowed me to focus and persevere with my Ph.D. work.

Above all, I thank the Almighty God for the spiritual guidance and strength throughout this journey, and for blessing me with the supportive people who contributed to the successful completion of this work.

(H.LALBIAKZUALI)

CONTENTS

PRELIMINARY SECTION	PAGE NO
Certificate	i
Declaration	ii
Acknowledgements	iii
Contents	iv-xi
List of tables	x
List of figures	xii

CHAPTER – I: INTRODUCTION

1.0	Introduction	1
1.1	Origin of Technological Pedagogical and Content Knowledge (TPACK)	4
1.2	Concept of TPACK	6
1.3	Components or Elements of TPACK	9
1.4	Technological Pedagogical Content Knowledge Framework	13
1.4.1	The Conceptual Framework	14
1.5	Importance of TPACK in modern education in the context of Mizoram	16
1.6	TPACK and teacher professional development	19
1.7	TPACK and student learning outcomes	22
1.8	Rationale of the Study	24
1.9	Research Questions	27
1.10	Statement of the Problem	28
1.11	Objective of the Study	28
1.12	Hypotheses of the Study	29
1.13	Operational definition of the key terms	30

1.14	Delimitation of the Study	32
------	---------------------------	----

CHAPTER – II: REVIEW OF RELATED LITERATURE

2.0	Introduction	33
2.1	Studies done in India	33
2.2	Studies conducted abroad	43
2.3	Analysis of Reviews on Teachers’ Perceived Level of TPACK	88
2.4	Analysis of Reviews on Demographic Factors Influencing Teachers’ Perceived TPACK	90
2.5	Research Gap and Context of the Study	91
2.6	Conclusion	93

CHAPTER – III: METHODOLOGY

3.1	Method of the Study	95
3.2	Population	95
3.3	Sample	97
3.4	Tools for data collection	101
3.4.1	The knowledge, perception, expertise and applications scale of technological pedagogical content knowledge (TPACK)	101
3.4.2	Observation schedule for assessing the effectiveness of teaching	110
3.4.3	Structured questionnaire to study the problems faced by the higher secondary school teacher in integrating technology in teaching	111
3.4.4	Evaluation schedule for assessing Teachers’ Effectiveness (for students)	112
3.5	Administration of tools and collection of data	115
3.6	Tabulation of data	117

3.7	Statistical techniques for analysis of data	118
-----	---	-----

CHAPTER – IV: ANALYSIS AND INTERPRETATION

4.1	Level of knowledge of higher secondary school teachers of Mizoram about TPACK	120
4.2	Comparison of the differences in self-perceived TPACK among higher secondary school teachers with reference to their educational discipline, gender and age	127
4.2.1	Difference in self-perceived TPACK with reference to educational discipline	127
4.2.2	Difference in self-perceived TPACK with reference to gender	132
4.2.3	Difference in self-perceived TPACK with reference to age	136
4.2.4	Difference in self-perceived TPACK with reference to teaching experience	140
4.2.5	Difference in self-perceived TPACK with reference to ICT training	145
4.3	Relationship of higher secondary school teachers self-perceived expertise in TPACK and its effectiveness in teaching.	147
4.4	Problems faced by the higher secondary school teachers of Mizoram in integrating technology in teaching	150
4.5	The perceived experience of students on the effectiveness of teaching of higher secondary school teachers of Mizoram using TPACK.	154

CHAPTER – V: MAJOR FINDINGS, DISCUSSIONS, EDUCATIONAL IMPLICATIONS, RECOMMENDATIONS AND SUGGESTIONS FOR FURTHER RESEARCH

5.1.0	Major findings	157
5.1.1	Findings regarding the level of knowledge of higher secondary school teachers of Mizoram about TPACK	157
5.1.2	Findings regarding the self-perceived TPACK of higher secondary school teachers in Mizoram with reference to educational discipline	158
5.1.3	Findings regarding the self-perceived TPACK of higher secondary school teachers in Mizoram with reference to their gender	159
5.1.4	Findings regarding the self-perceived TPACK of higher secondary school teachers in Mizoram with reference to their age	160
5.1.5	Findings regarding the self-perceived TPACK of higher secondary school teachers in Mizoram with reference to their teaching experience	161
5.1.6	Findings regarding the self-perceived TPACK of higher secondary school teachers in Mizoram with reference to their ICT training	162
5.1.7	Findings regarding the effectiveness of higher secondary school teachers in Mizoram in their classroom teaching	163
5.1.8	Findings regarding the relationship between self-perceived expertise in TPACK and teaching effectiveness of higher secondary school teachers in Mizoram	163
5.1.9	Findings on problems faced by the higher secondary school teachers of Mizoram in integrating technology in teaching	164
5.1.10	Findings regarding the perceived experience of students on the effectiveness of teaching of higher secondary school teachers of Mizoram using TPACK	165
5.2	Discussion on findings of the present study	167

5.2.1	Discussion on the findings relating to the level of knowledge of higher secondary school teachers of Mizoram about TPACK	167
5.2.2	Discussion on the findings relating to the comparison of self-perceived TPACK of higher secondary school teachers in Mizoram with reference to educational discipline	168
5.2.3	Discussion on the findings relating to the comparison of self-perceived TPACK of higher secondary school teachers in Mizoram with reference to their gender	169
5.2.4	Discussion on the findings relating to the comparison of self-perceived TPACK of higher secondary school teachers in Mizoram with reference to their age	170
5.2.5	Discussion on the findings relating to the comparison of self-perceived TPACK of higher secondary school teachers in Mizoram with reference to their teaching experience	172
5.2.6	Discussion on the findings relating to the comparison of self-perceived TPACK of higher secondary school teachers in Mizoram with reference to their ICT training	174
5.2.7	Discussion on the findings relating to the effectiveness of higher secondary school teachers in Mizoram in their classroom teaching	175
5.2.8	Discussion on the findings relating to the relationship between self-perceived expertise in TPACK and teaching effectiveness of higher secondary school teachers in Mizoram	177
5.2.9	Discussion on the findings on problems faced by the higher secondary school teachers of Mizoram in integrating technology in teaching	178
5.2.10	Discussion on the findings relating to the perceived experience of students on the effectiveness of teaching of higher secondary school teachers of Mizoram using TPACK	180
5.3	Educational Implications	182

5.4	Recommendations	185
5.5	Suggestions for further research	187

APPENDICES

Appendix – I	Perceptions of higher secondary school teachers on technological pedagogical content knowledge (TPACK)	188
Appendix – II	Problems faced by the higher secondary school teachers in integrating technology in teaching	193
Appendix – III	Observation schedule for assessing the effectiveness of teaching	195
Appendix – IV	Evaluation schedule for assessing teachers' effectiveness	197

BIBLIOGRAPHY

BRIEF BIO-DATA OF THE CANDIDATE

PUBLICATIONS

SEMINAR PRESENTATION CERTIFICATE

ANNEXURE – I

ANNEXURE - II

PARTICULARS OF THE CANDIDATE

LIST OF TABLES

Table No	Name of the table	Page No
2.1	Details of related studies reviewed	88
3.1	Total number of higher secondary school teachers and students in Mizoram	96
3.2	Total number of higher secondary school teachers and students in sample district in Mizoram	97
3.3	Name of schools and sample distribution	98
3.4	Gender and Stream Wise Distribution of Sample of Teachers and Students	100
3.5	Mean, Standard Deviation and t-value of High and Low groups on different Items of TPACK scale	104
3.6	Reliability Indices for TPACK scale	107
3.7	Initial Cronbach's Alpha and after combining with relevant domains of TPACK	108
3.8	The highest and lowest possible scores for each domain	108
3.9	Serial Number of Positive and Negative Statements	109
3.10	Interpretation of self-perceived TPACK	110
3.11	Reliability Indices for Evaluation schedule	115
4.0	Raw score with corresponding z-score	120
4.1	Norms for interpretation of the levels self-perceived TPACK based on z-score	123
4.2	Teachers self-perceived level of TPACK	124
4.3	Norms for interpretation of self-perceived TPACK with reference to educational discipline based on z-score	127
4.4	Educational discipline wise teachers' level of self-perceived TPACK	128
4.5	Difference in self-perceived TPACK of higher secondary	131

	school teachers with reference to their educational discipline	
4.6	Norms for interpretation of self-perceived TPACK with reference to gender based on z-score	132
4.7	Gender wise teachers' level of self-perceived TPACK	133
4.8	Difference in self-perceived TPACK of higher secondary school teachers with reference to their gender	135
4.9	Norms for interpretation of self-perceived TPACK with reference to age based on z-score	136
4.10	Teachers' Age level of self-perceived TPACK	137
4.11	Difference in self-perceived TPACK of higher secondary school teachers with reference to their age.	140
4.12	Norms for interpretation of self-perceived TPACK with reference to teaching experience based on z-score	141
4.13	Teachers' teaching experience level of self-perceived TPACK	142
4.14	Difference in self-perceived TPACK of higher secondary school teachers with reference to their teaching experience	144
4.15	Comparison of Teachers' Mean Scores on TPACK Domains Based on ICT Training	145
4.16	Difference in self-perceived TPACK of higher secondary school teachers with reference to their ICT Training	147
4.17	Effectiveness of higher secondary school teachers in classroom teaching	148
4.18	Relationship between self-perceived expertise in TPACK and teaching effectiveness of higher secondary	149
4.19	Problems faced by the higher secondary school teachers of Mizoram in integrating technology in teaching	150
4.20	The perceived experience of students on the effectiveness of teaching of higher secondary school teachers	154

LIST OF FIGURES

Figure No	Name of the figure	Page no
1.0	The Conceptual Framework	14
4.1	Teachers self-perceived level of TPACK	125
4.2	Educational discipline wise teachers' level of self-perceived TPACK	129

CHAPTER – I

1.0 INTRODUCTION

Technology has become an increasingly important part of students' lives beyond school, and even within the classroom it can also help increase their understanding of complex concepts or encourage collaboration among peers. Because of these benefits, current educational practice suggests that teachers implement some form of technology in their classrooms – but many teachers face difficulties in doing so. Cost, access, and time often form considerable barriers to classroom implementation, but another obstacle is a lack of knowledge regarding how technology can best be used to benefit students across diverse subject matter.

The evolving face of education greatly impacts the need for qualified faculty who cannot only teach, but also develop curriculum with instructional technology tools for use in synchronous and asynchronous courses. (Southern Association of Colleges and Schools, 2010a, 2010b). There are vast numbers of instructional technology tools available for educational purposes, yet research by Golde and Dore (2001) has suggested that instructors lack the technical skills to effectively utilize these tools to enhance student learning.

According to Yang and Liu (2004), faculty must become involved in continued learning in order to be more effective teachers. Support mechanisms should be designed for lifelong learners, in this case teachers, to hone existing skills and develop new knowledge and skills that can be translated into effective learner-centered instructional strategies. However, instructional technology tools have a negative connotation with some teachers. Some research (Austin, 2003; Hearn & Anderson, 2002; Jones, 2011) has suggested that teachers' autonomy, workload, and pedagogical interest are jeopardized when the use of technology as a learning mechanism is introduced. Technology as instructional mechanisms do not replace the role of the teacher. Instead, it is an integral component to the learning process just as pedagogy and subject content (Golde & Dore, 2001). A challenge of incorporating technology into pedagogy revolves around the need to understand how and in what capacity to implement technology as an instructional tool. An initial approach to finding a solution

would be to assess the technological knowledge of teacher, which would aid in analyzing the type of academic support necessary for successful implementation of the technology.

Globally, education systems are undergoing a digital transformation driven by the demand for 21st-century skills. Educational reforms worldwide emphasize the use of digital tools to improve the quality of teaching and learning (UNESCO, 2019). The Sustainable Development Goal 4 (SDG 4) also recognizes Information and Communication Technology (ICT) as a critical element for ensuring inclusive and equitable quality education. In India, initiatives such as the National Education Policy (NEP) 2020 and the Digital India campaign have encouraged educational institutions to integrate technology into pedagogical practices (Ministry of Education, 2020). These initiatives view technology not merely as a medium of instruction but as a transformative force that reshapes how teaching and learning occur.

Teachers are at the heart of this transformation. Their ability to effectively blend technology with pedagogy and content knowledge determines the success of technology integration in classrooms (Koehler & Mishra, 2009). Yet, many teachers report feeling unprepared to incorporate technology into their lessons due to inadequate training, limited exposure, and low confidence in their technological competence (Ertmer & Ottenbreit-Leftwich, 2010). Developing teachers' technological pedagogical and content knowledge (TPACK) has thus become a central concern in both pre-service and in-service teacher education programs.

Despite the widespread advocacy for technology-enhanced teaching, numerous studies have revealed persistent challenges in technology integration. Teachers often cite barriers such as lack of resources, insufficient time, inadequate institutional support, and uncertainty about appropriate pedagogical strategies (Hew & Brush, 2007). Moreover, teachers' beliefs and attitudes toward technology substantially influence their willingness to adopt it (Teo, 2011). Understanding these challenges is vital to designing professional development programs that foster positive attitudes and enhance teachers' readiness to integrate digital tools effectively.

Since the typical pedagogical boundaries in low and high consensus (educational) disciplines consist of limited technological usage, teachers are reluctant

to develop instructional technology competencies without performance incentives (Austin, 2003; Golde & Dore, 2001). This suggests that the inclusion of instructional technology tools could impose a major change to teachers' workload and autonomy. As a result, this highlights the need for academic support for continuous developmental training in addition to performance incentives to encourage the successful implementation of technology with existing pedagogy and content for student learning (Austin, 2003; Golde & Dore, 2001; Mezirow, 1991; Southern Association of Colleges and Schools, 2010b; Trower, Austin, & Sorcinelli, 2001; White & Myers, 2001)

Mishra and Koehler (2006), who developed the Technological Pedagogical and Content Knowledge (TPACK) framework, argue that successful technology integration depends on the dynamic interplay between three forms of knowledge: content, pedagogy, and technology. The intersection of these three domains represents the point where teachers can design and deliver meaningful, technology-supported learning experiences. Faculty members who explore this intersection often discover innovative instructional strategies that resonate with modern learners (Mangold, 2007).

The TPACK framework provides an essential lens through which to examine teachers' competencies in technology integration. Measuring teachers' self-perceived TPACK levels offers insight into their preparedness to teach effectively in technology-rich environments and helps identify areas needing targeted support and training. Prior research (Chai, Koh, & Tsai, 2013) highlights the importance of strengthening TPACK through structured professional development and continuous ICT exposure.

Given India's diverse educational landscape, the extent to which teachers integrate technology varies across regions, disciplines, and types of institutions. While some studies have examined teachers' TPACK in metropolitan or urban contexts, limited attention has been paid to teachers in smaller states like Mizoram, where access to technological infrastructure and professional development opportunities may differ. Furthermore, demographic variables such as teaching experience, age, gender, educational discipline, and ICT training may play a significant role in shaping teachers' self-perceived TPACK levels.

Change to a teacher's pedagogical routine can be hard to adapt too especially for those who have been teaching the same way throughout their teaching career. Mishra and Koehler (2006), the forefathers of the technological pedagogical content knowledge (TPACK) framework, and also the theoretical framework for this study, suggested that implementing change to existing pedagogical content knowledge (PCK) with technology should be an interlinking of technology, pedagogy, and content (see Figure 1). It is through this interlinking where faculty members will discover new instructional strategies conducive to teaching millennial learners (Mangold, 2007) within low and high consensus (educational) disciplines.

Therefore, this study seeks to examine the self-perceived TPACK of higher secondary school teachers in Mizoram and explore how various demographic factors influence their technological, pedagogical, and content knowledge. By doing so, it aims to contribute to the broader understanding of teachers' technology integration competencies within the Indian educational context and provide evidence-based recommendations for future teacher training and policy implementation.

1.1 ORIGIN OF TECHNOLOGICAL PEDAGOGICAL AND CONTENT KNOWLEDGE (TPACK)

TPACK was developed by Koehler and Mishra (2005) over Shulman's (1986) Pedagogical Content Knowledge (PCK) model. Elaborating upon the study of Shulman (1986), who proposed PCK referring to the intersection of subject-specific knowledge, pedagogical knowledge, and knowledge of the teaching context, Mishra and Koehler (2006) have proposed a framework to define the knowledge teachers need to acquire in order to integrate technology into teaching and learning process effectively. The term TPACK began to gain widespread popularity in 2006 after Mishra and Koehler's seminal work outlining the model and describing each of the central constructs (F. I. Karataş, 2014). The original acronym TPCK has been recently changed to TPACK for the ease of pronunciation of the term (Thompson & Mishra, 2007). The framework of TPACK consists of three main components of knowledge: technology, pedagogy, and content and interactions amongst these components, represented as pedagogical knowledge (PK), content knowledge (CK), and

technological knowledge (TK) (Mishra & Koehler, 2006). The framework proposes combining these three main components of knowledge in four additional types of knowledge; pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), and technological pedagogical content knowledge (TPACK) (Mishra & Koehler, 2006). The TPACK framework is commonly shown using a Venn diagram with three overlapping circles, each representing a distinct form of teacher knowledge (see Figure 1).

Technological Pedagogical Content Knowledge (TPACK) was introduced to the educational research field as a conceptual framework for understanding teacher knowledge that is required for technology integration (Mishra & Koehler, 2006). TPACK evolved from Shulman's (1986) theory of pedagogical content knowledge (PCK) and focuses on the need for teachers to skilfully demonstrate their ability to integrate technology within the constructs of content and pedagogical domains. TPACK can be perceived as a teacher's intuitive understanding for teaching subject-specific content with appropriate pedagogical methods and selected technologies. It is well understood that teaching is a complex cognitive activity that requires teachers to draw upon several types of knowledge (Koehler & Mishra, 2009). TPACK serves as a useful conceptual framework for thinking, analyzing, and evaluating what teachers must know to integrate technology into teaching, but ultimately it must be understood as a framework for ways in which teachers might best develop this integrated knowledge. To date, researchers have stressed the importance of teachers having a solid conceptual understanding of the interactions that occurs among technology, pedagogy, and content when planning instruction (Harris & Hofer, 2011; Koehler & Mishra, 2005). This framework provides a critical perspective with which to view technology integration in classroom settings.

Shulman (1986) claimed that the emphases on teachers' subject matter knowledge and pedagogy were being treated as mutually exclusive. He believed that teacher education programs should combine the two knowledge fields. To address this dichotomy, he introduced the notion of pedagogical content knowledge that includes pedagogical knowledge and content knowledge, among other categories. His initial description of teacher knowledge included curriculum knowledge, and knowledge of educational contexts.

1.2 CONCEPT OF TPACK

The Technological Pedagogical and Content Knowledge (TPACK) is a theoretical framework for understanding the teacher knowledge required for effective technology integration (Mishra & Koehler, 2006). It describes “how teachers’ understanding of technologies and pedagogical content interact with one another to produce effective teaching with technology” (Koehler & Mishra, 2008, p. 12). The TPACK framework includes the knowledge of how to make concepts understandable by using technology, knowledge of how to use technology with pedagogical knowledge to meet the diverse needs of students, knowledge of the difficulties students face in learning specific concepts, and strategies to eliminate these difficulties through the use of technology. It also encompasses teachers’ understanding of students’ prior knowledge and epistemological beliefs, and how technology can be used to enhance these beliefs and promote deeper learning (Koehler & Mishra, 2008).

The TPACK represents a “thoughtful interweaving of all three key sources of knowledge—technology, pedagogy, and content” (Mishra & Koehler, 2006, p. 14). As Koehler and Mishra (2008) argue, “at the heart of good teaching with technology are three components: content, pedagogy, and technology, and the relationships between them” (p. 11). According to Baran, Chuang, and Thompson (2011), the TPACK “acts as a useful framework for thinking about what knowledge teachers must have to integrate technology into teaching and how they might develop this knowledge” (p. 371). To understand the model proposed by Mishra and Koehler (2006), three main components—Content Knowledge (CK), Pedagogical Knowledge (PK), and Technological Knowledge (TK)—as well as four overlapping types—Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical Content Knowledge (TPACK)—must be recognized as integral parts of teacher expertise.

The TPACK framework goes beyond a simple combination of these domains. It emphasizes the complex and dynamic interaction between technology, pedagogy, and content within authentic classroom contexts. Mishra and Koehler (2006)

highlighted that effective teaching with technology depends not merely on the possession of discrete types of knowledge, but on the teacher's ability to integrate and apply them contextually. Technology integration is therefore not a one-size-fits-all process; it varies depending on the subject matter, learning goals, and classroom conditions. Thus, the TPACK model provides a contextualized understanding of teacher knowledge rather than a prescriptive set of steps.

Moreover, TPACK underscores the transformative potential of technology in reshaping the way teachers conceptualize and deliver content. Technology enables teachers to represent complex ideas in accessible and engaging forms. For instance, digital simulations in science can help students visualize molecular structures, while multimedia tools in social sciences can encourage collaboration and critical discussion (Harris et al., 2009). This demonstrates that technology, when combined with strong pedagogical strategies, can fundamentally alter both how knowledge is represented and how learning occurs.

Mishra and Koehler (2008) also introduced the idea of maintaining a “dynamic equilibrium” among technology, pedagogy, and content—an equilibrium that continually evolves as new tools and educational approaches emerge. Teachers with strong TPACK are able to flexibly adapt their teaching to different technological and pedagogical situations (Koh, Chai, & Tsai, 2010; Voogt et al., 2013). Such adaptability is increasingly important in the 21st-century learning environment, where digital literacy, collaboration, and creativity are considered essential student competencies.

In practice, TPACK manifests through teachers' informed decisions about when, why, and how to use technology effectively. Teachers with well-developed Technological Pedagogical Knowledge (TPK) understand how digital tools can enhance specific teaching methods—such as using interactive platforms for formative assessment or adopting blended learning models to increase student engagement. Similarly, Technological Content Knowledge (TCK) allows teachers to identify appropriate digital tools to explain complex subject concepts. When these elements intersect meaningfully, they form Technological Pedagogical Content Knowledge (TPACK)—a comprehensive understanding that allows teachers to design and facilitate technology-enhanced learning experiences (Koehler & Mishra, 2009).

Importantly, developing TPACK is not an endpoint but a continuous process that evolves through experience and reflection. Niess (2011) described this process as a “transformational journey,” where teachers progress from basic awareness of technology to its strategic and pedagogically sound application. Teachers cultivate TPACK through continuous learning, collaboration with peers, experimentation with new technologies, and reflective practice. This growth requires not only technical competence but also pedagogical reasoning—the ability to align technology use with instructional objectives and student needs.

Context plays a vital role in how TPACK is enacted. The same digital tool may be effective in one setting but inappropriate in another, depending on school infrastructure, access, and student characteristics. Koehler et al. (2013) emphasized that TPACK is inherently contextual and must be understood within specific teaching environments. For example, in resource-limited schools, teachers may creatively adapt low-cost tools, such as mobile-based applications or locally available digital content, to achieve meaningful integration. Therefore, TPACK is less about mastering particular technologies and more about adapting available tools to pedagogical realities.

Teachers’ beliefs and attitudes toward technology also influence their TPACK development. Ertmer and Ottenbreit-Leftwich (2010) found that teachers’ confidence, motivation, and openness to innovation play a significant role in how they apply technological knowledge. Teachers who perceive technology as a valuable tool for learning are more likely to integrate it meaningfully, whereas those with limited confidence or negative perceptions may resist its use despite access to resources. Consequently, fostering positive attitudes and providing sustained support are key to strengthening teachers’ TPACK.

Empirical studies reveal that TPACK levels differ across demographic and professional variables such as subject discipline, teaching experience, ICT training, and school type. Chai et al. (2013) and Koh et al. (2010) observed that teachers with prior ICT training or professional development in digital pedagogy tend to demonstrate higher TPACK levels, especially in the technological domains. Niess (2011) also found that science and mathematics teachers often exhibit stronger TPACK because their subjects lend themselves naturally to technology-enhanced demonstrations and

simulations. These findings underscore the importance of discipline-specific and context-sensitive professional development.

In the Indian context, where technology integration is still emerging, the TPACK framework provides a valuable guide for teacher education and curriculum reform. National initiatives such as the National Mission on Education through ICT (NMEICT) and the DIKSHA platform highlight the importance of preparing teachers to use digital tools for teaching, assessment, and continuous professional growth (Ministry of Education, 2020). However, studies (Kaur & Singh, 2021; Jangid & Lata, 2022) suggest that many teachers in India continue to face challenges related to infrastructure, time, and limited technological expertise. Applying the TPACK framework helps identify these gaps and develop targeted interventions to enhance teachers' digital readiness.

Ultimately, the concept of TPACK underscores that effective teaching in the digital era is knowledge-rich, adaptive, and contextually informed. Teachers must understand not only the affordances and constraints of technology but also how to align them with sound pedagogy and disciplinary content. When effectively implemented, the TPACK framework enables teachers to foster deeper understanding, engagement, and creativity among students—essential skills for lifelong learning in the 21st century. Thus, TPACK continues to serve as one of the most influential and practical models for conceptualizing and improving teacher knowledge in technology-integrated education.

So as to understand the model proposed by Mishra and Koehler (2006), the three main components of knowledge; content knowledge (CK), technology knowledge (TK), and pedagogy knowledge (PK) as well as four additional types of knowledge; pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), technological content knowledge (TCK), and technological pedagogical content knowledge (TPACK) are explained shortly below.

1.3 COMPONENTS OR ELEMENTS OF TPACK

Content Knowledge (CK): Content knowledge (CK) is teachers' knowledge about the subject matter to be learned or taught. The content to be covered in middle school

science or history is different from the content to be covered in an undergraduate course on art appreciation or a graduate seminar on astrophysics. This knowledge is about the actual subject matter that is to be taught to students in school (Mishra & Koehler, 2006; Koehler & Mishra, 2008). This knowledge refers to the knowledge, understanding, skill, and disposition that are to be learnt by school (Shulman, 1987). It describes teachers' own knowledge of the subject matter. CK may include knowledge of concepts, theories, evidence, and organizational frameworks within a particular subject matter; it may also include the field's best practices and established approaches to communicating this information to students (Mishra & Koehler, 2006; Shulman, 1987).

Pedagogical Knowledge (PK): This knowledge refers to the knowledge about teaching and learning process and practices and it includes educational purposes, goals, values, strategies, and more (Koehler & Mishra, 2008). It provides a definition of the methods, techniques, and approaches employed in teaching and learning so that teachers are aware of them. Pedagogical knowledge can be applied in more focused contexts, such as lesson planning, assessment, and the understanding of students' learning preferences/styles, classroom management skills in addition to covering the aims, principles, and purposes of education. According to Grossman (1990), pedagogical knowledge also involves teachers' understanding of the general principles and strategies of classroom instruction that transcend subject matter, enabling them to design and manage learning experiences that support diverse learners effectively.

Technological Knowledge (TK): This describes teachers' knowledge of, and ability to use, various technologies, technological tools, and associated resources. TK concerns understanding edtech, considering its possibilities for a specific subject area or classroom, learning to recognize when it will assist or impede learning, and continually learning and adapting to new technology offerings. (Mishra & Koehler, 2006; Koehler & Mishra, 2008). This knowledge refers to standard technologies such as books, chalk and blackboard, as well as more advanced technologies such as the Internet and digital video (Mishra & Koehler, 2006). According to Schmidt et al. (2009), technological knowledge also involves teachers' ability to operate, manage, and integrate both traditional and emerging technologies in ways that support

instructional goals and enhance student engagement and understanding. This dynamic knowledge base evolves as technology changes, requiring teachers to be adaptive and reflective in their use of digital tools in educational contexts.

Pedagogical Content Knowledge (PCK): This knowledge refers to the idea that pedagogy and content are interwoven that is applicable to the teaching of specific content (Koehler & Mishra, 2008; Shulman, 1987). This knowledge includes students' prior knowledge, different teaching strategies in a particular discipline, pedagogical technologies and effective teaching methods (Harris, Mishra, & Koehler, 2009; Koehler & Mishra, 2008; Mishra & Koehler, 2006). PCK also encompasses teachers' understanding of core aspects of teaching and learning, including curriculum design, assessment, and evaluation (Shulman, 1987; Gess-Newsome, 1999). It focuses on promoting meaningful learning by linking pedagogy with its supporting elements—such as curriculum, assessment, and instructional resources—and, similar to CK, it varies across grade levels and subject areas (Koehler & Mishra, 2008). Ultimately, PCK aims to improve teaching practice by strengthening the relationship between what is taught (content) and how it is taught (pedagogy) (Shulman, 1987; Koehler & Mishra, 2008).

Technological Content Knowledge (TCK) – This knowledge refers to an understanding that technology and content influence and constrain each other (Koehler & Mishra, 2008). It involves knowing how technology can create new representations and ways of understanding specific content areas (Baran, Chuang, & Thompson, 2011). TCK describes teachers' understanding of how technology and content can both shape and challenge each other in the teaching and learning process. It requires teachers to recognize how the presentation of subject matter can be transformed by technological tools and to determine which technologies are most effective for representing and engaging with specific disciplinary ideas. According to Niess (2005), technological content knowledge also encompasses teachers' ability to integrate technology into subject-specific teaching in a manner that enhances students' conceptual understanding and problem-solving within that discipline. In essence, TCK highlights the reciprocal relationship between technology and content, emphasizing

that effective teaching requires knowing not only the subject matter but also how technology can meaningfully represent and deepen that knowledge.

Technological Pedagogical Knowledge (TPK) – This knowledge refers to the understanding of how technology and pedagogy influence and constrain one another (Koehler & Mishra, 2008). It involves knowing how to use specific technologies in purposeful ways to transform teaching and learning processes (Harris, Mishra, & Koehler, 2009). TPK describes teachers' understanding of how particular technologies can modify both teaching and learning experiences by introducing new pedagogical affordances and constraints. Another aspect of TPK concerns understanding how technological tools can be effectively integrated with pedagogical strategies in ways that align with the subject matter and the progression of a lesson (Mishra & Koehler, 2006; Koehler & Mishra, 2008). According to Schmidt et al. (2009), TPK also encompasses teachers' ability to adapt instructional methods to effectively use digital tools, understanding how technology influences the instructional environment, learning activities, classroom interactions, and student engagement. Thus, TPK emphasizes the dynamic interplay between technological tools and pedagogical decisions that shape meaningful learning experiences.

Technological Pedagogical Content Knowledge (TPACK): A growing body of knowledge called TPACK goes beyond the three "core" components (content, pedagogy, and technology). Technological pedagogical content knowledge is an understanding that is the result of interactions between content, pedagogy, and technological knowledge. TPACK strengthens deeply skilled and highly relevant teaching with technology, which is distinct from individual knowledge of any of the three principles (Mishra & Koehler, 2009). The TPACK is different from knowledge and its individual component concepts and their intersections (Koehler & Mishra, 2008; Mishra & Koehler, 2006). This knowledge refers to the complex interrelationships between technological knowledge, pedagogical knowledge, and subject matter knowledge of teachers (Mishra & Koehler, 2006). The TPACK is not a simple combination of three independent components; rather, content, pedagogy, and technology are independent, each one affecting the others (Harris, Mishra, & Koehler, 2009). It refers to the complex interrelationships between a teacher's technology use,

instructional methods, and understanding of the subject matter (Mishra & Koehler, 2006).

1.4 TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE FRAMEWORK

Modeled after Lee S. Shulman's (1986) work on teacher knowledge, specifically teachers' pedagogical content knowledge, the Technological Pedagogical and Content Knowledge (TPACK) framework represents the relationships among a teacher's knowledge about technology, pedagogy, and content (Mishra & Koehler, 2006). In this framework, types of knowledge that teachers possess are briefly defined as: content knowledge is knowledge about the material being taught; pedagogical knowledge is knowledge about the processes and methods of teaching and learning based on knowledge of students; technological knowledge is knowledge about new and old technologies; and TPACK is the relationship formed among the three types of knowledge. A visual representation of the TPACK framework is seen in Figure 1. When teachers are thinking within the TPACK framework, they are simultaneously considering what they know about technology, pedagogy, and content as they are making decisions about instruction. (B.W., Melissa, 2013).

Punya Mishra and Matthew J. Koehler's 2006 TPACK framework, which focuses on technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK), offers a productive approach to many of the dilemmas that teachers face in implementing educational technology (edtech) in their classrooms. By differentiating among these three types of knowledge, the TPACK framework outlines how content (what is being taught) and pedagogy (how the teacher imparts that content) must form the foundation for any effective edtech integration. This order is important because the technology being implemented must communicate the content and support the pedagogy in order to enhance students' learning experience (Kurt, S. 2018).

According to the TPACK framework, specific technological tools (hardware, software, applications, associated information literacy practices, etc.) are best used to

instruct and guide students toward a better, more robust understanding of the subject matter. The three types of knowledge – TK, PK, and CK – are thus combined and recombined in various ways within the TPACK framework. Technological pedagogical knowledge (TPK) describes relationships and interactions between technological tools and specific pedagogical practices, while pedagogical content knowledge (PCK) describes the same between pedagogical practices and specific learning objectives; finally, technological content knowledge (TCK) describes relationships and intersections among technologies and learning objectives. These triangulated areas then constitute TPACK, which considers the relationships among all three areas and acknowledges that educators are acting within this complex space. (Mishra, P., & Koehler, M.J., 2006).

1.4.1 The Conceptual Framework

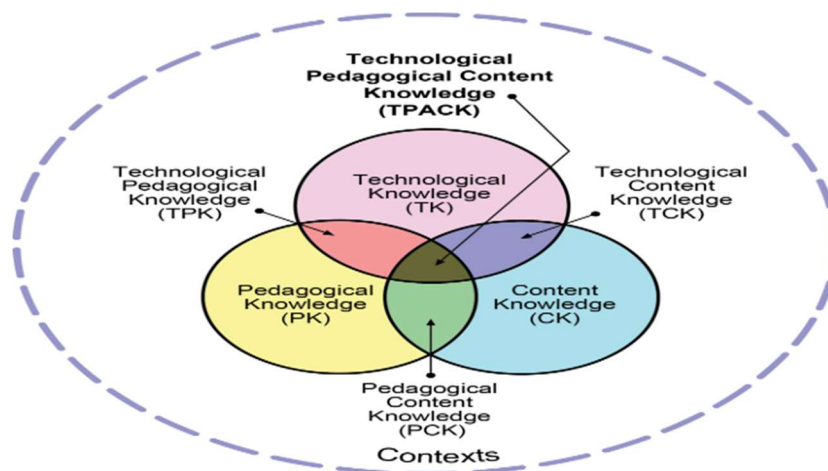


Figure1.0: The Conceptual Framework (This image was adopted from <http://tpack.org>.)

As seen above in Figure 1, the overlaps--Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), and Pedagogical Content Knowledge (PCK)-- of the three circles Pedagogical Knowledge (PK), Technological Knowledge (TK), and Content Knowledge (CK) represent the three aspects of the TPACK framework, which combine to form a central core of understanding known as TPACK. This core can provide a context for framing an

approach to the integration of technology. The TPACK core combines all three aspects of the TPACK framework to help develop an understanding for teachers to re-focus why a technology is being utilized. Conceptual Framework Koehler and Mishra (2008; 2006) have suggested that there are three distinct skills that an effective educator must possess, the first of which is the content knowledge (CK) of their respective disciplines, which allows for a depth of content in instruction. The second skill is pedagogical knowledge (PK); pedagogical knowledge allows the instructor to deliver the content in a variety of different ways. The third and final capability that an effective educator must possess is technological knowledge (TK). Technology has great potential to improve the effectiveness and delivery of content. This technological knowledge must blend with how students are taught (TPK) and the content (TCK) that is being delivered.

The TPACK framework is a conceptual model designed to rethink how a teacher might approach the integration of technology. Similar to the recommendations by Greenhow, Dexter and Hughes (2008), the TPACK framework helps the teacher to connect what is being taught to the way in which it is taught, with the technology used to enhance these connections. TPACK emphasizes "the connections among technologies, curriculum content, and specific pedagogical approaches, demonstrating a teachers' understanding of technology, pedagogy, and content that can interact with one another to produce effective discipline-based teaching with educational technologies" (Koehler & Mishra, 2008,). By considering the impact that technology could have on the content and its delivery, a teachers might be able to overcome different factors faced and embrace new approaches to academic success.

The Technological Pedagogical and Content Knowledge (TPACK) framework, developed by Mishra and Koehler (2006), provides a comprehensive model for understanding the types of knowledge teachers need to effectively integrate technology in their teaching. It expands on Shulman's (1986) concept of Pedagogical Content Knowledge (PCK) by adding the technological dimension, recognizing that effective teaching with technology requires an understanding of the complex interplay between technology, pedagogy, and content. The framework emphasizes that technology should not be treated as an isolated component but rather as an integrated element that influences both how content is delivered and how students learn (Koehler,

Mishra, & Cain, 2013). TPACK underscores the importance of teachers being able to flexibly navigate the relationships between these domains to design meaningful, technology-enhanced learning experiences. By developing TPACK, educators can make informed decisions about when and how to use specific technologies to support pedagogical goals and enhance student understanding of subject matter (Harris, Mishra, & Koehler, 2009). Overall, the TPACK framework serves as a guiding structure for teachers to effectively blend technology with pedagogical strategies and content expertise to improve teaching and learning outcomes.

1.5 IMPORTANCE OF TPACK IN MODERN EDUCATION IN THE CONTEXT OF MIZORAM

Technological Pedagogical and Content Knowledge (TPACK) is very important in modern education because it helps teachers use technology in the right way while teaching different subjects. In today's world, technology has become an essential part of learning and communication. The TPACK framework guides teachers to combine three main types of knowledge—content knowledge (what to teach), pedagogical knowledge (how to teach), and technological knowledge (how to use tools and resources)—to make learning more effective and enjoyable (Mishra & Koehler, 2006). When teachers have good TPACK skills, they are able to choose the best technological tools that fit the topic they are teaching and the methods they are using. This makes teaching more creative, interactive, and interesting for students (Koehler et al., 2013).

In the context of Mizoram, the importance of TPACK is even more significant because many schools are now moving toward digital education and smart classrooms. The use of projectors, computers, mobile devices, and online platforms has increased, especially after the COVID-19 pandemic. However, not all teachers are confident or skilled in using these technologies effectively (Lalchhuanawma & Fanai, 2022). By developing their TPACK, teachers in Mizoram can learn how to integrate technology meaningfully in their lessons, even with limited resources or internet access. It helps

them find simple but powerful ways to use technology for better explanation of concepts, student participation, and assessment.

Moreover, TPACK helps teachers become more reflective and adaptable in their teaching practices. It encourages them to think about which technology is suitable for a particular topic, age group, or learning style of students. This results in more personalized and student-centered teaching, where learners are actively involved in discovering knowledge rather than only receiving it (Chai et al., 2013). As education in Mizoram continues to modernize, teachers with strong TPACK skills can bridge the gap between traditional chalk-and-talk teaching and digital learning environments. In this way, TPACK not only improves teaching and learning quality but also prepares students in Mizoram to meet the challenges of a fast-changing, technology-driven world.

Furthermore, the integration of the TPACK framework into teacher education and professional development programs in Mizoram is essential for achieving sustainable improvements in teaching and learning. As technological tools continue to evolve rapidly, teachers need ongoing opportunities to develop the competencies required to effectively integrate these tools into their pedagogical practices (Koehler & Mishra, 2009; Voogt et al., 2013). Professional development initiatives that incorporate TPACK principles can help teachers move beyond basic technological proficiency toward a deeper understanding of how technology interacts with pedagogy and content in specific teaching contexts (Niess, 2011). Such programs encourage teachers to experiment, reflect, and redesign their instructional approaches using technology to enhance student engagement and achievement.

Teacher education institutions in Mizoram, therefore, play a pivotal role in cultivating teachers' TPACK through both pre-service and in-service training. Embedding TPACK-based instruction into teacher preparation curricula enables future educators to develop an integrated perspective on technology use before entering the classroom (Angeli & Valanides, 2009). This is particularly important in regions like Mizoram, where disparities in access to digital resources and infrastructure persist. By introducing simulated teaching environments, lesson design workshops, and

collaborative digital projects, teacher training colleges can help teachers internalize the connections between technological, pedagogical, and content knowledge (Chai, Koh, & Tsai, 2013).

Moreover, the Government of Mizoram and educational agencies have made significant efforts to promote the use of information and communication technology (ICT) in schools, aligning with India's National Education Policy (NEP, 2020) that emphasizes digital literacy and 21st-century skills. However, the successful implementation of ICT initiatives depends largely on teachers' readiness to adopt and integrate technology meaningfully into classroom practices (Harris & Hofer, 2011; Koh, Chai, & Tsai, 2014). Teachers with high levels of TPACK are more capable of adapting available digital tools—such as learning management systems, interactive whiteboards, and multimedia platforms—to suit diverse student needs and local classroom realities (Mouza et al., 2014).

In the context of Mizoram, where some schools, particularly in rural areas, still face limited internet access and technical infrastructure, developing teachers' TPACK becomes even more valuable. Teachers who possess strong TPACK can creatively utilize low-cost or offline technologies, such as locally stored multimedia content or mobile learning applications, to enhance students' learning experiences despite resource constraints (Lalchhuanawma & Fanai, 2022; Sahin, 2011). This adaptability ensures equity in education and bridges the digital divide between rural and urban schools. It also empowers teachers to innovate with the resources they have, fostering more inclusive, context-sensitive teaching practices (Koh & Divaharan, 2011).

Ultimately, strengthening teachers' TPACK in Mizoram contributes to the broader goal of transforming the educational landscape in alignment with global digital education standards. As classrooms transition toward blended and technology-rich learning environments, teachers must not only acquire technical skills but also develop pedagogical insight into how technology reshapes teaching and learning dynamics (Kohler et al., 2013; Chai, 2019). Teachers who demonstrate robust TPACK are better positioned to cultivate critical thinking, collaboration, creativity, and digital literacy among students—competencies essential for thriving in a knowledge-driven society

(Mishra, Koehler, & Cain, 2013). In this way, TPACK functions not merely as a theoretical model but as a transformative framework guiding Mizoram's educators toward effective, equitable, and future-oriented teaching practices.

1.6 TPACK AND TEACHER PROFESSIONAL DEVELOPMENT

Teacher professional development plays a crucial role in helping educators effectively integrate technology, pedagogy, and content knowledge in the classroom. TPACK is not just a theoretical framework; it provides practical guidance for teachers to reflect on and improve their teaching practices (Mishra & Koehler, 2006). Through professional development programs, teachers can learn how to select and use digital tools that best support specific subject content and teaching strategies. This includes training in the use of educational software, online collaboration platforms, interactive whiteboards, and other emerging technologies that enhance learning experiences (Koehler et al., 2013).

In the context of Mizoram, professional development in TPACK is particularly important because many teachers face challenges such as limited access to resources, insufficient training in technology use, and varying levels of digital literacy (Lalchhuanawma & Fanai, 2022). Structured workshops, seminars, and hands-on training sessions can help teachers overcome these challenges by building confidence and competence in integrating technology effectively. For example, teachers can learn how to design lesson plans that combine traditional pedagogical methods with interactive digital tools, enabling more student-centered and engaging classrooms.

Moreover, continuous professional development in TPACK encourages reflective teaching practices. Teachers are guided to assess the effectiveness of their technology use, experiment with new tools, and adapt their methods to meet the diverse needs of students. This reflective approach not only improves teaching quality but also fosters innovation, as teachers can develop creative ways to make lessons more meaningful and accessible (Chai et al., 2013). By emphasizing TPACK in professional development programs, educational authorities in Mizoram can ensure

that teachers are well-prepared to handle the demands of modern education and enhance student learning outcomes.

Finally, integrating TPACK into teacher development initiatives supports lifelong learning and keeps teachers up-to-date with rapidly evolving technological trends. It ensures that educators remain flexible and responsive to changes in digital learning environments, curriculum updates, and students' learning needs. In this way, TPACK-based professional development not only strengthens teachers' skills but also contributes to the overall modernization and effectiveness of the education system in Mizoram (Chai et al., 2013; Mishra & Koehler, 2006).

Furthermore, incorporating the TPACK framework into teacher professional development initiatives creates opportunities for schools and educational institutions to establish a culture of continuous improvement and innovation. According to Voogt et al. (2013), professional learning that emphasizes the interplay between technological, pedagogical, and content knowledge enables teachers to move from simply using technology as a presentation tool to integrating it as an active component of learning design. This transformation helps teachers design instructional activities that promote critical thinking, collaboration, and problem-solving among students. In Mizoram, such an approach is particularly beneficial as schools strive to meet the changing educational needs of a digital generation while maintaining alignment with local curricula and cultural values.

Collaboration and peer learning are also essential elements of TPACK-oriented professional development. Research by Koh and Divaharan (2011) highlights that collaborative learning communities, where teachers share experiences, co-develop digital lesson plans, and exchange feedback, foster a deeper and more sustained understanding of technology integration. Within the Mizoram context, forming teacher learning circles or communities of practice focused on TPACK can help bridge the knowledge gap between urban and rural educators. These collaborative platforms can encourage teachers to adapt digital innovations to their specific classroom realities, share success stories, and collectively address common challenges such as limited internet connectivity or insufficient ICT infrastructure (Niess, 2011).

Institutional support is another key factor influencing the success of TPACK-based professional development. School leadership, education departments, and teacher training institutions in Mizoram need to play proactive roles in providing both material and moral support for technology integration. This includes ensuring access to digital tools, reliable internet connectivity, and ongoing technical assistance, as well as recognizing teachers' efforts to innovate through incentives, awards, or professional advancement opportunities (Harris & Hofer, 2011; Koh, Chai, & Tsai, 2014). A strong administrative commitment helps sustain teachers' motivation and reinforces the practical application of TPACK principles in everyday teaching.

Moreover, aligning TPACK professional development with the objectives of the National Education Policy (NEP, 2020) can further strengthen Mizoram's educational modernization efforts. The NEP advocates for digital empowerment of teachers, emphasizing the integration of technology in teaching-learning processes and curriculum design. Embedding TPACK principles into such national and state-level initiatives ensures coherence between policy goals and classroom practices, thereby creating a unified direction for educational reform (Chai, 2019).

Finally, the long-term impact of TPACK-oriented professional development extends beyond technological proficiency to encompass teachers' professional identity and pedagogical philosophy. As teachers continually engage with new technologies and teaching strategies, they develop a mindset of lifelong learning and adaptability—qualities essential in the 21st-century education landscape (Mouza et al., 2014). In Mizoram, where teachers often work in diverse and resource-constrained environments, this mindset allows them to become agents of change who can creatively transform limitations into opportunities for innovation. Thus, integrating TPACK into professional development is not merely about improving technological skills but about empowering teachers to design learning experiences that are dynamic, inclusive, and relevant to students' real-world contexts. In essence, sustained investment in TPACK-based teacher professional development can play a transformative role in shaping the future of education in Mizoram, ensuring that both teachers and learners thrive in an increasingly digitalized world.

1.7 TPACK AND STUDENT LEARNING OUTCOMES

The integration of Technological Pedagogical and Content Knowledge (TPACK) in teaching has a direct impact on student learning outcomes. When teachers possess strong TPACK skills, they are able to design lessons that are more interactive, engaging, and meaningful, which enhances students' understanding of subject content (Mishra & Koehler, 2006). For example, a mathematics teacher who effectively combines technological tools such as graphing software with appropriate teaching strategies can help students visualize complex concepts, leading to better comprehension and retention. Similarly, language teachers can use multimedia resources, digital storytelling, and interactive exercises to improve students' reading, writing, and communication skills.

In the context of Mizoram, applying TPACK can help bridge gaps in student learning caused by limited access to traditional learning resources or diverse educational backgrounds. Teachers with strong TPACK competencies can use locally available digital tools to create inclusive learning environments that cater to the needs of all students. By integrating technology thoughtfully into pedagogy, teachers can encourage active participation, collaboration, and critical thinking among students, which are essential 21st-century skills (Chai et al., 2013).

Moreover, TPACK supports formative assessment and feedback, allowing teachers to monitor students' learning more effectively. For instance, online quizzes, interactive polls, and digital portfolios enable teachers to track student progress in real time and adjust instructional strategies accordingly. This not only improves academic performance but also enhances students' motivation and engagement in the learning process. Research shows that teachers' effective use of TPACK positively influences students' academic achievement, problem-solving abilities, and overall learning experiences (Koehler et al., 2013).

By developing and applying TPACK in classrooms, teachers in Mizoram can create learning experiences that are not only technology-driven but also pedagogically sound and content-appropriate. This ensures that students gain deeper understanding, develop critical skills, and are better prepared for future academic and professional challenges in a rapidly evolving, technology-rich world.

Furthermore, the TPACK framework enhances differentiated instruction, allowing teachers to tailor learning experiences based on students' varied abilities and learning preferences (Harris & Hofer, 2011). For instance, teachers can use adaptive learning platforms that adjust the difficulty of tasks according to individual progress, thereby supporting both high-achieving and struggling students. This flexibility is particularly valuable in Mizoram, where classrooms often include students from diverse linguistic and socio-economic backgrounds (Lalchhuanawma & Fanai, 2022). The effective integration of technology through TPACK thus promotes equity and inclusion, ensuring that every learner has the opportunity to succeed regardless of their starting point.

TPACK also fosters higher-order thinking skills such as analysis, evaluation, and creativity, which are essential components of quality education in the 21st century (Voogt et al., 2013). When technology is used strategically—such as through simulation-based learning, inquiry projects, and problem-based tasks—students move beyond rote memorization toward deeper conceptual understanding. For example, in science classrooms, virtual laboratories and simulations can provide authentic experiences that may not be possible due to resource limitations, thereby enhancing scientific inquiry and experimentation (Niess, 2011). Such practices encourage students to apply their knowledge in real-world contexts, which improves learning retention and transferability (Koh, Chai, & Tsai, 2014).

In addition, TPACK contributes to the development of students' digital literacy and lifelong learning skills. As students interact with a variety of technological tools and digital resources, they learn to navigate information critically, collaborate online, and communicate effectively using modern platforms (Chai, 2019). These competencies are vital for students in Mizoram to participate meaningfully in a globalized and technology-dependent economy. When teachers integrate TPACK effectively, they prepare learners not just to succeed academically but also to become adaptable, self-directed, and responsible digital citizens (Mouza et al., 2014).

The implementation of TPACK also promotes a more engaging and student-centered learning culture. Research by Koh and Divaharan (2011) emphasizes that technology-integrated pedagogies supported by TPACK increase students'

engagement and self-efficacy, as learners take an active role in constructing knowledge rather than passively receiving information. This shift aligns with constructivist and socio-cultural learning theories, which view learning as a collaborative and experiential process. In Mizoram's classrooms, where traditional teaching methods still dominate, the adoption of TPACK can thus bring a transformative shift toward participatory and inquiry-based learning environments.

Finally, TPACK's influence on student learning outcomes extends to the affective domain enhancing students' motivation, confidence, and attitudes toward learning. When technology is used effectively, it can make abstract or difficult concepts more accessible, thereby reducing anxiety and increasing students' willingness to engage with challenging material (Harris & Hofer, 2011). Studies have also shown that students taught by teachers with higher TPACK proficiency exhibit greater satisfaction and interest in learning, leading to sustained academic improvement and positive perceptions of school (Chai et al., 2013; Koh et al., 2014).

In conclusion, the integration of TPACK in teaching practices is a powerful determinant of student learning outcomes. For Mizoram, where educational transformation is closely linked with the effective use of technology, empowering teachers with strong TPACK skills can create ripple effects across the education system. Students benefit not only from enhanced academic performance but also from the development of critical life skills, creativity, and digital competence—attributes essential for thriving in the 21st-century knowledge society. Thus, TPACK serves as both a framework for effective teaching and a catalyst for improved student learning outcomes in Mizoram's evolving educational landscape.

1.8 RATIONALE OF THE STUDY

As one considers the impact that technology has had on society as a whole, one might also question these changes as they pertain to the teaching and learning environment. The transformative nature of educational technologies has profoundly changed pedagogical thinking and looks to revolutionize our educational system (Voogt et al., 2013). However, an important question remains are teachers really utilizing these technologies to their full potential in classroom practice? The

Technological Pedagogical and Content Knowledge (TPACK) framework provides a basis for examining this issue by considering three distinct areas in a teacher's ability to integrate technology and improve instructional effectiveness: content, which refers to the subject matter to be taught; pedagogy, which represents the method and practice of teaching; and technology, the digital tools or resources through which pedagogical strategies are implemented (Mishra & Koehler, 2006; Koehler, Mishra, & Cain, 2013). By emphasizing the dynamic relationship between these three domains, the TPACK framework highlights that effective teaching with technology requires not only technical proficiency but also a deep understanding of how technology interacts with pedagogy and content to enhance student learning outcomes (Chai, Koh, & Tsai, 2013).

Technology's impact on the teaching and learning environment has changed not only the way students process new concepts and achieve learning objectives, but it has also modified the way in which instruction is delivered (Koehler & Mishra, 2009). Students' needs are diverse, and the forms of technology that they encounter in their learning environment may not fit those needs of every student or subject (Voogt et al., 2013). The educational technologies that a teacher may use in the teaching and learning environment may not adapt to every diverse need; rather, it is the responsibility of the teacher to creatively apply these tools to meet the needs of individual learners (Harris & Hofer, 2011). According to Okojie, Olinzock, and Okojie-Boulder (2006), "technology in education is not a mere object to be introduced into learning activities without first considering the basic principles of learning and having a well-developed pedagogical methodology" (p. 66). How a teacher chooses to use technology in the classroom is dependent upon that teacher's expectations in each grade level, subject, and class, as well as past experiences and training (Chai, Koh, & Tsai, 2013). Examining different applications of technology in the classroom specifically how a teacher adapts technology to best fit the lesson may also reveal the way a teacher perceives technology and its role in supporting effective teaching and learning (Mishra & Koehler, 2006; Niess, 2011).

Teachers in the 21st century must not only be familiar with the operation of instructional technologies but also with their application within the curriculum and their classroom. (Eisenberg & Johnson, 1996). Topper (2004) suggests that "for

teachers to use technology in support of their teaching, and see it as a pedagogically useful tool, they must be confident and competent with the technology they are planning to use". As the successful use of technology continues to gain attention and becomes more ubiquitous in our society novice and veteran teachers may possess the pedagogy but lack a technological base from which to adapt the device.

In the context of Mizoram, the integration of technology into teaching and learning has been growing, particularly after the COVID-19 pandemic, which accelerated the adoption of digital tools in schools and higher education institutions (Lalchhuanawma & Fanai, 2022). However, despite the increasing availability of technological resources, many teachers still face challenges in effectively incorporating these tools into their pedagogical practices due to limited training, inadequate infrastructure, and varying levels of digital literacy. This gap underscores the need to examine teachers' self-perceived Technological Pedagogical and Content Knowledge (TPACK) and their ability to connect technology, pedagogy, and subject content meaningfully in their classrooms. Understanding teachers' TPACK levels can provide valuable insights for policymakers, teacher educators, and school administrators to design targeted professional development programs and support systems that enhance technology integration in Mizoram's education system (Harris & Hofer, 2011; Voogt et al., 2013). Hence, this study is significant as it seeks to assess and strengthen teachers' technological competencies, ultimately contributing to improved teaching practices and better student learning outcomes in the state.

The findings of this study may enrich the theoretical knowledge about Technological Pedagogical and Content Knowledge (TPACK), provide considerable ideas and suggestions for developing higher secondary school teachers' TPACK and their teaching effectiveness, and help educational policymakers, administrators, teacher educators, and other stakeholders in reformulating and improving strategies for the successful implementation of digital technologies in teaching. Strengthening teachers' TPACK has been shown to enhance instructional quality and foster meaningful technology integration across subjects (Mishra & Koehler, 2006; Koehler, Mishra, & Cain, 2013). Furthermore, previous studies emphasize that professional development programs grounded in the TPACK framework can improve teachers' pedagogical decision-making and adaptability in diverse classroom contexts (Voogt et

al., 2013; Koh, Chai, & Tsai, 2014). By aligning the study's outcomes with these theoretical perspectives, the results may offer practical guidance for policymakers and educational leaders in Mizoram to promote sustainable technology integration and support teachers' continuous professional growth (Harris & Hofer, 2011; Chai, Koh, & Tsai, 2013).

Hence, this study will take the established Technological Pedagogical and Content Knowledge (TPACK) framework and employ it in a manner that will help illuminate how the use of technology in educational classroom activities is influenced by higher secondary school teachers' perceptions, teaching effectiveness, and the barriers they face in Mizoram. The TPACK framework has been widely recognized as a comprehensive model for understanding the complex interplay between teachers' knowledge of technology, pedagogy, and content in the process of effective technology integration (Mishra & Koehler, 2006; Koehler, Mishra, & Cain, 2013). Exploring teachers' perceptions and challenges in applying TPACK can reveal important insights into how contextual factors such as infrastructure, training, and attitudes—affect classroom practices (Voogt et al., 2013; Niess, 2011). In the context of Mizoram, where teachers operate under diverse technological and pedagogical conditions, such an investigation can contribute to developing contextually relevant strategies for improving digital teaching effectiveness (Lalchhuanawma & Fanai, 2022). Based on the above rationale, several research questions emerged in the mind of the investigator, leading to the formulation of specific objectives for the present study.

1.9 RESEARCH QUESTIONS

1. Are the higher secondary school teachers of Mizoram expert in different components of technological pedagogical and content knowledge?
2. Is there a significant difference in higher secondary school teachers of Mizoram self-perceived technological pedagogical content knowledge based on educational discipline, gender, age, teaching experience and ICT training?

3. Is there a significant relationship of higher secondary school teacher's self-perceived expertise in technology pedagogy and content knowledge and its effectiveness in teaching?
4. What are the problems faced by higher secondary school teachers in integrating technology in teaching?
5. What are the experiences of students in the effectiveness of teaching of higher secondary school teachers of Mizoram using technological pedagogical content knowledge?

1.10 STATEMENT OF THE PROBLEM

With the hope of revealing about the technological, pedagogical and content knowledge of higher secondary school teachers perceived competencies and their teaching effectiveness, the present study is formulated as below:

“Technological, Pedagogical and Content Knowledge of Higher Secondary School Teachers and Teaching Effectiveness: A Critical study”

1.11 OBJECTIVES OF THE STUDY

1. To assess the self-perceived level of technological pedagogical and content knowledge (TPACK) of higher secondary school teachers in Mizoram.
2. To compare the differences in self-perceived TPACK among higher secondary school teachers with reference to their educational discipline, gender, age, teaching experience and ICT training.
3. To examine the relationship of higher secondary school teachers self-perceived expertise in TPACK and its effectiveness in teaching.
4. To find out the problems faced by the higher secondary school teachers of Mizoram in integrating technology in teaching
5. To investigate the perceived experience of students on the effectiveness of teaching of higher secondary school teachers of Mizoram using TPACK.

1.12 HYPOTHESES OF THE STUDY

1. There is a statistically significant relationship in higher secondary school teachers of Mizoram on self-perceived technological pedagogical content knowledge based on educational discipline.
2. There is a statistically significant relationship in higher secondary school teachers of Mizoram on self-perceived technological pedagogical content knowledge based on gender.
3. There is a statistically significant relationship in higher secondary school teachers of Mizoram on self-perceived technological pedagogical content knowledge based on age.
4. There is a statistically significant relationship in higher secondary school teachers of Mizoram on self-perceived technological pedagogical content knowledge based on teaching experience.
5. There is a statistically significant relationship in higher secondary school teachers of Mizoram on self-perceived technological pedagogical content knowledge based on ICT training.
6. There is a statistically significant relationship in higher secondary school teachers self-perceived expertise in TPACK and its effectiveness in teaching.

These hypotheses were converted into null hypotheses for the purpose of testing as follows: -

1. There is no statistically significant difference in higher secondary school teachers of Mizoram on self-perceived technological pedagogical content knowledge based on educational discipline.
2. There is no statistically significant relationship in higher secondary school teachers of Mizoram on self-perceived technological pedagogical content knowledge based on gender.
3. There is no statistically significant relationship in higher secondary school teachers of Mizoram on self-perceived technological pedagogical content knowledge based on age.

4. There is no statistically significant relationship in higher secondary school teachers of Mizoram on self-perceived technological pedagogical content knowledge based on teaching experience.
5. There is no statistically significant relationship in higher secondary school teachers of Mizoram on self-perceived technological pedagogical content knowledge based on ICT training.
6. There is no statistically significant relationship in higher secondary school teachers self-perceived expertise in TPACK and its effectiveness in teaching.

1.13 OPERATIONAL DEFINITION OF THE KEY TERMS

The key terms used in this study are given below:

Content Knowledge (CK) – In this study, content knowledge refers to teachers' knowledge about the subject matter to be learned or taught.

Pedagogical Knowledge (PK) – In this study, pedagogical knowledge refers to teachers' deep knowledge about the processes and practices or methods of teaching and learning.

Technology Knowledge (TK) – In this study, technological knowledge refers to knowledge about certain ways of thinking about, and working with technology, tools and resources.

Pedagogical Content Knowledge (PCK) – In this study, pedagogical content knowledge deals with the teaching process (Shulman, 1986)

Technological Content Knowledge (TCK) – In this study, technological content knowledge is an understanding of the manner in which technology and content influence and constrain one another.

Technological Pedagogical Knowledge (TPK) – In this study, technological pedagogical knowledge is an understanding of how teaching and learning can change when particular technologies are used in particular ways.

Technological Pedagogical Content Knowledge (TPACK) – In this study, TPACK refers to “the connections among technologies, curriculum content, and specific pedagogical approaches, demonstrating a teachers' understanding of technology, pedagogy, and content that can interact with one another to produce effective discipline-based teaching with educational technologies

Higher Secondary School Teachers – In this study higher secondary school teacher is a person who teaches classes 11th and 12th.

Age: In this study age is divided as above forty years and below forty years.

Gender: Gender refers to the male and female teachers.

Educational Discipline: In this study educational discipline relates to Science and Arts stream of education.

Teaching Experience: In the present study, teaching experience refers to the duration of time a teacher has been actively involved in the teaching profession at the higher secondary level. For analytical purposes, teaching experience is classified into two categories: teachers having below 10 years of teaching experience and those having above 10 years of teaching experience.

ICT Training: ICT Training refers to structured professional development programmes designed to build teachers' competence in the use of digital devices, educational software, and technology-based pedagogical practices. For the purpose of this study, teachers are classified into two groups as trained - those who have undergone at least one recognized ICT training programme or untrained - those who have not undergone any formal ICT training.

Mizoram. Mizoram, one of the states located in northeastern India, has Aizawl as its capital city. The name Mizoram translates to “Land of the Mizos.” Following India's independence from the British Empire in 1947, the region was designated as the Lushai Hills District under the administration of Assam. In 1972, it was declared a Union Territory and officially named Mizoram. Eventually, in 1986, Mizoram attained full statehood as a federal state of India.

1.14 DELIMITATION OF THE STUDY

The study is delimited to higher secondary schools of Aizawl District in Mizoram.

CHAPTER II

REVIEW OF RELATED LITERATURE

2.0 Introduction

This chapter deals with the review of related literature. The purpose of reviewing related studies is to understand what type of studies have been done and what has been explored before. The review of related literature gives any research an insight and direction into the problem that the researcher is going to undertake. It helps the investigator by giving an overview of the work that has been done in the field and helps him to keep up with recent developments. It not only provides conceptual frame of reference but also suggests methods, procedures, sources of data, tools and statistical techniques appropriate for the solution of problems selected for the present study.

In this chapter, the investigator has made an attempt to survey the earlier works and review the research studies related to the present investigation in India and abroad. These studies immensely helped the investigator in planning and designing the research work

2.1 Studies done in India.

The researcher was able to find a few studies conducted on Technological Pedagogical Content Knowledge of Secondary School Teacher in India.

Mishra and Koehler (2006) conducted a study entitle “Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge”. Research in the area of educational technology has often been critiqued for a lack of theoretical grounding. In this article we propose a conceptual framework for educational technology by building on Shulman’s formulation of “pedagogical content knowledge” and extend it to the phenomenon of teachers integrating technology in to their pedagogy. This framework is the result of 5 years of work on a program of research focused on teacher professional development and faculty development in higher education. It attempts to capture some of the essential qualities of teacher knowledge required for technology integration in teaching, while addressing the complex, multifaceted, and situated nature of this knowledge. We argue, briefly, that

thoughtful pedagogical uses of technology require the development of a complex, situated form of knowledge that we call Technological Pedagogical Content Knowledge (TPCK). In doing so, we posit the complex roles of, and interplay among, three main components of learning environments: content, pedagogy, and technology. We argue that this model has much to offer to discussions of technology integration at multiple levels: theoretical, pedagogical, and methodological.

Thakur (2015) conducted a study on “A study on implementation of techno-pedagogical skills, its challenges and role to release at higher level of education”. Techno-pedagogical skills are the ways to make accessible and affordable quality education to all. The NCF (2005), and XII five year plans (2011), emphasized to provide connectivity, valuable content and low cost computing devices to all the Institutions of higher learning in the country. This hybrid skill facilitates to enhance linguistic abilities, to sketch specific pedagogy with advance study materials, to design multi-grade instruction. In higher education, techno-pedagogical skills facing some challenges such as; destitute infrastructure of ICT, scarce competence on English language and online content, calamity, and lack of incentives and awareness of teachers, evils on research and development, hitch of using software, limited techno-pedagogical resources, lack of coordination among the departments, frequent power outages and fluctuations.

Basu and Ahmad (2016) studied entitled on ‘Attitude towards using new technology among higher secondary school teachers in District Budgam’. The study was conducted with an objective to compare the attitude of higher secondary schools’ teachers towards ICT. The sample for the proposed study consisted of 60 higher secondary school teachers (Govt. N= 30; Science = 15; Arts N= 15, Private N= 30; Science N= 15; Arts = N=15) belonged to different areas of Zone Dreygam District Budgam. Random sampling strategy was followed to draw the sample for the study. The data was subjected to various statistical treatments. The results reveal the Govt. secondary school teachers have altogether favourable attitude towards ICT than the private secondary school teachers.

Bindu (2016) studied on ‘Development of a package for enhancing Pedagogical Content Knowledge of Secondary School Teachers’. The objectives of the study were to assess the level of knowledge about Pedagogical Content Knowledge and to test the effectiveness of Package for enhancing Pedagogical Content Knowledge of Secondary School Teachers in Malayalam by comparing the Pre and Post Assessment scores. The result found that the level of knowledge of majority of teachers is high for the two components of PCK. The study has further revealed that there is significant difference between pre and post assessment PCK scores. Hence it can be inferred that PCK Package is effective in enhancing the Pedagogical Content Knowledge of Secondary School Teachers.

Padmavathi (2017) studied entitle “Preparing teachers for technology-based teaching- learning using TPACK”. Technological Pedagogical Content Knowledge (TPACK) is a conceptual framework for teachers to teach effectively using technology. This framework originates from the opinion that use of technology in educational context would be effective only if content; pedagogy and technology are aligned carefully. It implies that for teachers to use technology in their teaching, they need to be competent in all three domains. This present paper is an attempt to understand the assumptions and components of Technological Pedagogical and Content Knowledge (TPACK) as a conceptual framework. Further, the paper addresses the issues and challenges in preparing teachers with TPACK capabilities, apart from emphasizing the role of teacher educators, pre-service, and in-service teachers in understanding TPACK for effective classroom teaching and learning.

Jeyaraj and Ramnath (2018) conducted entitle “Study on Technological Pedagogical and Content Knowledge of B.Ed. Student-teachers in Puducherry Region”. Two hundred B.Ed. student teachers were selected through simple random sampling technique and used as the sample for the present study. The standardized Likert type of scale prepared by Ismail Sahin was used as the tool for the study. The tool consists of 47 items with five responses. The collected data were analyzed by using SPSS package. The result revealed that TPACK of B. Ed student teachers are moderate. There exists significant difference in TPACK of B. Ed student teachers with

respect to degree, access of e-content and technology usage frequency in teaching learning process.

Kumar and Gangmei (2018) conducted a study entitle “Technological Pedagogical Content Knowledge of Secondary Teacher Educators of Jharkhand; An Analysis”. The purpose of this study was; to assess Technological Pedagogical Content Knowledge of teacher educators teaching in Secondary Teacher Education College. Descriptive survey method was used and the instrument used in data gathering was questionnaire, observation and interview. This study revealed that; The TPACK of teacher educator was low. The maximum percentage (50%) of teacher educator lie in low, 16% have high level, and 34% have average TPACK. Those teacher educators have less content knowledge they, have not good infrastructure of college, have no attitude towards teaching and didn’t take participate in the ICT base orientation program or seminar or workshop. Those teacher educators have high TPACK, their classroom activities were good. The study also found out about 90% of teachers used smart phone but they were not able to use in the classroom for teaching learning process. So it is big challenge for Government and teacher education institution to uplift and enhance the quality of education.

Naaz and Khan (2018) examined “Measuring the technological pedagogical content knowledge (TPACK) of pre-service teachers in relation to their gender and streams”. The study is aimed to find out the level of Technological Pedagogical Content Knowledge (TPACK) of Pre-service teachers. The study also finds out the effect of gender and streams on TPACK of Pre- service teachers. For this purpose, a sample consist of 131 pre-service teachers of department of Education, Aligarh Muslim University Aligarh were selected by using Simple Random Sampling technique. TPACK scale developed by Hosseini, Z., & Anand, K.(2012) was used for data collection purpose. Data were analyzed by Mean, Standard Deviation, t-test and ANOVA. The findings of the study revealed the fact that on TPACK scale Pre-service teachers have high mean score in Technological Knowledge and low mean score in Technological Content Knowledge. This study indicates that, both male and female differ in Technological Knowledge, but overall TPACK of pre-service teachers have no difference on the basis of gender. Similarly, there exists no significant difference

in Technological pedagogical Content knowledge of pre-service teachers among different streams (science, art and social-sciences).

Parkash and Hooda (2018) conducted on entitled “A study of techno-pedagogical competency among teachers of government & private schools of Haryana state”. The techno pedagogy knowledge collaboratively developed frame work of scholars and researchers seeking to conceptualize and clarify the competencies that evolve from the intersection between pedagogy & technology. For this study a sample of 200 Higher Secondary School teachers were selected from 20 Government and 20 private schools by random technique from Haryana State and descriptive survey method was used. Results shows that mean value of techno pedagogical competency of private higher secondary school teachers is more than Government higher secondary school teachers. So, the techno pedagogical competency of private higher secondary school teachers is better than Government higher secondary school teachers because the facilities given in private schools are better than facilities in Government schools. The mean value of techno pedagogical competency of male teachers of Government and Private higher secondary school is better than female teachers of Government and Private higher secondary school. So, the techno pedagogical competency of male teachers of Government and private higher secondary school is better than female teachers of Government and private higher secondary school. The mean value of techno Pedagogical competency of urban Government and private higher secondary school teachers is more than rural Government & private higher secondary school teachers.

Pradeep Kumar (2018) conducted entitle “A Study of Techno - Pedagogical skills of Secondary school Hindi teachers working in Kerala”. Survey method was used for the present study for collecting necessary data. The Questionnaire consisted of seven items related with different aspects of Techno pedagogical skills. The Sample of the study consists of 488 Secondary school Hindi teachers working in the government and aided schools of Kerala. The data obtained was analysed by using appropriate statistical techniques like Percentages, Mean and Z test. The study shows that majority of the sample (75.20 per cent) are proficient in computer applications and 56.76 per cent are competent enough in utilizing the web facilities. As far as the

competency in the effective operation of modern equipment like LCD projector and the like are concerned, the percentages of teachers who have the competency is 50.82 and the percentage of the sample those are confident in using the IT devices effectively in the classroom is 50.61 which could be treated as average.

Sharma and Leena (2018) conducted a study on “Effectiveness of an ICT programme on technological pedagogical and content knowledge tpack teacher self-efficacy and teaching effectiveness among pre-service teacher educators”. Result of the study showed that pre-service teacher educators who were taught through ICT-EIP showed significant improvement in their Technological, Pedagogical & Content Knowledge (TPACK) scores then the pre-service teacher educators who received instructions through conventional method of teaching.

Sobita Devi (2018) studied entitle “Attitudes of Higher Secondary School Teachers Towards Using New Technology: A Case Study of Imphal East and Imphal West Districts of Manipur”. This study explored the attitudes of the higher secondary school teachers of Imphal East and Imphal West districts of Manipur towards the use of new technology. The sample consisted of 350 teachers out of a total population of 706 teachers from 26 higher secondary schools. The Attitude towards Using New Technology Scale (ATUNTS) developed by Rajasekar was used for the study. The results indicated that the higher secondary teachers have positive attitude towards using new technology in teaching. Teachers of government and private schools; and young/junior and senior/old teachers differ significantly in their attitudes towards using new technology.

Nibedita and Beura (2019) studied entitled “Techno-pedagogical competency of higher secondary school teachers in relation to students’ academic achievement in science”. The purpose of this study is to determining the technological and pedagogical competency of higher secondary school teachers with the relation to students’ academic achievement in science. This is a descriptive study. It was conducted using the survey model. This research aims to investigate whether the academic achievements in science of higher secondary school students and the techno-pedagogical competency of their teachers show statistically significant relationship in

terms of some variables like gender and locale. The study was administered upon 100 teachers and 100 students of Cuttack district. And the findings of the study were revealed that majority of teachers were having moderate level techno- pedagogical competency and teachers belong to urban area were having high techno-pedagogical competency than that of rural area because of the variability in facilities available in urban and rural school. The techno-pedagogical competency of teachers and academic achievement of students are related each other.

Palanisamy, Paavizhi and Saravanakumar (2020) conducted a study on “Techno pedagogical skills for teaching-learning process in smart class”. Education can be defined as a systematic process of determining the extent to which goals are made through perseverance and patience. According to Tagore, "education is what not only gives us details but makes our way of life harmonious throughout life." As the 21st- century approaches, the educated citizen is increasingly predicting the use of computer technology for information and acceptance. Understanding how to use digital information from resources to expanding resources is important. The education system is now witnessing a paradigm shift from the traditional chalk and on-board teaching to digital inclusion methodology. The change will not only increase the capacity of teachers but will enhance the knowledge base of students to make them more aggressive in the international arena. Therefore, the technologies that are being promoted wish to develop that will equip them to deal with students of the visible generation and in addition to addressing the challenges within the modern classroom. Modern technology for teaching and learning in instructional instruction has now been transferred to smart classes. It is a new concept in education. The smart class approach offers smart thinking tools and a techno-based environment that can be read by students of all ages.

Sanjukta and Tripathy (2020) studied entitle “Techno Pedagogical Skills of Bachelor of Education Students of Odisha”. The study aimed at assessment of the techno pedagogical skills of Bachelor of Education (B. Ed) Students of Odisha and to compare the TP skills with respect to gender and stream of education. Descriptive Survey Method was adopted for the study. The sample of the study consisted of 200 B. Ed students of 4 Teacher Education Institutes of Odisha. Data were collected

through a standardized tool developed by K.K. Sibichen and P. Annaraja (2009) namely Techno Pedagogical Skill Assessment Scale (TPSAS). Collected data were analysed with help of t test. The results of the study revealed that B. Ed students have positive and high techno-pedagogical skills in terms of learning, implementing instructional strategy and evaluation. Further, there is no significant difference found between male and female B. Ed students in techno- pedagogical skills and there is no significant difference found between male-arts and female-arts B. Ed students in their techno pedagogical skills but there is significant difference found between male-science and female science B. Ed students in their techno pedagogical skills.

Beri and Sharma (2021) studied on “Development of TPACK for teacher-educators”. The objectives of this study were to develop a valid and reliable TPACK (technological pedagogical content knowledge) scale based on the core components of TPACK framework in order to measure teacher-educators’ TPACK. The sample size of 642 teacher educators working in different colleges of education under different universities in state of Punjab were selected by using stratified random sampling techniques. The Exploratory Factor Analysis (EFA) was carried out in order to investigate the factor structure of the scale. EFA resulted in six factors named as Pedagogical skills, Creative thinking skills, Ethics, Instructional design, Innovativeness and Virtual learning environment. The Cronbach’s Alpha coefficient for the whole scale was calculated as .848. The KMO value was calculated as .889 and the Bartlett’s Test of Sphericity examined (chi-square = 17196.73; df = 1035), which is significant (P-Value<.001). Based on result and in comparison, with the Cronbach’s alpha coefficient values for other TPACK surveys in the literature as a whole and for their sub-components the TPACK scale established here can be said to have a high level of reliability in terms of its factors and as a whole.

Kalaimani and Stephen (2022) conducted a study on “A study on technological pedagogical content knowledge of high school teachers in Chennai”. The present study aimed to find out the level of the Technological Pedagogical Content Knowledge of high school teachers of Chennai and to compare the techno-pedagogical skills based on gender and stream of the subjects. Descriptive survey method was adopted for the study. The sample of the study consists of 30 high school teachers in

Chennai. Data were collected through a validated tool constructed by the researcher with the help of the research supervisor namely Technological Pedagogical Content Knowledge (TPACK). The collected data were analyzed with the help of statistical techniques. The findings of the study revealed that there is no significant difference of high school teachers based on gender and stream of the subjects. The result of the study revealed that the levels of Technological Pedagogical Content Knowledge of high school teachers are moderate in nature.

Akankshya, Joy Prakash and Dash (2023) studied title “Technological Pedagogical Content Knowledge of Science Teachers at the Higher Secondary stage in the Covid Era”. A descriptive survey method has been used to collect data. The researcher used Likert Scale to collect data from 202 higher secondary-stage Science teachers by adopting the Likert scale. The objectives of the study were, 1) to study the Technological Pedagogical Content Knowledge of Science Teachers at Higher Secondary stage, 2) to find out the Technological Pedagogical Content Knowledge of science teachers at the higher secondary stage concerning their teaching experiences, and 3) to investigate the differences in higher secondary stage science teachers’ Technological Pedagogical Content Knowledge regarding the type of institution. To draw out the result, two statistical techniques were used percentage and t-test. The researcher found that there is no significant difference in the TPACK means scores of novices and experienced teachers and government and private higher secondary school teachers.

Binjha et al (2023) conducted a study on ‘Pedagogical Innovation of Tpack Based K-4 Learning Transaction Model in Science and Social Sciences’. The sample comprised of 40 student-teachers belonging to science and social science of the first batch integrated B. Ed program of Ravenshaw University and 341 students of CBSE-affiliated schools of Cuttack City. The scheme of the experiment was carried out by adapting Solomon Four Group Design. The quantitative data gathered through achievement tests were analyzed using Mean, SD, One-way ANOVA, and t-test. Based on the feedback given by the pre-service teachers, the project team brought in the innovation of the TPACK-based K-4 Learning Transaction Model (K4 -LTM). The data relating to innovation on TPACK-based K4 -LTM were collected through the

reaction scale and analyzed by using percentage analysis. The findings revealed that there was a significant effect of the TPACK-based practice in teaching science and social science. The reaction of student teachers towards innovative TPACK-based K4-LTM was found to be effective.

Gayen and Sen (2023) conducted on ‘Evolution of Technological Pedagogical and Content Knowledge (TPACK)’. The chapter deals with the gradual evolution of Technological Pedagogical and Content Knowledge (TPACK) framework that was developed for the teachers. The authors have made extensive literature review both in India and abroad and prepared this article. Besides the different components of TPACK like Content Knowledge (CK), Pedagogical Knowledge (PK), Technological Knowledge (TK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), Pedagogical Content Knowledge (PCK) and Technological Pedagogical and Content Knowledge (TPACK) are also discussed.

Honngam (2023) conducted a study entitle “A study on technological pedagogical and content knowledge (tpack) of prospective elementary teachers”. The purpose of this study was to find out the prospective elementary teachers’ Technological Pedagogical Content and Knowledge (TPACK) in relation to gender, academic level, age and stream of study. A sample of 150 prospective teachers was selected through simple random sampling. The tool used for the study was Teachers’ Technological Pedagogical and Content Knowledge Scale (TTPACKS) developed by Hemant Lata and Leena Sharma (2017). Mean, SD, t-test and ANOVA were used to analysed the data. The findings of the study revealed Prospective Elementary Teachers’ Technological Pedagogical Content and Knowledge (TPACK) to be above average and no significant difference was found on the basis of gender, academic level, age and stream of study among the prospective elementary teachers.

Joshi (2023) studied entitle “TPACK and teachers’ self-efficacy: A systematic review”. This review aimed to provide data on research methods, study samples, subject domains, and evaluation approaches used in the TPACK studies to date. The review also aimed to analyze teachers’ TPACK self-efficacy, self-efficacy beliefs,

computer self-efficacy, and technology support concerning professional development. Five best bets (most searched databases) were selected on the Electronic Business Source Complete (EBSCO) host platform. An abstract level screening was conducted for 136 peer-reviewed articles, and 75 articles were selected for the detailed screening. The analyses were focused on year-wide appearance of TPACK studies, research methods, study samples, subject domains, and evaluation approaches used. The growth and development of TPACK self-efficacy was examined using the narrative approach. Results indicated that professional development interventions were effective in improving teachers' TPACK self-efficacy.

Joy Prakash, Pradhan and Akankshya (2023) studied entitle “A study of technological pedagogical content knowledge (TPACK) of teachers with relation to their gender and type of institutions”. The investigator used the Descriptive survey design and the sample comprised 108 secondary school teachers selected from Odisha by using purposive sampling techniques. The Likert scale has been adapted by the researcher for this research. The objectives of the study were to investigate the differences in teachers' Technological Pedagogical Content Knowledge concerning their gender and the type of institutions where they work. For the analysis purpose, the investigator used statistical techniques like t-tests. After the study, it was found by the investigator that there exists no significant difference in the TPACK mean scores of male and female teachers and mean scores of private school and government school teachers.

2.2 Studies conducted abroad

Harris, Mishra and Koehler (2009) studied entitled “Teachers' technological pedagogical content knowledge and learning activity types: Curriculum-based technology integration reframed”. In this paper we critically analyze extant approaches to technology integration in teaching, arguing that many current methods are techno centric, often omitting sufficient consideration of the dynamic and complex relationships among content, technology, pedagogy, and context. We recommend using the technology, pedagogy, and content knowledge (TPACK) frame work as a way to think about effective technology integration, recognizing technology,

pedagogy, content and context as interdependent aspects of teachers' knowledge necessary to teach content-based curricula effectively with educational technologies. We offer TPACK-based "activity types," rooted in previous research about content specific activity structures, as an alternative to existing professional development approaches and explain how this new way of thinking may authentically and successfully assist teachers' and teacher educators' technology integration efforts.

Guzey and Roehrig (2009) conducted a study entitled 'Teaching science with technology: Case studies of science teachers' development of technology, pedagogy, and content knowledge'. This study examines the development of technology, pedagogy, and content knowledge (TPACK) in four in-service secondary science teachers as they participated in a professional development program focusing on technology integration into K-12 classrooms to support science as inquiry teaching. In the program, probe ware, mind-mapping tools (C Maps), and Internet applications — computer simulations, digital images, and movies — were introduced to the science teachers. A descriptive multi-case study design was employed to track teachers' development over the yearlong program. Data included interviews, surveys, classroom observations, teachers' technology integration plans, and action research study reports. The program was found to have positive impacts to varying degrees on teachers' development of TPACK. Contextual factors and teachers' pedagogical reasoning affected teachers' ability to enact in their classrooms what they learned in the program.

Schmidt, Baran, Thompson, Mishra, Koehler and Shin (2009) studied on "Technological pedagogical content knowledge (tpack): The Development and Validation of an Assessment Instrument for Pre-service". Based in Shulman's idea of Pedagogical Content Knowledge, Technological Pedagogical Content Knowledge (TPACK) has emerged as a useful frame for describing and understanding the goals for technology use in pre-service teacher education. This paper addresses the need for a survey instrument designed to assess TPACK for pre-service teachers. The paper describes survey development process and results from a pilot study on 124 pre-service teachers. Data analysis procedures included Cronbach's alpha statistics on the TPACK knowledge domains and factor analysis for each domain. Results suggest that, with the modification and/or deletion of 18 of the survey items, the survey is a reliable and

valid instrument that will help educators design longitudinal studies to assess pre-service teachers' development of TPACK.

Abbit (2011) conducted entitle on “Investigation of the Relationship between Self-Efficacy Beliefs about Technology Integration and Technological Pedagogical Content Knowledge (TPACK) among Pre-service Teachers”. This exploratory study investigated the relationship between measures of Technological Pedagogical Content Knowledge (TPACK) and the self- efficacy beliefs of pre-service teachers about technology integration. Within a single-group, pretest–posttest de- sign, a correlational analysis identified several knowledge domains in the TPACK model that the researcher found to have a significant and positive correlation with self-efficacy beliefs about technology integration. A multiple regression analysis of pretest and posttest data indicated a change over time in the predictive relationship between the measures of knowledge in TPACK domains and self-efficacy beliefs. Findings from the study illustrate the changing nature of the complex relationship between knowledge and self-efficacy beliefs and high- light the potential areas of knowledge in TPACK domains that influence pre-service teachers' beliefs about technology integration.

Baran, Chuang and Thompson (2011) studied entitle “TPACK: An Emerging Research and Development Tool for Teacher Educators”. The study conducted in Taiwan examined the relationship between the degree of technology modeling uses during the teacher preparation stage and the development of early childhood teachers' TPACK in Taiwan. Quantitative data were collected from a sample of 335 in-service early childhood teachers in Taiwan. Follow-up interviews were also conducted with 5 survey respondents. Results from this study reinforce and validate the significance of the effect of technology modeling in the teacher preparation stage. In addition, it echoed findings from previous research from Preparing Tomorrow Teachers to Use Technology (PT3) grant projects on the positive effects of modeling in technology use and integration in teacher preparation courses for pre-service teachers' future use of technology in their professional career in K–12 schools. In this paper provides a means for measuring teachers' self-assessed TPACK and is proving to be a valuable tool for researchers interested in the development of TPACK in both in-service and pre-service teachers.

Harris and Hofer (2011) conducted a study on ‘Technological Pedagogical Content Knowledge (TPACK) in Action: A descriptive study of secondary teachers’ curriculum-based, technology-related instructional planning’. In an interpretive study of experienced secondary social studies teachers’ planning, we sought to discover clues to the nature and development of these teachers’ TPACK-in-action as it was expressed in their planning processes. Comparisons of interview data and planning products before and after engaging in professional development that addressed content-focused, TPACK-based learning activity types revealed three primary findings, each supported by participating teachers’ oral and written reflections upon their learning. The participating teachers’- 1. Selection and use of learning activities and technologies became more conscious, strategic, and varied. 2. Instructional planning became more student-centered, focusing primarily upon students’ intellectual, rather than affective, engagement. 3. Quality standards for technology integration were raised, resulting in deliberate decisions for more judicious educational technology use.

Stoilescu (2011) studied on “Technological Pedagogical Content Knowledge: Secondary School Mathematics Teachers’ Use of Technology”, a case study. The objective of the study was to analyze secondary school mathematics teachers’ choices in integrating technology. The study showed that there are three different ways of integrating technology in classroom. The teacher participants in this research have different personal, pedagogical and technical backgrounds. In order to teach their students mathematics, they used different technologies or use the same computer device 179 differently. Yet, they were able to show, in different ways, that their pedagogical approaches of integrating technology in mathematics classrooms remain successful.

Agyei and Voogt (2012) studied entitle “Developing technological pedagogical content knowledge in pre-service mathematics teachers through collaborative design”. Although many studies have shown the need to pay attention to teachers' preparation for the integration of technology in classroom practice, most teachers in Ghana have not had any preparation that develops their technological pedagogical content knowledge (TPCK). This paper a case study of four pre-service

mathematics teachers from the University of Cape Coast, Ghana, who worked in two design teams to develop lessons, and subsequently taught in a technology-based environment for the first time. It was evident from the findings that more systematic efforts are needed to engage pre-service teachers in technology-rich design activities, to develop their TPACK adequately. The study also showed the potential of TPACK as a new frame for developing pre-service teachers' experiences in technology integration within initial teacher education, particularly in Sub-Saharan African countries.

Guerra, Moreira, and Vieira (2012) studied entitled “Technological pedagogical content knowledge development: integrating technology with a research teaching perspective”. Technological Pedagogical Content Knowledge (TPCK) represents the teachers’ professional knowledge needed to integrate technology in education. Following a design-based approach this study describes the strategies for designing and assessing an in-service science teacher education course. Data was obtained through interviews, questionnaires, using participant observation and analysis of in-service science teachers’ professional portfolios. A detailed description of the research methodology and findings is given, including an overview of the implications of the study. Results show that integrating technology with a Research Teaching Perspective (RTP) could be a way to develop innovative science lessons for students.

Voogt et al (2012) studied entitled “Technological pedagogical content knowledge – a review of the literature”. This study is a systematic literature review about TPACK of 55 peer-reviewed journal articles (and one book chapter), published between 2005 and 2011. The purpose of the review was to investigate the theoretical basis and the practical use of TPACK. Findings showed different understandings of TPACK and of technological knowledge. Implications of these different views impacted the way TPACK was measured. Notions about TPACK in subject domains were hardly found in the studies selected for this review.

Handal, Campbell, Cavanagh, Petocz and Kelly (2013) studied on “Technological pedagogical content knowledge of secondary mathematics teachers”. The integration of technology, pedagogy, and content in the teaching of secondary

mathematics was explored among 280 secondary mathematics teachers in the State of New South Wales, Australia. The study adopted the technological pedagogical content knowledge (TPCK) model through the administration of a 30-item instrument called TPCK-M. The instrument consisted of three major theoretically based constructs: technological content knowledge (TCK), technological pedagogical knowledge (TPK) and technological pedagogical content knowledge (TPCK). Results indicated that PowerPoint and Excel constitute the two TCK modal technological capabilities while TPK scores revealed teachers' lower capacity to deal with the general information and communications technologies goals across the curriculum, such as creating digital assessment formats. TPCK-M scores seem to suggest a healthy standard in teachers' technological skills across a variety of mathematics education goals. However, the magnitude of such influence in practice needs to be further ascertained, given that the study identified a number of instructional, curricular, and organizational factors seriously inhibiting the integration of technology into teaching and learning.

Hosseini and Kamal (2013) examined 'A Survey on pre-service and in-service teachers' perceptions of Technological Pedagogical Content Knowledge (TPCK)'. This research aimed to measure teachers' knowledge for technology integration through the lens of TPCK. 236 pre-service and in-service teachers in five fields participated in this survey. An examination of the participants' TPCK showed that Pedagogy Knowledge (PK) was highest and Technological Pedagogical Knowledge (TPK) was lowest among participants. Furthermore, statistical analysis using MANOVA indicated that there was no significant relationship between the demographic variables of age and gender with TPCK and its components while the participants' field of study and teaching experience were significantly related to their TPCK. Moreover, the correlation between participants' attitude toward using technology and TPCK was not found to be significant.

Jang and Tsai (2013) studied on "Exploring the TPACK of Taiwanese secondary school science teachers using a new contextualized TPACK model". This study was to explore TPACK of secondary school science teachers using a new contextualized TPACK model. Associations between in-service teachers' TPACK and other factors were also examined. The TPACK questionnaire was mailed to secondary

schools randomly selected across different parts of Taiwan, and return envelopes were provided for completed questionnaires. There were 1292 science teachers from secondary schools for factor analysis. An independent samples t-test was conducted when there were two groups (i.e., gender) to be compared for TPACK. ANOVA was conducted when there were more than two groups (i.e., science teaching experience) compared for TPACK. The results indicated that secondary science teachers' TPACK was statistically significant according to gender and teaching experience. With the consideration of other TPACK sub-components, male science teachers rated their technology knowledge significantly higher than did female teachers. Experienced science teachers tended to rate their content knowledge and pedagogical content knowledge in context (PCKC) significantly higher than did novice science teachers. However, science teachers with less teaching experience tended to rate their technology knowledge and technological content knowledge in context (TPCKC) significantly higher than did teachers with more teaching experience. The study shows how gender and teaching experience were influential factors for secondary school science teachers' TPACK.

Karadeniz and Vatanartiran (2013) studied entitle ‘Adaptation of a TPACK survey to Turkish for secondary school teachers. The purpose of this study was to adapt technological pedagogical and content knowledge (TPACK) survey which was developed by Koh, Chai & Tsait (2010). The survey was administered to 285 teachers who teach a variety of subject areas at the secondary school level in Edime. The translation equivalence, back translation and content validity done by the specialists. All data was analysed by using Lisrel 8.7 and IBMSPSS19. The CFA results showed that original 5 factor scale fitted with Turkish data. All t-test results of upper 27% and lower 27% group were meaningful. The findings revealed that TPACK survey was a valid and reliable instrument for measuring secondary school teachers’ TPACK.

Liang, Chai, Koh, Yang and Tsai (2013) conducted a study on “Surveying in-service preschool teachers' technological pedagogical content knowledge”. This study utilizes the TPACK survey to explore 366 Taiwanese in-service preschool teachers' technological pedagogical content knowledge. Exploratory factor analyses of the TPACK survey used in this study yielded six scales: Content

knowledge (CK), pedagogical knowledge (PK), pedagogical content knowledge (PCK), technological knowledge (TK), a combined factor of technological pedagogical knowledge and technological content knowledge (TPTCK) and technological pedagogical content knowledge (TPCK), respectively. The exploratory factor analyses indicated adequate reliability and validity of the TPACK survey. The correlation analyses revealed that more senior preschool teachers might show a certain degree of resistance toward technology-integrated teaching environments.

Cengiz (2014) studied entitle “The development of TPACK, Technology Integrated Self- Efficacy and Instructional Technology Outcome Expectations of pre-service physical education teachers”. The purpose of this intervention has been to improve pre-service physical education teachers’ Technological Pedagogical Content Knowledge (TPCK or TPACK), Technology Integrated Self-Efficacy (TISE), and Instructional Technology Outcome Expectations (ITOE). A pre-/post-test design without a control group was used in the study. Participants were third-year students ($n = 42$) who have completed the Turkish version of TPACK, TISE, and ITOE before and after this 12-week intervention. The data were primarily analysed through descriptive and paired-sample t -test statistics ($p < .05$). Descriptive analyses showed an increase in all subscales of TPACK, TISE, and ITOE scores. The paired-sample t -tests revealed a significant difference in scores for content knowledge, pedagogical knowledge, technological pedagogical knowledge, over all TPACK and ITOE. However, no significant difference in technological knowledge, TPACK, and TISE scores was observed.

Kazu and Pinar (2014) studied on “Teachers’ Technological Pedagogical Content Knowledge Self-Efficacies”. The aim of this study was to determine teachers’ views on technological pedagogical content knowledge (TPACK), their self-efficacy, and whether these views changed according to sex, age, period of service, faculty graduated from, branch, access to the internet, the use of technology level, and access to in-service training which is oriented to the use of technology. Teachers’ self-efficacies which are oriented to TPACK and its sub-dimensions known as technological knowledge (TK), content knowledge (CK), pedagogical knowledge

(PK), pedagogical content knowledge (PCK), technological content knowledge (TCK) and technological pedagogical knowledge (TPK) were determined to be at a high level. According to this study, teachers' self-efficacy perceptions on TK, CK, PCK, TCK and TPACK did not change according to sex while the self-efficacy perceptions on PK and TPK changed according to sex. It was concluded that the self-efficacy perceptions of female teachers in these dimensions were higher when compared to those of male teachers. According to the study, teachers' self-efficacy at TK and PCK changed according to age and the period of service, while self-efficacy at CK, PK, TCK, TPK and TPACK did not change according to these variables.

Knolton (2014) carried out a study on “Technological, Pedagogical, Content Knowledge TPACK): An exploratory study of adjunct faculty technology proficiency”. This study was undertaken to investigate whether a relationship exists between (a) TPACK, (b) pedagogical training, and (c) personal technology, and which variables have the greatest influence in the willingness of adjunct faculty at a higher education institution to choose and integrate digital technology into curriculum. The result revealed significant relationships between pedagogical training and selection of appropriate technology and between personal technology use (PLS) and selection of appropriate technology.

Nelly and Irina (2014) studied entitle “Preparing special education teachers for teaching mathematics and science with technology by integrating the TPACK framework in to the curriculum: A study of teachers' perceptions”. This study examined the development of Technological Pedagogical and Content Knowledge (TPACK) in mathematics and science of pre-service special education teachers via one course. The course focused on the three domains of knowledge related specifically to integrating instructional technology into mathematics and science teaching and learning namely, Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK) and TPACK. The Survey of Pre-service Teachers' Knowledge of Teaching and Technology developed by Schmidt et al (2009) was used to measure pre-service teachers' perceptions of knowledge. A paired t-test revealed that upon completion of the course requirements, students perceived to have had significant gains in each of the domains of teacher knowledge addressed in the course

- effect sizes were large (between .69 and 1.10). Further, significant gains were also found in the area of Pedagogical Content Knowledge (PCK) but with moderate effect size.

Yigit (2014) examined 'A review of the literature: how pre-service mathematics teachers develop their Technological, Pedagogical, and Content Knowledge'. The main purpose of this study is to investigate and analyze the articles in mathematics education research that have explored how PSMTs develop their TPACK and how their development impacts their future teaching of mathematics. Specifically, the literature review attempts to identify PSMTs' development of the components of the TPACK framework, their perspectives for their future teaching, how their development of TPACK can be measured, and strategies to develop their TPACK. Findings show that PSMTs' active involvement in technology enhanced lessons or courses are the major strategy to develop their TPACK and to improve their future teaching of mathematics.

Barış (2015) studied entitle 'Examining techno-pedagogical knowledge competencies of teachers in terms of some variables. This research was carried out for the purpose of investigating teachers' levels of technological pedagogical content knowledge (TPCK) competencies. In line with this aim, teachers' levels of TPCK competencies were studied in terms of gender, branch and to attend in service training programs. The findings of the study reveal that the teachers in the sample group of the study have a high level of awareness regarding their techno-pedagogical knowledge competencies. According to the findings of the study, based on branch and to attend in service training programs, there are statistically significant differences among teachers' awareness levels on their TPCK competencies.

Jaipal-Jamani and Figg (2015) conducted entitle 'A case study of a TPACK-based approach to teacher professional development: Teaching science with blogs'. This paper presents a case study of a technology professional development initiative and illustrates how a workshop approach based on technology, pedagogy, and content knowledge (TPACK) was adapted for professional learning at a school site. The case further documents how three middle school science teacher participants developed

knowledge about how to teach with technology as they planned and implemented a blog activity in science over a 4-week period. The design of the professional development was informed by the underlying assumptions of the TPACK framework and characteristics for effective professional development for science and technology-enhanced teaching. A naturalistic case study design was used. Data collection procedures included researcher field notes during workshop sessions and lessons, videotaped classroom observations, audio-taped interviews, and teacher and student lesson artifacts. Data on teachers' planning and lesson implementation of the blog activity to Grade 8 students were analyzed using content analysis. Overall, the results indicate that TPACK is developed through a combination of workshop experiences and immediate application of knowledge gained in the workshop into practice in the real-life teaching context.

Karaca (2015) studied entitled “An investigation of pre-service teachers’ technological pedagogical content knowledge based on a variety of characteristics”. Survey research was conducted to examine pre-service teachers’ Technological Pedagogical Content Knowledge (TPACK) and how it differs based on a variety of characteristics (i.e. gender, grade level, type of high school graduated, possession of different technologies etc.). The participants of the study included 142 pre-service teachers from Computer Education and Instructional Technologies Department at Marmara University, Istanbul Turkey. The study results indicated that pre-service teachers’ TPACK scores differed based on gender, their reasons for choosing their profession, their perceptions of the value of school experience courses and their possession of tablet computers. Understanding the characteristics that would have an influence on pre-service teachers’ TPACK level provides valuable insights to the development of teacher preparation activities that would lead to more efficient use of technologies in their future professions. As pre-service education has a good potential to influence prospective teachers’ use of technologies in their future career, the study results will provide valuable insights about how to improve teachers’ technology integration starting from their undergraduate degrees.

Rosenberg and Koehler (2015) study on ‘Context and Technological Pedagogical Content Knowledge (TPACK): A systematic review’. To provide a

systematic and comprehensive view of the extent to which context is included in such research, and to understand the meaning of context when it is included, we conducted a systematic review of publications about TPACK. Context was included in descriptions, explanations, or operationalizations of TPACK among 36% of the 193 empirical journal articles we examined. When context was included, classroom and school factors and those related to teachers were more likely to be included than related to students and society. The grounds for both context being included among around one-third of the articles and why some contextual factors are examined more than others are discussed.

Atasoy, Uzun and Aygun (2016) conducted a study on ‘Technological pedagogical content knowledge of prospective mathematics teachers regarding evaluation and assessment’. This study aims to investigate technological pedagogical content knowledge (TPACK) of prospective mathematics teachers regarding the ‘evaluation’ and ‘assessment’ process. To achieve this aim, the method of qualitative research was conducted with 20 teachers. Video records and lesson plans were collected and a Mathematics Teacher TPACK Development Model was utilized to reveal themes and key features of the data. The findings revealed that, although the majority of teachers stated that they would like to use technology-integrated tools in the assessment and evaluation processes, they strongly preferred to use traditional assessment and evaluation techniques, such as pen and paper activities, multiple-choice questions in virtual environments, etc. Hence, the evidence suggests that teachers would be unable to use appropriately the technological assessment process in order to reveal students’ understanding of mathematics.

Ceylan (2016) conducted entitle “Improving Technological Pedagogical Content Knowledge (TPACK) of pre-service English language teachers”. This study aims to explore the effectiveness of a five-week workshop and training sessions on Technological Pedagogical Content Knowledge (TPACK) of pre-service English language teachers. The participants are 59 pre-service English language teachers enrolled in an ELT Methodology Course at a state university. The data is gathered through the TPACK Scale developed by Solak and Çakır (2014) and journal entries of pre-service English language teachers before and after the procedure. The results

indicate a statistically significant improvement in TPACK scores of both male and female pre-service English language teachers. The journal entries clearly indicate an increase in several possible applications or websites that can be used in the classroom with more effective and to the point objectives. The pre-service English language teachers have also displayed better performance in manufacturing and tailoring language learning/teaching materials with specific goals.

Özdemir (2016) studied title ‘An examination of the techno-pedagogical education competencies (TPACK) of pre-service elementary school and pre-school teachers’. The purpose of this study is to determine the technological pedagogical content knowledge of pre-service elementary school and preschool teachers. The fundamental problem of the study consists of the investigation of teachers' TPACK by their year of study and fields. This is a descriptive study. It was conducted using the survey model because it aimed to determine TPACK of the 995 pre-service elementary school and preschool teachers who participated in the study. They were in the departments of elementary school teaching and preschool teaching at three state universities in the spring term of the 2014-2015 academic year. The study found the means of junior (third year) and senior (fourth year) pre-service teachers in the departments of elementary school teaching and preschool teaching to be high. Their means were also high in the sub-dimensions of TPACK competence. The TPACK means of the pre-service elementary school and preschool teachers were found to be high. The TPACK means of senior pre-service elementary school and preschool teachers were determined to differ from those of junior pre-service preschool teachers.

Anderson, Griffith and Crawford (2017) conducted a study entitled “TPACK in special education: Pre-service teacher decision making while integrating iPads in to instruction”. This study provides insight into pre-service teachers’ experiences with integrating technology into lessons with children who had mild learning disabilities. Participants included 14 junior early childhood education majors enrolled in a special education course with a fieldwork component. The researchers collected and analyzed lesson plans, journal entries, focus group interviews, and field notes. The findings illustrated pre-service teachers’ use of iPad apps during fieldwork, identified their technology-related instructional decisions, and determined how those choices

exhibited emerging dimensions of technological, pedagogical, and content knowledge (TPACK). The pre-service teachers combined their knowledge of pedagogy, student understanding of content, and emerging knowledge of iPad apps to effectively develop and conduct lessons in various content areas. Interviews with the students supported the social validity of the iPad implementation.

Avni (2017) studied entitle “The factors affecting Techno-Pedagogical competencies and critical thinking skills of pre-service mathematics teachers”. At that point, this research is remarkable for presenting an idea in terms of educating more qualified mathematics teachers. This study was designed as a descriptive study. The sample of the research consists of 552 pre-service elementary mathematics teachers. Two types of data collection tools were used in this study: "TPACK Self-Efficacy Scale" and "Critical Thinking Scale". The data of the study were analyzed by using the Statistical Package for Social Science (SPSS) 21.0. The results of the study reveal that the techno-pedagogical competencies and critical thinking skills of pre-service mathematics teachers are mid level. On the other hand, there is a significant relation between the pre-service mathematics teachers’ critical thinking skills and techno-pedagogical competencies.

Durdu and Dag (2017) studied on ‘Pre-Service Teachers’ TPACK Development and Conceptions through a TPACK-Based Course’. This study examines pre-service teachers’ Technological Pedagogical Content Knowledge (TPACK) development and analyses their conceptions of learning and teaching with technology. With this aim in mind, researchers designed and implemented a computer-based mathematics course based on a TPACK framework. As a research methodology, a parallel mixed method approach was used. The data were collected from 71 pre-service teachers taking the course. The TPACK survey, a semi-structured interview, and evaluation scores of pre-service teachers’ microteaching performance, which also included analysis of lesson plans, were used as data collection instruments. The findings indicated that the implemented instructional processes affected pre-service teachers’ TPACK development positively. There were significant differences before and after the course implementation concerning Technology Knowledge,

Technological Content Knowledge, Technological Pedagogical Knowledge, and TPACK in general. Qualitative findings support and overlap the statistical inferences.

Saltan and Arslan (2017) studied title on “A comparison of in-service and pre- service teachers’ technological pedagogical content knowledge self-confidence”. This study aimed to investigate and compare in-service and pre-service teachers’ self-confidence on technological pedagogical content knowledge (TPACK) in relation to their teaching experience, expertise, technology usage, and gender. To achieve this goal, survey method was conducted as part of a quantitative method design. Participants of the study consisted of 388 pre-service and 211 in-service teachers from four different concentrations: science, mathematics, information, and communications technology (ICT) and classroom teachers. The data were analyzed using paired Sample T-test and MANOVA statistical analysis. Results showed that both pre-service and in-service participants exhibit the highest self-confidence level in the technological content knowledge domain. While pre-service teachers had the lowest score in TPACK, in-service teachers had the lowest score in the technological knowledge domain.

Turgut (2017) studied entitle “A comparison of pre-service, in-service and formation program for teachers’ perceptions of technological pedagogical content knowledge (TPACK) in English language teaching (ELT)”. In view of the rapid advancement of technology, technological pedagogical content knowledge (TPACK) has been extensively studied. However, research on technological pedagogical content knowledge (TPACK) in teaching English appear to be scarce and addressed either pre-service or in-service teachers, but not their comparison. Additionally, although teacher-certificate programs are employed in many countries, none of the existing studies have examined teacher-candidates’ TPACK, especially in English language teaching (ELT). To fill the gap, this study aims to compare TPACK among teacher-candidates, pre-service and in-service English as a foreign language (EFL) teacher in Turkey. Quantitative and qualitative data analysis indicated significant differences among them. Based on these findings, suggestions for teacher education and future research were made.

Bingimlas (2018) conducted a study entitle “Investigating the level of teachers’ Knowledge in Technology, Pedagogy, and Content (TPACK) in Saudi Arabia”. This self-assessment study aims to investigate Saudi teachers’ knowledge about the three essential components of TPACK, technology, content, and pedagogy. A quantitative research design was employed. The sample included 111 males and 132 females; out of which, 116 were primary grade teachers, 55 were middle grade teachers, and 72 were secondary grade teachers. Around 32% of the teachers had teaching experience of between 10 and 20 years, and about 27% had teaching experience of between 5 and 10 years. A majority of the teachers reported that they had an average confidence level of knowledge relative to the TPACK framework. Certain differences existed amongst them on the basis of their gender, teaching subjects, and teaching experience. Statistically, a significant difference was shown between technological content knowledge and teaching experience

Hardisky (2018) studied on "TPACK: Technology integration and teacher perceptions". The purpose of this study is to examine the ways teachers in a small urban school are integrating technology into their classrooms and to identify characteristics and patterns exhibited by those teachers in order to inform and improve training. The study revealed both time and support as emerging factors. Time was viewed as an obstacle in more than one way. One could consider “time” to mean frequency of use, or one might view “time” as the period needed to prepare a lesson. The different perspectives of time reflect distinct values among individual teachers. Some may find more time value in learning to use a technology than becoming aware of one. Others may find time better spent in preparing a lesson with technology than fully learning how to use it. Veteran participants, in particular, point to this difference in perceived time values, both in the TPACK questionnaire and open-ended survey.

Kim (2018) studied on “Technological, pedagogical, and content knowledge (TPACK) and beliefs of pre-service secondary mathematics teachers: Examining the relationships”. The purpose of this paper is to examine the relationships between pre-service secondary mathematics teachers’ beliefs and knowledge regarding teaching mathematics with technology. By conducting three semi-structured interviews, I investigated four pre-service secondary mathematics teachers’ technological,

pedagogical, and content knowledge (TPACK) and their beliefs about the nature of mathematics, learning and teaching mathematics, and technology use in the mathematics classroom. The findings of this study suggest that pre-service teachers with constructivist-oriented or student-centered beliefs about the nature of mathematics, learning mathematics, and technology use displayed higher levels of mathematical knowledge, pedagogical content knowledge, and technological content knowledge, respectively, than pre-service teachers with traditional or teacher-centered beliefs about mathematics, learning, and technology use.

Kim and Lee (2018) studied on “The effects of the TPACK-P educational program on teachers’TPACK: Programming as a technological tool”. This study examined the effects of introducing programming as a technological tool for teachers Technological Pedagogical Content Knowledge (TPACK) development. Thirty-two teachers were divided into two groups, completing different types of TPACK educational programs. The control group’s TPACK training program was based on information and communication technology (ICT), while that of the experimental group was based on programming. To verify the effectiveness of the TPACK training program, tests were administered before and after the educational program. A statistical analysis of questionnaire results also investigated changes resulting from TPACK. Both the control and experimental groups showed statistically significant improvements in the post-test compared with the pre-test. However, in the detailed areas of TPACK by group, the improvements in the two groups differed. Unlike the control group, the experimental group showed a statistically significant improvement in the knowledge related to technology. This result illustrated that programming is effective in solving the problem of integrating technology into the classroom. In contrast, there was no significant difference in the post-test, as this was applied in the short term.

Yildirim and Sensoy (2018) studied entitle “Effect of science teaching enriched with technological practices on attitudes of secondary school 7th grade students towards science course”. This research is to examine effect of science teaching enriched with technological practices on attitude levels of secondary school 7th grade students towards science course. Execution step of the research was

performed on 7th grade students attending to a government secondary school in Turkey in the academic year of 2015 and completed in 13 weeks. Work group of the study had 74 students (control group=38, experiment group=36). “The Attitude towards Science Course Scale” was used to collect data. The scale having 5-point Likert grading structure was applied as pretest, post-test and follow-up test. The execution step of the study was performed by the same teacher in science courses of control and experiment groups. The control group was not subjected to any experimental process and a student centered education in line with the existing science course curriculum was offered. The experiment group received education in parallel to the curriculum but technologically enriched science education programs were included in the teaching process. The research concluded that attitude levels of the experiment group significantly increased and this increase was still preserved three months after completing the research.

Altun (2019) studied entitled “Investigating pre-service early childhood education teachers’ Technological Pedagogical Content Knowledge (TPACK) competencies regarding digital literacy skills and their technology attitudes and usage”. This study sought to understand the contribution of the technology attitudes and usage, digital literacy skills, and online reading comprehension strategies in pre-service early childhood teachers’ TPACK competencies. The participants in the study were 481 voluntary pre-service early childhood teachers (female=398, male=83). The data were collected as a cross-sectional survey. The study findings revealed that pre-service teachers’ TPACK competencies are associated with their technology attitude and usage, digital literacy skills, and online reading comprehension strategies, as well as that the variables explained 38% of the variance. However, pre-service teachers’ grade level and GPA are not related to their self-reported TPACK competencies. These findings can be seen as signals of the necessity for theoretical knowledge and practice to be developed in pre-service teachers’ technology integration in education.

Fathi and Saman (2019) studied entitled “Assessing language Teachers’ Technological Pedagogical Content Knowledge (TPACK): EFL students’ perspectives”. The purpose of this study was set to assess Iranian EFL students’ perspectives regarding their teachers’ TPACK. A total of 148 Iranian EFL students

participated in this survey study. The data were collected through administering a previously validated TPACK questionnaire to the participants of the study. The findings obtained from the survey indicated that most EFL students perceived that their EFL teachers excelled in four components of TPACK such as technological knowledge (TK), pedagogical knowledge (PK), content knowledge (CK), and pedagogical content knowledge (PCK), but the teachers were perceived to be relatively less proficient in the other three components of the scale such as technological content knowledge (TCK), technological pedagogical knowledge (TPK), and TPACK. The results suggest that Iranian EFL teachers may require further training in these latter elements of the TPACK to gain the required proficiency to integrate technology more effectively into their language classrooms.

Ömer and Ziya (2019) studied entitle “Investigation of the Self-efficacy of the Teachers in Technological Pedagogical Content Knowledge and Their Use of Information and Communication Technologies”. The aim of this study was to determine the teachers' views on technological pedagogical content knowledge (TPACK) self-efficacy and the frequency of using ICT in education and to examine whether there is a differentiation in these views according to certain variables. In addition, the relationship between teachers' use of ICT and TPACK-ISTE self-efficacy in various processes is examined. The study which is carried out with a descriptive survey, causal comparison and correlational survey models includes 387 secondary and high school teachers as study sample. In the study, teachers consider themselves very competent especially in terms of content knowledge. TPACK-ISTE self-efficacy of vocational and technical teachers was significantly higher than that of the science and mathematics teachers. While teachers benefit from ICT tools less frequently in measurement and evaluation as well as in presenting the course subject; in terms of presenting the course subject, high school teachers use ICTs significantly more often than the secondary school teachers; those who did receive in-service training on the use of technology in education use ICTs significantly more often than those who did not receive it. It is seen from the study results that the variables such as preparing the lecture notes, presenting the course subject and doing study explain the TPACK-ISTE self-efficacy significantly.

Redmond and Lock (2019) studied entitle “Secondary pre-service teachers’ perceptions of technological pedagogical content knowledge (TPACK): What do they really think?”. Pre-service teachers often feel ill-prepared to plan for effective technology integration in their classrooms. Technological pedagogical content knowledge (TPACK) has provided educators with a theoretical framework to unpack the complexity of technology integration. It sits at the heart of three interrelated components: content knowledge, pedagogical knowledge, and technological knowledge. These knowledge areas interact, support, and constrain each other. This study investigated secondary pre-service teachers’ perceptions of TPACK. Data were collected through an online survey and interviews. Following a brief introduction to TPACK, this article explores secondary pre-service teachers’ perceptions of TPACK and its components, along with their professional learning needs for TPACK development.

Bakar, Maat and Rosli, (2020) studied on “Mathematics teacher’s self-efficacy of technology integration and Technological Pedagogical Content Knowledge”. This study conducted to determine the mathematics teacher’s self-efficacy of technology integration and Technological Pedagogical Content Knowledge (TPACK) based on gender and teaching experience. In this research, 66 mathematics teachers from national secondary schools were chosen as the samples to answer a survey questionnaire containing 71 items with a five point Likert scale. Descriptive statistics, such as mean, percentage, and standard deviation, were employed to analyze the data. T-test was used to gauge the mathematics teacher’s self-efficacy of technology integration and TPACK based on gender, and one-way ANOVA was employed to determine mathematics teacher’s self-efficacy of technology integration and TPACK based on teaching experience. Besides, Pearson’s correlation coefficient was used to determine the relationship between the mathematics teacher’s self-efficacy of technology integration and TPACK. The findings showed no significant difference between genders and the teaching experience of the mathematics teacher’s self-efficacy and TPACK. However, mathematics teacher’s self-efficacy of technology integration and TPACK were strongly associated.

Mulhayatiah, Suhendi & Windayani (2020) study entitled ‘TPACK’s understanding analysis of physics teachers in using learning media’. This study aims to determine the use of learning media used by physics teachers in the learning process. This research method is qualitative with research instruments in the form of questionnaires, document analysis and interviews. The study sample consisted of 60 physics teachers in West Java. The results of the study show that the majority of physics teachers still use PowerPoint media as the main media, then use electronic references, and interactive multimedia. Based on the media compilation process, almost most of them directly use existing media. The main reason is the lack of training gained by teachers in developing learning media. The conclusion of this study is that physics teachers still need technology and pedagogic knowledge in learning.

Nalurita, Priyanto and Muslikhin (2020) studied title “The effectiveness of technology, pedagogy and content knowledge (tpack) in learning”. Those factors are Technology Knowledge (TK), Pedagogy Knowledge (PK), Content Knowledge (CK) and Technology Pedagogy Knowledge (TPK). Curriculum 2013 has been applying for 5 years. However, an evaluation of how does the teacher deliver learning subjects (pedagogy knowledge), and the implementation of subject mastery (content knowledge) and technology mastery (technology knowledge) is strongly suggested. The study was quantitative with an associative method involving 200 teachers in Salatiga region as samples drawn with simple random sampling. The results of the study showed that PK has a positive effect on TPACK, while TK and CK do not have a positive effect on TPACK. Furthermore, TK, TPK, PK have positive effects on TPK, and TPK has a positive effect on TPACK. This study also suggested that age influences the development of technological knowledge and if one of the knowledge is not possessed by a teacher, the learning process will achieve maximum outcomes.

Nuangchalerm (2020) studied on “TPACK in ASEAN perspectives: Case study on Thai pre-service teacher”. This study focuses on identifying and summarizing the features of TPACK in ASEAN literatures. The review was conducted using the ACI database; a total of 11 articles describing TPACK based on specific search criteria. The framework of TPACK needs to generalize to school policy, administrative purposes and teacher development and teacher preparation program. Also, the

exploratory TPACK of 7 Thai pre-service science teachers in one-year school practicum provided significant findings through TPACK questionnaire and lesson plan analysis. Data were collected and analyzed by descriptive analysis. The explorative study illustrated the nature of their TPACK by concept and practice was at high level. The study needs pre-service teacher have technology integration in teacher preparation program, also TPACK should be implemented in teacher development program.

Severo, Bernardes and Andrade Neto (2020) conducted a study entitled “Technological Pedagogical Content Knowledge (Tpack) in pre-service and in-service Chemistry teacher training: A systematic literature review”. This research sought to investigate the literature on how the theoretical model TPACK is being used for the integration of technology in Chemistry teaching. This investigation was based on a Systematic Literature Review (SLR), reaching a sample of 23 articles published in scientific journals from 2006 to 2019. In general, the researches that composed this SLR use the theoretical model TPACK in a more theoretical way and mostly in in-service teacher training. The lack of research in the Brazilian context signals the need for more work supported by this framework, which can lead to practices that are more aligned with the contemporary needs of Chemistry teacher training.

Aydin-Gunbatar and Fatma Nur Akin (2021) studied on “Pre-service chemistry teachers’ use of pedagogical transformation competence to develop topic-specific pedagogical content knowledge for planning to teach acid–base equilibrium”. This study based on mixed-methods design, the main aim was to examine to what extent the participants underwent pedagogical transformation and developed topic-specific pedagogical content knowledge (PCK) for planning to teach acid–base equilibrium. For this, training for the acquisition of pedagogical transformation competence to develop topic-specific PCK was provided for 12 weeks during the teaching methods course. The findings revealed that the participants showed more progress in transferring content knowledge to students’ difficulties and alternative conceptions, and instructional strategies than in the assessment component of topic-specific PCK.

Erol and Tuncay (2021) conducted a study on “Comparing pre-service teachers’ self-confidence levels in technological pedagogical content knowledge in terms of several variables”. This study aimed to investigate and compare pre-service teachers’ self-confidence in technological pedagogical content knowledge (TPACK) concerning their gender, department, and owned digital technologies. To achieve this goal, the survey method was conducted as part of a quantitative method design. Participants of the study consisted of 252 pre-service teachers from four different concentrations: physics, chemistry, biology, and german language teaching. TPACK Self Confidence Scale (TPACK-SCS), which was constructed by Graham, Burgoyne, Cantrell, Smith, and Harris (2009) and adapted to Turkish by Timur and Taşar (2011), was used as the data collection tool. The Cronbach’s Alpha internal reliability coefficients of the scale were calculated between .78 and .94. Since the data obtained did not show normal distribution it was analyzed by Mann-Whitney U and Kruskal Wallis - H tests. According to the results, significant differences were found in the level of self-confidence and sub-dimensions of students’ TPACK according to gender, department, and owned digital technologies for education.

Holvio (2021) studied on “Teaching and learning in Mozambican primary schools: how does teacher content knowledge affect student achievement”. This study seeks to answer how large a causal impact teacher content knowledge has on student achievement in Mozambican primary schools. The data for this study come from a Service Delivery Indicator survey in Mozambique from 2014. They include assessments of fourth-grade students and their teachers in math and Portuguese. The main results suggest that teacher content knowledge in math and Portuguese does not have a statistically significant impact on student achievement. However, further analyses show that there is considerable heterogeneity in the results. This is not unexpected, as Mozambique itself is a rather heterogenous country with large contrasts. Increasing teacher content knowledge by 1 SD increases student achievement by 0.14 SD among students with Portuguese as their first language, and by 0.13 SD among students in urban schools. Increasing the content knowledge of teachers whose knowledge is above the median also increases the achievement of students whose knowledge is above the median by over 0.12 SD.

Kartal and Dilek (2021) studied title ‘Pre-service science teachers’ TPACK development in a technology-enhanced science teaching method course’. This study investigated pre-service elementary science teachers’ TPACK development throughout a science teaching method course. The pretest-posttest control group was used in the study. At the end of the study, a self-reported TPACK measure was administered to the experimental (n=26) and control (n=23) groups. The experimental group learned about instructional technologies that can be used in science teaching; prepared technology-based science activities, shared these activities with their peers; planned and taught a mini technology-based lesson, evaluated the lesson, and re-planned and re-taught the lessons. The results showed that the experimental group had positive gains about how to integrate technologies into science teaching. Participants in the experimental group comprehended that teaching science with technology requires more than technical knowledge and skills and that it is essential to realize the interactions between science, technology, and pedagogy. Besides, the experimental group’s TPACK significantly differed from the control group.

Santos and Castro (2021) studied on “Technological Pedagogical content knowledge (TPACK) in action: Application of learning in the classroom by pre-service teachers (PST)”. This study evaluated the application of TPACK of pre-service teachers in different public schools around Bulacan. The pre-service teachers were evaluated by their Cooperating Teachers and the result was supported by an interview made to the pre-service teachers and their supervisors. The findings of the study revealed that pre-service teachers have ‘*strong knowledge*’ in the seven elements of TPACK. The educational technology tools in public schools were rated ‘*fairly adequate*’. TPACK and Ed Tech tools are significantly correlated but with a very weak uphill relationship. Among the independent variables, PSTs’ TPACK applications were primarily influenced by TPK and TCK. The other independent variables were not significant. Between TPK and TCK, TPK had a stronger influence on pre-service teachers’ TPACK applications. TPK and TCK were primarily influenced the application of TPACK.

Abebe, Gaskill, Hansen and Liu (2022) conducted a study on a topic entitled “Investigating K-12 Pre-Service Teacher TPACK in Instructional Technology Learning”. This study was undertaken to investigate the change in pre-service teachers’ Technological Pedagogical Content Knowledge (TPACK) self-efficacy beliefs in a technology integration course in a teacher education program. It assessed knowledge components that predicted TPACK self-efficacy beliefs. Pre and post-surveys were administered using Schmidt et al. (2009) instrument at the beginning and end of the course. The study revealed statistically significant change in all dimensions of TPACK self-efficacy beliefs. Cohen’s effect size revealed medium effect size on TPACK self-efficacy beliefs during the pre-service teacher education technology integration course. PCK and TPK were the significant predictors of TPACK in both pre and post-survey report. Content Knowledge (CK) was a significant predictor of TPACK in the post-survey. The result implies that instructional technology courses should pay attention to the factors affecting TPACK during curriculum design and course delivery. In the current research context CK, PCK and TPK predicted TPACK. TK and PK can be mediated by TPK and PCK respectively.

Ali and Mohammadzadeh (2022) studied on “Iraqi Kurdish EFL teachers’ beliefs about technological pedagogical and content knowledge: The role of teacher experience and education”. This study probed teachers’ beliefs towards TPACK in general and its components in particular in Iraqi Kurdistan. Additionally, the role of teaching experience and education degree in affecting the teachers’ beliefs was explored. The data was collected through a questionnaire responded by 105 EFL (English a Foreign Language) teachers and enriched by qualitative data gathered through a structured interview. Overall, it was found that teachers generally had a higher level of pedagogy and subject matter knowledge than technological knowledge. Although the quantitative data indicated that the experienced teachers had significantly higher pedagogical, content, technological, and pedagogical content knowledge than the novice teachers, the qualitative analysis revealed that novice teachers were more skilled in the utilization of technology-related knowledge domains. Furthermore, Ph.D. participants demonstrated higher level of TPACK confidence than the BA ones.

The findings are discussed in the light of theories on teachers' beliefs, and implications for teachers and teacher educators are presented.

Ali, Ur Rehman and Noor Ullah (2022) conducted a study on “Measuring University Teacher Educators' Knowledge and Skills Using TPACK in Teachers Education Programs’. This study focuses on the perceptions that teacher educators have of their own effectiveness and capabilities with regard to the integration of technological pedagogical and content knowledge into their courses. In order to accomplish the objective of the research, quantitative research design was employed and teacher educators from public and private universities in Karachi, Pakistan were solicited to take part in a quantitative survey. The data were gathered with the assistance of a modified survey instrument that possesses a high level of reliability and validity. The data were then analyzed with the assistance of Statistical Software for the Social Sciences. The results of the study indicated that teachers' TPACK has a significant impact on the instructional strategies they choose to implement in their classrooms.

Andoh, Asare-Danso, Sefenu, Adams (2022) conducted a study on a topic entitled “Assessment of Technological Pedagogical Content Knowledge of Senior High School Business Teachers in the Central Region, Ghana”. The objectives of the study was to explored business teachers’ level of Technological, Pedagogical and Content Knowledge (TPACK) in Senior High Schools in the Central Region of Ghana and examined the differences in teachers’ level of TPACK on the basis of some demographic variables using the mixed methods approach. The study used descriptive survey design. Simple random sampling technique was used to select 248 business teachers. Questionnaire was used to gather quantitative data. Mean and standard deviation were used to examine business teachers’ level of TPACK. Independent samples t-test was used to examine whether differences exist in teachers’ TPACK and gender. One-way (ANOVA) was also used to examine whether differences exist in teachers’ TPACK based on age. The finding showed that teachers possessed higher Content, Pedagogical and Pedagogical Content Knowledge and moderate Technological Knowledge, Technological Content Knowledge, Technological Pedagogical Knowledge and TPACK. The study found that there was statistically

significant difference in teachers' TK, TCK and gender in favour of the male teachers. The study concluded that teachers' high content knowledge, pedagogical knowledge, pedagogical knowledge suggests that teachers seem to focus much on developing these knowledge to the neglect of other vital contemporary skills such the use of technology.

Asamoah, Asiedu and Buadi (2022) studied on 'use of ict in teaching and learning in second cycle institutions: understanding the technological aspect of the tpack model' and the study revealed that both teachers and students have a positive perception about the integration of ICT into teaching and learning.

Blomberg, Högström and Liljekvist (2022) studied on Learning opportunities for pre-service teachers to develop pedagogical content knowledge for statistical inference. This study presents a qualitative study of pre-service teachers participating in a collaborative learning setup in a mathematics course to be prepared for teaching statistics in primary school aged 6–10 years. The study reported here is the first cycle of a design research project. This first-phase study explores how pre-service teachers' pedagogical content knowledge for statistical inference can be developed during their mathematics course. The findings show that pre-service teachers' learning opportunities regarding pedagogical content knowledge for statistical inference are insufficient. Based on the initial results, an initial conjecture map was constructed that guides the forthcoming design cycle.

Can and Boz (2022) conducted a study titled 'Development of pre-service teachers' pedagogical content knowledge and the factors affecting that development: a longitudinal study'. The objective of the study was to explore the development of pre-service chemistry teachers' pedagogical content knowledge regarding the effect of temperature on reaction rate topic as they took pedagogical content knowledge courses throughout the teacher education program. Pre-service teachers' pedagogical content knowledge was examined under five components: Orientations toward science teaching, Knowledge of curriculum, Knowledge of instructional strategies, Knowledge of learners, and Knowledge of assessment. Two pre-service chemistry teachers participated in the study. Data were collected through a vignette and semi-structured interviews over two years. Analysis of data revealed that both participants'

pedagogical content knowledge components showed development. However, there was an uneven development of components of pedagogical content knowledge. Moreover, the degree and pattern of development were different for some components of pedagogical content knowledge for each participant

Cardoso, Ponte and Quaresma (2022) study entitled ‘The development of pedagogical content knowledge of prospective primary teachers in a lesson study’. This study took place in a teacher education institution where a LS was carried out during the last semester of the academic year with the participation of two prospective teachers, a teacher educator, a cooperating teacher and a researcher. The results suggest that prospective teachers may develop PCK when they participate in LS, regarding lesson planning (goals and lesson plan), task design, students’ difficulties and solving strategies, whole-class discussions and observation of student learning. This development occurs through the engagement in LS activities that allow prospective teachers to deepen their knowledge. This study investigate show the development of prospective teachers’ PCK occurs during LS, providing knowledge about how different activities of the LS help develop different aspects of PCK.

Choi (2022) studied on ‘Towards Purposeful Technology-Integration Practices: Developing TPACK’. Results indicated that more than 80% of the survey participants agreed that they can teach lessons that appropriately combine content area, technologies, and teaching approaches. To further understand these self-reported data, TPACK constructs discussed in this exploration focus on three of the seven domains—TCK, TPK, and TPACK. Actionable considerations for pre-service teachers are proposed, including a professional development learning module to build teachers' TPACK knowledge.

Cui and Zhang (2022) conducted a study titled ‘Integrating teacher data literacy with TPACK: A self-report study based on a novel framework for teachers’ professional development’. This study aimed to combine teacher data literacy with TPACK (technological pedagogical content knowledge). The researcher used qualitative methods to develop this integrated framework, then distributed a quantitative self-report survey based on the framework to teachers, and analyzed the

resulting data. The qualitative phase highlighted five types of teachers' knowledge required in an integrated core knowledge system incorporating data literacy and provided insights for reflecting on teaching and learning in smart learning environments. The finding reveals that most teachers were competent practitioners but had some areas for improvement. Experienced teachers in their 30s and 40s performed at higher levels, while some of those aged over 50 displayed incremental decreases in performance. Other factors such as the age, experience, academic qualifications, and role of teachers may affect different aspects of their knowledge, including their data literacy.

Diputera and Handayani et.al. (2022) study titled Content Validity and Reliability of Expert Assessment PLP Guide Book Based on Technological Pedagogical and Content Knowledge. This study main purpose was to determine the content validity and reliability of agreement among experts in assessing the Technological Pedagogical and Content Knowledge on Introduction to the school field (PLP) Guidebook. The research method uses a development model. TPACK based handbook tested by 3 experts. Validity analysis was carried out using Aiken's V analysis and Reliability using Interclass Consistency. The results of the study prove that the manual with v value of 0.95 is declared valid content with high criteria and an ICC value of 0.517 is declared an expert in assessing. The conclusion of this research is that the content is valid and the experts are appropriate in conducting the assessment. Suggestions for the TPACK based PLP guidebook can be used as guidelines for implementing PLP for lecturers, tutors and students.

Hayati, Kadarohman, Sopandi et.al. (2022) conducted a study entitled 'Chemistry Teachers' TPACK Competence: Teacher Perception and Lesson Plan Analysis' and found that the analysis on TPACK component show that chemistry teachers are unsure or doubtful about their abilities, while the results of the analysis of lesson plans are in the very poor category.

Joldanova, Tleuzhanova, Kitibayeva, Smanova and Mirza (2022) conducted a study titled 'Formation of TPACK and Acmeological Competency of Future Teachers in Foreign Language Education'. The aim of the study was to

determine the effects of acmeological-based teaching activities in foreign language lessons on learners' foreign language self-efficacy, foreign language learning motivation and Technological Pedagogical Content Knowledge (TPACK) skills. The study was conducted with 35 students in the experimental and 35 control groups for 6 weeks. Foreign language learning self-efficacy scale, foreign language learning motivation scale and TPACK skill test were used as data collection tools. The findings reveals that there was a significant difference in favor of the experimental group in the post-test scores (foreign language learning self-efficacy, foreign language learning motivation and TPACK skill test scores) of the experimental group, in which activities based on the acmeological approach, and the control group, in which traditional teaching was applied.

Joshual (2022) conducted a study entitled “Technological Pedagogical and Content Knowledge (TPACK) of teachers in relation to the context and their teaching performance, Loon, Bohol”. This study chiefly intends to determine the TPACK level in relation to the context and their teaching performance. This study utilized a quantitative- correlational method using a survey research design to gather the TPACK and context levels; and a documentary analysis of the Individual Performance Commitment and Review Form (IPCRF), the school year 2019-2020, to gather the teaching performance. The respondents of the study were the teachers from the public secondary school of Loon, Bohol, with 90 teachers as the sample. The researcher complied with the Research Ethics Committee’s requirements to guarantee the proper observation of the research ethics protocol. Results showed that the teacher respondents had a very high level of TPACK and a very satisfactory teaching performance. The respondents also rated their context with a very high level. In the further analysis of the gathered results, findings revealed that the respondents’ TPACK had a significant relationship to the context, but none to the teaching performance. It also showed that the respondents’ context and teaching performance had insignificant relationship.

Kartal (2022) studied on “Examining pre-service mathematics teachers’ technological pedagogical content knowledge development in the natural setting of a teacher preparation program”. This study examined pre-service elementary

mathematics teachers' technological pedagogical content knowledge (TPACK) development throughout their final year in the natural setting of a teacher preparation program. Data were collected from 38 pre-service teachers via a TPACK self-assessment scale with seven subdomains at the beginning and end of the final year of their training. Descriptive statistics, correlation, and regression analysis were used. Results showed that participants had significantly positive gains in their pedagogical knowledge (PK), technological knowledge (TK), technological pedagogical knowledge (TPK), pedagogical content knowledge (PCK), and TPACK with medium-to-large effect sizes. Correlation analysis indicated that participants developed a more integrative understanding of TPACK. Participants' TCK, TPK, and PCK were significant predictors of their TPACK at the end of the program. The teacher preparation program seems to primarily support pre-service teachers' pedagogical thinking.

Kulaksiz and Karaca (2022) conducted a study entitled 'Elaboration of science teachers' technology-based lesson practices in terms of contextual factors influencing TPACK'. The findings indicated that TPACK is not only a stand-alone knowledge and skills, but also it is context-oriented. The multifaceted factors represent components of a multi-layered structure of the context. These factors can be perceived by the teachers at different levels according to school types. Furthermore, sub-themes of the contextual factors showed complex interrelationships.

Kusaini, Mahamod and Wan Mohammad (2022) study titled Validation Instrumentation and Measurement of Technological Pedagogical Content Knowledge (TPACK) for Teachers. The aim of the study was to develop and verify a questionnaire to evaluate the demand for technological pedagogical content knowledge (TPACK) measurement towards teachers. They added two new components such as technological pedagogical content knowledge and contextual knowledge. The instrument was implemented with 400 teachers who teach Malay language subject at Secondary school in Malaysia. The verified questionnaire had eight components, and the dependability of the instrument was quantified using Cronbach's alpha coefficient. Eight components were analysed using confirmatory factor analysis (CFA) to determine the credibility of the structure. The results showed that the eight-factor

variable model fits well and met the requirements of goodness of fit indices ($>.90$) and RMSEA ($<.80$). The knowledge and teaching skills possessed by teachers will grow in line with their experience in national education arena.

Kusuma (2022) study entitled ‘How Does a TPACK-related Program Support EFL Pre-service Teachers’ Flipped Classrooms?’ and the results revealed that the TPACK-related program helped the EFL pre-service teachers improve their understanding of flipped classrooms, develop considerations when implementing flipped classrooms, and successfully implement technology in their flipped classrooms.

Lee, Chung and Wei (2022) conducted a study entitled ‘Research on Technological Pedagogical and Content Knowledge: A Bibliometric Analysis From 2011 to 2020’. This study aims to explore the bibliometric characteristics of TPACK from 2011 to 2020. The VOS viewer software tool and Biblio-matrix R package were used for information analysis. The results confirmed that there are 700 articles, representing 63 countries and 159 journals scanned. Articles in 2013 were cited the most times, and since 2016, the number of articles is on the rise every year. The United States, Turkey, and Australia were the three leading countries in this field. Most of the articles were published in educational technology journals. The total articles published by American institutions are more than the others, followed by Asian institutions. The most prolific authors are all Asians, followed by Americans. Core themes from the highly cited articles have been surrounding PCK, teacher education, skill, and pedagogy. The development of TPACK has gradually turned to practical strategies and tried to find strategic ways to facilitate teachers to implement technology-assisted teaching.

Liu (2022) study entitled ‘Exploring secondary mathematics teachers’ TPACK development and student-centred beliefs’. To remedy the shortage of investigations about the correlation between a wider range of the belief systems and TPACK in mathematics, based on the assumption that TPACK enhancement requires mathematics teachers’ practical use of digital hardware and software, this essay focuses on student-centred beliefs and reveals that TPACK is an extension of the belief

systems rather than an isolated area of knowledge, and student-centred beliefs tend to advantage TPACK development. The obstacles of strengthening TPACK include the unavailability of digital tools, scheduled teaching to prevent technology use and opportunities to experience the strengths of technology, and mathematics teachers' intrinsic resistance to change their practice to integrate more technology into teaching. In response to these, it is necessary to provide specific projects and ICT intervention schemes focusing on pedagogy, set standards for TPACK level before obtaining qualified teacher status, and construct a shared space that mathematics teachers, mathematics education researchers, policymakers, and digital technology designers can communicate and collaborate to promote TPACK learning and enhancement.

Ly and Soutte (2022) studied on Technological Pedagogical Content Knowledge Framework as a Lens for Transformative Social and Emotional Learning Online: A Perspective. This study used Mishra and Koehler's technological pedagogical content knowledge (TPACK) framework as a lens for understanding how teachers integrate transformative social and emotional learning in all learning environments (i.e., online and hybrid). The authors implemented a reflexive thematic analysis approach with interviews of 15 participants consisting of students, parents, and teachers. Findings illustrate that teachers were infusing social and emotional learning (SEL) into technological pedagogical content knowledge, and that interaction among all three bodies of knowledge supported students' social-emotional wellness during the COVID-19 pandemic. Integration of SEL allowed for rich authentic learning experiences across content areas as well connections to the class community in online or hybrid learning environments.

Masry-Herzalah and Dor-Haim, (2022), conducted a study on a topic entitled "Teachers' technological competence and success in online teaching during the COVID-19 crisis: the moderating role of resistance to change". The purpose of the study was to examine the relationship between Israeli teachers' technological competence and their success in online teaching during the COVID-19 crisis. The study was based on 383 teachers' who responded to a questionnaire about a month and a half after the transition to online teaching due to the COVID-19 crisis. The study revealed a significant, positive relationship between technological competence and

success in online teaching. Further, the study found that resistance to change among teachers played a key role in teaching success, such that it moderated the association between technological competency and online teaching success. Theoretical and practical implications are suggested.

Muhammad Yassir; Husain Syam; Hasanah Nur (2022) studied on “Higher order thinking skills-based assessment for learning model in problem-based learning using SIAVO for vocational school students”. This study aims to find out: (1) an AFL model based on HOTS SIAVO; and (2) a valid and practical model. The model can be applied to learning in the field of computer networks for vocational high school students. This research is development research using the modified HC-ADDIE model, namely collaboration and modification of the Hopkins and Clark research, development, and diffusion (RDD) model with the ISD ADDIE model and classroom action research (CAR). The development stages involve activities of prototype model design, model validation, readability testing, training teachers/observers, and conducting limited and expanded trials as implementation, analysis, and evaluation activities through CAR diffusion including dissemination of research results through seminars and journals. The results showed that the HOTS based AFL model for learning in the field of computer networks for students developed through the modified HC-ADDIE model is valid and practical.

Njiku (2022) conducted a study titled ‘Attitude and technological pedagogical and content knowledge: The reciprocal predictors?’ and found that attitude and TPACK were seen to have a strong positive correlation. Models involving attitude dimensions and TPACK dimensions were seen to predict TPACK and attitude respectively.

Onbasili, Tuncay, Seker and Kiray (2022) studied on ‘an examination of pre-service teachers’ experiences in creating a scientific digital story in the context of their self confidence in technological pedagogical content knowledge’ the findings revealed that the experiences of pre-service teachers in creating a scientific digital story increased statistically significantly in the TK dimension of the TPACK scale and in the TPACK total self-confidence scores. The qualitative findings of the research

showed that it had a positive effect on TCK, TPK, and TPCK dimensions, as well as on the TK and total score of TPACK.

Putri, Sulaeman and Aristya Putra (2022) conducted a study on trend of Technological Pedagogical Content Knowledge (TPACK) for Pre-service Science Teacher: A historical review. This research aims to provide a historical overview of TPACK-related studies for pre-service teachers, particularly those in the science department. The databases held 143 papers from 2012 to 2022, which were reviewed in four steps: identification, screening, eligibility, and inclusion, yielding 44 noteworthy articles on TPACK research. According to the data, most studies measure pre-service teachers' TPACK using a variety of techniques and samples. And recently, the quantitative method has grabbed the lead. TPACK studies have grown in quantity over time, with the emphasis on measuring and enhancing pre-service teachers' TPACK. Despite the fact that the trend is increasing, the Indonesian context is still rare, and this study suggests that additional research into the TPACK environment in Indonesia is essential.

Sintawati, Erviana, Habil et al. (2022) study titled the effect of Project-Based Learning on Technological Pedagogical Content Knowledge among Elementary School Pre-Service Teacher. The goal of this study was to describe the impact of Project-Based Learning (PjBL) on TPCK in elementary school pre-service teachers. This research is an experimental study with a one-group pre test-post test design. A total of 94 pre-service elementary school teachers are included in this study's sample. Data collection instruments to measure TPCK are questionnaires and assessment sheets. The questionnaire was used to measure TK, PK, CK, TCK, PCK, and TPK. The assessment is used to measure TPCK. TPCK is assessed using the outcomes of student-created learning materials. The data is analyzed using descriptive statistics and inferential statistics. To test the study hypotheses, inferential statistics are used. The paired sample t-test was used to test the hypothesis. The descriptive analysis results suggest that the TPCK for pre-service teachers is in the high range. The results of hypothesis testing show a significant effect of using PjBL on TPCK of pre-service elementary school teachers. These findings highlighted PjBL's potential for TPCK development. Keywords: Elementary school, PjBL; TPCK.

Tan and Chen (2022) published a paper on ‘Spiral model of collaborative lesson design: A model to develop TPACK and TEL design competency in pre-service teachers’. Results showed that pre-service teachers’ TPACK and their TEL design competency had improved and the proposed model will contribute significantly to the professional development of pre-service teacher education.

Zulyusri, Desy, Santosa and Yulianti (2022) studied on “Meta-analysis the effect of the technological pedagogical content knowledge (TPACK) model through online learning on biology learning outcomes, learning effectiveness, and 21st century competencies of Post-Covid-19 students and teachers”. This research is a type of meta-analysis research. This research sample comes from national and international journals that have been published from 2017-2022. Sample search through journal databases accessed through Google Scholar, Eric journal, Emerald, Elsevier, Sage Journal, Taylor and Francis and IEEE. The data selection technique in this study was through purposive sampling technique. The data that was sampled was in accordance with the criteria or related to TPCK in science learning on the variables of effectiveness and student learning outcomes. The data analysis used is quantitative data analysis with the help of SPSS version 16 application by looking at the value of N-gain and Effect size (ES). The results of this study concluded that the Technological Pedagogical Content Knowledge (TPCK) learning model through online learning had a significant effect on student learning outcomes with an average value of 70.5, student learning effectiveness with an average of 73 with an N-gain of 0.61, and 21st century competence of students and Teachers obtained an average of 77.33 with an effect size of 0.48 with moderate criteria.

Anud and Caro (2023) conducted a study on “Relationship between Technological Pedagogical and Content Knowledge (TPACK) Self-efficacy, 21st Century Instructional Skills and Performance of Science Teachers”. This study for which descriptive co-relational research design was used. Three hundred and eighty-six (386) Science educators participated in the study, and their responses were examined using descriptive-co-relational and causal comparative techniques. Path analysis was used to examine the parsimonious link between the causal models and other variables. Science teachers demonstrated excellent TPACK self-efficacy and 21st

century instructional skills, resulting in a very satisfying teaching performance. Science teachers' performance was significantly correlated with technological knowledge (TK) which was also the 1 predictor of their performance. The best fitting model of Science teachers' performance was directly anchored to technological knowledge supported by pedagogical content knowledge, content knowledge, communicative and collaborative skills and innovative and ICT skills.

Ayo-Vaughan, Ajani and Oyebade (2023) studied titled 'Secondary school teachers' technology pedagogical content knowledge (TPACK) levels and its implications for curriculum implementation in Delta State'. This was therefore, the focus of this study. Descriptive survey research design was employed in the study. Secondary school teachers in public schools in Delta State constituted the population. Purposive, multi-stage and simple random sampling techniques were used in selecting 88 schools and 2,200 teachers from five local government areas that made up the sample size. Data collected was analyzed using descriptive statistics of frequency count, mean and standard deviation. The study found that secondary school teachers have high TPACK levels necessary for effective curriculum implementation. It was therefore recommended among others that, factors responsible for the high TPACK levels be identified and sustained.

Bashir and Jimmy (2023) studied entitle "Pre-service teachers' technological, pedagogical and content capability and digital pedagogy readiness". The study sought to investigate pre-service teachers' perceptions of their technological, pedagogical, content capabilities; validate the digital pedagogy readiness model; and establish the influence of technological, pedagogical and content capabilities on pre-service teachers' digital pedagogy readiness. Mishra and Koehler's TPACK Framework (2006) formed the study's theoretical ground to derive the technological-pedagogical-content capability sub-constructs. A 30-item scale was used to collect data from 351 pre-service teachers of Kyambogo University. Descriptive statistical analysis was employed to establish the respondents' perceptions on the variables under study, while Structural Equation Modeling (SEM) was applied to validate the model and test the hypotheses. Findings revealed that pre-service teachers were in agreement regarding their perceptions of the capabilities; the hypothesised digital pedagogy Readiness

model showed fit to the data; and the influence of technological pedagogical content capability on pre-service teachers' digital pedagogy readiness was statistically significant.

Bwalya, Rutegwa, Tukahabwa and Mapulanga (2023) studied title on “Enhancing pre-service biology teachers’ technological pedagogical content knowledge through a TPACK-based technology integration course”. This study aimed to enhance the technological pedagogical content knowledge (TPACK) of five pre-service Biology teachers (PSBTs) by implementing a TPACK- Instructional Design (TPACK-ID) model-based technology integration course at a Zambian public university. An explanatory case study design was used. Data sources for the study included semi-structured interviews, video lesson recordings, lesson plan reports and PSBTs’ reflection notes. Data from interviews and reflection notes were analyzed using deductive thematic analysis while a TPACK rubric was used to simultaneously analyze lesson plan reports and video lesson recordings. The findings indicated that the TPACK-ID model-based technology integration course improved PSBTs’ overall TPACK and sub-knowledge domains: pedagogical knowledge, technology knowledge, technological content knowledge, and technological pedagogical knowledge.

Durusoy and Karamete (2023) studied on “Enhancing Pre-Service Teachers' Technological Pedagogical Content Knowledge (TPACK) through the Learning by Design Framework: A Fink Taxonomy-based Study”. This study aimed to develop Technological Pedagogical Content Knowledge (TPACK) through the use of the Learning by Design (LBD) framework in a teaching process for pre-service teachers. During a 12- week period that included both teaching and data collection, 19 pre-service teachers produced 10 unique instructional materials. TPACK levels and self-confidence were assessed using scales and qualitative data from interviews, with the Fink Taxonomy used to analyze the interviews and determine the significance of the LBD- TPACK teaching process in terms of learning outcomes. The results showed a significant increase in pre-service teachers’ TPACK scores and TPACK self-confidence scores after the teaching process ($\alpha=0.05$, $p=0.00$). Qualitative data

supported these findings, demonstrating that pre-service teachers had achieved significant learning outcomes by the end of the process.

Loseñara and Jugar (2023) conducted a study entitled ‘Technological, pedagogical, and content knowledge of diploma in professional education graduates teaching biology’. This study investigated the teaching competence of biology teachers who are DPE graduates, specifically their Technological, Pedagogical, Content Knowledge (TPACK) and Biology teaching competence to design a teacher professional development (TPD) programme. Most teachers were BS Nursing graduates with professional teaching licenses and teaching experience ranging from 3 to 10 years. Also, most teachers received between one to five TPDs focused on biology, pedagogy, and technology. Among the TPACK components, the teachers perceived that they were least competent in pedagogical knowledge (PK) and pedagogical content knowledge (PCK).

Özen and Kurtuluş (2023) conducted on “A study on mathematics teachers' technological pedagogical content knowledge (TPACK) and frequency of use of educational information network (EBA) assessment tools”. In this context, the aim of this study is to examine mathematics teachers' TPACKs within the framework of their demographic characteristics and frequency of using EBA assessment tools. The study was designed with the survey model of quantitative method. The study's participants are the math teachers employed by public and private schools in the province of Eskişehir. Within the scope of the study, the link of the relevant data collection tool was sent to the study group by obtaining the necessary application permissions and data were collected from 369 mathematics teachers. As a result of the study, it is concluded that mathematics teachers need to develop their TPACK to improve students' mathematics skills and optimize students' learning process and that teachers should have knowledge about the use of technological tools and online assessment tools such as EBA and be able to use these tools effectively.

Pratumsala and Nuangchalerm (2023) conducted a study entitled “Enhancing scientific literacy of lower secondary students through Technological Pedagogical and Content Knowledge Framework”. All students today attach a great

deal of importance to having access to a technologically enhanced education. As a result, teachers are pressured to integrate their teaching, material, and technological expertise in to their classes. The TPACK framework was utilized to teach science in lower secondary schools as part of this action research. This investigation, the most significant individual were 19-year-old students from on school. As study methods, a test of scientific literacy, observations of behavior patterns, and eight TPAC lesson plans were utilized. During the first academic year of 2022, the spiraling action plan was implemented twice. Results indicated that TPACK played a significant role in increasing students' scientific literacy. The first cycle of instruction, the scientific literacy levels of students were high, and after the second cycle, they were very high. There is potential for TPACK implementation in contemporary schools, however, teachers will need to provide instructional materials that are appropriate for student learning and apply instructional approaches that are adapted to the individual academic pursuits of their students.

Su (2023) Pre-service teachers' technological pedagogical content knowledge development: A bibliometric review. This review aims to analyze the global trends of the research on pre-service teachers' technological pedagogical content knowledge (TPACK) development. The bibliometric approach examines pre-service teachers' TPACK by identifying the most cited publications, journals, authors, funding agencies, and keywords used in the eligible studies (N=114). The results show that pre-service teachers' TPACK research began in 2007 and the scientific community's interest in this subject has been irregular. This study presents a global perspective on pre-service teachers' TPACK and provides researchers with future directions.

Thohir, Ahdhianto, Mas'ula, April Yanti and Sukarelawan (2023) conducted a study on "The effects of TPACK and facility condition on pre-service teachers' acceptance of virtual reality in science education course". This study aims to determine the effects of facility condition (FC), technological acceptance model (TAM), and TPACK on pre-service teachers' use of VR in Indonesian science education courses. This condition emphasizes the description of these teachers' readiness in designing VR for learning and teaching integration. The survey was

conducted using 406 pre-service teachers from 12 Indonesian universities, with confirmatory factor analysis (CFA) and partial least square-structural equation model (PLS-SEM) subsequently utilized. The results showed that PU (perceived usefulness), PEOU (perceived ease of use), behavior Intention (BI), TPACK, and FC were significantly and positively related. However, two hypotheses emphasizing the relationship between FC and TPACK to PEOU were rejected. These results are expected to facilitate pre-service teachers in easily adopting VR learning in courses.

Adelita, Karen and Alberto (2024) conducted a study entitle ‘Assessing technological pedagogical content knowledge (TPACK) and teaching effectiveness of senior high school teachers: An input for teacher development plan’. This study investigates the importance of integrating technology effectively in education. Technology-Enhanced Pedagogical Skills are crucial for enhancing learning outcomes through the appropriate use of technology in teaching specific subjects. The study involved 54 teachers from seven schools who were selected based on their proficiency in digital tools. Using a survey questionnaire, the research assessed teachers’ TPACK competency, socio-demographic backgrounds, and perceived teaching effectiveness. The findings aim to determine the correlation between TPACK levels and teaching effectiveness and provide insights for educational policies and professional development programs to enhance technology integration in teaching practices, ultimately improving student learning experiences and outcomes.

Alhamid and Mohammad-Salehi (2024) conducted a study on “Examining EFL teachers’ Technological Pedagogical Content Knowledge (TPACK) and their attitudes towards online teaching”. Technological Pedagogical Content Knowledge (TPACK) is a model of CALL competence to integrate technology into education. Cultivating attitudes of EFL teachers in light of online instruction and examining its relationship with TPACK Seems to be a crucial aspect of current teaching practices. Thus, this correlational study attempted to explore the relationship between Iraqi EFL teachers' attitudes towards online instruction and TPACK components. Sixty teachers of English as a foreign language from Thi-Qar, selected via availability sampling, took part in the study. They responded to two questionnaires, one with 28-items on TPACK and the other containing 16 items on online teaching English. A series of Pearson

correlation tests were conducted to examine the seven research hypotheses about the participants' attitudes towards online instruction and technological pedagogical content knowledge components, including CK, PK, TK, TCK, PCK, TPK, and TPACK. The findings demonstrated a range of low to moderate positive associations between instructors' attitudes towards online instruction and TPACK domains.

Guzmán González and Vesga Bravo (2024) conducted a study on 'TPACK in in-service secondary education teachers: A systematic review of the literature'. The present study aimed to categorize and establish the main research findings around TPACK between 2017 and 2022, specifically in practicing teachers at the secondary education level. A systematic literature technology in the classroom review guided by the PRISMA statement was conducted. The review of the studies made it possible to establish that the papers were mainly grouped in to two categories: the first related to teachers' perception of TPACK, which includes research with self-perception questionnaires, case studies and relationships of self-perception with other variables such as barriers to technology integration in the classroom, pedagogical beliefs, and online education; and the second to developing training courses based on TPACK, complemented with self-perception questionnaires in the form of pretest-posts, classroom observations, and interviews. The results of the first category are dissimilar since TPACK levels differ from one study to another in variables such as gender and teaching experience. From the second, it is established that teacher professional development courses favor improving technological integration in the classroom.

Kanyarat, Kanyarat and Sitti (2024) studied entitled 'The effects of teachers' Technological Pedagogical Content Knowledge (TPACK) on students' scientific competency'. The integration of Technological Pedagogical Content Knowledge (TPACK) into instructional design is pivotal for teachers. This intricate knowledge framework encompasses the interplay between technology, pedagogy, and subject matter, profoundly impacting the multifaceted aspects of student learning, encompassing knowledge acquisition, skill development, and the cultivation of desirable attributes. This research at hand adopts an exploratory approach, examining two sample groups: 1) Science teachers from secondary schools under the Northeastern Region of Thailand during the academic year 2565–2566, totaling 124

individuals, and 2) Secondary school students receiving instruction in science-related subjects from the aforementioned teachers, with a minimum of one classroom involved. Data collection tools include a survey on TPACK, a scientific competency assessment, and semi-structured interviews. Statistical analysis employs mean, standard deviation, and content analysis. Testing of hypothesis uses One-Way Analysis of Variance (One-Way ANOVA). The study reveals that students taught by science teachers with varying levels of TPACK exhibit statistically significant differences in scientific competency at a 0.05 significance level. When comparing scientific competency with TPACK levels of teachers, statistically significant differences at the 0.05 level are found in two pairs: 1) the Adapting level and the Advancing level and 2) the Exploring level and the Advancing level.

Kocagül and Ünal Çoban (2024) studied on “Evaluation of pre-service science and Math teachers’ online teaching experiences within the TPACK framework”. The purpose of this study is to identify the factors that shape pre-service teachers’ (PSTs) online teaching practices within the technological pedagogical content knowledge (TPACK) framework. Ten science PSTs and nine mathematics PSTs who experienced the practical part face-to-face and the theoretical part online of the Teaching Practice 2 course participated in this study based on a multiple case study design. The researchers collected data through online lesson videos and the TPACK in Online Teaching Survey. Descriptive statistics were used for the survey analysis, while the document analysis technique was through TPACK in Online Teaching Checklist for online lesson videos. The results show that PSTs have some problems, especially in the technological and pedagogical knowledge components of TPACK. Both groups do not have adequate knowledge of the technological tools of assessment, because they give it the least importance.

Ramirez (2024) studied entitled “E-training package for secondary pre-service teachers”. The study was conducted at Bukidnon State University from 2021-2022. Using Research and Development, an e-training package on TPACK involving Content Knowledge, Technological Knowledge, and Pedagogical Content Knowledge was developed. The level of TPACK knowledge of secondary pre-service teachers was measured using weighted mean and SD. Findings revealed that pre-service teachers’

TPACK level of knowledge shows advancement across all levels of knowledge except for pedagogical knowledge, which is expert. From the needs analysis result, an e-training package on content knowledge, technological knowledge, and pedagogical knowledge was designed.

Rosyidi, Punaji, Kuswandi and Henry (2024) conducted a study on “A structural correlation model of ELF teachers’ technological pedagogical content knowledge and their teaching effectiveness”. This study is designed to examine the structural correlation between EFL teachers’ TPACK and their teaching effectiveness. A quantitative method was employed in this study, which involved 216 EFL teachers of primary schools with more than two-year teaching experiences in Gresik, East Java-Indonesia. A validated questionnaire was utilized to collect the data. It was then analyzed by using Structural Equation Modeling–Partial Least Square (SEM-PLS) with Smart PLS 3.2.9 program to test the proposed hypotheses. The findings revealed that only three domains of teachers’ TPACK support their teaching effectiveness, i.e.; pedagogical content knowledge, technological pedagogical knowledge, and technological pedagogical content knowledge.

Shambare and Simuja (2024) studied titled ‘Mapping TPACK competency among life sciences teachers in rural and marginalised secondary schools: A descriptive analysis’. This descriptive study assessed technological, pedagogical and content knowledge (TPACK) competency among life sciences teachers in rural and marginalized schools. The study was guided by Koehler and Mishra’s (2006) TPACK framework as its theoretical lens. Data gathered through questionnaires from 235 Teachers in the Eastern Cape province, South Africa, was analysed using descriptive statistical analysis. The results unveiled a prevalent low level of TPACK competency among respondents. Moreover, an examination of individual TPACK domains, a significant mastery in non-technology related areas such as content knowledge (CK), pedagogical knowledge (PK), and pedagogical content knowledge (PCK) surfaces, underscoring the pivotal role of teaching experience in fostering foundational knowledge.

Wijayanto, Rahmanelli, Novio, Pratama and Fadila (2024) studied on “Development of Technological, Pedagogical, and Content Knowledge Learning Models Based on Massive Open Online Course (MOOC) Geography Teachers in West Sumatera”. This research aims to examine the ability of geography teachers to utilize TPACK and to support teachers in implementing technology-based learning models with the guidance of 21st-century education. One specific type of online learning platform that can be used in this context is MOOC or Massive Open Online Course. The research employed a development research methodology and used the ADDIE model. The sample for need analysis consisted of 30 geography teachers from SMA/MA schools in West Sumatra, with the experiment school being SMANegeri1 Pariaman and SMANegeri1 Bukittingi. The results of the research indicate that the development of a TPACK-based MOOC learning model for SMA/MA Geography teachers in West Sumatra is both feasible and appropriate. This model effectively helped teachers to integrate the three main aspects of learning, namely content, pedagogy, and technology. The results of the geography teacher TPACK mapping show that the teachers are in the medium category.

Umi Hanifah, Budayasa and Sulaiman (2025) studied entitled “Technology, pedagogy, and content knowledge in mathematics education: a systematic literature review”. This study examines how TPACK affects mathematics classroom instruction, student engagement, and learning outcomes. A detailed examination and synthesis of pertinent publications over the last decade will accomplish this. The study illuminates significant topics, including digital technology utilization, teacher professional development program enhancement, and TPACK acceptability. It also highlights long-standing issues such as limited technology budgets, teacher training issues, and the need for ongoing support. This post provides current ideas and a full literature review to assist us in understanding TPACK. The findings impact educational policy makers, teacher professional development programs, and math teachers. The paper then advises future research.

An Overview of the Span of Years and Studies Conducted in India and Abroad is presented in the following tables.

Table 2.1: Details of related studies reviewed

Sl. No.	Location of Studies	Span of years	Total
1	Studies on Technological, Pedagogical and Content Knowledge (TPACK) of Teachers conducted in India	2006 - 2023	23
2	Studies on Technological, Pedagogical and Content Knowledge (TPACK) of Teachers conducted Abroad	2009 - 2025	100
Total			123

A comprehensive review of related literature was undertaken to understand the extent and scope of research on Technological, Pedagogical and Content Knowledge (TPACK) of teachers. The review covered a total of 123 studies, of which 23 were conducted in India between 2006 and 2023, and 100 were conducted abroad between 2009 and 2025. This broad span of years and locations indicates that TPACK has been an important focus of educational research globally as well as within India. The reviewed studies provided valuable insights into teachers' integration of technology, pedagogy, and content knowledge, highlighting trends, gaps, and implications that guided the formulation of the present research.

2.3 Analysis of Reviews on Teachers' Perceived Level of TPACK

A considerable number of studies have examined teachers' Technological Pedagogical Content Knowledge (TPACK) across diverse educational contexts. These include investigations involving pre-service teachers (Schmidt et al., 2009; Koh et al., 2010; Lehtinen et al., 2016), in-service teachers (Koh et al., 2013), and teachers engaged in professional development programs (Wu et al., 2015). Research has been conducted at both the school level (Hill & Uribe-Florez, 2020; Graham et al., 2009; Jang & Tsai, 2013) and the university level (Ammade et al., 2020; Fahadi & Khan, n.d.; Reyes et al., 2017), revealing variations in teachers' perceived levels of TPACK depending on context and setting.

Findings from these studies indicate that teachers' self-perceptions of TPACK differ widely across countries and educational levels. For instance, school teachers in Saudi Arabia demonstrated a moderate confidence level in their TPACK ($M = 3.65$) on a five-point Likert scale (Bingimlas, 2018), while middle and high school mathematics and special education teachers in rural U.S. schools reported an overall mean score of 3.91 (Hill & Uribe-Florez, 2020). Similarly, tertiary-level lecturers in Indonesia showed a moderate level of technological, pedagogical, and content literacy (Ammade et al., 2020). In Nigeria, teacher educators had a mean TPACK score of 3.81, indicating above-average competency (Ifinedo et al., 2019). In South Asia, tertiary-level teachers in Bangladesh demonstrated a relatively higher TPACK perception ($M = 4.17$) (Fahadi & Khan, n.d.), whereas in India, Technology Knowledge (TK) was reported as the highest ($M = 4.08$) and Technological Content Knowledge (TCK) as the lowest ($M = 3.45$) (Naaz & Khan, 2018). Further analysis in Bangladesh also revealed that technology-enhanced teaching domains—such as TPCK, TPK, TCK, and CK—had the highest mean ($M = 4.21$), while TK remained the lowest ($M = 4.13$) among tertiary educators (Fahadi & Khan, n.d.).

Studies from Singapore, based on a seven-point Likert scale, showed that both practicing and pre-service teachers rated all TPACK domains above average (Koh et al., 2011; Koh et al., 2014). Practicing teachers in Singapore demonstrated the highest confidence in Content Knowledge (CK; $M = 5.84$) and the lowest in Contextualized TPACK (C-TPACK; $M = 4.86$) (Koh et al., 2014), while pre-service teachers similarly scored highest in CK ($M = 5.13$) and lowest in TCK ($M = 4.41$) (Koh et al., 2011). In contrast, U.S. teachers' online survey responses revealed that Pedagogical Knowledge (PK) and Pedagogical Content Knowledge (PCK) achieved the highest mean values ($M = 4.04$), while TK was comparatively lower ($M = 3.23$) on a five-point scale (Archambault & Barnett, 2010). Comparable findings were also reported in Saudi Arabia (PK = 4.13, TK = 3.15; Bingimlas, 2018) and the U.S. (PK = 4.49, TK = 3.70; Hill & Uribe-Florez, 2020), suggesting that teachers generally feel more confident in pedagogy than in technology integration.

Similarly, in Finland, pre-service science teachers' beliefs about simulation-based teaching showed that PK had the highest mean ($M = 4.85$) compared to other

domains in both pre-test and post-test measures (Lehtinen et al., 2016). Overall, the evidence across contexts suggests that while teachers tend to be more confident in pedagogical and content knowledge, technological aspects of TPACK especially TK and TCK are often rated lower. It is important to note that teachers' perceptions and attitudes toward the TPACK framework are dynamic rather than static. They evolve over time with greater exposure to ICT integration, experience in digital pedagogy, and contextual factors such as institutional support and training opportunities (Schmidt et al., 2009).

2.4 Analysis of Reviews on Demographic Factors Influencing Teachers' Perceived TPACK

Several demographic variables such as gender, age, teaching experience, subject area, teaching level, and institutional location have been found to influence teachers' perceptions of TPACK. Numerous studies have reported significant gender-based differences (e.g., Bingimlas, 2018; Naaz & Khan, 2018; Koh et al., 2014; Jang & Tsai, 2013; Lin et al., 2013; Koh et al., 2010). However, other studies have shown no gender-related variation in overall TPACK (e.g., Jang & Tsai, 2012; Koh et al., 2011; Naaz & Khan, 2018). In cases where gender differences were observed, male teachers generally scored higher in domains such as Technological Knowledge (TK) (Bingimlas, 2018; Naaz & Khan, 2018; Koh et al., 2014; Jang & Tsai, 2013; Koh et al., 2010), Technological Content Knowledge (TCK) (Bingimlas, 2018; Koh et al., 2014), and Contextualized TPACK (C-TPACK) (Koh et al., 2014) compared to female teachers.

Regarding age, significant differences were noted in Bangladesh across domains such as TPCK, TPK, TCK, and CK (Fahadi & Khan, n.d.), although other researchers found no substantial age-related variation (e.g., Koh et al., 2014; Jang & Tsai, 2013). Teaching experience has also been reported as an influential factor in several studies (e.g., Bingimlas, 2018; Koh et al., 2014; Jang & Tsai, 2013, 2012; Lee & Tsai, 2010). Yet, in the Bangladeshi context, no significant difference in teachers' TPACK was attributed to experience (Fahadi & Khan, n.d.). In Taiwan, experienced elementary science and mathematics teachers scored higher in CK, PCKC, TPCKC, and overall TPACK (Jang & Tsai, 2012), and experienced secondary science teachers

showed stronger CK and Pedagogical Content Knowledge in Context (PCKC) than novices (Jang & Tsai, 2013). Conversely, less experienced science teachers reported higher TK and Technological Pedagogical Content Knowledge in Context (TPCKC) (Jang & Tsai, 2013), as well as higher web-based TPACK scores (Lee & Tsai, 2010).

Differences in TPACK have also been associated with teaching subjects. Studies such as Bingimlas (2018), Fahadi and Khan (n.d.), and Lye (2013) found significant subject-based variations, whereas Naaz and Khan (2018) reported no difference across academic streams (science, arts, and social sciences) in India. Similarly, in Bangladesh, no significant differences were found in TPCK, TPK, TCK, or CK; however, variations were observed in PK, PCK, and TK across disciplines like Chemistry, Architecture, Textile Engineering, and Physics (Fahadi & Khan, n.d.). Bingimlas (2018) also found that TK and TPACK scores differed by subject area. Teaching level appeared to influence TPACK perceptions as well. Among Singaporean teachers, secondary and junior college educators demonstrated higher confidence in C-TPACK compared to primary school teachers (Koh et al., 2014).

Institutional location has also been identified as a factor shaping teachers' access to resources and attitudes toward technology integration. Research revealed that rural teachers often held more positive attitudes toward ICT integration than their urban counterparts (Thomas & Falls, 2019). Interestingly, Howley et al. (2011) reported that teachers' technology use was not significantly correlated with remoteness or socioeconomic status.

2.5 Research Gap and Context of the Study

The TPACK framework underwent a decade of conceptual refinement during its first generation (2006–2016), primarily focusing on clarifying its structure. The current, second generation of TPACK research emphasizes situational and contextual factors that remain underexplored (Soomro et al., 2018). Since its inception by Koehler and Mishra (2006), a substantial body of research has emerged examining teachers' TPACK competencies across different regions particularly in technologically advanced countries such as Singapore (Lin et al., 2013; Chai et al., 2010; Koh et al., 2010), Taiwan (Jang & Tsai, 2013; Shih & Chuang, 2013), China (Dong et al., 2015),

Turkey (Cengiz, 2015; Öz, 2015; Pamuk et al., 2015; Kuzu & Erten, 2014), and the United States (Kopcha et al., 2014; Shinas et al., 2013; Lee & Tsai, 2010).

In contrast, research in developing nations such as Pakistan, Ghana, India, and Vietnam—where technological infrastructure is comparatively limited has primarily focused on assessing the relationship between teachers’ technological proficiency and TPACK (Sadaf et al., 2019; Rahman et al., 2018; Aslam et al., 2021; Agyei & Keengwe, 2012; Paristiowati et al., 2019; Tan et al., 2020). However, fewer studies have examined how demographic factors shape teachers’ TPACK perceptions in these contexts. Existing evidence highlights significant cross-cultural variations. For example, teachers in Pakistan, Malaysia, Bhutan, and Kenya reported lower confidence in their Technological Knowledge (TK) compared to educators in developed nations such as Denmark and Estonia (Castéra et al., 2020; Elisha & Fredrick, 2020; Mai & Hamza, 2016). Conversely, secondary ICT teachers in Malaysia expressed optimism regarding their ability to integrate technology effectively, even with limited TK (Chieng & Tan, 2021). Interestingly, despite being technologically advanced, France reported lower Technological Pedagogical Knowledge (TPK) scores than Pakistan, suggesting potential lags in technology adoption within French educational systems (Castéra et al., 2020).

Differences in teachers’ perceived TPACK have been linked to demographic factors such as gender (Mai & Hamza, 2016; Koh et al., 2010; Altun & Akyildiz, 2019), subject area (Hill & Uribe-Florez, 2020; Graham et al., 2009; Jang & Tsai, 2013; Fahadi & Khan, n.d.; Lye, 2013), teaching experience (Lee & Tsai, 2010; Bingimlas, 2018), teaching level (Koh et al., 2013), and location (Thomas & Falls, 2019). Hence, exploring TPACK across different cultural and contextual settings is essential to understand its development and global applicability. In Bangladesh, only a few studies have addressed TPACK, most of which have focused on ICT integration among primary and secondary teachers (Islam, 2020; Mou, 2016; Rouf, 2016; Jamil, 2015; Mia & Haque, 2013). At the tertiary level, research on TPACK remains scarce, with limited studies examining ICT use in higher education (e.g., Fahadi & Khan, n.d.). Moreover, most prior research has centered on teacher education programs (Salam, 2018; Khan, 2014; Khan & Hasan, 2013) rather than directly measuring teachers’ TPACK competence. Although professional development programs can enhance

teachers' TPACK, Bangladesh lacks a mandatory pre-service training system for university faculty. Even in-service training opportunities are often non-compulsory and inconsistent across universities (Raqib, 2019).

The National Education Policy (Ministry of Education, 2020) emphasizes recruiting qualified teachers and strengthening their professional capacity through training, yet implementation remains uneven. Against this backdrop, the present study seeks to explore the levels and determinants of secondary school teachers' TPACK in Mizoram. By focusing on demographic variables and contextual influences, this research aims to fill a significant gap in the existing literature and contribute to a more comprehensive understanding of teachers' technological, pedagogical, and content knowledge in higher education.

2.6 Conclusion

The review of related literature, both from India and abroad, provided valuable insights into the current state of research on teachers' Technological Pedagogical and Content Knowledge (TPACK). Studies conducted internationally indicate that teachers generally demonstrate a moderate to high level of self-perceived TPACK, particularly in developed educational contexts where technology integration is systematically supported. Research from India, however, reveals varying levels of TPACK, often influenced by limited access to technological resources, insufficient training, and contextual constraints within the education system.

The analysis of previous studies further highlighted that teachers' perceived level of TPACK is not uniform across all domains. While teachers tend to exhibit stronger pedagogical and content knowledge, technological knowledge and technological pedagogical knowledge are often comparatively weaker. This disparity underscores the continuing need for professional development programs focused on technology integration. Moreover, demographic factors such as teaching experience, educational discipline, gender, and ICT training have been found to significantly influence teachers' perceived TPACK in several studies. For instance, teachers with prior ICT training or longer teaching experience generally report higher TPACK levels, whereas novice teachers or those without formal ICT exposure tend to perceive lower competence.

Despite the substantial body of literature, notable research gaps remain. Most existing studies have been conducted in specific regions or educational levels, leaving limited evidence on higher secondary teachers in the context of Mizoram. Furthermore, few studies have comprehensively examined how demographic variables jointly influence teachers' self-perceived TPACK in this setting.

In light of these gaps, the present study is designed to explore the self-perceived TPACK of higher secondary school teachers in Mizoram, with particular attention to how demographic factors such as educational discipline, gender, age, stream of studies, teaching experience, and ICT training shape their technological, pedagogical, and content knowledge. This contextual focus aims to contribute to the broader understanding of teachers' technology integration competencies in the Indian education system.

CHAPTER III

METHODOLOGY

Methodology plays a significant role in all forms of research, outlining the guidelines that researchers must adhere to throughout the study. The methodology should detail the steps taken by the researcher, including aspects such as research design, the selection of the study's population and sample, the methods and tools employed for data collection, how data is administered and collected, the organization of data, and the statistical methods used for data analysis. Therefore, the current chapter on methodology and procedure addresses these key aspects.

3.1.0 Method of the study

3.2.0 Population

3.3.0 Sample

3.4.0 Tools used for data collection

3.5.0 Administration of tools and collection of data

3.6.0 Tabulation of data

3.7.0 Statistical techniques for analysis of data

3.1.0 METHOD OF THE STUDY:

The present study is descriptive in nature. Therefore, descriptive survey method has been employed. Quantitative analysis has been employed in the present investigation.

3.2.0 POPULATION:

The population of the study comprised of all the higher secondary schools' teachers and students in Mizoram. The Enrolment of higher secondary school teachers and students is presented in the following table.

Table No. 3.1***Total number of higher secondary school teachers and students in Mizoram***

Management	No. of School	Teachers			Students		
		Male	Female	Total	Boys	Girls	Total
Central	9	46	27	73	414	391	805
State	21	231	270	501	3671	4464	8135
Samagra	19	59	71	130	291	351	642
Deficit	7	90	78	168	1718	2112	3830
Adhoc Aided	12	88	69	157	547	709	1256
Lumpsum Aided	52	178	142	320	1747	1934	3681
Private	84	290	249	539	3486	3529	7015
TOTAL	204	982	906	1888	11874	13490	25364

Source: UDISE (2022-2023)

(Summation of all of higher secondary schools as on 31 August 2023 by Government of Mizoram, Department of School Education)

The Government of Mizoram, Department of School Education, recorded that in the year 2022–2023, Mizoram had a total of 204 higher secondary schools employing 1,888 teachers (982 male and 906 female) and enrolling 25,364 students (11,874 boys and 13,490 girls). Overall, the data shows that higher secondary education in the state is managed through a mix of Central, State, Aided, and Private institutions.

Table No. 3.2***Total number of higher secondary school teachers and students in sample district in Mizoram***

Management	No. of School	Teachers			Students		
		Male	Female	Total	Boys	Girls	Total
Central	2	16	3	19	121	110	231
State	9	108	146	254	1978	2480	4458
Samagra	4	11	19	30	62	76	138
Deficit	4	46	50	96	1003	1291	2294
Adhoc Aided	4	30	24	54	207	291	498
Lumpsum Aided	10	36	26	62	395	482	877
Private	40	160	153	313	2553	2598	5151
TOTAL	73	407	421	828	6319	7328	13647

Source: UDISE (2022-2023)

(Lists of schools with number of teachers & enrolment of students in Aizawl District)
by Government of Mizoram, Department of School Education

In sample district, the total number of higher secondary schools was 73. The total number of higher secondary school teachers were 823. There were 407 male teachers while 421 female teachers. There are 6319 girls and 7328 boys of higher secondary school in Aizawl district. Thus, the total number of students in higher secondary schools was 13647.

For the present study, the data collected was delimited to higher secondary schools in Aizawl district offering both science and arts. The scope of data collection was confined to this stream due to constraints in resources and time.

3.3.0 SAMPLE:

For the present study, out of 73 higher secondary schools in Aizawl district, 21 schools offering both science and arts were selected as a representative sample. The final sample consisted of 200 higher secondary school teachers in Aizawl District,

comprising 100 male and 100 female teachers, with 100 teachers from the science stream and 100 from the arts stream. Teachers from the Commerce stream were not included, as this stream is not offered in every school and was unavailable in most institutions. The student sample consisted of 152 Arts students and 155 Science students and a sum of 307 students constitutes the sample of the study.

The samples were selected following Convenience Sampling Technique. The name of schools and sample distribution of the teachers and students is presented in the following Table 3.3

Table 3.3

Name of schools and sample distribution

Sl No.	Name of School	Number of Respondent					
		Teachers				Students	
		Male	Female	Arts	Science	Arts	Science
1	Govt. K.M HSS	7	7	5	9	10	10
2	Sihphir HSS	1	2	-	3	-	6
3	Ch. Chhunga HSS	3	5	-	8	-	16
4	Govt. Mizo HSS	6	1	2	5	-	20
5	Greenland HSS	4	3	3	4	10	-

6	Staine's Memorial School	5	4	4	5	-	11
7	Govt. JL HSS	5	5	10	-	10	-
8	Govt. Mamawii HSS	4	6	10	-	12	-
9	Boston HSS	5	4	3	6	-	11
10	Mount Carmel School	8	9	6	11	10	10
11	Govt. Chaltlang HSS	2	3	2	3	20	-
12	Public HSS	3	3	6	-	11	-
13	Modern English HSS	5	3	4	4	10	-
14	Govt. Centrsl HSS	3	5	8	-	10	-
15	Govt. Zemabawk HSS	6	5	11	-	20	-
16	Home Mission HSS	5	4	4	5	-	20

17	St. Joseph HSS	14	10	9	15	16	20
18	Synod HSS	5	6	4	7	-	10
19	Dawrpui School of Science and Teachnology	2	3	-	5	-	5
20	St. Paul's HSS	5	9	4	10	4	16
21	Lengpui HSS	2	3	5	-	9	-
TOTAL		100	100	100	100	152	155

Out of the 73 higher secondary schools in Aizawl district, 21 schools offering both Science and Arts streams were selected as the representative sample. The final sample included 200 teachers (100 males and 100 females), with an equal distribution of 100 Arts and 100 Science teachers, along with 307 students—bringing the total number of respondents to 508. The student sample comprised 152 Arts students (49.5%) and 155 Science students (50.5%), reflecting an almost equal representation of both streams.

Table 3.4

Gender and Stream Wise Distribution of Sample of Teachers and Students

Category	Male	Female	Arts Stream	Science Stream	Total
Teachers	100	100	100	100	200
Students	—	—	152	155	307

As presented in Tables 3.2 and 3.3, the samples of teachers and students were randomly selected from higher secondary schools. A total of 200 teachers were included in the study, comprising 100 males and 100 females and 100 from arts stream and 100 from science stream. Similarly, 307 students were selected, of which 152 belonged to the Arts stream and 155 to the Science stream.

3.4.0 TOOLS FOR DATA COLLECTION:

The following tools were used for the present study

1. The Perception Scale on TPACK for teachers developed by researcher.
2. Observation schedule for assessing the effectiveness of teaching.
3. Structured questionnaire to study the problems faced by the higher secondary school teacher in integrating technology in teaching.
4. Evaluation schedule for assessing Teachers' Effectiveness for students.

3.4.1 The perceptions scale on TPACK for Teachers:

To measure teachers' perceptions on Technological Pedagogical Content Knowledge (TPACK), a structured questionnaire consisting of 33 statements across different components was used. Respondents were asked to indicate their level of agreement with each statement on a five-point Likert scale as follows: Strongly Agree (5), Agree (4), Undecided (3), Disagree (2) and Strongly Disagree (1).

The five-point scale was adopted to capture the degree of teachers' perceptions more accurately and to allow sufficient variability in responses. Higher scores indicated stronger agreement with the statements, reflecting greater levels of technological, pedagogical, and content knowledge. Negatively worded items were reverse-scored during analysis to maintain consistency in interpretation.

Procedure for Construction and Standardization of Questionnaire

The questionnaire for this study was constructed and standardized following systematic procedures to ensure its validity and reliability. The steps undertaken were as follows:

Identification of Dimensions

Based on the review of related literature and theoretical framework of Technological Pedagogical Content Knowledge (TPACK) and teachers' effectiveness, the key dimensions and indicators were identified. These included areas such as teaching methods, content knowledge, classroom management, creativity, rapport with students, professional development, and integration of technology.

Item Construction

A pool of items was initially developed for each dimension, ensuring that the statements were clear, simple, and measurable. Care was taken to frame both positively and negatively worded items to reduce response bias. Items were designed in the form of statements to be rated on a Likert-type scale, with response categories of 'Strongly Agree,' 'Agree,' 'Undecided,' 'Disagree,' and 'Strongly Disagree.' A total of 55 items were selected for the final scale. The respective number of items for each component of the domains were as follows: Technological Knowledge (TK) – 7 items, Content Knowledge (CK) – 6 items, Pedagogical Knowledge (PK) – 7 items, Pedagogical Content Knowledge (PCK) – 8 items, Technological Content Knowledge (TCK) – 8 items, Technological Pedagogical Knowledge (TPK) – 9 items, and Technological Pedagogical Content Knowledge (TPACK) – 10 items.

Content Validation

The draft questionnaire was subjected to expert review by subject experts within the university in education, psychology, and educational

technology. Their suggestions were incorporated to improve the clarity, relevance, and coverage of the items. On the basis of the opinions of the experts, some items were rejected and some items were modified. After this, the draft now contained 41 statements, the respective number of items for each component of the domains were as follows: Technological Knowledge (TK) – 5 items, Content Knowledge (CK) – 5 items, Pedagogical Knowledge (PK) – 5 items, Pedagogical Content Knowledge (PCK) – 6 items, Technological Content Knowledge (TCK) – 6 items, Technological Pedagogical Knowledge (TPK) – 6 items, and Technological Pedagogical Content Knowledge (TPACK) – 8 items expressing both positive and negative attitude scale. This process established the content validity of the instrument.

Trying out the test

After preparing a total of 41 items for the TPACK scale, it was first tried out and was administered to 58 teachers from different schools using online app (google form app). The link for the scale was obtained and was sent to Arts and Science teachers of higher secondary schools of all the districts of Mizoram during the time the sample was taken. After administering the test to 58 teachers, the scale was again administered within a time gap of 30 days and item analysis was done by finding out the discrimination value of each item.

Item analysis:

After administration of the test to 58 higher secondary school's teachers, scoring was done using Likert scoring procedure. The scores were then arranged in descending order, and the upper 27% and lower 27% were set aside for item analysis and discrimination. Student's t-test and Discriminating Index were calculated. A t-test for each of the items was calculated from the upper 27% and lower 27%. Mean and standard deviation value of score for each of 41 items were calculated, separately, for the top and bottom 27% group of respondents.

After this, those items having t-value above 2.98 i.e., statements which are significant at 0.01 level of confidence and t-value between 2.14 and 2.98 i.e., statements which are significant at 0.05 level of confidence were retained for the final scale and statements having t value less than 2.14 were rejected. Out of 41 statements, 8 statements were rejected/not significant and the significant items consists of 33 statements. The Mean and Standard Deviation value of top and bottom group on each of the 41 statements and the discrimination value in the form of 't-value' are given in Table No. 3.5

Table: 3.5

Mean, Standard Deviation and t-value of High and Low groups on different

Items of TPACK scale

Item No.	High Group		Low Group		t-value	Significance
	Mean	SD	Mean	SD		
1	3.27	0.78	4.27	0.21	4.18	**
2	3.4	0.54	4.26	0.21	3.66	**
3	3.06	0.35	3.86	0.83	3.29	**
4	3.06	0.63	4.13	0.12	4.29	**
5	2.93	0.63	4.13	0.12	4.93	**
6	2.53	0.40	3.8	0.17	6.14	**
7	2.66	0.66	4.06	0.35	5.13	**
8	2.73	0.49	3.8	0.74	3.55	**
9	3.6	0.25	4.26	0.20	3.56	**
10	3.33	0.52	4.2	0.31	3.38	**
11	2.8	0.17	3.93	0.20	6.85	**

12	2.46	0.26	3.93	0.35	6.81	**
13	2.86	0.26	3.86	0.12	10.24	**
14	3.46	0.55	4.2	0.17	4.03	**
15	3.53	0.26	4.13	0.12	3.67	**
16	2.33	0.52	2.53	1.12	0.50	NS
17	2.4	0.4	2.53	1.12	0.16	NS
18	3.6	0.4	3.86	0.26	1.46	NS
19	2.86	1.12	3.13	1.55	0.67	NS
20	2.86	0.40	3.2	1.02	0.89	NS
21	3.86	0.12	3.86	0.40	1.76	NS
22	3.8	0.31	3.8	0.88	1.7	NS
23	3.46	0.26	4.13	0.26	3.16	**
24	2.93	0.49	4.06	0.06	6.85	**
25	3.13	0.40	4	0	5.24	**
26	2.73	0.20	3.53	0.69	3.05	**
27	3.06	0.49	4.06	0.06	5.12	**
28	3.2	0.17	4	0.14	5.52	**
29	3.4	0.25	4.2	0.17	4.58	**
30	3.2	0.45	4	0.14	3.59	**
31	2.86	0.55	2.93	0.63	0.23	NS
32	3.4	0.25	4.06	0.20	4.18	**

33	3.4	0.25	3.93	0.20	3.22	**
34	3.47	0.27	4.13	0.27	4.18	**
35	2.87	0.41	4.07	0.07	6.87	**
36	3	0.43	4	0.01	5.91	**
37	2.6	0.3	3.14	0.83	2.52	**
38	3.33	0.38	4.07	0.07	4.03	**
39	3.33	0.24	4	0.14	3.56	**
40	3.4	0.25	4.06	0.49	2.64	**
41	3.27	0.35	4	0.29	3.21	**

NS means Not Significant, ** means significant at both 0.01 and 0.05 level

Reliability:

To establish the reliability of the instrument, the investigator employed both the test–retest method and Cronbach’s alpha coefficient. The test–retest method was applied by administering the same instrument to the same group of respondents with a time interval of 30 days to determine the stability of the responses over time. The correlation between the two sets of scores indicated the temporal stability of the scale. In addition, Cronbach’s alpha coefficient was computed to assess the internal consistency of the items within the scale, ensuring that all items reliably measured the same underlying construct.

- a) Test-Retest Method:** Test had been conducted with a time gap of 30 days on a sample of 58 higher secondary school teachers. The coefficient of reliability was computed between the two tests by using the “Product Moment Correlation”. The coefficient of reliability of the scale came out to be 0.89 which can be considered adequate for

TPACK scale. The detailed information on reliability co-efficient are presented in table no. 3.6

Table no: 3.6
Reliability Indices for TPACK scale

RELIABILITIES		
Mean <i>(mean of overall TPACK)</i>	SD <i>(SD of overall TPACK)</i>	Product-Moment Correlation
N=58 (teachers) after 30 days	N=58 (teachers) after 30 days	N=58
126.18	20.01	0.89

b) Cronbach's alpha coefficients: Cronbach's alpha coefficients were computed to assess the internal consistency of items within each TPACK domain. Based on the analysis, a refined 33 items scale was finalized. The final version of the scale comprised the following domains: Technological Knowledge (TK) – 4 items, Pedagogical Knowledge (PK) – 5 items, Content Knowledge (CK) – 5 items, Technological Pedagogical Knowledge (TPK) – 5 items, Technological Content Knowledge (TCK) – 4 items, Pedagogical Content Knowledge (PCK) – 4 items, and Technological Pedagogical and Content Knowledge (TPACK) – 6 items. The details of the initial Cronbach's alpha values and those obtained after combining relevant domains of TPACK are presented in Table 3.7.

Table 3.7
Initial Cronbach's Alpha and after combining with relevant domains of TPACK

Domain	Cronbach's Alpha	
TK	.72	
PK	.77	PK & TPK= .80, PK & PCK=
CK	.63	.82, PK & TPACK= .83
TPK	.78	CK & TCK=.76, CK & PCK=
TCK	.62	.79, CK & TPACK=.83
PCK	.71	TK & TCK=.74, CK &
TPACK	.84	TCK=.76

Scoring:

The scoring pattern for TPACK scale suggested by Likert was followed for the present TPACK scale. Each item has five alternative responses - 'strongly agree', 'agree', 'undecided', 'disagree' and 'strongly disagree'. For scoring purposes, the positive statements were given the scores 5, 4, 3, 2, 1 and the negative statements were given the scores 1, 2, 3, 4, 5. The negative items are given star-mark. The total number of statements in the scale was 33, distributed across seven domains as follows: Technological Knowledge (TK) – 4 items, Pedagogical Knowledge (PK) – 5 items, Content Knowledge (CK) – 5 items, Technological Pedagogical Knowledge (TPK) – 5 items, Technological Content Knowledge (TCK) – 4 items, Pedagogical Content Knowledge (PCK) – 4 items, and Technological Pedagogical and Content Knowledge (TPACK) – 6 items. The highest and lowest possible scores for each domain are presented in table 3.8

Table 3.8

The highest and lowest possible scores for each domain

Domain	No. of Items	Highest Possible Score (5 × items)	Lowest Possible Score (1 × items)
--------	--------------	------------------------------------	-----------------------------------

TK	4	20	4
PK	5	25	5
CK	5	25	5
TPK	5	25	5
TCK	4	20	4
PCK	4	20	4
TPACK	6	30	6
Overall Scale	33	165	33

Thus, the highest possible score on the overall TPACK scale was 165, and the lowest possible score was 33, reflecting the respondent's overall level of technological pedagogical and content knowledge. The item numbers corresponding to positive and negative statements are presented in Table 3.9.

Table no: 3.9
Serial Number of Positive and Negative Statements

Type of statements	Item numbers	Total
Positive	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 22, 23, 24, 25, 28, 29, 31, 32	27
Negative	20, 21, 26, 27, 30, 33	6
TOTAL		33

Norms and Interpretation of Attitude Scale:

The newly constructed perception scale on TPACK was administered on 200 higher secondary school teachers selected from all the higher secondary schools in Aizawl District. For the purpose of establishing norms for interpretation of the scale,

the investigator converted the raw score into z score and then transform into the standard score.

The norm for interpretation of the score on the level of self-perceived TPACK is given in the following table no. 3.10

Table 3.10
Interpretation of self-perceived TPACK

Interpretation	Score Range						
	TK	PK	CK	TPK	TCK	PCK	TPACK
High (1σ and above)	Above 16	Above 21	Above 20	Above 21	Above 16	Above 16	Above 27
Average (-1σ to 1σ)	11-15	15-20	16-19	16-20	12-15	12-15	20-26
Low (-1σ and below)	Below 11	Below 14	Below 15	Below 15	Below 11	Below 11	Below 19

3.4.2 Observation schedule for assessing the effectiveness of teaching.

To evaluate the effectiveness of teaching among higher secondary school teachers, a structured Classroom Observation Schedule was developed. The tool was constructed after a thorough review of related literature, existing standardized observation formats, and frameworks on teaching effectiveness. It was also adapted in consultation with subject experts to ensure comprehensiveness and relevance.

The schedule consisted of seven major dimensions, each with specific indicators of effective teaching practices:

Planning and Objectives – Clarity of lesson objectives, use of teaching-learning materials (TLM), structuring of the lesson, and review of the lesson.

Knowledge and Understanding – Mastery of subject content, appropriateness of instructional materials, and presentation of knowledge in an interesting and relevant manner.

Medium of Instruction – Integration of digital devices, effective use of instructional materials, appropriate selection of technologies, and provision of reinforcement.

Teaching Methods – Linking lessons with prior knowledge, utilizing students' ideas and experiences, use of varied activities and questioning, clarity of instructions, active student participation, and encouragement of accuracy and high standards.

Classroom Management – Praise and reinforcement, management of student behaviour, fairness, and classroom organization.

Assessment – Use of questioning to assess understanding, identification and constructive handling of mistakes, and regular evaluation of written work.

Homework and Assignment – Appropriateness of tasks and follow-up of previously assigned work.

Each item was rated on a three-point scale: 3 – Strongly Displayed, 2 – Apparently Displayed 1 – Not Displayed

This observation schedule provided both quantitative and qualitative insights into the classroom practices of teachers.

3.4.3 Structured questionnaire to study the problems faced by the higher secondary school teacher in integrating technology in teaching.

To identify the challenges faced by Higher Secondary School Teachers in integrating technology into their classroom practices, a structured questionnaire was developed. The initial draft comprised 26 items formulated

after an extensive review of related literature, with a specific focus on four key areas:

- Availability of technology
- Accessibility of resources
- Training received in technology use
- Perceived challenges in using technology

Tool Refinement and Reliability

The drafted questionnaire was subjected to content validation by a panel of experts in the field of education. Based on their valuable feedback, 12 items were deleted, and the language of several remaining items was refined for clarity. The final questionnaire used for data collection consisted of 14 items.

Establishing Reliability

The reliability of the final 14-item structured questionnaire was established using the test-retest method. The instrument was administered to a pilot group of 32 respondents on two separate occasions: once in September 2023 and again in October 2023. The scores from the two administrations were subsequently compared, and the Spearman's rank correlation coefficient (ρ) was calculated using the formula:

$$\rho = 1 - \frac{6\sum d_i^2}{n(n^2 - 1)}$$

The resulting coefficient, (ρ)= 0.68, indicated a high and acceptable level of reliability for the research instrument.

3.4.4 Evaluation schedule for assessing Teachers' Effectiveness for students

For the purpose of this study, an evaluation schedule was developed to assess the effectiveness of teachers. The schedule consisted of 14 professional areas that reflect different dimensions of effective use of technology, creativity,

rapport with students and parents, classroom planning, and ability to maintain discipline. The development of the tool followed a systematic process as outlined below:

1. Identification of Dimensions

Based on a review of related literature, discussion with teacher educators, and analysis of the professional roles of higher secondary teachers, fourteen areas of teacher effectiveness were identified. These areas were considered essential for assessing teachers' professional performance.

2. Item Construction

For each professional area, simple and direct items were framed to suit the comprehension level of higher secondary students. The items were written in a way that students could easily rate their teachers' effectiveness without ambiguity.

3. Scaling Technique

A three-point rating scale was developed to record students' responses: Poor/Low (30%), Average/Moderate (50%), Good/High (above 50%). This scaling technique was chosen for its simplicity and suitability for students' evaluative judgment.

4. Validity

The drafted evaluation schedule was subjected to expert review by subject experts in the field of education within the university, in order to establish its content validity. Their suggestions were incorporated to improve the clarity, relevance, and coverage of the items. On the basis of the opinions of the experts, some items were rejected and some items were modified. Finally, the draft now contained 14 items for collection of data. This process established the content validity of the instrument.

5. Trying out the test

After preparing the evaluation schedule, it was first tried out with a small group of 36 students of higher secondary schools in the month of October 2023 and secondly it was tried out in the month of November 2023 with the same 36 respondents.

6. Reliability

The investigator employed the Test–Retest Method to establish the reliability of the evaluation schedule. For this purpose, the test was administered twice with an interval of 30 days on a sample of 36 higher secondary school students. The Product Moment Correlation Coefficient (Pearson's r) was computed between the two sets of scores to assess the temporal consistency of the instrument. The obtained reliability coefficients for each category were as follows:

Low – $r = 0.55$,

Average – $r = 0.89$, and

High – $r = 0.93$.

These results indicate a moderate correlation in the Low category and very high correlations in the Average and High categories. Overall, the coefficients suggest that the evaluation schedule demonstrates strong consistency across the two test administrations. The detailed results of the reliability analysis are presented in Table 3.11.

Table no: 3.11
Reliability Indices for Evaluation schedule

Category	N	Test 1 (Mean score)	Test 2 (Mean score)	Pearson's r (Coefficient)	Interpretation
Low	36	5.64	6.57	0.55	Moderate Consistency

Average	36	17.07	16.14	0.89	Very high Consistency
High	36	13.29	13.29	0.93	Very High Consistency

3.5.0 ADMINISTRATION OF TOOLS AND COLLECTION OF DATA:

Data were collected using a structured survey questionnaire comprising two main sections. The first section gathered demographic details of the respondents, including gender, age, subject taught, ICT training status (trained or untrained), and years of teaching experience for teacher respondents, as well as stream of study and name of school for student respondents.

The second section was divided into two parts. The first part assessed respondents' TPACK across various domains using a five-point Likert scale, with response options: SD = “strongly disagree,” D = “disagree,” N = “neutral,” A = “agree,” and SA = “strongly agree.” The second part aimed to identify the challenges teachers encounter while integrating technology into classroom teaching, with response options limited to “yes” or “no.”

Data were also collected from students using a three-point rating scale to assess the effectiveness of teachers. The response options were Poor/Low (30%), Average/Moderate (50%), and Good/High (above 50%).

The investigator personally visited the selected institutions to conduct the data collection process in a systematic and ethical manner. Prior to administering the questionnaires, formal permission was obtained from the respective headmasters of each school. The purpose and nature of the study were clearly explained to them, and their cooperation was sought to facilitate smooth data collection. Upon receiving consent, the investigator distributed the questionnaires to all teachers and students who were present on the day of the visit.

Before the administration, the investigator provided a brief orientation to the respondents, clearly explaining the objectives of the study, the significance of their participation, and the confidentiality of their responses. The respondents were encouraged to read each statement carefully and to provide responses that reflected their genuine opinions and experiences. Emphasis was placed on the voluntary nature of participation, assuring them that the information collected would be used strictly for academic and research purposes only.

During the process, the investigator remained available to clarify any doubts or questions raised by the participants to ensure accurate understanding of the items. After the respondents had completed the questionnaires, the investigator carefully collected them and thoroughly checked to ensure completeness. Care was taken to verify that all items were answered appropriately and that the required demographic and personal details were duly filled in. This careful and systematic approach helped to ensure the reliability and validity of the collected data.

Additionally, for the observation component of the study, the investigator personally visited the selected schools and sought prior permission from the headmasters and the concerned teachers to observe their classroom teaching. Prior to conducting any observation, the investigator thoroughly explained the objectives and significance of the study to both the school authorities and the participating teachers. This was done to ensure that the purpose of the observation was clearly understood and that the teachers felt comfortable and confident about participating. The ethical aspects of the study were emphasized, and teachers were assured that the data collected would be used strictly for academic and research purposes, maintaining complete confidentiality and anonymity. This personal and transparent approach helped to build mutual trust and cooperation between the investigator and the teachers.

As a preliminary step, the teachers were requested to complete the TPACK perception scale questionnaire. This initial phase was intended to gather insights into their self-reported understanding and application of technology, pedagogy, and content knowledge in their teaching practices. After the completion of the questionnaire, arrangements were made in consultation with each teacher to observe their classroom

sessions. The scheduling of these observations was carried out thoughtfully to minimize any disruption to their regular teaching routine and to capture the teachers' natural classroom behaviors in an authentic environment.

During the observation period, the investigator closely and systematically observed the teaching-learning process of the same teachers who had earlier completed the TPACK perception scale. Each classroom session was carefully examined to understand how teachers integrated technology into their lessons, how they applied appropriate pedagogical strategies, and how effectively they connected content knowledge with technological and instructional approaches. Detailed notes and observations were recorded using a structured observation schedule that had been specifically designed and validated for this study. This instrument provided a systematic framework for documenting key aspects of teaching behavior, such as lesson organization, instructional delivery, classroom interaction, use of technological tools, and methods of student engagement.

Throughout the observation process, the investigator exercised great care to ensure that the data collection was objective, comprehensive, and consistent with the overall purpose of the research. The observations were conducted in a non-intrusive manner to avoid influencing the natural flow of the teaching process. The collected data thus provided a rich and reliable account of how teachers practically demonstrated their TPACK competencies in real classroom settings. This phase of observation complemented the questionnaire data, thereby enhancing the credibility and depth of the study's findings through methodological triangulation.

3.6.0 TABULATION OF DATA

The data for the present study were collected from a total of 200 teachers and 307 students. Once collected, the data were meticulously examined to ensure accuracy, completeness, and consistency. Each response from the teachers and students, obtained through the various research instruments including the questionnaire, observation schedule, and evaluation schedule was carefully scrutinized. Following this, the

responses were systematically classified and assigned scores in accordance with the standard procedures established for each instrument.

To maintain proper organization and traceability, each respondent was assigned a unique serial number corresponding to the specific variable under investigation. The scored responses were then entered into a tabulation sheet, allowing for systematic arrangement of the data. This process facilitated a clear overview of the responses and enabled the identification of patterns, trends, and distributions.

Once the tabulation was complete, the data were subjected to appropriate statistical treatment to ensure rigorous analysis. The statistical techniques employed were carefully selected based on the nature of the data and the objectives of the study, thereby enabling meaningful interpretation and in-depth understanding of the results. This structured and methodical approach ensured that the analysis was both reliable and valid, providing a solid foundation for drawing conclusions and making recommendations

3.7.0 STATISTICAL TECHNIQUES FOR ANALYSIS OF DATA

Quantitative analysis was done for the present research. Quantitative analysis of data was done by making use of descriptive and inferential statistics like measures of central tendency, percentages and z-score, along with Pearson product moment correlation, Spearman rank correlation coefficient and t-test.

CHAPTER IV

ANALYSIS AND INTERPRETATION

This present chapter focused on the examination and comprehension of the gathered data. The primary aim of this study is to investigate various aspects of higher secondary school teachers' use of TPACK (Technological Pedagogical Content Knowledge) in Mizoram. Additionally, it also aims to evaluate the teachers' knowledge level, the self-perceived expertise regarding TPACK.

The study also aims to find out the differences in self-perceived TPACK based on discipline, gender and age of higher secondary school teachers in Mizoram and how they integrate digital technologies into their teaching and their competency in applying TPACK. Finally, it aims to identify challenges they face when integrating technology into teaching and also aims to investigate students' perceptions of their teachers' effectiveness in using TPACK.

The study's findings were subsequently interpreted in a meaningful manner. In this chapter, the outcomes of the research are presented in accordance with the objectives outlined in the first chapter:

1. To assess the self-perceived level of Technological Pedagogical and Content Knowledge (TPACK) of higher secondary school teachers in Mizoram.
2. To compare the differences in self-perceived TPACK among higher secondary school teachers with reference to their educational discipline, gender, age, teaching experience and ICT training.
3. To examine the relationship of higher secondary school teachers self-perceived expertise in TPACK and its effectiveness in teaching.
4. To find out the problems faced by the higher secondary school teachers of Mizoram in integrating technology in teaching
5. To investigate the perceived experience of students on the effectiveness of teaching of higher secondary school teachers of Mizoram using TPACK.

4.1.0. SELF-PERCEIVED LEVEL OF TECHNOLOGICAL PEDAGOGICAL AND CONTENT KNOWLEDGE (TPACK) OF HIGHER SECONDARY SCHOOL TEACHERS IN MIZORAM.

To evaluate the self-perceived level of TPACK of higher secondary school teachers in Mizoram, the investigator established specific norms as per the response of the respondents. In order to determine the level of teachers' self-perceived across the seven TPACK domains, the raw scores were converted into Z-scores. Based on these standardized scores, teachers' levels of self-perceived were categorized into three levels Good, Average, and Poor according to established norms. This classification provided a clear understanding of teachers' relative standing in each domain of TPACK.

The raw scores of all 200 higher secondary school teachers were transformed into z-score as shown in the following table

Table 4.0
Raw score with corresponding z-score

Raw score	Z-score	Raw score	Z-score	Raw score	Z-score	Raw score	Z-score
58	-3.88	108	-0.61	120	0.18	127	0.63
79	-2.51	108	-0.61	120	0.18	127	0.63
79	-2.51	109	-0.54	120	0.18	128	0.70
80	-2.44	109	-0.54	121	0.24	128	0.70
80	-2.44	109	-0.54	121	0.24	128	0.70
81	-2.37	110	-0.48	121	0.24	128	0.70
82	-2.31	111	-0.41	121	0.24	128	0.70
84	-2.18	111	-0.41	121	0.24	128	0.70

87	-1.98	112	-0.35	121	0.24	128	0.70
89	-1.85	112	-0.35	121	0.24	128	0.70
90	-1.79	113	-0.28	122	0.31	129	0.76
91	-1.72	113	-0.28	122	0.31	129	0.76
91	-1.72	113	-0.28	122	0.31	130	0.83
92	-1.66	114	-0.22	122	0.31	130	0.83
92	-1.66	114	-0.22	122	0.31	130	0.83
93	-1.59	114	-0.22	122	0.31	130	0.83
94	-1.52	114	-0.22	122	0.31	130	0.83
95	-1.46	114	-0.22	123	0.37	130	0.83
96	-1.39	114	-0.22	123	0.37	131	0.89
96	-1.39	114	-0.22	123	0.37	131	0.89
96	-1.39	114	-0.22	123	0.37	131	0.89
97	-1.33	114	-0.22	123	0.37	132	0.96
97	-1.33	114	-0.22	123	0.37	132	0.96
98	-1.26	114	-0.22	124	0.44	132	0.96
98	-1.26	115	-0.15	124	0.44	132	0.96
99	-1.20	115	-0.15	124	0.44	133	1.03
99	-1.20	115	-0.15	124	0.44	133	1.03
99	-1.20	115	-0.15	125	0.50	133	1.03
100	-1.13	115	-0.15	125	0.50	134	1.09

101	-1.07	116	-0.09	125	0.50	134	1.09
101	-1.07	116	-0.09	125	0.50	134	1.09
103	-0.94	116	-0.09	125	0.50	134	1.09
103	-0.94	117	-0.02	125	0.50	135	1.16
103	-0.94	117	-0.02	125	0.50	135	1.16
104	-0.87	117	-0.02	125	0.50	135	1.16
104	-0.87	117	-0.02	125	0.50	136	1.22
105	-0.81	117	-0.02	125	0.50	136	1.22
105	-0.81	117	-0.02	126	0.57	137	1.29
105	-0.81	118	0.04	126	0.57	137	1.29
105	-0.81	118	0.04	126	0.57	137	1.29
106	-0.74	118	0.04	126	0.57	138	1.35
106	-0.74	118	0.04	126	0.57	139	1.42
106	-0.74	119	0.11	126	0.57	141	1.55
106	-0.74	119	0.11	126	0.57	142	1.61
107	-0.67	119	0.11	127	0.63	145	1.81
107	-0.67	119	0.11	127	0.63	145	1.81
107	-0.67	119	0.11	127	0.63	146	1.88
107	-0.67	119	0.11	127	0.63	147	1.94
108	-0.61	120	0.18	127	0.63	152	2.27
108	-0.61	120	0.18	127	0.63	157	2.59

Based on the range of z-score, level of self-perceived TPACK was classified into 3 levels for the interpretation of the present study as depicted in the following table no 4.1

Table 4.1
Norms for interpretation of the levels self-perceived TPACK based on z-score

Level of self-perceived TPACK	Range	Range of score						
		TK	PK	CK	TPK	TCK	PCK	TPACK
Good	Above Mean + 1SD	Above 16	Above 21	Above 20	Above 21	Above 16	Above 16	Above 27
Average	Mean - 1SD to Mean +1SD	11-15	15-20	16-19	16-20	12-15	12-15	20-26
Poor	Below Mean- 1SD	Below 11	Below 14	Below 15	Below 15	Below 11	Below 11	Below 19

Table 4.1 presents the norms used for interpreting the levels of teachers' self-perceived Technological Pedagogical and Content Knowledge (TPACK) based on the calculated *z-scores*. The table classifies teachers' knowledge levels into three categories High, Average, and Low for each of the seven TPACK domains: Technological Knowledge (TK), Pedagogical Knowledge (PK), Content Knowledge (CK), Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK), and the overall TPACK.

Teachers whose scores fall above one standard deviation (Mean + 1SD) from the mean are categorized as having a high level of knowledge. Those whose scores lie between one standard deviation below and above the mean (Mean - 1SD to Mean + 1SD) are classified as having an Average level of knowledge, while teachers scoring below one standard deviation from the mean (Below Mean - 1SD) are considered to have a low level of knowledge. The corresponding raw score ranges for each domain are also shown. For instance, in the Technological Knowledge (TK) domain, scores above 16 indicate a high level, between 11 and 15 represent an average level, and below 11 indicate a low level of knowledge. Similarly, for the overall TPACK, scores above 27 are interpreted as high, between 20 and 26 as average, and below 19 as low.

Table 4.2
Teachers self-perceived level of TPACK
(N=200)

Domains	Mean	SD	Good	Average	Poor
Technological Knowledge (TK)	13.72	1.99	31 (15.5%)	136 (68%)	33 (16.5%)
Pedagogical Knowledge (PK)	17.51	2.56	18 (9%)	157 (78.5%)	25 (12.5%)
Content knowledge (CK)	17.58	2.33	35 (17.5%)	123 (61.5%)	42 (21%)
Technological Pedagogical Knowledge (TPK)	17.70	2.44	19 (9.5%)	143 (71.5%)	38 (19%)
	13.86	1.87	33	148	19

Technological Content Knowledge (TCK)	(16.5%)	(74%)	(9.5%)		
	13.78	2.06	38	134	28
Pedagogical Content Knowledge (PCK)	(19%)	(67%)	(14%)		
	23.17	3.35	5	170	25
TPACK	(2.5%)	(85%)	(12.5%)		

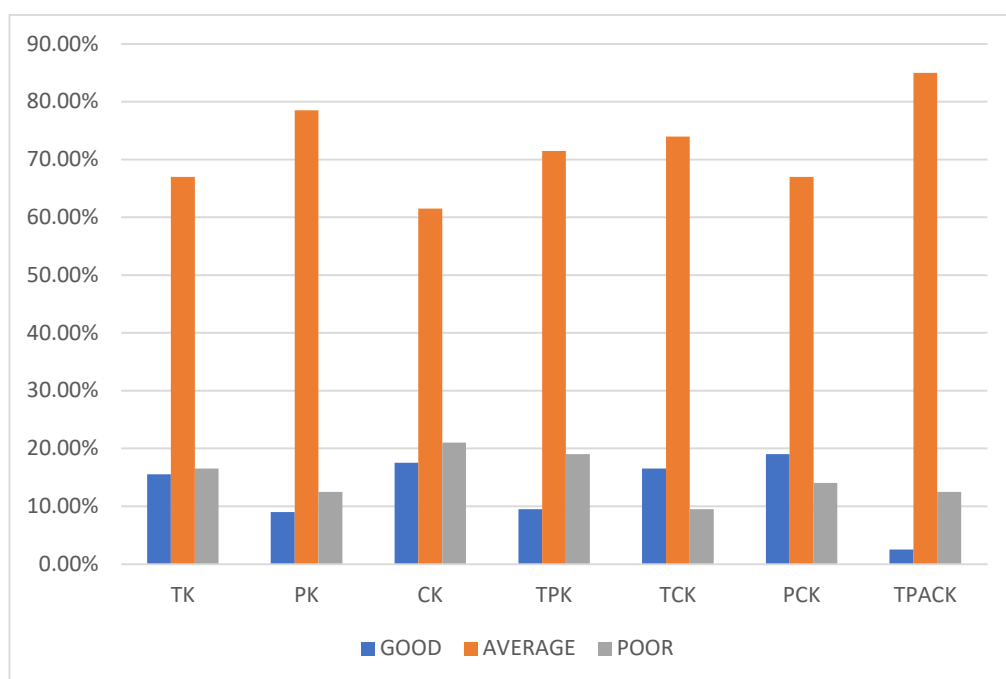


Figure 4.1 Teachers self-perceived level of TPACK

The data presented in Table 4.2 and figure 4.1 shows the teachers' self-perceived levels in the seven domains of the Technological Pedagogical and Content Knowledge (TPACK) framework. The findings reveal variations in teachers' self-assessed competencies across the different domains. (TK) domain recorded a mean score of 13.72 with a standard deviation of 1.99, indicating a moderate level of technological proficiency. A majority of teachers (68%) were found to have average

technological knowledge, while 15.5% had good and 16.5% had poor knowledge in this area. In the (PK) domain, the mean score was 17.51 ($SD = 2.56$), suggesting a relatively strong understanding of general teaching strategies and methods. Most teachers (78.5%) perceived themselves to have average pedagogical knowledge, whereas 9% reported good and 12.5% poor knowledge. (CK) domain obtained a mean of 17.58 ($SD = 2.33$). While 61.5% of teachers demonstrated average content knowledge, 17.5% perceived themselves to have good knowledge, and 21% fell into the poor category, reflecting some inconsistency in subject-matter confidence. Regarding (TPK), the mean score of 17.70 ($SD = 2.44$) indicates a moderate competence in integrating technology with pedagogy. The majority (71.5%) rated themselves average, while 9.5% had good and 19% had poor knowledge in this domain. (TCK) domain had a mean of 13.86 ($SD = 1.87$). Most teachers (74%) fell under the average level, 16.5% had good, and 9.5% had poor knowledge, implying a fairly stable but moderate understanding of how technology relates to content areas. In (PCK), the mean score was 13.78 ($SD = 2.06$). About 67% of teachers demonstrated an average level, while 19% and 14% showed good and poor knowledge respectively. This indicates that most teachers possess a moderate ability to link pedagogy with subject content. Finally, the overall TPACK score shows a mean of 23.17 with a standard deviation of 3.35, where a large majority (85%) of teachers rated themselves as having average integrated knowledge of technology, pedagogy, and content. Only 2.5% perceived themselves as having good TPACK, whereas 12.5% had poor levels.

An examination of the mean scores of all individual statements revealed both the highest and lowest mean values across domains. The statement with the highest mean ($M = 4.49$, $SD = 0.68$) under the Technological Content Knowledge (TCK) domain suggests that most teachers were proficient in using technology to demonstrate subject concepts effectively. Conversely, the statement with the lowest mean ($M = 3.30$, $SD = 1.11$) under the Technological Pedagogical Knowledge (TPK) domain indicates that only a few teachers were able to engage students in higher-order thinking activities such as problem-solving, critical thinking, and decision-making through the use of technology.

4.2.0 COMPARISON OF THE DIFFERENCES IN SELF-PERCEIVED TPACK AMONG HIGHER SECONDARY SCHOOL TEACHERS WITH REFERENCE TO THEIR EDUCATIONAL DISCIPLINE, GENDER, AGE, TEACHING EXPERIENCE AND ICT TRAINING

The study involved a comparison of higher secondary school teachers of self-perceived TPACK based on their educational discipline, gender age, teaching experience and ICT training. For this, the mean and standard deviation of the scores across the different domains were calculated. The mean differences were tested by applying ‘t’ test and the details are presented in the following tables.

4.2.1 Difference in self-perceived TPACK with reference to educational discipline

Hypothesis no1. states that “There is no statistically significant relationship in higher secondary school teachers of Mizoram on self-perceived technological pedagogical content knowledge based on educational discipline.”

The following tables and figure present a comparison between Science and Arts respondents across each domain with respect to their self-perceived TPACK.

Table 4.3

Norms for interpretation of self-perceived TPACK with reference to educational discipline based on z-score

Level of self-perceived TPACK		High	Moderate	Low
Range		Above Mean + 1SD	Mean -1SD to Mean +1SD	Below Mean-1SD
Range of score				
TK	Science	Above 17	13 - 16	Below 12
	Arts	Above 17	13 - 16	Below 12
PK	Science	Above 21	16 – 20	Below 15
	Arts	Above 20	15 - 19	Below 13

CK	Science	Above 22	17 - 21	Below 16
	Arts	Above 21	16 - 20	Below 15
TPK	Science	Above 20	16 - 19	Below 15
	Arts	Above 20	15 - 19	Below 14
TCK	Science	Above 17	13 - 16	Below 12
	Arts	Above 16	12 - 15	Below 11
PCK	Science	Above 17	13 - 15	Below 12
	Arts	Above 16	12 - 15	Below 11
TPACK	Science	Above 25	20 - 24	Below 19
	Arts	Above 24	20 - 23	Below 19

Table 4.3 presents the norms for interpreting the levels of teachers' self-perceived TPACK with reference to their educational discipline, based on z-scores. The levels are categorized as High, Moderate, and Low for both Science and Arts teachers across the seven TPACK domains (TK, PK, CK, TPK, TCK, PCK, and overall TPACK).

Teachers scoring above one standard deviation from the mean are classified as having a High level of knowledge, those within one standard deviation above or below the mean as Moderate, and those below one standard deviation from the mean as Low. The table provides the corresponding score ranges for each domain and discipline, showing slight variations between Science and Arts teachers.

Table 4.4
Educational discipline wise teachers' level of self-perceived TPACK

Domains	Science	Arts		High	Moderate	Low
	(n=100)	(n=100)				
	Discipline	Mean	SD			
TK	Science	14.54	1.74	8%	83%	9%

	Arts	14.45	2.08	15%	68%	17%
	Science	17.98	2.21	8%	81%	11%
PK	Arts	16.76	2.63	12%	67%	21%
	Science	18.58	2.51	12%	71%	17%
CK	Arts	17.84	2.62	10%	74%	16%
	Science	17.91	2.08	21%	70%	9%
TPK	Arts	16.64	2.56	9%	64%	27%
	Science	14.59	1.64	10%	83%	7%
TCK	Arts	13.66	2.27	20%	57%	23%
	Science	14.46	1.76	7%	80%	13%
PCK	Arts	13.57	2.37	20%	52%	28%
	Science	22.1	2.56	18%	73%	9%
TPACK	Arts	21.86	2.02	10%	84%	6%

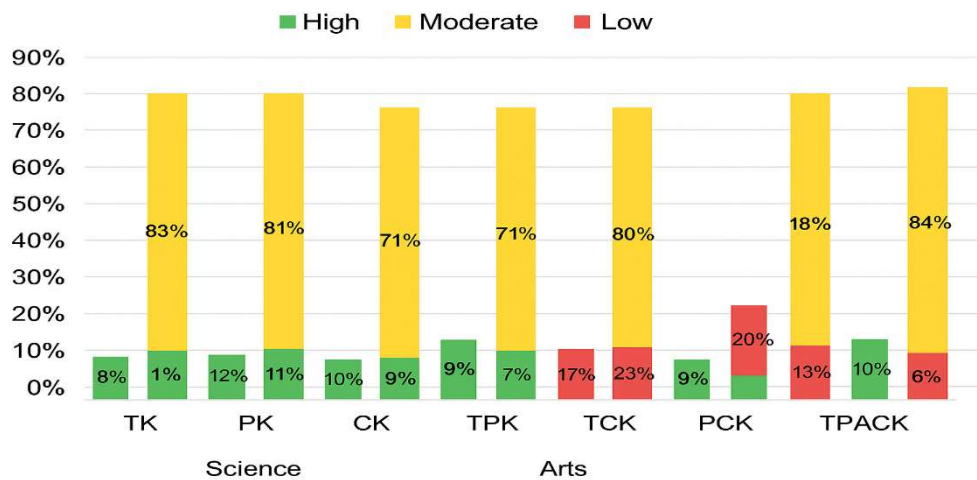


Figure 4.2 Educational discipline wise teachers' level of self-perceived TPACK

Table 4.4 and figure 4.2 presents the comparison of higher secondary school teachers' self-perceived TPACK across seven domains based on their educational discipline - Science and Arts. The results show that both groups generally perceive themselves at a moderate level of knowledge in all domains; however, noticeable variations exist between the two disciplines.

Overall, science teachers obtained higher mean scores across all domains compared to arts teachers. For instance, in Technological Knowledge (TK), science teachers recorded a slightly higher mean ($M = 14.54$, $SD = 1.74$) than arts teachers ($M = 14.45$, $SD = 2.08$). The same pattern is observed in Pedagogical Knowledge (PK) ($M = 17.98$ vs. 16.76), Technological Pedagogical Knowledge (TPK) ($M = 17.91$ vs. 16.64), and Technological Content Knowledge (TCK) ($M = 14.59$ vs. 13.66). These results suggest that science teachers perceive themselves as more confident and skilled in integrating technology into their subject teaching.

In terms of knowledge levels, the majority of both groups fall under the moderate category, but science teachers have a relatively higher proportion of respondents in the high-level category, particularly in TPK (21%) and TPACK (18%), compared to arts teachers (9% and 10%, respectively). On the other hand, a larger proportion of arts teachers appear in the low-level category, especially in domains such as TPK (27%), TCK (23%), and PCK (28%), indicating comparatively weaker technological and pedagogical integration.

In the overall TPACK domain, science teachers also showed a slightly higher mean ($M = 22.10$, $SD = 2.56$) than arts teachers ($M = 21.86$, $SD = 2.02$), although both groups maintained a moderate perception level (73% and 84%, respectively).

These findings reveal that science teachers tend to have stronger self-perceived technological, pedagogical, and content knowledge integration than arts teachers. This difference may be attributed to the nature of science subjects, which often involve practical demonstrations, simulations, and digital experimentation that encourage the use of technology in instruction. In contrast, arts teachers may rely more on discussion-based or traditional approaches, leading to relatively lower technological integration.

In conclusion, while both science and arts teachers generally demonstrate a moderate level of TPACK, science teachers exhibit a higher overall self-perceived competence, particularly in technology-related domains, reflecting a stronger inclination toward the use of ICT tools and digital resources in teaching and learning.

Table no. 4.5 shows the calculation of t-test of Science and Arts teachers with respect to their educational discipline.

Table no: 4.5
Difference in self-perceived TPACK of higher secondary school teachers with reference to their educational discipline.

Educational Discipline	N	Mean Value (mean of overall TPACK)	df	SD	Calculated t- value	Critical value	Sig Level
						0.05 0.01	
Science	100	17.17	198	2.07			*
Arts	100	16.40		2.36	2.48	1.97 2.60	

*Significant at 0.05 level

Looking at Table 4.5, it shows that the calculated t-value is 2.48 which is more than the critical value at 0.05 level. This means that there is a significant difference in the educational discipline of higher secondary school teachers. The calculated t-value was not significant at 0.01 level and at 0.05 level it was found to be significant. Thus, the hypothesis (No.1) stating “there is no statistically significant relationship in higher secondary school teachers of Mizoram on self-perceived technological pedagogical content knowledge based on educational discipline was rejected. Science teachers have better mean of overall domains score of 17.17 in comparison with Arts teachers who have a mean score of 16.40. It can be concluded that there is a significant difference in higher secondary school teachers of Mizoram on self-perceived technological pedagogical content knowledge based on educational discipline

4.2.2 Difference in self-perceived TPACK with reference to gender

Hypothesis no2. states that “There is no statistically significant relationship in higher secondary school teachers of Mizoram on self-perceived technological pedagogical content knowledge based on gender.”

The following table and figure show the comparison of male and female respondents with respect to their self-perceived TPACK.

Table 4.6

Norms for interpretation of self-perceived TPACK with reference to gender based on z-score

Level of self-perceived TPACK		High	Moderate	Low
Range		Above Mean + 1SD	Mean -1SD to Mean +1SD	Below Mean-1SD
Range of score				
TK	Male	Above 16	12 - 15	Below 11
	Female	Above 12	12 - 14	Below 11
PK	Male	Above 22	17 – 21	Below 16
	Female	Above 22	16 - 21	Below 15
CK	Male	Above 23	18 - 22	Below 17
	Female	Above 22	16 -21	Below 15
TPK	Male	Above 23	17 - 22	Below 16
	Female	Above 21	15 - 20	Below 14
TCK	Male	Above 15	12 - 14	Below 11
	Female	Above 15	12 - 14	Below 11
PCK	Male	Above 15	12 - 14	Below 11
	Female	Above 15	12 - 14	Below 11
TPACK	Male	Above 25	20 - 24	Below 19
	Female	Above 26	19 - 25	Below 18

Table 4.6 shows the norms for interpreting the levels of teachers' self-perceived TPACK with reference to gender, based on z-scores. The levels are classified as High, Moderate, and Low for both male and female teachers across the seven TPACK domains (TK, PK, CK, TPK, TCK, PCK, and overall TPACK).

Teachers scoring above one standard deviation from the mean are categorized as High, those within one standard deviation above or below the mean as Moderate, and those below one standard deviation from the mean as Low. The table also shows the corresponding score ranges for each domain, indicating slight differences between male and female teachers in certain areas.

Table 4.7
Gender wise teachers' level of self-perceived TPACK

Domains	Male	Female		High	Moderate	Low
	(n=100)	(n=100)				
	Gender	Mean	SD			
TK	Male	13.55	1.89	20%	65%	15%
	Female	12.7	1.60	12%	74%	14%
PK	Male	19.21	2.83	22%	65%	13%
	Female	18.35	3.01	10%	70%	20%
CK	Male	19.89	2.73	13%	70%	17%
	Female	18.4	2.85	14%	67%	19%
TPK	Male	19.25	2.89	14%	73%	13%
	Female	17.81	2.91	26%	61%	13%
TCK	Male	12.97	1.80	18%	64%	18%

	Female	12.61	1.59	8%	68%	24%
	Male	13.09	1.84	19%	62%	19%
PCK	Female	12.7	1.51	6%	75%	19%
	Male	21.91	2.53	12%	72%	16%
TPACK	Female	22.1	3.24	14%	71%	15%

The data reveal that both male and female teachers generally fall within the moderate level of self-perceived knowledge in all domains, but some notable differences can be observed in their mean scores and distribution across levels. Overall, male teachers showed slightly higher mean scores than female teachers in most of the TPACK domains, such as Technological Knowledge (TK) ($M = 13.55$, $SD = 1.89$) compared to females ($M = 12.70$, $SD = 1.60$), Pedagogical Knowledge (PK) ($M = 19.21$ vs. 18.35), and Technological Pedagogical Knowledge (TPK) ($M = 19.25$ vs. 17.81). Similar trends are seen in Technological Content Knowledge (TCK) and Pedagogical Content Knowledge (PCK), where male teachers consistently scored marginally higher.

However, in the overall TPACK domain, female teachers recorded a slightly higher mean score ($M = 22.10$, $SD = 3.24$) than male teachers ($M = 21.91$, $SD = 2.53$), though the difference is minimal. This suggests that both groups perceive themselves as having comparable overall integration of technology, pedagogy, and content in their teaching practices.

Regarding levels of knowledge, a larger percentage of male teachers fell under the high-level category in most domains, particularly in TK (20%), PK (22%), and PCK (19%), while female teachers had a higher percentage in the moderate range across all domains. For example, 75% of female teachers were at a moderate level in PCK compared to 62% of male teachers.

These findings indicate that male teachers tend to have a slightly stronger technological and pedagogical confidence, which may be linked to greater exposure or comfort with technology-related tools and practices. Female teachers, on the other hand, generally perceive themselves as moderately competent but show a balanced and consistent performance across domains, particularly in the overall TPACK domain. In summary, while both male and female teachers possess a moderate level of self-perceived TPACK, male teachers demonstrated marginally higher proficiency in individual technological and pedagogical domains, whereas female teachers exhibited a comparable or slightly higher overall integration (TPACK). This suggests that gender differences in TPACK perceptions are relatively minor but may reflect varied experiences and access to technology use in teaching.

Table no. 4.8 shows the calculation of t-test of higher secondary school teachers with respect to their gender.

Table no: 4.8
Difference in self-perceived TPACK of higher secondary school teachers with reference to their gender.

Gender	N	Mean Value	df	SD	Calculated t- value	Critical value	Sig Level
		(overall mean of TPACK)				0.05 0.01	
Male	100	17.12		2.36	2.24	1.97 2.60	*
Female	100	16.38	198	2.39			

***Significant at 0.05 level**

Looking at Table 4.8, it shows that the calculated t-value is 2.24 which is more than the critical value at 0.05 level. This means that there is a significant difference in self-perceived TPACK between male and female of higher secondary school teachers. The calculated t-value was not significant at 0.01 level and at 0.05 level it was found

to be significant. Thus, the hypothesis (No.2) stating “there is no statistically significant relationship in higher secondary school teachers of Mizoram on self-perceived technological pedagogical content knowledge based on gender was rejected. Male teachers have better mean score of 17.12 in comparison with female teachers who have a mean score of 16.38. It can be concluded that there is a significant difference in male and female of higher secondary school teachers of Mizoram on self-perceived technological pedagogical content knowledge.

4.2.3 Difference in self-perceived TPACK with reference to age.

Hypothesis no3. states that “There is no statistically significant relationship in higher secondary school teachers of Mizoram on self-perceived technological pedagogical content knowledge based on age.”

The following table and figure show the comparison of teachers’ age with respect to their self-perceived TPACK.

Table 4.9

Norms for interpretation of self-perceived TPACK with reference to age based on z-score

Level of self-perceived TPACK		High	Moderate	Low
Range	Range of score	Above Mean + 1SD	Mean -1SD to Mean +1SD	Below Mean-1SD
TK	Below 40	Above 16	13 - 15	Below 12
	Above 40	Above 16	12 - 15	Below 11
PK	Below 40	Above 22	17 – 21	Below 16
	Above 40	Above 20	14 - 19	Below 13
CK	Below 40	Above 23	18 - 22	Below 17
	Above 40	Above 21	15 -20	Below 14

TPK	Below 40	Above 22	16 - 21	Below 15
	Above 40	Above 19	14 - 18	Below 13
TCK	Below 40	Above 16	12 - 15	Below 11
	Above 40	Above 15	11 - 14	Below 10
PCK	Below 40	Above 16	12 - 15	Below 11
	Above 40	Above 15	11 - 14	Below 10
TPACK	Below 40	Above 25	22 - 24	Below 21
	Above 40	Above 25	18 - 24	Below 17

Table 4.9 shows the norms for interpreting the levels of teachers' self-perceived TPACK with reference to age, based on z-scores. The levels are categorized as High, Moderate, and Low for teachers aged below 40 years and above 40 years across all seven TPACK domains (TK, PK, CK, TPK, TCK, PCK, and overall TPACK).

Teachers with scores above one standard deviation from the mean are considered to have a High level of knowledge, those within one standard deviation above or below the mean are classified as Moderate, and those below one standard deviation from the mean are categorized as Low. The table presents the specific score ranges for each domain according to the two age groups.

Table 4.10
Teachers' Age level of self-perceived TPACK

Domains	Below 40	Above 40		High	Moderate	Low
	(n=136)	(n=64)				
	Age	Mean	SD			
TK	Below 40	14.08	1.66	24	97	15
				17.6%	71.3%	11%
	Above 40	13.22	2.18	4	43	17
				9.3%	67.1%	26.5%

PK	Below 40	18.91	2.47	13	103	20
				9.5%	75.7%	14.7%
	Above 40	16.13	2.93	11	40	13
				17.1%	62.5%	20.3%
CK	Below 40	19.92	2.47	21	88	27
				15.4%	64.7%	19.8%
	Above 40	17.14	3.11	9	43	12
				14%	67.1%	18.7%
TPK	Below 40	18.51	2.59	13	107	16
				9.5%	78.6%	11.7%
	Above 40	15.92	2.90	12	37	15
				18.7%	57.8%	23.4%
TCK	Below 40	13.60	1.86	21	99	16
				15.4%	72.7%	11.7%
	Above 40	12.28	2.10	12	42	10
				18.7%	65.6%	15.6%
PCK	Below 40	13.65	1.82	20	105	11
				14.7%	77.2%	8%
	Above 40	12.25	1.94	6	47	11
				9.3%	73.4%	8%
TPACK	Below 40	23.16	1.51	25	101	10
				18.3%	74.2%	7.3%
	Above 40	20.88	3.36	2	52	10
				3.1%	84.3%	15.6%

The above table 4.10 indicate that teachers below 40 years of age have higher mean scores across all TPACK domains compared to teachers above 40 years. In the Technological Knowledge (TK) domain, younger teachers obtained a higher mean ($M = 14.08$, $SD = 1.66$) than older teachers ($M = 13.22$, $SD = 2.18$). This trend continues across other domains such as Pedagogical Knowledge (PK) ($M = 18.91$ vs. 16.13),

Technological Pedagogical Knowledge (TPK) ($M = 18.51$ vs. 15.92), and Technological Pedagogical and Content Knowledge (TPACK) ($M = 23.16$ vs. 20.88).

In terms of levels, the majority of teachers in both age groups fell into the moderate level of self-perceived knowledge. However, a higher percentage of younger teachers were found in the high-level category across most domains. For instance, 17.6% of teachers below 40 years reported high TK compared to only 9.3% among those above 40 years. Similarly, in the overall TPACK domain, 18.3% of teachers below 40 years perceived themselves at a high level, while only 3.1% of those above 40 years rated themselves high.

Conversely, a relatively larger proportion of teachers above 40 years fell into the low-level category, particularly in the technology-related domains (TK, TPK, and TCK). For instance, 26.5% of older teachers showed low TK compared to only 11% among the younger group.

These findings suggest that younger teachers tend to have stronger confidence and competence in integrating technology into their teaching, which may be attributed to their greater familiarity and frequent exposure to digital tools and ICT-based pedagogy in their professional preparation and practice. On the other hand, teachers aged above 40 years appear to rely more on traditional teaching approaches and may have had limited opportunities for formal ICT training or technological upskilling, resulting in comparatively lower TPACK perceptions. In summary, age has a clear influence on teachers' self-perceived TPACK, with younger teachers (below 40 years) demonstrating higher perceived knowledge and integration of technology, pedagogy, and content than their older counterparts.

Table no. 4.9 shows the calculation of t-test of higher secondary school teachers with respect to their age.

Table no: 4.11

Difference in self-perceived TPACK of higher secondary school teachers with reference to their age.

Age	N	Mean Value	df	SD	Calculated t- value	Critical value	Sig Level
						0.05 0.01	
Below 40	136	15.40		2.65			
Above 40	64	17.41	198	2.05	6.09	1.97 2.60	*

***Significant at 0.01 level**

Looking at Table 4.11, it shows that the calculated t-value is 6.09 which is more than the critical value at 0.01 and 0.05 level. This means that there is a significant difference in self-perceived TPACK between teachers' age groups. Thus, the hypothesis (No.3) stating "there is no statistically significant relationship in higher secondary school teachers of Mizoram on self-perceived technological pedagogical content knowledge based on their age was rejected. Teachers below 40 years of age have better mean score of 17.41 in comparison with teachers above 40 years of age who have a mean score 15.40. It can be concluded that there is a significant difference among higher secondary school teachers based on age in their self-perceived technological pedagogical content knowledge.

4.2.4 Difference in self-perceived TPACK with reference to teaching experience.

Hypothesis no4. states that "There is no statistically significant relationship in higher secondary school teachers of Mizoram on self-perceived technological pedagogical content knowledge based on teaching experience."

The following table and figure show the comparison of teachers' teaching experience with respect to their self-perceived TPACK.

Table 4.12
Norms for interpretation of self-perceived TPACK with reference to teaching experience based on z-score

Level of self-perceived expertise		High	Moderate	Low
Range		Above Mean + 1SD	Mean -1SD to Mean +1SD	Below Mean-1SD
Range of score				
TK	Below 10	Above 16	12 - 15	Below 11
	Above 10	Above 14	10 - 13	Below 9
PK	Below 10	Above 23	17 – 22	Below 16
	Above 10	Above 22	14 - 21	Below 13
CK	Below 10	Above 23	18 - 22	Below 17
	Above 10	Above 22	15 -21	Below 14
TPK	Below 10	Above 23	18 - 22	Below 16
	Above 10	Above 22	15 - 21	Below 14
TCK	Below 10	Above 16	11 - 15	Below 10
	Above 10	Above 14	10 - 13	Below 9
PCK	Below 10	Above 16	11 - 15	Below 10
	Above 10	Above 14	11 - 13	Below 10
TPACK	Below 10	Above 27	22 - 25	Below 21
	Above 10	Above 26	19 - 24	Below 10

Table 4.12 presents the norms for interpreting the levels of teachers' self-perceived TPACK with reference to their teaching experience, based on z-scores. The levels are categorized as High, Moderate, and Low for teachers with below 10 years and above 10 years of teaching experience across the seven TPACK domains (TK, PK, CK, TPK, TCK, PCK, and overall TPACK).

Teachers whose scores are above one standard deviation from the mean are classified as having a High level of knowledge, those within one standard deviation

above or below the mean as Moderate, and those below one standard deviation from the mean as Low. The table provides the specific score ranges for each group and domain.

Overall, the norms indicate that teachers with less than 10 years of experience generally had slightly higher score cut-offs, suggesting that they perceived themselves as having somewhat higher levels of TPACK compared to teachers with more than 10 years of experience.

Table 4.13
Teachers' teaching experience level of self-perceived TPACK

Domains	Below 10	Above 10		High	Moderate	Low
	(n=125)	(n=75)				
	Teaching experience	Mean	SD			
TK	Below 10	13.43	2.02	17	98	10
				13.6%	78.4%	8%
	Above 10	11.68	1.71	6	60	9
				8%	80%	12%
PK	Below 10	19.68	2.75	18	80	27
				14.4%	64%	21.6%
	Above 10	17.63	3.67	15	48	12
				20%	64%	16%
CK	Below 10	19.62	2.55	12	86	27
				9.6%	68.8%	21.6%
	Above 10	17.97	3.72	15	42	18
				20%	56%	24%
TPK	Below 10	19.53	2.72	19	80	26
				15.2%	64%	20.8%
	Above 10	17.67	3.64	9	48	18
				12%	64%	24%

TCK	Below 10	13.08	2.20	17	105	3
				13.6%	84%	2.4%
	Above 10	11.51	1.76	11	53	11
				14.6%	70.6%	14.6%
PCK	Below 10	12.99	2.19	17	104	4
				13.6%	83.2%	3.2%
	Above 10	11.72	1.60	6	54	15
				8%	72%	20%
TPACK	Below 10	23.30	1.91	4	105	16
				3.2%	84%	12.8%
	Above 10	22.04	3.24	8	57	10
				10.6%	76%	13.3%

The table presents the comparison of higher secondary school teachers' self-perceived TPACK across seven domains according to their teaching experience — teachers with less than 10 years of experience and those with more than 10 years.

Overall, teachers with below 10 years of experience scored higher mean values in all TPACK domains compared to those with above 10 years of experience. For instance, teachers with less than 10 years of experience had a higher mean in Technological Knowledge (TK) ($M = 13.43$, $SD = 2.02$) than those with over 10 years of experience ($M = 11.68$, $SD = 1.71$). A similar trend is seen in Technological Pedagogical Knowledge (TPK) ($M = 19.53$ vs. 17.67) and Technological Content Knowledge (TCK) ($M = 13.08$ vs. 11.51).

In all domains, the majority of both groups fell within the moderate level of self-perceived knowledge, but a higher percentage of teachers with fewer years of experience appeared in the high-level category across most domains. For example, 15.2 % of teachers below 10 years of experience reported high TPK compared to only 12 % of those above 10 years. Likewise, in the overall TPACK domain, 3.2 % of the less-experienced teachers had high self-perceived TPACK, while 10.6 % of the more-

experienced teachers rated themselves high, though the majority in both groups remained at the moderate level (84 % and 76 %, respectively).

This pattern indicates that while both groups generally perceive themselves to have an average level of TPACK, teachers with less than 10 years of experience tend to have slightly higher technological and integrative knowledge than those with longer experience. This may be because younger teachers or those newer to the profession have had more recent exposure to ICT tools and digital pedagogy during their training, leading to higher self-confidence in using technology for teaching.

Table no. 4.14 shows the calculation of t-test of higher secondary school teachers with respect to their teaching experience.

Table no: 4.14

Difference in self-perceived TPACK of higher secondary school teachers with reference to their teaching experience.

Teaching Experience	N	Mean Value	df	SD	Calculated t- value	Critical value	Sig Level
						0.05 0.01	*
Below 10	125	17.38		2.33			
Above 10	75	15.74	198	2.76	4.43	1.97 2.60	*

***= Significant at 0.01 level**

The above table shows the comparison of self-perceived Technological, Pedagogical, and Content Knowledge (TPACK) of higher secondary school teachers based on their teaching experience. Teachers with less than 10 years of experience (N = 125) have a mean score of 17.38 with a standard deviation of 2.33, whereas those with more than 10 years of experience (N = 75) have a mean score of 15.74 with a standard deviation of 2.76. The calculated t-value 4.43 exceeds both the critical values at the 0.05 level (1.97) and the 0.01 level (2.60), indicating that the difference is

statistically significant at the 0.01 level. Thus, the hypothesis (No.4) stating “there is no statistically significant relationship in higher secondary school teachers of Mizoram on self-perceived technological pedagogical content knowledge based on their teaching experience was rejected. This result implies that there is a significant difference in self-perceived TPACK between teachers of different teaching experience levels. Specifically, teachers with less than 10 years of teaching experience demonstrate significantly higher self-perceived TPACK compared to those with more than 10 years of experience.

4.2.5 Difference in self-perceived TPACK based on ICT Training

Hypothesis no5. states that “There is no statistically significant relationship in higher secondary school teachers of Mizoram on self-perceived technological pedagogical content knowledge based on ICT training.”

To examine the impact of ICT training on teachers’ TPACK competencies, the mean scores of teachers with and without ICT training were compared across the various TPACK domains. The following table shows the comparison of teachers’ self-perceived TPACK with reference to ICT training.

Table 4.15
Comparison of Teachers’ Mean Scores on TPACK Domains Based on ICT Training

Domains	<i>Yes (n=107)</i>		<i>No (n= 93)</i>	
	<i>Mean</i>	<i>SD</i>	<i>Mean</i>	<i>SD</i>
TK	15.40	1.05	12.26	1.37
TPK	19.40	1.30	19.06	1.75
PCK	15.36	1.19	11.97	1.16
TPACK	25.32	0.78	20.70	3.47
OVERALL	18.45	3.35	16.96	3.49

The comparison between teachers with ICT training (Yes = 107) and those without ICT training (No = 93) shows that teachers who have undergone ICT training scored higher across all TPACK domains. Specifically, the mean scores for teachers with ICT training were higher in Technological Knowledge (TK = 15.40, SD = 1.05), Technological Pedagogical Knowledge (TPK = 19.40, SD = 1.30), Pedagogical Content Knowledge (PCK = 15.36, SD = 1.19), and overall Technological Pedagogical and Content Knowledge (TPACK = 25.32, SD = 0.78) compared to teachers without ICT training (TK = 12.26, SD = 1.37; TPK = 19.06, SD = 1.75; PCK = 11.97, SD = 1.16; TPACK = 20.70, SD = 3.47).

The table indicates that teachers who received ICT training scored higher in all TPACK domains—Technological Knowledge (TK), Technological Pedagogical Knowledge (TPK), Pedagogical Content Knowledge (PCK), and overall TPACK—compared to teachers without ICT training. This difference can be attributed to the enhanced technological understanding gained through ICT training, which not only improves their TK but also enables them to effectively integrate technology with pedagogy and content, thereby raising their overall TPACK scores.

Moreover, teachers with ICT training appeared to face fewer challenges in selecting appropriate technologies to support and enhance their teaching strategies. In addition to technology-related competencies, these teachers also demonstrated higher PCK, suggesting that the training helped them organize and sequence teaching content more efficiently than their non-trained counterparts. This implies that ICT training not only strengthens teachers' ability to integrate technology in the classroom but also positively influences broader aspects of teaching and learning, including pedagogical planning and content delivery.

Table no. 4.13 shows the calculation of t-test of higher secondary school teachers with respect to ICT training.

Table 4.16

Difference in self-perceived TPACK of higher secondary school teachers with reference to their ICT Training

ICT training	N	Mean Value	df	SD	Calculated t- value	Critical value	Sig Level
						0.05 0.01	*
Trained	107	18.45		3.35			
Untrained	93	16.87	198	3.45	3.43	1.97 2.60	*

***Significant at 0.01 level**

The table shows the difference in self-perceived TPACK of higher secondary school teachers with reference to their ICT training. The mean score of teachers who had ICT training (Mean = 18.45, SD = 3.35) was higher than those without ICT training (Mean = 16.87, SD = 3.45). The calculated *t*-value (3.43) exceeded the critical values at both 0.05 (1.97) and 0.01 (2.60) significance levels. This indicates that the difference is statistically significant at the 0.01 level. Thus, the hypothesis (No.5) stating “there is no statistically significant relationship in higher secondary school teachers of Mizoram on self-perceived technological pedagogical content knowledge based on their ICT training was rejected. Therefore, it can be concluded that teachers who received ICT training have significantly higher self-perceived TPACK compared to teachers who did not receive ICT training. This suggests that ICT training plays a crucial role in enhancing teachers’ technological, pedagogical, and content integration skills.

4.3.0 RELATIONSHIP OF HIGHER SECONDARY SCHOOL TEACHERS SELF- PERCEIVED EXPERTISE IN TPACK AND ITS EFFECTIVENESS IN TEACHING.

In order to assess the effectiveness of higher secondary school teachers in classroom teaching, an observation schedule was employed. The schedule consisted of seven major criteria: lesson planning, teacher’s knowledge, medium of instruction, teaching methods, classroom management, assessment practices, and homework/assignments. Each criterion was rated on a three-point scale (3 = Strong, 2

= Apparent, 1 = Not Displayed). Data collected from classroom observations were analyzed for each criterion, as shown in the following table.

Table 4.17
Effectiveness of higher secondary school teachers in classroom teaching

Sl. No.	Observation Criteria	Rating (N=40)		
		3=strong	2=apparent	1=not displayed
1	The teacher plans effectively and sets clear objectives that are understood.	14 (35%)	26 (65%)	0
2	The teacher shows knowledge and understanding.	26 (65%)	14 (35%)	0
3	Medium of instruction.	3 (7.5%)	33 (82.5%)	4 (10%)
4	Teaching methods used enable all students to learn effectively.	18 (45%)	22 (55%)	0
5	Classroom management	7 (17.5%)	33 (82.5%)	0
6	Assessment.	15 (37.5%)	23 (57.5%)	2 (5%)
7	Homework and assignments	25 (60%)	15 (37.5%)	0

The above table shows that regarding teacher planning, most teachers (65%) showed planning that was apparent, while 35% displayed strong planning. None failed to show this skill. While in knowledge and understanding, a majority (65%) demonstrated strong knowledge, and 35% were apparent, indicating good subject mastery. Again, regarding medium of instruction, most teachers (82.5%) used the

medium apparently, while only 7.5% were strong, and 10% did not display effective language use.

More than half (55%) used teaching methods apparently, and 45% used them strongly, showing moderate variation in teaching strategies while a very high percentage (82.5%) were apparent, while only 17.5% were strong, meaning management was adequate but not outstanding.

Again, more than half (57.5%) applied assessment apparently, 37.5% strongly, and 5% did not display any assessment during observation. And regarding homework and assignment, majority (60%) strongly provided homework, and 37.5% were apparent, indicating this is well-practiced.

Hypothesis no.6 states that ‘There is no statistically significant relationship in higher secondary school teachers self-perceived expertise in TPACK and its effectiveness in teaching’.

In order to find out the relationship between self-perceived expertise in TPACK and teaching effectiveness of higher secondary school teachers in Mizoram, Pearson Product Moment Correlation Coefficient (r) was employed.

Table 4.18
Relationship between self-perceived expertise in TPACK and teaching effectiveness of higher secondary school teachers in Mizoram. N=40

Variables	Critical r value		Calculated r	Significance
Self-perceived expertise	0.05	0.01		
Teaching effectiveness	0.325	0.418	0.77	significant

Table 4.18 indicates that the r value is 0.77 in relation to the correlations between self-perceived expertise in TPACK and teaching effectiveness of higher secondary school teachers, which is high correlation or marked relationship. By looking at the critical table, it reveals that the r value at 0.05 and 0.01 levels of significance are 0.325 and 0.418 respectively. Since the calculated r value is higher than the critical value of r , it may be concluded that there is significantly positive correlation between self-perceived expertise in TPACK and teaching effectiveness of higher secondary school teachers. Thus, the hypothesis (no.6) stating that ‘There is no statistically significant relationship in higher secondary school teachers self-perceived expertise in TPACK and its effectiveness in teaching’ was rejected. This implies that with greater self-perceived expertise in TPACK, their teaching effectiveness will also increase.

4.4.0 PROBLEMS FACED BY THE HIGHER SECONDARY SCHOOL TEACHERS OF MIZORAM IN INTEGRATING TECHNOLOGY IN TEACHING

The integration of technology in teaching among higher secondary school teachers in Mizoram is influenced by multiple factors related to infrastructure, training, time constraints, and teacher perceptions. The analysis of the responses reveals the following findings

Table 4.19

Problems faced by the higher secondary school teachers of Mizoram in integrating technology in teaching

Sl No.	Items	Yes	No
		N= 200	
1	Computers and other technological devices are not available in the classroom	104 (52%)	96 (48%)

2	Institution and teacher prepare themselves to make students work together on various devices.	114 (57%)	86 (43%)
3	Proper and timely guidance are provided to teachers for effective use of technology	85 (42.5%)	115 (57.5%)
4	Teacher interacts and engages with students through various technology-based learning	107 (53.5%)	93 (46.5%)
5	Fear of unknowns with new technologies and scared to experiment with new technologies	49 (24.5%)	151 (75.5%)
6	Appropriate training and technical support are provided	77 (38.5%)	123 (61.5%)
7	Shortage of time to practice with new and ever-changing technologies	129 (64.5%)	71 (35.5%)
8	Professional training or workshops have prepared teachers to integrate digital technology in their teaching effectively	93 (46.5%)	107 (53.5%)
9	Preparing lessons to include new technologies can be time consuming	119 (59.5%)	81 (40.5%)
10	Teachers do not have computers or other technological devices, have sufficient data or internet access at home.	56 (28%)	144 (72%)
11	School does not have the network infrastructure needed to support teaching.	81 (40.5%)	119 (59.5%)
12	Sufficient funds are available to implement and sustain technology in the classroom.	103 (51.5%)	97 (48.5%)
13	Adoption of new technological tools or devices in a classroom setting is a major challenge for a teacher.	138 (69%)	62 (31%)

14	Utilizing technology in a curriculum may help teacher to boost their comfort and teaching effectiveness.	187 (93.5%)	13 (6.5%)
-----------	--	----------------	--------------

Table 4.19 of the analysis reveals that the primary challenges are related to time constraints, adoption difficulties, and lack of professional support.

The results indicate that the most widely perceived problems and challenges are:

Rank	Problem Item	Teacher Agreement ('Yes')	Interpretation
1	Adoption of new technological tools or devices in a classroom setting is a major challenge for a teacher. (Item 13)	69% (138 respondents)	This is the single most agreed-upon challenge, highlighting that the act of integrating new tools into the pedagogical routine is the greatest hurdle.
2	Shortage of time to practice with new and ever-changing technologies. (Item 7)	64.5% (129 respondents)	Time constraints are a critical infrastructural barrier, suggesting that teacher workloads do not permit adequate time for professional development and practice.
3	Preparing lessons to include new technologies can be time consuming. (Item 9)	59.5% (119 respondents)	This directly reinforces the time constraint issue, specifying that lesson planning is significantly impacted and slowed down by technology integration.

The analysis further highlights that 52% of teachers reported that computers and other technological devices are not available in their classrooms.

It is also found that 57% of respondents stated that teachers and institutions are preparing themselves to help students collaborate using various devices. This shows that while efforts are being made, a substantial 43% are still not engaged in such preparatory practices, indicating inconsistency across schools.

The above table also shows that only 42.5% of teachers reported receiving proper and timely guidance for the effective use of technology. While 53.5% of teachers stated they interact with students through various technology-based learning activities and only 24.5% of teachers expressed fear of unknown technologies or hesitation in experimenting with them.

The table also indicates that only 38.5% of teachers confirmed they receive appropriate training and technical support. It is also found that only 46.5% agreed that professional training or workshops have adequately prepared them.

The table also reveals that only 28% of teachers reported not having devices or sufficient internet access at home. While 40.5% indicated their schools do not have the necessary network infrastructure to support digital teaching.

While 51.5% believed sufficient funds are available to implement and sustain technology in the classroom and a strong 93.5% agreed that utilizing technology can boost their comfort and teaching effectiveness. This overwhelmingly positive perception highlights that most teachers are not opposed to using technology, instead, they are constrained by external barriers.

4.5.0 THE PERCEIVED EXPERIENCE OF STUDENTS ON THE EFFECTIVENESS OF TEACHING OF HIGHER SECONDARY SCHOOL TEACHERS OF MIZORAM USING TPACK.

To assess the effectiveness of teaching among higher secondary school teachers of Mizoram, a student perception survey was conducted using a structured questionnaire based on TPACK components. Responses were collected from 307 students, and the results are presented in Table no. 4.12. The responses were categorized into three levels: Poor/Low (Below 30%), Average/Moderate (30%–50%), Good/High (Above 50%)

Table: 4.20

The perceived experience of students on the effectiveness of teaching of higher secondary school teachers

Sl No.	Areas	Poor/Low 30%	Average /Moderate 50%	Good / High above 50%
		(n=307)		
1	Teaching Methods	1.95% (6)	51.46% (158)	46.57% (143)
2	Knowledge of the content he/she teaches	3.25% (10)	41.69% (128)	61.56% (189)
3	Effective use of technology	39.73% (122)	48.2% (148)	12.05% (37)
4	Initiative / Strategies	7.81% (24)	71.98% (221)	19.86% (61)
5	Creativity	11.4% (35)	58.63% (180)	29.96% (92)

6	Enthusiasm	9.44% (29)	59.6% (183)	31.27% (96)
7	Ability to work with supervisors/principal/head	6.84% (21)	42.34% (130)	51.14% (157)
8	Ability to work with peers	5.53% (17)	47.55% (146)	46.9% (144)
9	Rapport with parents	14.65% (45)	56.02% (172)	29.31% (90)
10	Rapport with students	10.74% (33)	49.83% (153)	42.67% (131)
11	Classroom planning	18.56% (57)	46.57% (143)	34.85% (107)
12	Ability to maintain discipline	5.21% (16)	32.57% (100)	62.21% (191)
13	Willingness to improve professionally	5.53% (17)	45.92% (141)	48.53% (149)
14	Overall teaching success	2.6% (8)	44.29% (136)	53.09% (163)

The data in the above table reveals that the majority of students rated teachers' knowledge of the content and ability to maintain discipline at a high level (61.56% and 62.21%, respectively). This indicates that teachers were strong in subject expertise and classroom control. The overall teaching success was also rated highly by more than half of the respondents (53.09%), reflecting students' overall satisfaction with the teachers' performance. Additionally, areas such as willingness to improve professionally (48.53%) and ability to work with supervisors and peers (51.14% and 46.90%) were perceived positively by a considerable number of students.

On the other hand, the effective use of technology emerged as the weakest area, with 39.73% rating it poor/low and only 12.05% rating it high, indicating that technology integration remains a challenge despite the TPACK framework emphasis. Similarly, initiative/strategies, creativity, and rapport with parents were mostly in the moderate range, showing scope for improvement in innovative teaching practices and parent-teacher communication.

The findings suggest that while teachers are strong in content knowledge and classroom discipline, there is a clear need for professional development in technology integration, creative teaching strategies, and parent engagement to achieve comprehensive teaching effectiveness aligned with TPACK principles.

CHAPTER V

MAJOR FINDINGS AND DISCUSSIONS, EDUCATIONAL IMPLICATIONS, RECOMMEDATIONS AND SUGGESTIONS FOR FURTHER RESEARCH

The present chapter deals with the major findings, discussions, educational implications, suggestions for further research and to make recommendations for improving Technological, Pedagogical and Content Knowledge of Higher Secondary School Teachers and Teaching Effectiveness.

5.1.0 MAJOR FINDINGS

5.1.1 Findings regarding the self-perceived level of TPACK of higher secondary school teachers in Mizoram.

- The analysis of data highlights teachers' self-perceived levels of knowledge across the seven domains of the TPACK framework, revealing notable variations in their competencies. In the Technological Knowledge (TK) domain, teachers reported a mean score of 13.72 (SD = 1.99), indicating a moderate level of technological proficiency. Most teachers (68%) perceived their technological knowledge as average, while 15.5 percent and 16.5 percent rated themselves as having good and poor knowledge, respectively.
- In the Pedagogical Knowledge (PK) domain, the mean score was 17.51 (SD = 2.56), reflecting a relatively strong understanding of teaching strategies. The majority (78.5%) assessed themselves at an average level, with (9%) and (12.5%) reporting good and poor knowledge, respectively. For Content Knowledge (CK), teachers obtained a mean score of 17.58 (SD = 2.33). While (61.5%) rated themselves as average, (17.5%) reported good knowledge, and (21%) fell into the poor category, indicating some inconsistency in subject-matter confidence.
- Regarding the integration domains, Technological Pedagogical Knowledge (TPK) had a mean of 17.70 (SD = 2.44), showing moderate competence in combining technology with pedagogy. Most teachers (71.5%) considered themselves average, (9.5%) good, and (19%) poor in

this domain. Technological Content Knowledge (TCK) recorded a mean of 13.86 (SD = 1.87), with 74 percent at an average level, 16.5 percent good, and 9.5 percent poor, suggesting a fairly stable but moderate understanding of the relationship between technology and subject content. In Pedagogical Content Knowledge (PCK), the mean score was 13.78 (SD = 2.06); 67 percent of teachers were average, while 19 percent and 14 percent demonstrated good and poor knowledge, respectively, indicating a moderate ability to connect pedagogy with content.

- The overall TPACK score revealed a mean of 23.17 (SD = 3.35), with the vast majority of teachers (85%) perceiving themselves as having average integrated knowledge. Only (2.5%) rated themselves as having good TPACK, whereas 12.5 percent reported poor levels.
- An examination of individual statement means identified the highest and lowest rated items across domains. The highest mean (M = 4.49, SD = 0.68) was observed in the TCK domain, suggesting that most teachers were proficient in using technology to demonstrate subject concepts. Conversely, the lowest mean (M = 3.30, SD = 1.11) appeared in the TPK domain, indicating limited ability among teachers to engage students in higher-order thinking—such as problem-solving, critical thinking, and decision-making—through technological tools.

5.1.2 Findings regarding the self-perceived TPACK of higher secondary school teachers in Mizoram with reference to educational discipline.

- The comparison of higher secondary school teachers' self-perceived TPACK across Science and Arts disciplines revealed that both groups generally perceive themselves at a moderate level in all domains, with science teachers reporting slightly higher mean scores across the board. Science teachers showed greater confidence in integrating technology into teaching, particularly in TPK (M = 17.91) and TCK (M = 14.59), compared to arts teachers (M = 16.64 and 13.66, respectively). A higher proportion of science teachers fell into the high-level category, while arts teachers had

more respondents in the low-level category, especially in TPK, TCK, and PCK, indicating weaker integration of technology and pedagogy. Overall TPACK scores were also higher for science teachers ($M = 22.10$) than arts teachers ($M = 21.86$). Statistical analysis confirmed a significant difference between the two groups at the 0.05 level ($t = 2.48$), supporting the hypothesis that educational discipline influences teachers' self-perceived TPACK.

5.1.3 Findings regarding the self-perceived TPACK of higher secondary school teachers in Mizoram with reference to their gender.

- The comparison of male and female higher secondary school teachers' self-perceived TPACK revealed that both groups generally fall within the moderate level across all domains, though some differences are evident. Male teachers recorded slightly higher mean scores in most domains, including TK ($M = 13.55$), PK ($M = 19.21$), and TPK ($M = 19.25$), compared to female teachers ($M = 12.70, 18.35$, and 17.81 , respectively). Similar trends were found in TCK and PCK, suggesting that male teachers perceive themselves as more confident in technological and pedagogical aspects of teaching. In contrast, female teachers obtained a slightly higher mean score in the overall TPACK domain ($M = 22.10$) than males ($M = 21.91$), reflecting comparable overall integration of technology, pedagogy, and content.
- A higher proportion of male teachers were found in the high-level category, particularly in TK, PK, and PCK, while most female teachers remained within the moderate range across all domains. This indicates that male teachers tend to show greater confidence in technology use, whereas female teachers demonstrate more consistency and balance across domains. The calculated t-value (2.24) exceeded the critical value at the 0.05 level, confirming a statistically significant difference in self-perceived TPACK between male and female teachers. Therefore, Hypothesis 3 was accepted,

establishing that gender significantly influences self-perceived TPACK among higher secondary school teachers in Mizoram.

5.1.4 Findings regarding the self-perceived TPACK of higher secondary school teachers in Mizoram with reference to their age.

- The findings indicate that teachers below 40 years of age have higher mean scores across all TPACK domains compared to those above 40 years. In the Technological Knowledge (TK) domain, younger teachers achieved a higher mean ($M = 14.08$, $SD = 1.66$) than older teachers ($M = 13.22$, $SD = 2.18$). This pattern continues across other domains, including Pedagogical Knowledge (PK) ($M = 18.91$ vs. 16.13), Technological Pedagogical Knowledge (TPK) ($M = 18.51$ vs. 15.92), and Technological Pedagogical and Content Knowledge (TPACK) ($M = 23.16$ vs. 20.88), indicating greater confidence and integration of technology among younger teachers.
- In terms of knowledge levels, most teachers in both age groups fell within the moderate range; however, a higher proportion of younger teachers were represented in the high-level category across all domains. For instance, 17.6 percent of teachers below 40 years reported high TK, compared to only 9.3 percent of those above 40 years. Similarly, in the overall TPACK domain, 18.3 percent of younger teachers rated themselves high, while only 3.1 percent of older teachers did so. Conversely, a larger percentage of teachers above 40 years fell into the low-level category, particularly in technology-related domains such as TK, TPK, and TCK—for example, 26.5 percent of older teachers demonstrated low TK compared to 11 percent among younger teachers.
- Statistical analysis revealed a t-value of 6.09, which exceeds the critical value at both 0.05 and 0.01 significance levels, confirming a significant difference in self-perceived TPACK between age groups. Consequently, Hypothesis 4, which states that “there is a statistically significant relationship in self-perceived TPACK among higher secondary school

teachers of Mizoram based on age,” was accepted. Teachers below 40 years recorded a higher overall mean score ($M = 17.41$) compared to those above 40 years ($M = 15.40$), indicating that younger teachers possess significantly higher self-perceived technological, pedagogical, and content integration skills.

5.1.5 Findings regarding the self-perceived TPACK of higher secondary school teachers in Mizoram with reference to their teaching experience.

- The comparison of self-perceived TPACK based on teaching experience revealed that teachers with less than 10 years of experience scored higher across all domains than those with more than 10 years. Less-experienced teachers demonstrated stronger technological and integrative abilities, particularly in TK ($M = 13.43$ vs. 11.68), TPK ($M = 19.53$ vs. 17.67), and TCK ($M = 13.08$ vs. 11.51). This suggests that newer teachers are more confident in using technology in their teaching practices. Although both groups predominantly fell within the moderate category, a greater proportion of teachers with fewer years of experience were represented in the high-level category across domains.
- For example, 15.2 percent of less-experienced teachers reported high TPK compared to 12 percent among more-experienced teachers. The overall TPACK mean was also higher for teachers with less than 10 years of experience ($M = 17.38$) than those with more than 10 years ($M = 15.74$). This difference may reflect younger teachers’ greater exposure to ICT training and digital tools during their professional preparation. The calculated t-value (4.43) exceeded the critical values at both 0.05 and 0.01 levels, confirming a statistically significant difference. Therefore, Hypothesis 5 was accepted, indicating that teachers with less teaching experience possess significantly higher self-perceived TPACK than their more-experienced counterparts.

5.1.6 Findings regarding the self-perceived TPACK of higher secondary school teachers in Mizoram with reference to ICT training.

- The comparison between teachers with and without ICT training revealed that those who had undergone ICT training demonstrated higher self-perceived TPACK across all domains. Teachers with ICT training ($n = 107$) scored higher mean values in Technological Knowledge ($TK = 15.40$, $SD = 1.05$), Technological Pedagogical Knowledge ($TPK = 19.40$, $SD = 1.30$), Pedagogical Content Knowledge ($PCK = 15.36$, $SD = 1.19$), and overall TPACK ($M = 25.32$, $SD = 0.78$), compared to teachers without ICT training ($n = 93$) who scored $TK = 12.26$ ($SD = 1.37$), $TPK = 19.06$ ($SD = 1.75$), $PCK = 11.97$ ($SD = 1.16$), and overall TPACK = 20.70 ($SD = 3.47$).
- The overall mean difference (trained = 18.45 , $SD = 3.35$; untrained = 16.87 , $SD = 3.45$) was found to be statistically significant, as indicated by the calculated t-value (3.43) exceeding the critical values at both 0.05 (1.97) and 0.01 (2.60) levels. Hence, the hypothesis stating that there is a statistically significant difference in self-perceived TPACK of higher secondary school teachers of Mizoram based on ICT training was accepted.
- These findings clearly suggest that ICT training substantially enhances teachers' technological, pedagogical, and content integration abilities. Teachers who received ICT training not only possessed stronger technological knowledge but also demonstrated improved capacity to integrate technology with pedagogy and subject content effectively. The training likely contributed to greater confidence in selecting and applying appropriate technological tools to enrich classroom instruction.
- Furthermore, ICT-trained teachers exhibited higher Pedagogical Content Knowledge, indicating that the training may have helped them organize and present content more efficiently and adopt diverse instructional strategies. Thus, ICT training appears to play a pivotal role in developing

teachers' holistic professional competence by strengthening their understanding and application of technology in teaching and learning.

5.1.7 Findings regarding the effectiveness of higher secondary school teachers in Mizoram in their classroom teaching.

- The findings of the study revealed that in terms of teacher planning, a majority of teachers (65%) exhibited planning that was apparent, while (35%) demonstrated strong planning, and none failed to display this skill. Regarding knowledge and understanding, most teachers (65%) showed a strong level of subject knowledge, whereas (35%) displayed it at an apparent level, reflecting good mastery of the subject matter. In relation to the medium of instruction, the majority of teachers (82.5%) used the language of instruction at an apparent level, (7.5%) showed strong proficiency, while (10%) were found to be less effective in their language use.
- The findings indicated that more than half of the teachers (55%) employed teaching methods at an apparent level, while 45 percent demonstrated strong use, suggesting moderate variation in their teaching strategies. With regard to classroom management, a very high proportion (82.5%) exhibited apparent performance, whereas only 17.5 percent showed strong management skills, indicating that overall management was adequate but not exceptional.
- The findings further revealed that more than half of the teachers (57.5%) applied assessment practices at an apparent level, (37.5%) demonstrated strong application, while (5%) did not display any assessment during observation. In terms of homework and assignments, 60% provided them strongly, and (37.5%) at an apparent level, indicating that assigning homework and related tasks is a well-established and consistently practiced aspect of their teaching.

5.1.8 Findings regarding the relationship between self-perceived expertise in TPACK and teaching effectiveness of higher secondary school teachers in Mizoram.

- The analysis of the relationship between self-perceived expertise in TPACK and teaching effectiveness of higher secondary school teachers revealed a correlation coefficient (R value) of 0.77, which indicates a high and positive relationship between the two variables. When compared with the critical values of r (0.325 at the 0.05 level of significance and 0.418 at the 0.01 level), it is evident that the obtained value is substantially higher than both. Hence, it can be concluded that there exists a significant positive correlation between self-perceived expertise in TPACK and teaching effectiveness among higher secondary school teachers. In other words, teachers who perceive themselves as more competent and knowledgeable in integrating technology, pedagogy, and content are likely to be more effective in their classroom teaching practices. This implies that as teachers' self-perceived TPACK expertise increases, their teaching effectiveness also tends to improve.

5.1.9 Findings on problems faced by the higher secondary school teachers of Mizoram in integrating technology in teaching

- The adoption of new technological tools in classroom settings emerged as the most significant challenge (69%), indicating that teachers struggle most with incorporating new devices into daily teaching.
- Shortage of time to practice and update technological skills was reported by 64.5 percent of teachers, highlighting workload and scheduling limitations.
- Preparing technology-integrated lessons was seen as time-consuming by 59.5 percent, reinforcing time constraint as a persistent issue.

- Regarding infrastructure and access Issues, 52 percent of teachers reported that computers and other digital devices were not available in their classrooms and 28 percent lacked access to devices or stable internet at home, and 40.5 percent indicated that their schools lacked adequate network infrastructure to support digital instruction.
- In terms of training and professional support, only 38.5 percent of teachers received adequate technical training and support, and 46.5 percent felt that professional workshops had effectively prepared them for technology use and just 42.5 percent reported receiving timely guidance on technology integration, indicating insufficient institutional support.
- In teacher attitudes and practices, 53.5 percent of teachers engaged students in technology-based learning activities. Only 24.5 percent expressed fear or hesitation toward using new technologies, suggesting that resistance is not widespread and a strong 93.5 percent agreed that using technology enhances their comfort and teaching effectiveness, showing high willingness despite practical barriers.
- The findings reveals that regarding institutional readiness, 57 percent of teachers stated that schools are making efforts to help students collaborate using digital tools, though 43 percent reported limited engagement, revealing inconsistency in institutional preparedness. 51.5 percent believed that sufficient funds are available for sustaining technology-based teaching, though utilization may vary by school.

5.1.10 Findings regarding the perceived experience of students on the effectiveness of teaching of higher secondary school teachers of Mizoram using TPACK.

- **The perceived experience of students on the effectiveness of teaching of higher secondary school teachers revealed the following:**

- 51.46 percent of students rated teachers' teaching methods as average or moderate, while 46.57 percent found them good or high, and only 1.95 percent rated them as poor.
- In terms of knowledge of the content taught, 61.56 percent of students rated teachers high, 41.69 percent moderate, and only 3.25 percent low, showing that teachers were generally well-versed in their subject matter.
- Regarding effective use of technology, 48.2 percent perceived it as moderate, 39.73 percent as low, and only 12.05 percent as high, indicating a comparatively weaker area among teachers.
- On initiative and strategies, 71.98 percent rated teachers moderate, 19.86 percent high, and 7.81 percent low, suggesting that most teachers were average in adopting new strategies.
- Concerning creativity, 58.63 percent of students rated teachers moderate, 29.96 percent high, and 11.4 percent low.
- In terms of enthusiasm, 59.6 percent rated teachers moderate, 31.27 percent high, and 9.44 percent low.
- For ability to work with supervisors or heads, 51.14 percent rated teachers high, 42.34% moderate, and 6.84 percent low, indicating good professional relationships.
- Regarding ability to work with peers, 47.55 percent rated teachers moderate, 46.9 percent high, and 5.53 percent low, showing healthy collegial interactions.
- On rapport with parents, 56.02 percent rated teachers moderate, 29.31 percent high, and 14.65 percent low, reflecting a need for improvement in parent–teacher communication.
- For rapport with students, 49.83 percent rated teachers moderate, 42.67 percent high, and 10.74 percent low, suggesting generally positive teacher–student relationships.
- Regarding classroom planning, 46.57 percent rated teachers moderate, 34.85 percent high, and 18.56 percent low, indicating scope for better planning.

- On ability to maintain discipline, 62.21 percent rated teachers high, 32.57 percent moderate, and only 5.21 percent low, highlighting this as a strong area.
- For willingness to improve professionally, 48.53 percent rated teachers high, 45.92 percent moderate, and 5.53 percent low, indicating a generally positive attitude toward professional growth.
- Finally, overall teaching success was rated high by 53.09 percent of students, moderate by 44.29 percent, and low by only 2.6 percent, reflecting overall effective teaching performance among higher secondary teachers.

5.2 DISCUSSION ON FINDINGS OF THE PRESENT STUDY

5.2.1 Discussion on the findings relating to the self-perceived level of TPACK of higher secondary school teachers in Mizoram.

- The findings revealed that teachers generally perceived themselves to have a moderate level of knowledge across all seven TPACK domains, with relatively higher scores in Pedagogical Knowledge (PK) and Content Knowledge (CK) and lower scores in the integrative domains such as Technological Pedagogical Knowledge (TPK) and Technological Content Knowledge (TCK). This pattern is consistent with previous studies (Koehler & Mishra, 2009; Doukakis et al., 2021) showing that teachers tend to feel more confident in pedagogy and subject matter than in integrating technology with teaching. The highest-rated statement under TCK suggested teachers could use technology to demonstrate subject concepts, while the lowest-rated TPK item showed difficulty in engaging students in higher-order thinking using technology.
- This may indicate that while teachers are comfortable using technology for presentation and explanation, they struggle to apply it for interactive or inquiry-based learning. Similar results were observed by Jiménez Sierra et al. (2023), who reported that teachers often develop technological and

pedagogical knowledge separately, without deep integration. Limited exposure to ICT-focused training, inadequate infrastructure, and exam-oriented classroom practices could also explain these moderate perceptions. Moreover, heavy teaching loads and lack of institutional support might prevent teachers from experimenting with technology-enhanced pedagogy.

- Overall, the findings imply that teachers in Mizoram possess a sound foundational understanding of technology, pedagogy, and content, but need more support to develop the ability to integrate these domains effectively. Professional development that emphasises technology-integrated lesson design and collaborative practice could help strengthen teachers' overall TPACK competence.

5.2.2 Discussion on the findings relating to the comparison of self-perceived TPACK of higher secondary school teachers in Mizoram with reference to educational discipline.

- The findings revealed that science teachers possessed slightly higher self-perceived TPACK than arts teachers, with significant differences observed at the 0.05 level. This suggests that educational discipline plays an important role in shaping teachers' technological integration abilities. Similar results were reported by Pamuk et al. (2012) and Valtonen et al. (2020), who found that teachers in science-related fields tend to exhibit stronger technological competencies, likely due to the greater use of digital tools and simulations in science instruction. Science teachers' higher scores in domains such as TPK and TCK may be attributed to the nature of their subjects, which often demand visual demonstrations, experimentation, and data analysis—processes that naturally integrate technology.
- Conversely, arts teachers' lower scores in these domains could stem from fewer opportunities or subject-specific needs for technology integration, as arts subjects often rely on discussion-based or creative approaches rather than digital simulations. The disparity may also reflect unequal access to digital resources, limited training specific to arts pedagogy, or varying levels of institutional encouragement across disciplines. Studies by Koh and Chai

(2016) and Mouza et al. (2021) similarly emphasised that teachers' technology adoption depends heavily on the disciplinary context and perceived relevance to their teaching.

- Overall, the results indicate that while both science and arts teachers maintain a moderate level of TPACK, science teachers demonstrate a stronger capacity to blend technology with pedagogy and content. Strengthening ICT-focused training tailored to different subject areas could help bridge this disciplinary gap and enhance technology integration across all fields.

5.2.3 Discussion on the findings relating to the comparison of self-perceived TPACK of higher secondary school teachers in Mizoram with reference to their gender.

- The study revealed a significant difference in self-perceived TPACK between male and female higher secondary school teachers in Mizoram, with male teachers reporting higher mean scores across most domains. This finding suggests that gender influences teachers' technological, pedagogical, and content integration abilities, as well as their confidence in applying technology in the classroom.
- Similar patterns have been observed in prior studies. Sang et al. (2010) and Chai, Koh, and Tsai (2013) found that male teachers tend to exhibit greater confidence and familiarity with technology-based teaching tools compared to female teachers. Likewise, Sathyan and Mathew (2020) reported that male teachers scored higher in technological knowledge and its classroom application, indicating a consistent gender gap in technology-related competencies across different educational contexts.
- Several factors may explain these gender-based differences. Male teachers often have greater access to and engagement with digital devices and technological activities, both in professional and personal contexts, leading to higher confidence and comfort in technology integration. They may also be more inclined to experiment with new technological tools and pedagogical approaches. In contrast, female teachers may encounter constraints such as

limited access to digital resources, fewer opportunities for hands-on practice, or less institutional encouragement to engage in technology-related professional development. Additionally, cultural and social factors could contribute to differing levels of technological exposure and self-efficacy between genders.

- These disparities highlight the importance of ensuring equitable access to ICT training and ongoing professional development for both male and female teachers. Providing supportive environments, mentoring programs, and gender-inclusive technology workshops can help build confidence and competence among female teachers. By doing so, schools can foster balanced technological proficiency and promote inclusive pedagogical innovation among all educators.
- In conclusion, while male teachers in this study demonstrated higher self-perceived TPACK, the findings emphasize the need for targeted initiatives that empower female teachers with equal technological learning opportunities. Such measures would contribute to minimizing gender-based gaps in TPACK and advancing more equitable technology integration in higher secondary education

5.2.4 Discussion on the findings relating to the comparison of self-perceived TPACK of higher secondary school teachers in Mizoram with reference to their age.

- The findings reveal a significant difference in self-perceived TPACK among higher secondary school teachers based on age, with teachers below 40 years exhibiting higher mean scores across all domains compared to those above 40 years. Younger teachers reported higher mean scores in Technological Knowledge (TK = 14.08), Pedagogical Knowledge (PK = 18.91), Technological Pedagogical Knowledge (TPK = 18.51), and overall Technological Pedagogical and Content Knowledge (TPACK = 23.16), while older teachers recorded comparatively lower means across the same domains. The t-value (6.09) exceeded the critical values at both 0.05 and 0.01 levels,

indicating that the difference between the two age groups is statistically significant.

- This outcome suggests that younger teachers are generally more confident and proficient in integrating technology with pedagogy and content. One probable explanation is that younger teachers, being more digitally native, have had greater exposure to technology during their education and early professional careers. Their familiarity with digital tools, online platforms, and multimedia resources likely contributes to stronger technological and pedagogical integration skills. In contrast, many older teachers may have received their formal training in periods when technology played a limited role in education, which could explain their relatively lower technological competence.
- The trend observed in this study aligns with previous research that found younger teachers tend to have higher levels of technological self-efficacy and are more open to adopting innovative teaching practices (e.g., Sang et al., 2010; Koh & Chai, 2014). These studies emphasize that younger educators, being more adaptable to new digital environments, integrate technology into instruction more seamlessly. Moreover, younger teachers often participate in professional development programs and ICT-based initiatives more actively, further strengthening their TPACK.
- The results also indicate that a larger proportion of teachers above 40 years fall into the low-level category, particularly in technology-related domains such as TK, TPK, and TCK. This could stem from limited access to hands-on ICT training, lower motivation to adopt emerging technologies, or apprehension toward changing established teaching practices. Conversely, younger teachers' higher representation in the high-level category across domains reflects their readiness to engage in technology-supported pedagogy and their confidence in using digital tools for instructional purposes.
- In summary, age appears to be an influential factor in shaping teachers' TPACK. Younger teachers demonstrate stronger technological and

pedagogical integration skills, likely due to their digital familiarity, greater exposure to technology-enhanced learning, and positive attitudes toward innovation. These findings underscore the need for targeted ICT professional development programs for older teachers to bridge the digital competence gap and promote equitable technology integration across all age groups in higher secondary education.

- The study revealed that teachers below 40 years of age had a higher mean score of self-perceived TPACK compared to those above 40 years, and the difference was found to be statistically significant. This indicates that younger teachers possess greater confidence and competence in integrating technology into their teaching practices. This finding is consistent with the results of Chai, Koh, and Tsai (2013), who reported that younger teachers tend to have stronger technological knowledge due to their familiarity and comfort with digital tools. Similarly, Pamuk, Ergun, Cakir, Yilmaz, and Ayas (2015), Teo (2011) also observed that younger teachers are more willing to experiment with technology and show higher levels of technology acceptance than their older counterparts. The reasons for this difference could be that younger teachers are more technologically inclined, having grown up in a digital environment, and are often more eager to use modern tools in teaching. In contrast, older teachers may face technological anxiety, lack of training, or limited exposure to new digital platforms, making them less confident in integrating technology effectively. Continuous professional development and mentoring programs could help bridge this gap across age groups.

5.2.5 Discussion on the findings relating to the comparison of self-perceived TPACK of higher secondary school teachers in Mizoram with reference to their teaching experience.

- The findings of the study indicate a significant difference in self-perceived TPACK among higher secondary school teachers based on their years of teaching experience. Teachers with less than 10 years of experience scored higher across all domains compared to those with more than 10 years of

experience. Less-experienced teachers demonstrated stronger competencies in Technological Knowledge (TK = 13.43 vs. 11.68), Technological Pedagogical Knowledge (TPK = 19.53 vs. 17.67), and Technological Content Knowledge (TCK = 13.08 vs. 11.51). The overall mean TPACK score was also higher for teachers with fewer years of experience (M = 17.38) than for those with longer experience (M = 15.74). The calculated t-value (4.43) exceeded the critical values at both 0.05 and 0.01 significance levels, confirming that the difference is statistically significant.

- These results suggest that teachers with less teaching experience tend to have higher confidence and competence in integrating technology into their teaching practices. One probable reason is that newer teachers belong to a generation that has been more exposed to digital technologies during their academic and professional training. They often receive pre-service education that incorporates ICT-based pedagogy and are more accustomed to using online tools, digital platforms, and multimedia resources in instructional design. Consequently, they demonstrate greater technological fluency and adaptability in classroom settings.
- This finding aligns with the results of previous studies. Research by Teo (2011) and Koh, Chai, and Tsai (2013) similarly reported that novice or early-career teachers tend to display higher technological proficiency and more positive attitudes toward ICT integration compared to their senior counterparts. In contrast, more-experienced teachers, while possessing stronger pedagogical and content expertise, may face challenges adapting to evolving technologies or may have limited training opportunities in ICT. Their reliance on traditional teaching methods and limited exposure to technology-enhanced instruction could contribute to lower self-perceived TPACK.
- Furthermore, the greater proportion of less-experienced teachers in the high-level category across domains indicates their openness to innovation and experimentation with new tools. In contrast, more-experienced teachers may

exhibit reluctance or resistance to change due to established routines or lack of institutional support for continuous ICT skill development.

- In summary, the results highlight that teaching experience is an influential factor affecting teachers' TPACK. Less-experienced teachers demonstrate higher technological and integrative competence, likely due to their exposure to digital learning environments and recent pedagogical training. Therefore, ongoing professional development programs targeting experienced teachers are essential to update their technological skills and enhance their confidence in integrating technology with pedagogy and content. Such initiatives would ensure that all teachers, regardless of experience, can effectively participate in technology-driven education.

5.2.6 Discussion on the findings relating to the comparison of self-perceived TPACK of higher secondary school teachers in Mizoram with reference to ICT training.

- The findings of the study revealed a significant difference in self-perceived TPACK between teachers with and without ICT training. Teachers who had undergone ICT training scored higher mean values across all domains—Technological Knowledge (TK = 15.40 vs. 12.26), Technological Pedagogical Knowledge (TPK = 19.40 vs. 19.06), Pedagogical Content Knowledge (PCK = 15.36 vs. 11.97), and overall TPACK (25.32 vs. 20.70). The overall mean difference (trained = 18.45; untrained = 16.87) was statistically significant, as the calculated t-value (3.43) exceeded the critical values at both 0.05 and 0.01 levels. This confirms that ICT training has a substantial impact on teachers' perceived ability to integrate technology with pedagogy and content knowledge.
- These results suggest that ICT training enhances teachers' technological competence and promotes confidence in using digital tools to support instructional strategies. Trained teachers appear better equipped to select and apply appropriate technologies to enrich learning experiences, demonstrating more effective integration of technology with pedagogical and content-

related aspects of teaching. The training likely exposed them to hands-on technological applications, digital resources, and innovative instructional approaches, thereby strengthening their overall TPACK.

- The present findings are consistent with previous research. Chai, Koh, and Tsai (2013) and Agyei and Voogt (2012) emphasized that professional ICT training significantly improves teachers' ability to integrate technology effectively into their pedagogy. Similarly, Jimoyiannis (2010) observed that ICT-based professional development programs enhance teachers' technological self-efficacy and encourage experimentation with digital instructional tools. Studies by Sang et al. (2010) and Koh and Chai (2014) also found that teachers with formal ICT training tend to demonstrate higher confidence and competence in applying technology to their teaching compared to untrained teachers.
- Moreover, ICT-trained teachers in this study also exhibited higher Pedagogical Content Knowledge (PCK), indicating that such training not only improves technical proficiency but also refines pedagogical planning and content organization. This may be because ICT training often includes exposure to technology-supported instructional design, digital content creation, and learner-centered methodologies that help teachers manage lessons more effectively. In contrast, teachers without ICT training may rely more heavily on traditional instructional methods, which limit their ability to integrate technology meaningfully.
- Overall, these findings highlight the critical role of ICT training in fostering teachers' professional growth. ICT training equips teachers with the necessary knowledge, skills, and confidence to integrate technology into their teaching practices effectively. Therefore, it is essential for educational institutions and policymakers to provide regular, well-structured ICT training opportunities that emphasize both technical and pedagogical dimensions, ensuring that all teachers—regardless of prior exposure—can develop strong TPACK competencies for the digital era of education.

5.2.7 Discussion on the findings relating to the effectiveness of higher secondary school teachers in Mizoram in their classroom teaching.

- The findings of the present study revealed that in terms of teacher planning, a majority of teachers exhibited planning that was apparent rather than strong. This indicates that while most teachers prepared their lessons to some extent, their planning may not have been detailed or innovative enough to integrate diverse teaching strategies and technology. Similar findings were reported by Koehler and Mishra (2009), who emphasized that effective planning requires the thoughtful combination of technological, pedagogical, and content knowledge (TPACK). The apparent level of planning observed in this study may be due to factors such as time limitations, lack of professional development programs, or inadequate institutional support for lesson preparation.
- With regard to knowledge and understanding, most teachers showed a strong level of subject knowledge. This finding aligns with Chai, Koh, and Tsai (2010), who found that teachers often demonstrate strong content knowledge, which forms the foundation of effective teaching. This suggests that teachers in the present study have a good grasp of their subject matter, enabling them to explain concepts clearly and confidently.
- In relation to the medium of instruction, the majority of teachers used the language of instruction at an apparent level. This implies that while teachers generally adhered to the prescribed instructional language, they may not have fully utilized it to promote interactive communication or deep understanding among students. This finding is supported by Ghavifekr and Rosdy (2015), who noted that although teachers follow language guidelines, they often face challenges in engaging students effectively, especially in multilingual or mixed-ability classrooms. The probable reasons could include varying levels of language proficiency among teachers or students, lack of linguistic training, or a tendency to switch between languages to ensure comprehension.
- The present study revealed that more than half of the teachers employed teaching methods at an apparent level, this suggests a moderate variation in

teachers' instructional approaches, indicating that while many teachers are aware of diverse strategies, only a portion consistently apply them effectively in the classroom. Similar findings were reported by Ghavifekr and Rosdy (2015), who found that teachers often rely on traditional, teacher-centered methods due to limited exposure to innovative pedagogical approaches and lack of institutional support. The apparent level of teaching method usage observed in the present study could also be attributed to factors such as large class sizes, time constraints, and inadequate access to teaching aids and technology.

- In terms of classroom management, a very high proportion of teachers exhibited apparent performance, while only seventeen percent demonstrated strong management skills. This indicates that teachers maintain adequate control and organization in the classroom, but may not be fully effective in fostering an engaging and interactive learning environment. This finding is consistent with the study of Yilmaz and Cavas (2008), who reported that teachers often manage classroom routines effectively but struggle with maintaining student motivation and active participation. The probable reasons could include limited classroom space, diverse student needs, and insufficient training in student-centered classroom management techniques.
- With respect to assessment practices, more than half of the teachers applied assessment at an apparent level, implying that evaluation methods were somewhat routine and primarily focused on summative rather than formative aspects. This aligns with the observations of Koh, Chai, and Tsai (2013), who noted that many teachers use assessment mainly for grading rather than as a tool to improve teaching and learning. Possible reasons for this pattern include heavy workload, lack of awareness about alternative assessment methods, and limited time for individualized feedback.
- Regarding homework and assignments, the majority of teachers provided them strongly, suggesting that this is one area where teachers showed consistent effort and accountability. Similar results were observed by Chai et al. (2010), who found that teachers often rely on homework as a means to

reinforce classroom learning and ensure student engagement beyond school hours. This may be because assigning homework is a well-established practice requiring less technological integration or innovation, making it easier for teachers to implement effectively.

5.2.8 Discussion on the findings relating to the relationship between self-perceived expertise in TPACK and teaching effectiveness of higher secondary school teachers in Mizoram.

- The findings of the study revealed a high positive correlation ($r = 0.77$) between teachers' self-perceived expertise in TPACK and their teaching effectiveness. Since the obtained value was higher than the critical values at both 0.05 and 0.01 levels, it can be concluded that the relationship is statistically significant. This means that teachers who perceive themselves as more competent in integrating technology, pedagogy, and content tend to be more effective in their classroom teaching.
- This result supports the findings of Koh, Chai, and Tsai (2013), who reported that teachers with higher TPACK competence exhibit better instructional design and classroom engagement. Similarly, Chai et al. (2010) found that teachers confident in their technological and pedagogical knowledge create more meaningful learning experiences.
- The probable reason for this positive relationship may be that teachers with strong TPACK skills are more willing to use innovative teaching methods and technology, leading to greater student involvement and improved learning outcomes. It may also be due to their continuous effort to update teaching strategies and adapt to changing classroom needs. Hence, enhancing teachers' TPACK through ongoing professional training and institutional support can significantly contribute to improving teaching effectiveness among higher secondary school teachers.

5.2.9 Discussion on the findings on problems faced by the higher secondary school teachers of Mizoram in integrating technology in teaching.

- The study found that slightly more than half of the teachers reported that computers and other technological devices were not available in their classrooms, showing that many institutions still face infrastructural limitations. This finding is in line with Ghavifekr and Rosdy (2015), who observed that the lack of technological facilities remains a key barrier to effective technology integration in schools. Similarly, Hew and Brush (2007) emphasized that limited access to ICT tools and poor internet connectivity reduce teachers' ability to use digital resources in teaching. The probable reasons for this may include insufficient funding, unequal distribution of resources, and lack of proper maintenance of existing equipment.
- Gap in institutional support and professional development as one of the problems was agreed by other studies done by Ertmer and Ottenbreit-Leftwich (2010), Ghavifekr and Rosdy (2015).
- Majority of teachers perceive a lack of continuous professional development and structured technical assistance, which limits their ability to effectively integrate technology into teaching and learning. This result is consistent with the findings of Ghavifekr and Rosdy (2015), Ertmer and Ottenbreit-Leftwich (2010), Hew and Brush (2007).
- Majority of teachers reported that appropriate training and technical support were not provided, indicating a major challenge in the effective integration of technology in teaching and learning. Similar findings were reported by L P Lalduhawma, L Thangmawia & Jamal Hussain (2022), Ghavifekr and Rosdy (2015), who highlighted that insufficient training and lack of technical assistance remain key barriers to successful ICT implementation in schools. Likewise, Ertmer and Ottenbreit-Leftwich (2010) emphasized that continuous support and hands-on training are essential for building teachers' confidence and competence in technology use. Hew and Brush (2007) also noted that the absence of regular training programs and limited access to technical expertise discourage teachers from adopting innovative technological practices.

- The study revealed that a majority of teachers reported a shortage of time to practice with new and ever-changing technologies, and more than half agreed that preparing lessons incorporating technology is time-consuming. This finding highlights that time constraint is one of the major barriers affecting the effective integration of technology in teaching. Similar findings were reported by Ertmer and Ottenbreit-Leftwich (2010), who identified lack of time as a persistent challenge preventing teachers from exploring and adopting digital tools. Additionally, Buabeng-Andoh (2012) emphasized that limited time for practice and professional training significantly hinders teachers' ability to integrate ICT effectively in the classroom.
- The findings of the study revealed that majority of the teachers indicated that professional training or workshops have not adequately prepared them to use digital tools in teaching. This suggests that while training programs are being conducted, they may not be sufficiently practical, continuous, or aligned with teachers' classroom needs. As a result, many teachers still feel unprepared to effectively integrate technology into their instructional practices. Tondeur et al. (2017), Buabeng-Andoh (2012), Ertmer and Ottenbreit-Leftwich (2010), Ghavifekr and Rosdy (2015) also found that one of the major barriers to successful ICT implementation is the inadequacy of professional training programs that focus mainly on theory rather than hands-on practice.
- Majority of teachers agreed that adopting new technological tools in classroom settings is a major challenge, reflecting their struggle to keep pace with rapid technological advancements. This suggests that teachers often feel unprepared to adapt to constant changes in digital tools and platforms, which can hinder effective technology integration in teaching. Similar findings were reported by Buabeng-Andoh (2012), who noted that frequent technological updates make it difficult for teachers to stay current without continuous training and support. Tondeur et al. (2017) also emphasized that many professional development programs fail to keep teachers up to date with new innovations. Koh, Chai, and Lim (2017) highlighted that ongoing

professional learning and peer collaboration are essential for helping teachers adapt to evolving digital tools.

5.2.10 Discussion on the findings relating to the perceived experience of students on the effectiveness of teaching of higher secondary school teachers of Mizoram using TPACK.

- The findings showed that most students rated teachers' teaching methods as average, while their content knowledge was rated high. This suggests that teachers possess strong subject expertise but may need improvement in pedagogical practices. Similar observations were made by Mishra and Koehler (2006) and Koh, Chai, and Tsai (2013), who found that teachers often have sound content knowledge but face challenges in applying effective teaching strategies.
- The findings showed that most teachers exhibited moderate initiative and strategy use, while only twelve percent demonstrated high effectiveness in technology use, indicating that technology integration remains a weaker area. Similar results were found by Koh, Chai, and Tsai (2013) and Ertmer and Ottenbreit-Leftwich (2010), who noted that limited training and institutional support often hinder teachers' effective technology use. The probable reason may be insufficient professional development and time constraints, highlighting the need for continuous training to strengthen teachers' technological and instructional competence.
- The findings revealed that the majority of students rated teachers' creativity and enthusiasm as moderate, suggesting that while teachers show interest in teaching, there is scope for greater innovation and motivational engagement in the classroom. Similar findings were reported by Koh, Chai, and Tsai (2013), who observed that teachers often display moderate creativity due to limited exposure to innovative pedagogical practices. Likewise, Ertmer and Ottenbreit-Leftwich (2010) noted that lack of confidence in using new methods and insufficient institutional encouragement can limit teachers' enthusiasm. The probable reason could be workload pressure, limited

recognition, or lack of creative teaching resources, indicating the need for supportive environments that promote teacher motivation and creativity.

- The findings revealed that teachers maintained good professional relationships with supervisors and heads and demonstrated healthy interactions with peers, indicating positive collegial collaboration within schools. However, rapport with parents was rated moderate by fifty six percent, suggesting that communication between teachers and parents requires further strengthening. Meanwhile, rapport with students was also largely moderate, though a substantial proportion reflected strong relationships. Similar findings were reported by Rao and Rao (2015), who observed that while teachers often maintain effective peer and supervisory relationships, they face challenges in sustaining consistent communication with parents due to time constraints and workload. Jayashree and Ramesh (2019) also noted that strong teacher–student rapport is essential for effective classroom management and motivation.
- The findings revealed that nearly half of the students rated teachers’ classroom planning as moderate, suggesting the need for improved lesson organization and preparation. In contrast, the majority rated teachers high in maintaining discipline, indicating effective classroom management and control. Similar results were reported by Koh, Chai, and Tsai (2013), who noted that while teachers often demonstrate strong classroom control, they may require further training to enhance planning and instructional design.
- The findings showed that most teachers demonstrated a positive attitude toward professional growth, with forty eight percent rated high in their willingness to improve professionally. Moreover, overall teaching success was rated high by fifty three percent of students, reflecting generally effective teaching performance among higher secondary teachers. Similar findings were reported by Koh, Chai, and Tsai (2013), who found that teachers with higher professional motivation tend to exhibit greater teaching effectiveness. Likewise, Ertmer and Ottenbreit-Leftwich (2010) emphasized that teachers’

openness to learning and self-improvement directly influences their classroom success.

5.3 Educational Implications

The findings of the present study carry noteworthy educational implications for enhancing the quality of teaching and learning among higher secondary school teachers in Mizoram. The moderate level of TPACK observed among most teachers indicates that, while they possess adequate pedagogical and content knowledge, there remains a substantial need to strengthen their ability to integrate technology meaningfully into classroom practices. Hence, professional development programmes should be designed to go beyond the basic acquisition of technological skills and instead focus on pedagogically grounded applications of technology. Training should provide teachers with structured opportunities to design lessons that explicitly align technology with content and pedagogical objectives. Such programmes may include model demonstrations, co-teaching opportunities, lesson study, and reflective practice sessions that enable teachers to experiment with and refine their technology-integrated instructional strategies. Continuous in-service training and mentoring systems would also help sustain teachers' professional growth and gradually enhance both their TPACK competencies and overall teaching effectiveness.

For teachers, the findings underscore the importance of adopting a more proactive role in enhancing their TPACK competencies. Teachers need to continuously update their digital skills, engage meaningfully in professional development activities, and embrace reflective practices that allow them to assess the effectiveness of technology-based lessons. They are encouraged to collaborate with peers through professional learning communities, share innovative instructional strategies, and participate in peer observation to improve their classroom practices. Additionally, teachers must shift toward student-centred digital pedagogies that promote higher-order thinking, problem solving, creativity, and active engagement. By integrating technology

thoughtfully and purposefully, teachers can enhance learning outcomes and create more inclusive and interactive classroom environments.

At the institutional level, effective leadership is crucial for fostering a school culture that promotes and sustains technology integration. School heads and administrators should provide adequate infrastructural support, such as reliable connectivity, multimedia equipment, and access to digital learning resources. However, investment in hardware alone will not suffice; what is equally important is the establishment of professional learning communities that encourage collaboration, peer observation, and reflective dialogue focused on improving technology-supported pedagogy. School leaders can initiate mentoring systems where experienced teachers guide others in lesson planning and classroom implementation grounded in the TPACK framework. Similarly, pre-service teacher education programmes should embed the TPACK model across subject pedagogy courses so that new teachers enter the profession equipped with both conceptual understanding and practical competence in technology-integrated teaching. Such measures will ensure a sustainable and contextually relevant approach to professional capacity building in Mizoram.

At the broader policy and curriculum level, it is imperative that the higher secondary curriculum and assessment framework be aligned with digital pedagogical practices that promote innovation, critical thinking, and creativity. Policymakers should consider integrating technology-based learning activities and formative assessments that evaluate students' analytical, problem-solving, and collaborative skills, rather than relying solely on memory-based examinations. Furthermore, to address the disparities in digital access across Mizoram, strategies for digital equity—such as the provision of offline learning materials, community learning centers, and affordable digital devices—should be prioritized. These initiatives would ensure that all learners, irrespective of their socio-economic or geographic background, benefit equally from technology-enhanced education.

Additionally, the findings highlight the need to strengthen ongoing monitoring and evaluation mechanisms to ensure that technology integration efforts are producing the desired outcomes. Regular evaluation of teachers' TPACK development—through classroom observations, digital lesson portfolios, and feedback from students—would provide valuable insights into areas requiring further improvement. Such evidence-based monitoring would enable schools and policymakers to refine professional development initiatives, allocate resources more effectively, and identify best practices that can be scaled across districts. Moreover, creating platforms where teachers can share exemplary technology-integrated lessons, innovative teaching approaches, and classroom challenges will foster a culture of continuous learning. Embedding such reflective and evaluative practices within the education system will not only enhance teachers' technological and pedagogical growth but also contribute to the overall improvement of teaching quality in Mizoram.

In conclusion, strengthening TPACK among higher secondary teachers in Mizoram requires a multi-level approach encompassing teacher training, institutional support, and systemic policy reform. When effectively implemented, such efforts can transform classroom practices, enrich students' learning experiences, and ultimately elevate the standard of secondary education in the state.

5.4 Recommendations

Based on the findings of the present study, the following recommendations are made to enhance the Technological, Pedagogical, and Content Knowledge (TPACK) of higher secondary school teachers in Mizoram and thereby improve their teaching effectiveness.

- 1. Continuous and Context-Based Professional Development:** Regular professional development programs should be organized to enhance teachers' competencies in integrating technology with pedagogy and content. These training programs should be contextually designed, keeping in mind the specific challenges faced by teachers in Mizoram such as limited access to digital infrastructure and varying levels of technological literacy. Workshops should include hands-on sessions on digital lesson planning, use of interactive teaching tools, and strategies for creating locally relevant digital content. Continuous training will empower teachers to become more confident and effective in technology-enabled teaching.
- 2. Establishment of Local Learning Communities:** Schools and educational authorities should encourage the formation of Professional Learning Communities (PLCs) at the district and institutional levels. Through these communities, teachers can collaborate, share best practices, and mentor each other in technology integration. Peer collaboration is particularly valuable in remote areas of Mizoram, where collective problem-solving can overcome resource and infrastructure limitations.
- 3. Integration of TPACK Framework in Pre-Service and In-Service Teacher Education:** Teacher education institutions under the Mizoram Board of School Education (MBSE) and the Directorate of School Education should embed TPACK-based training modules into their curriculum. Both pre-service and in-service teachers should be trained not only in using ICT tools but also in aligning those tools effectively with pedagogical methods and subject content. Such integration will help teachers develop holistic technological competence.
- 4. Improvement of Technological Infrastructure and Support:** The Government of Mizoram should prioritize strengthening ICT infrastructure in higher secondary schools, particularly in rural and hilly areas. Reliable internet connectivity, access to digital devices, and smart classrooms can significantly enhance teachers' ability to implement TPACK effectively. Moreover, appointing ICT support personnel at the school level can help teachers troubleshoot and sustain the use of technology in classrooms.

- 5. Promotion of Reflective and Innovative Practices:** Teachers should be encouraged to engage in reflective practices to evaluate their teaching strategies and identify areas for improvement. Encouraging innovation through experimentation with educational technologies, digital storytelling, online assessment tools, and AI-assisted platforms can make lessons more engaging and relevant to students. Reflective teaching journals or portfolios can also be introduced to help teachers track their TPACK development over time.
- 6. Policy and Administrative Support:** The State Education Department should formulate policies that promote technology integration and recognize teachers who demonstrate excellence in TPACK-based teaching. Incentives such as awards, professional credits, or opportunities for higher study can motivate teachers to continually upgrade their technological and pedagogical skills. Policies should also ensure equitable access to digital resources for all schools, bridging the urban–rural digital divide in Mizoram.
- 7. Development of Culturally and Linguistically Relevant Digital Content:** Since Mizoram has a distinct linguistic and cultural context, digital learning materials should be designed to reflect local culture, language, and values. Encouraging teachers to develop bilingual or vernacular digital content can enhance student understanding and engagement. Collaboration between teachers, local education experts, and digital content developers will make TPACK implementation more contextually effective and sustainable.

5.5 Suggestions for further research

The following suggestions are proposed:

1. Extend the study to other districts of Mizoram or Northeastern states for a broader understanding of teachers' TPACK.
2. Conduct subject-specific studies to explore differences in TPACK across disciplines.
3. Undertake longitudinal research to examine changes in teachers' TPACK over time.

4. Design intervention-based studies to test the effectiveness of training programs in enhancing TPACK.
5. Investigate the relationship between teachers' TPACK and students' learning outcomes.
6. Use qualitative or mixed-method approaches for deeper insights into teachers' experiences and challenges.
7. Assess the impact of digital literacy programs and ICT initiatives on teachers' technological and pedagogical skills.

Appendix – 1

PERCEPTIONS OF HIGHER SECONDARY SCHOOL TEACHERS ON TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE (TPACK)

Respected Madam/Sir,

Greetings! I am H.Lalbiakzuali, a Ph.D. scholar at Department of Education, Mizoram University. I currently conducting a study on *"Technological, Pedagogical and Content Knowledge of Higher Secondary School Teachers and Teaching Effectiveness: A Critical study"*. I would like to request your valuable time and effort to answer each of the questions to the best of your knowledge. Your thoughtfulness and candid responses will be greatly appreciated. This research is solely for academic purposes, and your participation and information will be kept strictly confidential and only be used for the following research purposes. Thank You

Please provide the following information accurately:

Name:

Gender: Male () Female ()

Age: Below forty (40) years () / Above forty (40) years ()

Educational Discipline: Science () Arts ()

Teaching experience: Below ten (10) years () / Above ten (10) years ()

Training on ICT : Yes () (completed at least one recognized ICT training programme)/ No () (not undergone any formal ICT training)

Name of the School:

INSTRUCTIONS

The present perception scale is designed to assess the perceptions of higher secondary school teachers regarding the Technological Pedagogical and Content Knowledge (TPACK) framework. The scale consists of two parts:

Part I: Contains 33 statements related to different aspects of TPACK. Please indicate your degree of agreement with each statement by ticking (✓) one of the following options: Strongly Agree, Agree, Undecided, Disagree, or Strongly Disagree.

Part II: Seeks to identify the problems faced by teachers in integrating technology into classroom teaching. For each item, please select either “Yes” or “No.”

PART I: This part will measure your self-perceived knowledge of content, pedagogy and technology. For the purpose of this questionnaire, technology term is used to refer to digital tools and resource such as computers, projectors, laptops, iPads, handhelds, interactive whiteboards, software programs, websites, video streaming, eBooks, smartphones etc. Please answer all of the questions and if you are uncertain of or neutral about your response you may always select "Undecided".

Sl.No.	Statements on TPACK	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
		1	2	3	4	5
	TECHNOLGICAL KNOWLEDGE (TK)					
1	I know how to use various digital technologies.					
2	I can learn technology easily.					
3	I am familiar with a variety of hardware, software and technology tools that I can use for teaching.					
4	I know how to solve my own technical problem with digital technologies					
	CONTENT KNOWLEDGE (CK)					
5	I have sufficient knowledge to understand new concepts in my learning					
6	I can use a logical way of thinking to solve problems					
7	I have various strategies to develop my understanding of new topics					
8	I can evaluate information to determine if it is accurate or reliable					
9	I can connect what I already know with new information					
	PEDAGOGICAL KNOWLEDGE (PK)					
10	I can adapt my teaching style to different learners					

11	I have a wide range of teaching approaches in the classroom setting					
12	I have a clear understanding of designing instruction in my discipline					
13	I know how to organize and maintain classroom management					
14	I can select effective teaching approaches to guide student thinking and learning					
	PEDAGOGICAL CONTENT KNOWLEDGE (PCK)					
15	I can provide multiple representations of content, such as analogies, examples, demonstrations and classroom activities					
16	I understand what topics or concepts are easy or difficult to learn					
17	I am knowledgeable about effective approaches to guiding student thinking and learning in my discipline					
18	I can adapt material to students' abilities, prior knowledge, preconceptions and misconceptions					
	TECHNOLOGICAL PEDAGOGICAL KNOWLEDGE (TPK)					
19	I can adapt digital technologies to support learning in my classroom					
20	I do not understand how technology can be integrated into teaching and learning.					
21	I do not know how to adapt technologies to support teaching and learning					
22	I am thinking critically about how to use technology in my classroom					
23	I understand how teaching and learning change when certain technologies are used					
	TECHNOLOGICAL CONTENT KNOWLEDGE (TCK)					
24	I can effectively integrate the appropriate technology into specific content					
25	I can choose technologies that enhance the effectiveness for a specific lesson.					

26	I would not be able to teach my content effectively through an online programme					
27	I am unable to select specific technologies that are best suited for addressing learning objectives in my discipline					
	TECHNOLOGICAL, PEDAGOGICAL, AND CONTENT KNOWLEDGE (TPACK)					
28	I can use technology-based learning (learning via electronics technology, including the Internet, intranets, satellite broadcasts, audio and video conferencing, bulletin boards. Chat rooms etc.) methods to teach content and provide opportunities for learners to interact with ideas.					
29	I know how to operate digital technologies and can incorporate them into my particular discipline to enhance student learning.					
30	I cannot determine when a technology resource (any electronic equipment used to support learning) may fit with one learning situation in my discipline, and not with another.					
31	I can flexibly incorporate new tools and resources into content and my teaching methods to enhance learning.					
32	I can use appropriate instructional strategies to teach specific curriculum content topics with technology					
33	Integrating educational technologies into teaching learning process is a challenge for me					

Appendix – II

PROBLEMS FACED BY THE HIGHER SECONDARY SCHOOL TEACHERS IN INTEGRATING TECHNOLOGY IN TEACHING

Part II: This part will measure the problems faced by you in integrating technology in your teaching. Please answer all of the questions and you may response by selecting “Yes” or “No”.

Sl No.	Items	Yes	No
1	Computers and other technological devices are not available in the classroom		
2	Institution and teacher prepare themselves to make students work together on various devices.		
3	Proper and timely guidance are provided to teachers for effective use of technology		
4	Teacher interacts and engages with students through various technology-based learning		
5	Fear of unknowns with new technologies and scared to experiment with new technologies		
6	Appropriate training and technical support are provided		
7	Shortage of time to practice with new and ever-changing technologies		
8	Professional training or workshops have prepared teachers to integrate digital technology in their teaching effectively		
9	Preparing lessons to include new technologies can be time consuming		
10	Teachers do not have computers or other technological devices, have sufficient data or internet access at home.		

11	School does not have the network infrastructure needed to support teaching.		
12	Sufficient funds are available to implement and sustain technology in the classroom.		
13	Adoption of new technological tools or devices in a classroom setting is a major challenge for a teacher.		
14	Utilizing technology in a curriculum may help teacher to boost their comfort and teaching effectiveness.		

Appendix – III

OBSERVATION SCHEDULE FOR ASSESSING THE EFFECTIVENESS OF TEACHING

CLASSROOM OBSERVATION FORMAT

3 – Strong 2-Apparent 1-Not displayed

1. The teacher plans effectively and sets clear objectives that are understood.	3	2	1
a) Objectives are communicated clearly at the start of the lesson			
b) TLM used in the teaching			
c) Lesson is structured			
d) The lesson is reviewed at the end			
2. The teacher shows knowledge and understanding.			
a) Teacher has thorough knowledge of the subject content covered in the lesson			
b) Instructional materials were appropriate for the lesson.			
c) Knowledge is made relevant and interesting for students			
3. Medium of instructions			
a) Teacher integrated digital devices in the lesson			
b) The instructional materials used capture the interest of the students.			
c) Teacher chooses appropriate technologies that enhance student's learning for lesson.			
d) Appropriate reinforcement is given by the teacher.			

4. Teaching methods used enables all students to learn effectively.			
a) The lesson is link to previous teaching or learning.			
b) The ideas and experiences of the students are drawn upon.			
c) A variety of activity and questioning techniques are used.			
d) Instructions and explanations are clear and specific.			
e) Teacher involves all the students, listen to them and respond appropriately.			
f) High standard of efforts, accuracy and presentation are encouraged.			
5. Classroom Management			
a) Students are praised regularly for their effort and achievement.			
b) Prompt action is taken to address poor behavior.			
c) All students are treated fairly			
d) Teacher knows how to organized and maintain classroom management			
6. Assessment			
a) Student's understanding is assessed thoroughly the lesson use of teacher's questions.			
b) Mistake and misconceptions are recognized and used constructively to facilitate learning.			
c) Students written work are assessed regularly and accurately			
7. Homework and Assignment			
a) Homework & Assignment are appropriate.			
b) Homework & Assignment is followed up if it is set previously			

Appendix – IV

EVALUATION SCHEDULE FOR ASSESSING TEACHERS' EFFECTIVENESS

Respected Students,

Greetings! I am H.Lalbiakzuali, a Ph.D. scholar at Department of Education, Mizoram University. I currently conducting a study on "*Technological, Pedagogical and Content Knowledge of Higher Secondary School Teachers and Teaching Effectiveness: A Critical study*". I would like to request your valuable time and effort to answer each of the questions to the best of your knowledge. Your thoughtfulness and candid responses will be greatly appreciated. This research is solely for academic purposes, and your participation and information will be kept strictly confidential and only be used for the following research purposes. Thank You

Please provide the following information accurately:

Name:

Gender: Male () Female ()

Stream : Science () Arts ()

Name of the School:

INSTRUCTIONS

Please read the following instructions carefully before filling out the schedule.

This evaluation schedule is designed to assess the teaching effectiveness of teachers as perceived by students. It consists of fourteen (14) professional areas covering different aspects of a teacher's performance. You are requested to rate your teacher's effectiveness in each area by selecting one of the following categories:

Rating Category	Description	Indicative Score Range
Poor / Low	Performance below expected level	Up to 30%
Average /Moderate	Performance meets expected level	Around 50%
Good /High	Performance exceeds expected level	Above 50%

Please read each item carefully and provide your honest and unbiased responses. There are no right or wrong answers. All information obtained through this schedule will be used strictly for academic and research purposes and will remain confidential.

Sl No.	Areas	Poor/Low 30%	Average /Moderate 50%	Good / High above 50%
1	Teaching Methods			
2	Knowledge of the content he/she teaches			
3	Effective use of technology			
4	Initiative / Strategies			
5	Creativity			
6	Enthusiasm			

7	Ability to work with supervisors/principal/head			
8	Ability to work with peers			
9	Rapport with parents			
10	Rapport with students			
11	Classroom planning			
12	Ability to maintain discipline			
13	Willingness to improve professionally			
14	Overall teaching success			

Bibliography

- Abbit, J. T. (2011). Investigation of the relationship between self-efficacy beliefs about technology integration and Technological Pedagogical Content Knowledge (TPACK) among pre-service teachers. *Journal of Digital Learning in Teacher Education*, 27(4), 134-145.
- Abebe, F. F., Gaskill, M., Hansen, T., & Liu, X. (2022). Investigating K-12 pre-service teacher TPACK in instructional technology learning. *International Journal of Teacher Education and Professional Development*. 5(1), 1-16. DOI: <https://doi.org/10.4018/IJTEPD.2022010104>
- Adelita, D. C., Karen, A. M., & Alberto, D. Y. (2024). Assessing technological pedagogical content knowledge (TPACK) and teaching effectiveness of senior high school teachers: An input for teacher development plan. *Education Policy and Development*, 2(2), 66-81. DOI: <https://doi.org/10.31098/epd.v2i2.2511>
- Agyei, D. D., & Voogt, J. (2012). Developing technological pedagogical content knowledge in pre-service mathematics teachers through collaborative design. *Australasian Journal of Educational Technology*, 28(4). 547- 564. <https://doi.org/10.14742/ajet.827>
- Agyei, D.D. and Keengwe, J. (2014) ‘Using technology pedagogical content knowledge development to enhance learning outcomes’, *Education and Information Technology*, Vol. 19, pp.155–171. Doi: 10.1007/s10639-012-9204-1.
- Akankshya, P., Prakash, J. D., & Dash, N. (2023). A study of technological pedagogical content knowledge of science teachers at the higher secondary stage. *Scholarly Research Journal for Humanity Science & English Language*, 11(56), 14104-14111. DOI:<https://dx.doi.org/10.5281/zenodo.8238601>
- Alhamid, I. S. G., & Mohammad-Salehi, B. (2024). Examining EFL teachers’ Technological Pedagogical Content Knowledge (TPACK) and their attitudes towards online teaching. *LEARN Journal: Language Education and Acquisition Research Network*, 17(1), 715-733. <https://so04.tci-thaijo.org/index.php/LEARN/index>

- Ali, S. S., & Mohammadzadeh, B. (2022). Iraqi Kurdish EFL teachers' beliefs about technological pedagogical and content knowledge: The role of teacher experience and education. *Frontiers in Psychology*, 13, 1-12. <https://doi.org/10.3389/fpsyg.2022.969195>
- Ali, Z., Ur Rehman, H., & Noor Ullah. (2022). Measuring University Teacher Educators' Knowledge and Skills Using TPACK in Teachers Education Programs. *Research Journal of Social Sciences & Economics Review*, 3(3), 83-91. DOI: [https://doi.org/10.36902/rjsser-vol3-iss3-2022\(83-91\)](https://doi.org/10.36902/rjsser-vol3-iss3-2022(83-91))
- Altun, D. (2019). Investigating pre-service early childhood education teachers' Technological Pedagogical Content Knowledge (TPACK) competencies regarding digital literacy skills and their technology attitudes and usage. *Journal of Education and Learning*, 8(1), 249-263. <https://doi.org/10.5539/jel.v8n1p249>
- Altun, T. and Akyildiz, S. (2017) 'Investigating student teachers technological pedagogical content knowledge (TPACK) levels based on some variables', *European Journal of Education Studies*, Vol. 3, No. 5, pp.2501–1111.
- Alzahrani, A. (2014) *The Effects of Instructors' Technological Pedagogical and Content Knowledge (TPACK) on Online Courses*, Texas Tech University. <http://hdl.handle.net/2346/58720>
- Ammade, S., Mahmud, M., Jabu, B. and Tahmir, S. (2020) 'TPACK model based instruction in teaching writing: an analysis on TPACK literacy', *International Journal of Language Education*, Vol. 4, No. 1, pp.129–140.
- Anderson, S., Griffith, R., & Crawford, L. (2017). TPACK in special education: Pre-service teacher decision making while integrating iPads in to instruction. *Contemporary Issues in Technology and Teacher Education*, 17(1), 97-127.
- Andoh, N., Asare-Danso, S., Sefenu, J. C., & Adams, A. (2022). *Assessment of Technological Pedagogical Content Knowledge of Senior High School Business Teachers in the Central Region, Ghana*. *International Journal of Social Science and Education Research Studies*, 2(10), 535-551. DOI: <https://doi.org/10.55677/ijssers/V02I10Y2022-05>
- 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. <https://doi.org/10.1016/j.compedu.2008.07.006>

Angeli, C., & Valanides, N. (2015). *Technological pedagogical content knowledge: Exploring, developing, and assessing teachers' knowledge of technology-enhanced teaching*. Springer.

Anud, E. M., & Caro, V. B. (2023). Relationship between technological pedagogical and content knowledge (TPACK) Self-efficacy, 21st Century instructional skills and performance of science teachers. *In 3rd International Conference on Education and Technology*, 620-636. DOI:10.2991/978-2-38476-056-5_60

Archambault, L.M. and Barnett, J.H. (2010) 'Revisiting technological pedagogical content knowledge: exploring the TPACK framework', *Computers and Education*, Vol. 55, No. 4, pp.1656–1662.

Asamoah, R., Asiedu, N. S., & Buadi, D. W. (2022). Use of ict in teaching and learning in second cycle institutions: understanding the technological aspect of the tpack model. *UDS International Journal of Development*, 9(1), 736-748. DOI: <https://doi.org/10.47740/537.UDSIJD6i>

Aslam, R., Khan, N., Asad, M.M. and Ahmed, U. (2021) *Impact of technological pedagogical content knowledge on teachers' digital proficiency at classroom in higher education institution of Pakistan*, *Interactive Technology and Smart Education*, Doi: 10.1108/ITSE-11- 2020-0222.

Atasoy, E., Uzun, N., & Aygun, B. (2016). Technological pedagogical content knowledge of prospective mathematics teachers regarding evaluation and assessment. *World Journal on Educational Technology*, 8(1), 18-24. <http://sproc.org/ojs/index.php/wjet>

Austin, A. E. (2003). *Creating a bridge to the future: Preparing new faculty to face changing expectations in a shifting context*. *Review of Higher Education*, 26(2), 119–144.

Avni, Y. (2017). The factors affecting Techno-Pedagogical competencies and critical thinking skills of pre-service mathematics teachers. *Malaysian Online Journal*

of Educational Sciences, 5(2), 1-19.
<https://www.researchgate.net/publication/330729272>

- Aydin-Gunbatar, S., & Fatma Nur Akin (2021). Pre-service chemistry teachers' use of pedagogical transformation competence to develop topic-specific pedagogical content knowledge for planning to teach acid–base equilibrium. *Chemistry Education Research and Practice*, 23(1), 137-158. DOI: 10.1039/D1RP00106J
- Ayo-Vaughan, A. F., Ajani, D., & Oyebade, M.O. (2023). Secondary school teachers technology pedagogical content knowledge (TPACK) levels and its implications for curriculum implementation in Delta State. *International Journal of Research and Innovation in Social Science (IJRISS)*, 8(10), 1364-1373. DOI:<https://dx.doi.org/10.47772/IJRISS.2023.701105>
- 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>.
- Bangladesh Bureau of Educational Information and Statistics (BANBEIS) (2018) *Bangladesh Education Statistics 2018*. Government of Bangladesh.
- Baran, E., Chuang, H. H., & Thompson, A. (2011). TPACK: An Emerging Research and Development Tool for Teacher Educators. *The Turkish Online Journal of Educational Technology*, 10(4), 370-377.
- Barış, S. (2015). Examining techno-pedagogical knowledge competencies of teachers in terms of some variables. *Procedia- Social and Behavioral Sciences*, 174, 208 – 215. <http://creativecommons.org/licenses/by-nc-nd/4.0/>
- Bashir, K., & Jimmy, L. (2023). Pre-service teachers' technological, pedagogical and content capability and digital pedagogy readiness. *Journal of Teacher Education and Educators*, 12(3), 303-326.
- Basu, N., & Ahmad, G. (2016). Attitude towards using new technology among higher secondary school teachers in District Budgam. *Journal of Information Engineering and Applications*, 6(2), 16-21.

- Beri, N., & Sharma, L. (2021). Development of TPACK for teacher-educators: A technological pedagogical content knowledge scale. *Linguistics and Culture Review*, 5(1), 1397-1418. <https://doi.org/10.21744/lingcure.v5nS1.1646>
- Bingimlas, K. (2018) 'Investigating the level of teachers knowledge in technology, pedagogy, and content (TPACK) in Saudi Arabia', *South African Journal of Education*, Vol. 38, No. 3, pp.1–12.
- Binjha, P. B., Das, B. C., Dansana, A., & Das, B. K. (2023). Pedagogical Innovation of Tpack Based K-4 Learning Transaction Model in Science and Social Sciences. *Asian Journal of Education and Social Studies*, 39(1), 42-52. <https://www.sdiarticle5.com/review-history/95941>
- Blomberg, P., Högström, P., & Liljekvist, Y. (2022). Learning opportunities for pre-service teachers to develop pedagogical content knowledge for statistical inference. *Congress of the European Society for Research in Mathematics Education*, 1-9. <https://hal.science/hal-03751811v1>
- Brush, T., Glazewski, K., Rutowski, K., Berg, K., Stromfors, C. and Van-Nest, M.H. et al. (2003) 'Integrating technology into a field-based teacher training program: the PT3@ASU project', *Educational Technology Research and Development*, Vol. 51, pp.57–72.
- Bwalya, A., Rutegwa, M., Tukahabwa, D., & Mapulanga, T. (2023). Enhancing pre-service biology teachers' technological pedagogical content knowledge through a TPACK-based technology integration course. *Journal of Baltic Science Education*, 22(6), 956-973. <https://doi.org/10.33225/jbse/23.22.956>
- Can, H. B., & Boz, Y. (2022). Development of pre-service teachers' pedagogical content knowledge and the factors affecting that development: a longitudinal study. *Chemistry Education Research and Practice*, 23(4), 980-997. DOI <https://doi.org/10.1039/D2RP00106C>
- Cardoso, L., Ponte, J. P., & Quaresma, M. (2022). The development of pedagogical content knowledge of prospective primary teachers in a lesson study. *International Journal for Lesson and Learning Studies*, 12(2), 152-165. <https://www.emerald.com/insight/2046-8253.htm>
- Castéra, J., Marre, C.C., Yok, M.C.K., Sherab, K. and Impedovo, M.A. et al. (2020)

- ‘Self- reported TPACK of teacher educators across six countries in Asia and Europe’, *Education and Information Technologies*, Vol. 25, pp.3003–3019.
- Celik, I. (2022). Towards Intelligent-TPACK: An empirical study on teachers’ professional knowledge to ethically integrate artificial intelligence (AI)-based tools into education. *Computers in Human Behavior*, 138, 1-12. <https://doi.org/10.1016/j.chb.2022.107468>
- Cengiz, C. (2014). The development of TPACK, Technology Integrated Self- Efficacy and Instructional Technology Outcome Expectations of pre-service physical education teachers. *Asia-Pacific Journal of Teacher Education*, 1-12. DOI: [10.1080/1359866X.2014.932332](https://doi.org/10.1080/1359866X.2014.932332)
- Ceylan, Y. E. (2016). Improving Technological Pedagogical Content Knowledge (TPACK) of pre-service English language teachers. *International Education Studies*, 9(5), 18-27. <http://dx.doi.org/10.5539/ies.v9n5p18>
- Chai, C. S. (2019). Teacher professional development for technology integration: Towards a framework of TPACK knowledge creation. *Australasian Journal of Educational Technology*, 35(4), 143–159. <https://doi.org/10.14742/ajet.4162>
- 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.
- Chen, Y.H. and Jang, S.J. (2014) ‘Interrelationship between stages of concern and technological, pedagogical, and content knowledge: a study on Taiwanese senior high school in-service teachers’, *Computers in Human Behavior*, Vol. 32, pp.79–91.
- Chieng, Y.E. and Tan, C.K. (2021) ‘A sequential exploratory investigation of TPACK: Malaysian science teachers survey and perspective’, *International Journal of information and Education Technology*, Vol. 11, No. 5, pp.235–241.
- Choi, C. (2022). Towards purposeful technology-integration practices: Developing TPACK. *Standards and Best Practices*, 37-57. <https://doi.org/10.4018/978-1-6684-5478-7.ch003>
- Creswell, J.W. (2012) *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research*, 4th ed., Pearson Education, Inc.

- Creswell, J.W. (2014) *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*, 4th ed., SAGE Publications, Inc.
- Cui, Y., & Zhang, H. (2022). Integrating teacher data literacy with TPACK: A self-report study based on a novel framework for teachers' professional development. *Frontiers in Psychology*, 13, 1-17. Doi:10.3389/fpsyg.2022.966575
- Daniela, L., Visvizi, A., Gutiérrez-Braojos, C. and Lytras, M.D. (2018) 'Sustainable higher education and technology-enhanced learning (TEL)', *Sustainability*, Vol. 10.
- Diputera A.M., Yus, A., Handayani P.H., & Anjas Wulan, D. S. (2022). Content validity and reliability of expert assessment PLP guide book based on Technological Pedagogical and Content Knowledge. *Budapest International Research and Critics Institute*, (2), 15700-15707. DOI: <https://doi.org/10.33258/birci.v5i2.5476>
- Dong, Y., Chai, C.S., Sang, G-Y., Koh, H.L. and Tsai, C-C. (2015) 'Exploring the profiles and interplays of pre-service and inservice teachers technological pedagogical content knowledge (TPACK) in China', *Educational Technology and Society*, Vol. 18, No. 1, pp.158–169.
- Drummond, A. and Sweeney, T. (2017) 'Can an objective measure of technological pedagogical content knowledge (TPACK) supplement existing TPACK measures?', *British Journal of Educational Technology*, Vol. 48, No. 4, pp.928–939.
- Durdu, L., & Dag, F. (2017). Pre-Service Teachers' TPACK development and conceptions through a TPACK-Based Course. *Australian Journal of Teacher Education*, 42(11), 150-171. <https://www.researchgate.net/publication/321536901>
- Durusoy, O., & Karamete, A. (2023). Enhancing pre-service teachers' technological pedagogical content knowledge (TPACK) through the learning by design framework: A Fink Taxonomy-based study. *Journal of Science and Mathematics Education*, 17(1), 174-210. <https://doi.org/10.17522/balikesirnef.1262115>

- Ekrem, S. and Recep, C. (2014) 'Examining preservice EFL teachers' TPACK competencies in Turkey', *Journal of Educators Online*, Vol. 11, No. 2, pp.1–22.
- Erol, S., & Tuncay, A. (2021). Comparing pre-service teachers' self-confidence levels in technological pedagogical content knowledge in terms of several variables. *Journal of Education and Learning*, 10(1), 82-93. <https://doi.org/10.5539/jel.v10n1p82>
- Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher technology change: How knowledge, confidence, beliefs, and culture intersect. *Journal of Research on Technology in Education*, 42(3), 255–284.
- Ertmer, P.A., Ottenbreit-Leftwich, A.T., Sadik, O., Sendurur, E. and Sendurur, P. (2012) 'Teacher beliefs and technology integration practices: a critical relationship', *Computers and Education*, Vol. 59, No. 2, pp.423–435.
- Fahadi, M. and Khan, M.S.H. (n.d.) 'Technology enhanced teaching in engineering education: teachers' knowledge construction using TPACK framework', *International Journal of Instruction*.
- Fathi, J., & Saman, Y. (2019). Assessing language Teachers' Technological Pedagogical Content Knowledge (TPACK): EFL students' perspectives. *Research in English Language Pedagogy*, 7(2), 255-282. DOI:10.30486/relp.2019.665888
- Garrett, K.N. (2014) *A Quantitative Study of Higher Education Faculty Self-Assessments of Technological, Pedagogical, and Content Knowledge (TPaCK) and Technology Training* (Doctoral dissertation). ProQuest Dissertations & Theses Database (No. 3639104).
- Gayen, P., & Sen, S. (2023). Evolution of Technological Pedagogical and Content Knowledge (TPACK). *Education in Transition*, 41-51. <https://www.researchgate.net/publication/369792717>
- Gess-Newsome, J. (1999). *Pedagogical content knowledge: An introduction and orientation*. In J. Gess-Newsome & N. G. Lederman (Eds.), *Examining pedagogical content knowledge: The construct and its implications for science education* (pp. 3–17). Kluwer Academic Publishers.

- Glowatz, M. and O'Brien, O. (2017) 'Academic engagement and technology: revisiting the technological, pedagogical and content knowledge framework (TPACK) in higher education (HE): the academics' perspectives', *IAFOR Journal of Education*, Vol. 5
- Golde, C. M., & Dore, T. M. (2001). *At cross purposes: What the experiences of doctoral students reveal about doctoral education*. Philadelphia: The Pew Charitable Trusts.
- Graham, R. C., Burgoyne, N., Cantrell, P., Smith, L., St. Clair, L. and Harris, R. (2009) 'Measuring the TPACK confidence of inservice science teachers', *TechTrends*, Vol. 53, No. 5, pp.70–79.
- Grossman, P. (1990) *The Making of a Teacher: Teacher Knowledge and Teacher Education*, Teachers College Press, New York.
- Guerra, C., Moreira, A., & Vieira, R. (2012). Technological pedagogical content knowledge development: integrating technology with a research teaching perspective. *Digital Education Review*, 32, 85-96. <http://greav.ub.edu/der/>
- Guzey, S. S., & Roehrig, G. H. (2009). Teaching science with technology: Case studies of science teachers' development of technology, pedagogy, and content knowledge. *Contemporary Issues in Technology and Teacher Education*, 9(1), 25-45.
- Guzmán González, J.R. & Vesga Bravo, G.J. (2024). TPACK in in-service secondary education teachers: A systematic review of the literature. *International Journal of Education in Mathematics, Science, and Technology*, 12(1), 282-296. <https://doi.org/10.46328/ijemst.3198>
- Handal, B., Campbell, C., Cavanagh, M., Petocz, P., & Kelly, N. (2013). Technological pedagogical content knowledge of secondary mathematics teachers. *Contemporary Issues in Technology and Teacher Education*, 13(1), 22-40. <http://www.citejournal.org>
- Hardisky, M. (2018). *TPACK: Technology integration and teacher perceptions* (Doctoral dissertation). <https://tpack.org/tpackrefs/archives/2075>

- Harris, J. B., 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(3), 393-416. <https://scholarworks.wm.edu/educationpubs>
- Harris, J., & Hofer, M. (2011). Technological pedagogical content knowledge (TPACK) in action. *Journal of Research on Technology in Education*, 43(3), 211–229.
- 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.
- Hayati, N., Kadarohman, A., Sopandi, W., Martoprawiro, M. A., & Rochintaniawati, D. (2022). Chemistry Teachers' TPACK Competence: Teacher Perception and Lesson Plan Analysis. *Technium Social Sciences Journal*, 34, 237-247.
- Hearns, M., & Anderson, K. (2002). *Technology and teacher autonomy*. London: Routledge.
- Hew, K. F., & Brush, T. (2007). Integrating technology into K–12 teaching and learning: Current knowledge gaps and recommendations for future research. *Educational Technology Research and Development*, 55(3), 223–252.
- Hill, J.E. and Uribe-Florez, L. (2020) 'Understanding secondary school teachers TPACK and technology implementation in mathematics classrooms', *International Journal of Technology in Education (IJTE)*, Vol. 3, No. 1, pp.1–13.
- Holvio, A. (2021). *Teaching and learning in Mozambican primary schools: how does teacher content knowledge affect student achievement?* (Ph. D Theses), <http://hdl.handle.net/10138/336031>
- Honngam, K. (2023). A study on technological pedagogical and content knowledge (tpack) of prospective elementary teachers. *International Journal of Creative Research Thoughts*, 11(9), 915-920. <http://www.ijcrt.org/>
- Hosseini, Z. and Kamal, A. (2012) 'Developing an instrument to measure perceived

- technology integration knowledge of teachers', *Proceedings of International Conference of Advanced Information System, E-Education & Development*, pp.7–8.
- Hosseini, Z., & Kamal, A. (2013). A Survey on pre-service and in-service teachers' perceptions of Technological Pedagogical Content Knowledge (TPCK). *Malaysian Online Journal of Educational Technology*, 1(2), 1-7. <http://www.mojet.net/frontend/articles/pdf/v01i02/v01i02-01.pdf>
- Howley, A., Howley, C., Klein, R., Belcher, J., Tusay, M., Clonch, S., Miyafusa, S., Foley, G., Pendarvis, E., Perko, H., Howley, M. and Jimerson, L. (2010) Community and Place in Mathematics Education in Selected Rural Schools, *Appalachian Collaborative Center for Learning, Instruction, and Assessment in Mathematics*, Ohio University, Athens, OH. <http://files.eric.ed.gov/fulltext/ED512400.pdf>
- Ifinedo, E., Saarela, M. and Hämäläinen, T. (2019) 'Analysing the Nigerian teacher's readiness for technology integration', *International Journal of Education and Development using Information and Communication Technology*, Vol. 15, No. 3, pp.34–52.
- International Society for Technology in Education (2008) *National Educational Technology Standards and Performance Indicators for Teachers*, ISTE
- Islam, M.S. (2020) 'Exploring teachers self-efficacy towards ICT integration in government primary schools of Bangladesh', *International Journal of Advance Research and Innovative Ideas in Education*, Vol. 6, No. 2, pp.2395–4396.
- Jaipal-Jamani, K., & Figg, C. (2015). A case study of a TPACK-based approach to teacher professional development: Teaching science with blogs. *Contemporary Issues in Technology and Teacher Education*, 15(2), 1-25. <http://www.citejournal.org/vol15/iss2/science/article2.cfm>
- Jamil, M.G. (2015) 'Technology enhanced teacher-learning in Rural Bangladesh: A Critical Realist Inquiry with Secondary Teachers of English, University of Southampton, School of Education, Doctoral Thesis.

- Jang, S. J., & Tsai, M. F. (2013). Exploring the TPACK of Taiwanese secondary school science teachers using a new contextualized TPACK model. *Australasian Journal of Educational Technology*, 29(4), 566-580. <https://doi.org/10.14742/ajet.282>
- Jang, S-J. and Tsai, M-F. (2012) 'Exploring the TPACK of Taiwanese elementary mathematics and science teachers with respect to use of interactive whiteboards', *Computers and Education*, Vol. 59, No. 2, pp.327–338.
- Jangid, S., & Lata, P. (2022). Teachers' self-perceived technological pedagogical content knowledge in Indian schools. *International Journal of Education and Development*, 7(3), 85–97.
- Jeyaraj, I., & Ramnath, R. A. (2018). Study on Technological Pedagogical and Content Knowledge of B.Ed. Student-teachers in Puducherry Region. *World Wide Journal of Multidisciplinary Research and Development*, 4(1), 306-308. DOI: <https://www.jmr.com/archive/2018/1/743/a-study-on-technological-pedagogical-and-content-knowledge-of-b-ed-student-teachers-in-puducherry-region>
- Johnson, P. (1976) 'Women and power: toward a theory of effectiveness', *Journal of Social Issues*, Vol. 32, No. 3, pp.99–110.
- Johnson, R.B. and Christensen, L. (2014) *Educational Research: Quantitative, Qualitative, and Mixed Approaches*, 5th ed., SAGE Publications, Inc.
- Joldanova, D., Tleuzhanova, G., Kitibayeva, A., Smanova, G., & Mirza, N. (2022). Formation of TPACK and acme logical competency of future teachers in foreign language education. *International Journal of Education in Mathematics, Science, and Technology*, 10(4), 935-954. <https://doi.org/10.46328/ijemst.2717>
- Jones, M. (2011). Teachers' attitudes toward technology integration. *Educational Research Journal*, 28(4), 345–360.
- Joshi, S. C. (2023). TPACK and teachers' self-efficacy: A systematic review. *Canadian Journal of Learning and Technology*, 49(2), 1-23.
- Joshual, R. (2022) Technological Pedagogical and Content Knowledge (TPACK) of teachers in relation to the context and their teaching performance, Loon, Bohol. *ACADEME University of Bohol Graduate School and Professional Studies Journal*, 20, 13-38. DOI:<https://doi.org/10.15631/aubgps.v20i1.177>

- Joy Prakash, D., Pradhan, P., & Akankshya, P. (2023). A study of technological pedagogical content knowledge (TPACK) of teachers with relation to their gender and type of institutions. *Education and Society*, 46(4), 291-296. DOI:<https://www.researchgate.net/publication/379602445>
- Kalaimani, K., & Stephen, L. G. (2022). A study on technological pedagogical content knowledge of high school teachers in Chennai. *Journal of Positive School Psychology*, 6(2), 6303–6308. DOI:<http://dx.doi.org/journalppw.com>
- Kanyarat, S., Kanyarat, C. & Sitti, S. (2024). The effects of Teachers' Technological Pedagogical Content Knowledge (TPACK) on students' scientific competency. *Journal of Education and Learning*, 13(5), 91-101. <https://doi.org/10.5539/jel.v13n5p91>
- Karaca, F. (2015). An investigation of pre-service teachers' technological pedagogical content knowledge based on a variety of characteristics. *International Journal of Higher Education*, 4(4), 128-136. <http://dx.doi.org/10.5430/ijhe.v4n4p128>
- Karadeniz, Ş., & Vatanartıran, S. (2013). Adaptation of a TPACK survey to Turkish for secondary school teachers. *International Journal of Human Sciences*, 10(2), 34-47. <https://www.researchgate.net/publication/258446975>
- Kartal, B. (2022). Examining pre-service mathematics teachers' technological pedagogical content knowledge development in the natural setting of a teacher preparation program. *inquiry in education*, 14(2), 1- 26. <https://digitalcommons.nl.edu/ic/vol14/iss2/4>
- Kartal, T. & Dilek, I. (2021). Preservice science teachers' TPACK development in a technology-enhanced science teaching method course. *Journal of Education in Science, Environment and Health*, 7(4), 339-353. <https://doi.org/10.21891/jeseh.994458>
- Kaur, G., & Singh, R. (2021). Examining teachers' TPACK competencies in Indian secondary education. *Asian Journal of Education and Training*, 7(2), 99–108.
- Kay, R. (2006) 'Evaluating strategies used to incorporate technology into preservice education: a review of the literature', *Journal of Research on Technology in Education*, Vol. 38, pp.383–408.

- Kazu, I.Y. and Erten, P. (2014) 'Teachers' technological pedagogical content knowledge self- efficacies', *Journal of Education and Training Studies*, Vol. 2, No. 2, pp.126–144.
- Khan, M.S. (2014) 'A model for integrating ICT into teacher training programs in Bangladesh based on TPACK', *International Journal of Education and Development using Information and Communication Technology (IJEDICT)*, Vol. 10, No. 3, pp.21–31.
- Khan, M.S. and Hasan, M. (2013) 'Introducing ICT into teacher-training programs: problems in Bangladesh', *Journal of Education and Practice*, Vol. 4, No. 14, pp.79–85.
- Kim, S. (2018). Technological, pedagogical, and content knowledge (TPACK) and beliefs of pre-service secondary mathematics teachers: Examining the relationships. *EURASIA Journal of Mathematics, Science and Technology Education*, 14(10), 1-24. <https://doi.org/10.29333/ejmste/93179>
- Kim, S. W., & Lee, Y. (2018). The effects of the TPACK-P educational program on teachers' TPACK: Programming as a technological tool. *International Journal of Engineering & Technology*, 7 (3), 636-643.
- Knolton, D. V. (2014). *Technological, Pedagogical, Content Knowledge TPACK): An exploratory study of adjunct faculty technology proficiency*. (Unpublished Dissertation).
- Kocagül, M. & ÜnalÇoban, G. (2024). Evaluation of pre-service science and Math teachers' online teaching experiences within the TPACK framework. *Journal of Educational Technology & Online Learning*, 7(2), 149-167. Doi: <http://doi.org/10.31681/jetol.1332419>
- Koehler, M. J., & Mishra, P. (2006). *Technological pedagogical content knowledge: A framework for teacher knowledge*. *Teachers College Record*, 108(6), 1017–1054.
- Koehler, M. J., & Mishra, P. (2008). Introducing technological pedagogical content knowledge. *Annual Meeting of the American Educational Research Association*.

- Koehler, M. J., & Mishra, P. (2008). Introducing TPACK. In AACTE Committee on Innovation and Technology (Ed.), *Handbook of technological pedagogical content knowledge (TPCK) for educators* (pp. 3–29). Routledge.
- Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)? *Contemporary Issues in Technology and Teacher Education*, 9(1), 60–70.
- Koehler, M. J., Mishra, P., & Cain, W. (2013). What is technological pedagogical content knowledge (TPACK)? *Journal of Education*, 193(3), 13–19.
- Koehler, M. J., Mishra, P., Kereluik, K., Shin, T. S., & Graham, C. R. (2013). The technological pedagogical content knowledge framework. In *Handbook of Research on Educational Communications and Technology* (pp. 101–111). Springer.
- Koehler, M.J. and Mishra, P. (2008) ‘Introducing TPACK. AACTE committee on innovation and technology (Ed.)’, *The Handbook of Technological Pedagogical Content Knowledge (TPCK) for Educators*, Lawrence Erlbaum Associates, Mahwah, NJ, pp.3–29.
- Koh, J. H. L., & Divaharan, S. (2011). Developing pre-service teachers’ technology integration expertise through the TPACK-developing instructional model. *Journal of Educational Computing Research*, 44(1), 35–58.
- Koh, J. H. L., Chai, C. S., & Tsai, C. C. (2010). Examining the technological pedagogical content knowledge of Singapore pre-service teachers. *Australasian Journal of Educational Technology*, 26(6), 751–770.
- Koh, J. H. L., Chai, C. S., & Tsai, C. C. (2014). Demystifying technological pedagogical content knowledge (TPACK): The influence of educational technology courses on preservice teachers. *Australasian Journal of Educational Technology*, 30(6), 713–727.
- Koh, J. H. L., Chai, C. S., & Tsai, C. C. (2014). Demystifying technological pedagogical content knowledge (TPACK): The role of educational technology experts. *Asia-Pacific Journal of Teacher Education*, 42(3), 271–284.

- Koh, J.H.L. and Chai, C.S. (2011) 'Modeling pre-service teachers technological pedagogical content knowledge (TPACK) perceptions: the influence of demographic factors and TPACK constructs', in Williams, G., Statham, P., Brown, N. and Cleland, B. (Eds): *Changing Demands, Changing Directions*, pp.735–746.
- Koh, J.H.L., Chai, C.C. and Tsai, C.C. (2013) 'Examining practicing teachers' perceptions of technological pedagogical content knowledge (TPACK) pathways: a structural equation modeling approach', *Instructional Science*, Vol. 41, pp.793–809.
- Koh, J.H.L., Chai, C.S. and Lim, W.Y. (2016) 'Teacher professional development for TPACK- 21CL: effects on teacher ICT integration and student outcomes', *Journal of Educational Computing Research*, Vol. 55, No. 2, pp.172–196.
- Koh, J.H.L., Chai, C.S. and 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*, Vol. 26, No. 6, pp.563–573.
- Koh, J.H.L., Chai, C.S. and Tsai, C.C. (2014) 'Demographic factors, TPACK constructs, and teachers' perceptions of constructivist-oriented TPACK', *Educational Technology and Society*, Vol. 17, No. 1, pp.185–196.
- Kopcha, T.J., Ottenbreit-Leftwich, A., Jung, J. and Baser, D. (2014) 'Examining the TPACK framework through the convergent and discriminant validity of two measures', *Computers and Education*, Vol. 78, No. 1, pp.87–96.
- Kulaksız, T., & Karaca, F. (2022). Elaboration of science teachers' technology-based lesson practices in terms of contextual factors influencing TPACK. *Research in Science & Technological Education*, 42(2), 357–377. <https://doi.org/10.1080/02635143.2022.2083598>
- Kumar, J. and Pasricha, A. (2014) 'ICT in education: enhancing teaching and learning', *Scholarly Research Journal For Interdisciplinary Studies*, Vols. II/X, pp.935–946.

- Kumar, S., & Gangmei, E. (2018). Technological Pedagogical Content Knowledge of Secondary Teacher Educators of Jharkhand; An Analysis. *International Journal of Innovative Studies in Sociology and Humanities*, 3(8), 31-39. DOI: <http://www.ijissh.org/>
- Kusaini, E. A., Mahamod, Z., & Mohammad, W. M. R. W. (2022). Validation Instrumentation and Measurement of Technological Pedagogical Content Knowledge (TPACK) for Teachers. *Open Journal of Social Sciences*, 10, 69-98. <https://doi.org/10.4236/jss.2022.1010006>
- Kusuma, I. (2022). How Does a TPACK-related Program Support EFL Pre-service Teachers' Flipped Classrooms?. *Language Education and Acquisition Research Network*, 15(2), 300-325. <https://so04.tci-thaijo.org/index.php/LEARN/index>
- Kwangsawad, T. (2016) 'Examining EFL pre-service teachers' TPACK trough self-report, lesson plans and actual practice', *Journal of Education and Learning*, Vol. 10, No. 2, pp.103–108.
- Lalchhuanawma, & Fanai, L. (2022). Integration of ICT in school education of Mizoram: Issues and challenges. *Journal of Educational Research and Practice*, 12(1), 45–54.
- Larsen, N.A. (2014) *Examining the differences in Technological Pedagogical Content Knowledge (TPACK) self-assessment scores of foreign language instructors and first-line supervisors in six institutes of higher education (IHE) in California*, Brandman University.
- Lee, H. Y., Chung, C. Y., & Wei, G. (2022) Research on Technological Pedagogical and Content Knowledge: A bibliometric analysis from 2011 to 2020. *Frontiers in Education*, 7, 1-14. doi: <https://doi.org/10.3389/educ.2022.765233>
- Lee, M.H. and Tasi, C.C. (2010) 'Exploring teachers perceived self-efficacy and technological pedagogical content knowledge with respect to educational use of the world wide web', *Instructional Science*, Vol. 38, pp.1–21.
- Lehtinen, A., Nieminen, P. and Viiri, J. (2016) 'Preservice teachers TPACK beliefs and attitudes toward simulations', *Contemporary Issues in Technology and Teacher Education*, Vol. 16, No. 2, pp.151–171.

- Liang, J. C., Chai, C. S., Koh, J. H., Yang, C. J., & Tsai, C. C. (2013). Surveying in-service preschool teachers' technological pedagogical content knowledge. *Australasian Journal of Educational Technology*, 29(4), 581-594.
- Lin, T.C., Tsai, C.C., Chai, C.C. and Lee, M.H. (2013) 'Identifying science teachers perceptions of technological pedagogical and content knowledge (TPACK)', *Journal of Science Education and Technology*, Vol. 22, pp.325–336.
- Liu, B. (2022). Exploring secondary mathematics teachers' TPACK development and student-centred beliefs. *Advances in Social Science, Education and Humanities Research*, 664, 305-312. <http://creativecommons.org/licenses/by-nc/4.0/>.
- Loseñara, J. M. & Jugar, R. R. (2023). Technological, pedagogical, and content knowledge of diploma in professional education graduates teaching biology. *Jurnal Pendidikan Biologi Indonesia*, 9(1), 1-14. <https://doi.org/10.22219/jpbi.v9i1.24070>
- Ly, C. N., & Soutte, M. (2022). Technological Pedagogical Content Knowledge Framework as a Lens for Transformative Social and Emotional Learning Online: A Perspective. *Information Resources Management Association*, 1-17. DOI: <https://doi.org/10.4018/978-1-7998-9168-0.ch004>
- Lye, L.T. (2013) 'Opportunities and challenges faced by private higher education institution using the TPACK model in Malaysia', *Procedia – Social and Behavioral Sciences*, Vol. 91, pp.294–305.
- Lyublinskaya, I. and Tournaki, N. (2011) 'The effects of teacher content authoring on tpack and on student achievement in algebra: research on instruction with the TI-Nspire Handheld', in Koehler, M. and Mishra, P. (Eds): *Proceedings of SITE 2011--Society for Information Technology and Teacher Education International Conference*, Association for the Advancement of Computing in Education (AACE), Nashville, Tennessee, USA, pp.4396–4401.
- Mai, M.Y. and Hamzah, M. (2016) 'Primary science teachers' perceptions of technological pedagogical and content knowledge (TPACK) in Malaysia', *European Journal of Social Sciences Education and Research*, Vol. 3, No. 2, pp.167–179. Doi: 10.26417/ejser.v6i2.

- Mangold, K. (2007). Educating a new generation: Teaching baby boomer faculty about millennial students. *Nurse Educator*, 32(1), 21–23.
- Martin, N.K., Yin, Z. and Mayall, H. (2007/2008) ‘The attitudes & beliefs on classroom control inventory-revised and revisited: a continuation of construct validation’, *The Journal of Classroom Interaction*, Vol. 42, No. 2, pp.11–20.
- Masry-Herzalah, A., & Dor-Haim, P. (2022). Teachers’ technological competence and success in online teaching during the COVID-19 crisis: the moderating role of resistance to change. *International Journal of Educational Management*, 36(1), 1-13. DOI:[10.1108/IJEM-03-2021-0086](https://doi.org/10.1108/IJEM-03-2021-0086)
- Mia, M.A.H and Haque, M.Z. (2013) ‘Perception and usage level of ICT of the primary school teachers in Bangladesh’, *Bangladesh Journal of MIS*, Vol. 6, No. 1, pp.3–17.
- Ministry of Education (2010) *Bangladesh National Education Policy 2010*. Government of the People’s Republic of Bangladesh.
- Ministry of Education (2011) *Bangladesh National Skills Development Policy 2011*. https://www.skillsforemployment.org/KSP/en/Details/?dn=FM11G_021629
- Ministry of Education (2013) *Master Plan for Information and Communication Technology in Education (2012–2021)*, Ministry of Education, Government of the People’s Republic of Bangladesh, Dhaka.
- Ministry of Education. (2020). *National Education Policy 2020*. Government of India.
- Ministry of Education. (2021). *Annual report 2020–21*. Government of India.
- Ministry of Post, Telecommunication and Information Technology (2009) *National ICT Policy – 2009*, Ministry of Education, Government of the People’s Republic of Bangladesh, Dhaka.
- Ministry of Post, Telecommunication and Information Technology (2016) *Bangladesh ICT Fellowship and Donation Policy (Amendment) 2016*, Ministry of Education, Government of the People’s Republic of Bangladesh, Dhaka.

- Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, 108(6), 1017–1054.
- Mishra, P., Koehler, M. J., & Cain, W. (2013). The TPACK framework: A review and update. In *Handbook of Research on Educational Communications and Technology* (pp. 101–111). Springer.
- Mou, S. (2016) ‘Possibilities and challenges of ICT integration in the Bangladesh education system’, *Educational Technology*, Vol. 56, No. 2, pp.50–53.
- Mourlam, D. (2017) ‘Preparing for infusion: emergence of a model for faculty TPACK development’, *Journal of Technology and Teacher Education*, Vol. 25, No. 3, pp.301–325.
- Mouza, C. (2011) ‘Promoting urban teachers understanding of technology, content, and pedagogy in the context of case development’, *Journal of Research on Technology in Education*, Vol. 44, No. 1, pp.1–29.
- Mouza, C., Karchmer-Klein, R., Nandakumar, R., Yilmaz Ozden, S., & Hu, L. (2014). Investigating the impact of an integrated approach to the development of preservice teachers’ technological pedagogical content knowledge (TPACK). *Computers & Education*, 71, 206–221.
- Muhammad, Y., Husain, S., & Hasanah, N. (2022). Higher order thinking skills based assessment for learning model in problem based learning using SIAVO for vocational school students. *Asian Journal of Applied Sciences*, 10(1), 9-15. DOI:10.24203/ajas.v10i1.6876
- Mulhayatiah, D., Suhendi, H.Y., & Windayani, N. (2020). TPACK’s Understanding Analysis of Physics Teachers in Using Learning Media. *Jurnal Pendidikan Progresif*, 10(3), 526-533. doi: 10.23960/jpp.v10.i1.202014.
- Naaz, S. and Khan, Z. (2018) ‘American international journal of research in humanities’, *Arts and Social Sciences*, Vol. 22, No. 1, pp.50–55.
- Naaz, S., & Khan, Z. N. (2018). Measuring the technological pedagogical content knowledge (TPACK) of pre-service teachers in relation to their gender and

- streams. *American International Journal of Research in Humanities, Arts and Social Sciences*, 22(1), 50-55. <http://www.iasir.net>
- Nalurita, A., Priyanto & Muslikhin. (2020). The effectiveness of technology, pedagogy and content knowledge (tpack) in learning. *Jurnal Pendidikan Teknologidan Kejuruan*, 26(1), 43-51. DOI: <https://doi.org/10.21831/jptk.v26i1.24012>
- National Education Policy (NEP). (2020). *National Education Policy 2020*. Ministry of Education, Government of India. <https://www.education.gov.in/nep/>
- Nelly, T., & Irina, L. (2014). Preparing special education teachers for teaching mathematics and science with technology by integrating the TPACK framework in to the curriculum: A study of teachers' perceptions. *Jl. of Technology and Teacher Education*, 22(2), 243-259. <https://www.researchgate.net/publication/261725239>
- Nelson, J., Christopher, A. and Mims, C. (2009) 'Transformation of teaching and learning', *Teach Trends*, Vol. 53, No. 5, pp.80–85.
- Nibedita, G., & Beura, M. K. (2019). Techno-pedagogical competency of higher secondary school teachers in relation to students' academic achievement in science. *International Journal of Applied Research*, 5(12), 362-370. <https://www.researchgate.net/publication/354837346>
- Niess, M. L. (2005). Preparing teachers to teach science and mathematics with technology: Developing a technology pedagogical content knowledge. *Teaching and Teacher Education*, 21(5), 509–523.
- Niess, M. L. (2011). Investigating TPACK: Knowledge growth in teaching with technology. *Journal of Educational Computing Research*, 44(3), 299–317.
- Njiku, J. (2022). Attitude and technological pedagogical and content knowledge: The reciprocal predictors?. *Journal of Research on Technology in Education*, 55(1), 1-16. DOI:10.1080/15391523.2022.2089409
- Njiku, J., Mutarutinya, V., & Maniraho, J. F. (2021). Building mathematics teachers' TPACK through collaborative lesson design activities. *Contemporary Educational Technology*, 13(2), 1-14. <https://doi.org/10.30935/cedtech/9686>

- Nuangchalem, P. (2020). TPACK in ASEAN perspectives: Case study on Thai pre-service teacher. *International Journal of Evaluation and Research in Education*, 9(4), 993-999. DOI:10.11591/ijere.v9i4.20700
- Ömer, Ş., & Ziya, F. S. (2019). Investigation of the self-efficacy of the teachers in Technological Pedagogical Content Knowledge and their use of information and communication technologies. *World Journal of Education*, 9(1), 196-208. <https://doi.org/10.5430/wje.v9n1p196>
- Onbasili, U. I., Tuncay, A. A., Seker, B. S., & Kiray, S. A. (2022). An examination of pre-service teachers' experiences in creating a scientific digital story in the context of their self confidence in technological pedagogical content knowledge. *Journal of Baltic Science Education*. 21(2):207-223. DOI:[10.33225/jbse/22.21.207](https://doi.org/10.33225/jbse/22.21.207)
- Öz, H. (2015) 'Assessing pre-service English as a foreign language teachers technological pedagogical content knowledge', *International Education Studies*, Vol. 8, No. 5, pp.119–30.
- Özdemir, M. (2016). An examination of the techno-pedagogical education competencies (TPACK) of pre-service elementary school and pre-school teachers. *Journal of Education and Training Studies*, 4(10), 70-78. <http://dx.doi.org/10.11114/jets.v4i10.1816>
- Özen, E., & Kurtuluş, A. (2023). A study on mathematics teachers' technological pedagogical content knowledge (TPACK) and frequency of use of educational information network (EBA) assessment tools. *Journal of Educational Technology & Online Learning*, 6(4), 1009-1026. <http://doi.org/10.31681/jetol.1335993>
- Padmavathi, M. (2017). Preparing teachers for technology based teaching- learning using TPACK. *I-manager's Journal on School Educational Technology*, 12, 1-9.
- Palanisamy, P., Paavizhi, K., & Saravanakumar, AR. (2020). Techno Pedagogical Skills for Teaching-Learning Process In Smart Class. *International Research Association for Talent Development and Excellence*, 12(1), 4984-4994. <https://www.researchgate.net/publication/342467314>
- Pamuk, S., Ergun, M., Cakir, R., Yilmaz, H.B. and Ayas, C. (2015) 'Exploring

- relationships among TPACK components and development of the TPACK instrument', *Education and Information Technologies*, Vol. 20, pp.241–263.
- Paristiowati, M. et al. (2019) 'Analyze of chemistry teacher profiles using technological pedagogical and content knowledge (TPACK) framework', *Journal of Physics: Conference Series*, No. 5, pp.1–6.
- Parkash, J., & Hooda, S. R. (2018). A study of techno-pedagogical competency among teachers of government & private schools of Haryana state. *International Journal of Current Advanced Research*, 7(1), 9301-9306. DOI: <http://dx.doi.org/10.24327/ijcar.2018.9306.1532>
- Pradeep Kumar, S. L. (2018). A study of techno - pedagogical skills of secondary school Hindi teachers working in Kerala. *International Journal of Advance Research and Innovative Ideas in Education*, 4(1), 909-913. <http://www.ijariie.com>
- Pratumsala, K., & Nuangchalerm, P. (2023). Enhancing scientific literacy of lower secondary students through Technological Pedagogical and Content Knowledge Framework. *International Journal on Social and Education Sciences*, 5(2), 263-274. <https://doi.org/10.46328/ijonses.499>
- Putri, S. A., Sulaeman, N. F., & Aristya Putra, P. D. (2022). Trend of Technological Pedagogical Content Knowledge (TPACK) for Pre-service Science Teacher: A historical review. *Jurnal Pendidikan Fisika*, 10(2), 165 – 175. DOI: <https://doi.org/10.26618/jpf.v10i2.7801>
- Rahman, F.U., Hussain, M.A. and Khalid, S. (2018) 'Technological pedagogical content knowledge (TPACK) and preparedness of tutors in open and distance learning (ODL) for new teacher education programs', *Journal of Educational Research*, Vol. 21, No. 2, pp.147–161.
- Ramirez, I. A. L. (2024). E-training package for secondary pre-service teachers. *International Journal of Technology in Education (IJTE)*, 7(3), 417-433. <https://doi.org/10.46328/ijte.593>
- Raqib, A.B.M.A. (2019) 'Innovations in teacher training at higher education in Bangladesh', *Social Science Review [The Dhaka University Studies, Part-D]*, Vol. 36, No. 1, pp.221–231.

- Redmond, P., & Lock, J. (2019). Secondary pre-service teachers' perceptions of technological pedagogical content knowledge (TPACK): What do they really think? *Australasian Journal of Educational Technology*, 35(3), 45-54. <https://doi.org/10.14742/ajet.4214>
- Reyes, V.C., Reading, C., Doyle, H. and Gregory, S. (2017) 'Integrating ICT into teacher education programs from a TPACK perspective: exploring perceptions of university lecturers', *Computers and Education*, Vol. 115, pp.1–19.
- Rosenberg, J. M., & Koehler, M. J. (2015). Context and Technological Pedagogical Content Knowledge (TPACK): A systematic review. *Journal of Research on Technology in Education*, 47, 186-210. <http://dx.doi.org/10.1080/15391523.2015.1052663>
- Rosyidi, A., Punaji, S., Kuswandi, D., & Henry, P. (2024). A structural correlation model of ELF teachers' technological pedagogical content knowledge and their teaching effectiveness. *Language Teaching Research Quarterly*, 40, 147-160. <https://doi.org/10.32038/ltrq.2024.40.09>
- Rouf, M. (2016) 'Secondary school English language teachers' technological skills in Bangladesh: a case study', *International Journal of Instruction*, Vol. 11, No. 4, pp.701–716.
- Sadaf, M., Tariq, M. and Haider, A. (2019) 'Measuring the impact of technological pedagogical content knowledge on teacher resilience in universities of Pakistan', *International Journal of Management Excellence*, Vol. 12, No. 3, pp.1872–1881.
- Sahin, I. (2011). Development of survey of technological pedagogical and content knowledge (TPACK). *The Turkish Online Journal of Educational Technology*, 10(1), 97–105.
- Salam, M.A. (2018) *Professional Development and Pedagogy of University Teachers in Bangladesh: An Exploratory Study*, University of Dhaka, 103.221.252.46.
- Saltan, F., & Arslan, K. (2017). A comparison of in-service and pre-service teachers' technological pedagogical content knowledge self-confidence, *Cogent Education*, 4(1), 1-12. <https://doi.org/10.1080/2331186X.2017.1311501>
- Sanjukta, B., & Tripathy, M. K. (2020). Techno pedagogical skills of bachelor of education students of Odisha. *Scholarly Research Journal for Interdisciplinary*

Studies. 8(62), 14554-14564.
<https://www.researchgate.net/publication/348807247>

- Santos, J. M., & Castro, R. D. R. (2021). *Technological pedagogical content knowledge (TPACK) in action: Application of learning in the classroom by pre-service teachers (PST)*. *Social Science & Humanities Open*, 3(1), 1-8. DOI: <https://www.sciencedirect.com/science/article/pii/S2590291121000061>
- 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.
- Severo, T., Bernardes, & Andrade Neto, A. S. (2020). Technological Pedagogical Content Knowledge (Tpack) in pre-service and in-service Chemistry teacher training: A systematic literature review. *Revista Novas Tecnologiasna Educação*, 18(2), 611-621.
- Shambare, B. & Simuja, C. (2024). Mapping TPACK competency among life sciences teachers in rural and marginalised secondary schools: A descriptive analysis. *International Journal of Technology in Education and Science*, 8(4), 522-541. <https://doi.org/10.46328/ijtes.573>
- Sharma, H., & Leena, S. (2018). Effectiveness of an ICT programme on technological pedagogical and content knowledge tpack teacher self efficacy and teaching effectiveness among pre-service teacher educators. *International Journal of Research in Social Sciences*, 8(6). 30-43. <http://www.ijmra.us>
- Shih, C.L. and Chuang, H.H. (2013) ‘The development and validation of an instrument for assessing college students’ perceptions of faculty knowledge in technology-supported class environments’, *Computers and Education*, Vol. 63, pp.109–118.
- Shinas, V.H., Ozden, S.Y., Mouza, C., Klein, R.K. and Glutting, J.J. (2013) ‘Examining domains of technological pedagogical content knowledge using factor analysis’, *Journal of Research on Technology in Education*, Vol. 45, No. 4, pp.339–360.

- Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, 57(1), 1–22.
- Shulman, L.S. (1986) ‘Those who understand: knowledge growth in teaching’, *Educational Researcher*, Vol. 15, No. 2, pp.4–14.
- Sintawati, M., Erviana, Y. V., Bhattacharyya, E., Habil, H., & Fatmawati, L. (2022). The effect of project-based learning on technological pedagogical content knowledge among elementary school pre-service teacher. *Pegem Journal of Education and Instruction*, 12(2), 151–156. <https://doi.org/10.47750/pegegog.12.02.15>
- Sobita Devi, K. (2018). Attitudes of higher secondary school teachers towards using new technology: A case study of Imphal East and Imphal West Districts of Manipur. *International Journal of Educational Research and Technology*, 9(1), 33-40. DOI:10.15515/ijert.0976 4089.9.1.3340
- Soomro, S., Soomro, A.B., Ali, N.I., Bhatti, T., Basir, N. and Gill, N.P. (2018) ‘TPACK adaptation among faculty members of education and ICT departments in university of Sindh, Pakistan’, *International Journal of Advanced Computer Science and Applications*. Vol. 9, No. 5, pp.203–209.
- Southern Association of Colleges and Schools. (2010a). *Principles of accreditation: Foundations for quality enhancement*. Decatur, GA: SACS.
- Southern Association of Colleges and Schools. (2010b). *Faculty credentials guidelines*. Decatur, GA: SACS.
- Stoilescu, D. (2011). *Technological Pedagogical Content Knowledge: Secondary School Mathematics Teachers’ Use of Technology*. (Unpublished Ph. D thesis).
- Su, J. (2023). Pre-service teachers’ technological pedagogical content knowledge development: A bibliometric review. *Frontiers in Education*, 1-12. doi: 10.3389/feduc.2022.1033895
- Tan, C.K. and Nguyen, B.D. et al. (2020) ‘The impact of the design teams approach on preservice teachers TPACK in the vietnamese context’, *Studies in English Language Teaching*, Vol. 8, No. 1, pp.2372–9740.

- Tan, J. S. H., & Chen, W. (2022). Spiral model of collaborative lesson design: A model to develop TPACK and TEL design competency in pre-service teachers. *International Society of the Learning Sciences*, 91-98.
- Teo, T. (2011). Factors influencing teachers' intention to use technology: Model development and test. *Computers & Education*, 57(4), 2432–2440.
- Thakur, N. (2015). A study on implementation of techno-pedagogical skills, its challenges and role to release at higher level of education. *American International Journal of Research in Humanities ,Arts and Social Sciences*, 9(2), 182-186. <https://www.researchgate.net/publication/278158081>
- Thohir, M.A., Ahdhianto, E., Mas'ula, S., April Yanti, F., & Sukarelawan, M.I. (2023). The effects of TPACK and facility condition on pre-service teachers' acceptance of virtual reality in science education course. *Contemporary Educational Technology*, 15(2), 1-15. <https://doi.org/10.30935/cedtech/12918>
- Thomas, A. and Falls, Z. (2019) 'Rural elementary teachers access to and use of technology resources in STEM classrooms', in Graziano, K. (Ed.): *Proceedings of Society for Information Technology and Teacher Education International Conference*, Las Vegas, NV, pp.2549–2553. Available online at: <https://www.learntechlib.org/primary/p/208007/> (accessed 30 December 2020).
- Tondeur, J., Roblin, N.P., Braak, J.V., Fisser, P. and Voogt, J. (2013) 'Technological pedagogical content knowledge in teacher education: in search of a new curriculum', *Educational Studies*, Vol. 39, No. 2, pp.239–243.
- Turgut, Y. (2017). A comparison of pre-service, in-service and formation program for teachers' perceptions of technological pedagogical content knowledge (TPACK) in English language teaching (ELT). *Educational Research and Reviews*, 12(22), 1091-1106. <http://www.academicjournals.org/ERR>
- Umi Hanifah, Budayasa, IK., & Sulaiman, R. (2025). Technology, pedagogy, and content knowledge in mathematics education: a systematic literature review. *Journal of Education and Learning*, 19(1), 579-586. DOI: <http://www.org./10.11591/edulearn.v19i1.21816>
- UNESCO (2018) *UNESCO ICT Competency Framework for Teachers*, United Nations Educational, Scientific and Cultural Organization, Paris.

- UNESCO. (2019). *ICT Competency Framework for Teachers (Version 3)*. Paris: UNESCO.
- Voogt, J., Fisser, P., Pareja Roblin, N., Tondeur, J., & Van Braak, J. (2012). *Technological pedagogical content knowledge – a review of the literature*. Journal of Computer Assisted Learning. <https://www.researchgate.net/publication/235733342>
- 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(2), 109–121.
- Wijayanto, B., Rahmanelli, Novio, R., Pratama, W., & Fadila, N. (2024). Development of Technological, Pedagogical, and Content Knowledge Learning Models Based on Massive Open Online Course (MOOC) Geography Teachers in West Sumatera. *Pegem Journal of Education and Instruction*, 14(3), 337-346. DOI: <http://www.10.47750/pegegog.14.03.31>
- Wu, B., Hu, Y., Gu, X. and Lim, C.P. (2015) ‘Professional development of new higher education teachers with information and communication technology in Shanghai: a Kirkpatrick’s evaluation approach’, *Journal of Educational Computing Research*, Vol. 54, No. 5.
- Yang, C., & Liu, M. (2004). Faculty development: Strategies for building a learning community. *Journal of Educational Technology Development and Exchange*, 7(2), 15–27.
- 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.
- Yildirim, H. I., & Sensoy, O. (2018). Effect of science teaching enriched with technological practices on attitudes of secondary school 7th grade students towards science course. *Universal Journal of Educational Research*, 6(5): 947-959. <http://www.hrpub.org.10.13189/ujer.2018.060516>

BRIEF BIO-DATA OF THE CANDIDATE

NAME:	H. LALBIAKZUALI
FATHER'S NAME:	H. LALRINPUIA
DATE OF BIRTH:	29.07.1993
ADDRESS:	BETHLEHEM VENGTHLANG, AIZAWL, MIZORAM
GENDER:	FEMALE
RELIGION:	CHRISTIAN
MARITAL STATUS:	MARRIED
EDUCATIONAL QUALIFICATION:	MA. B.ED
MZU REGISTRATION NO:	4717 OF 2011
PH.D. REGISTRATION NO:	MZU/PH.D./1630 OF 21.10.2020
DEPARTMENT:	EDUCATION, MIZORAM UNIVERSITY
TITLE OF THE THESIS:	TECHNOLOGICAL, PEDAGOGICAL AND CONTENT KNOWLEDGE OF HIGHER SECONDARY SCHOOL TEACHERS AND TEACHING EFFECTIVENESS: A CRITICAL STUDY

Pre-Service Teacher's Perceptions on Technological Pedagogical and Content Knowledge (TPACK)

H. Lalbiakzuali¹, Lokanath Mishra²

¹Research Scholar, Department of Education, Mizoram University

²Professor, Department of Education, Mizoram University

Abstract

This is 21st century, an era of aligns standardized curriculum, advanced technologies and integrated knowledge. To meet the challenges of this changing world there is a need to enhance the certain core competencies of teachers such as collaboration, digital literacy, critical thinking, problems solving and the knowledge of teaching and technology to achieve the goals of quality of education and students' achievement. Technological Pedagogical and Content Knowledge (TPACK) is a technical framework of collective and composite knowledge required for teachers teaching practices in the classrooms with technology integration. So, in this study the perceptions of pre-service teacher's about TPACK were assessed through cross sectional survey. Sixty-five secondary school pre-service teachers from Department of Education, Mizoram University were selected as sample of the study. A five-point Likert scale was used in this study to collect the information from the respondents. The research reveals that majority of pre service teachers has average level of professional knowledge of technology integration and its use in their teaching practices and there was no significant difference in their perceptions of TPACK with reference to their gender.

Keywords: TPACK, Pre-Service Teachers, Perceptions, technology integration.

Introduction:

The teacher is the most pivotal person during the implementation of all education reforms at the base line in education. A teacher plays a crucial role in the upbringing and intellectual nourishment of students. A qualified and skilful teacher is the one who can build the nation and determines the values, gives priority to learning first over teaching. The academic qualifications, knowledge of content, good competence level, pedagogical knowhow and teachers' willingness played an important role in the teaching-learning process. (Sharma, Leena, 2017). The able teacher can bring a great change in society through his believes in the broader perspective of education, which completely transforms an individual. Teachers should be well equipped with the knowledge of their subject, its delivering methods and skill for its management.

To get the best teaching excellence and commitment to professional it is necessary to get a preparation before entering to teaching service. During such activities where a teacher is required to instruct their students, technology use play an important role so that students must remain engaged in learning process (Kuzu & Gunuc, 2014). Having involvement of technologies provides readily available information, the teacher is bond to provide it being the facilitator, advisor or as a mentor. The role of a teacher is to develop

an environment in which he can guide them in the right direction and students learn a lot through it (Hardisky, Michael (2018). Therefore, researchers have agreed that teachers must be compatible to combined technology with their pedagogical skills and content knowledge accordingly (Mishra & Koehler, 2006; Otrell-Cass et al., 2010).

Significance of the study:

Teachers in the 21st century must not only be familiar with the operation of instructional technologies but also with their application within the curriculum and their classroom. As the successful use of technology continues to gain attention and becomes more ubiquitous in our society novice and veteran teachers may possess the pedagogy but lack a technological base from which to adapt the device (B.W. Melissa. (2013). This research focuses on knowledge of teaching and technology and teaching practices with the use of technologies as contexts for the awareness of technology integration in teaching learning process for pre-service teachers. So, in this study the perceptions of pre-service teacher's about TPACK were assessed through cross sectional survey. The purpose of the study is also sought to explore the perceptions of pre service teachers' technological pedagogical content knowledge (TPACK) and the competency level of teachers' professional knowledge of technology integration. This research focused on the professional knowledge of pre services teachers and their teaching practices with the use of technologies as contexts for the awareness of technology integration in teaching learning process

Objective of the study:

1. To find out the competency level of pre-service teachers' professional knowledge of technology integration and its use in their teaching practices.
2. To compare the pre-service teacher's perceptions of technological pedagogical content knowledge (TPACK) with reference to their gender.

Hypotheses of the Study

There is a significant relationship in pre-service teacher's perceptions on their knowledge of technology, pedagogy and content with reference to their gender.

Methodology:

For this study, descriptive survey method was used. Out of 100 pre-service secondary school teachers in the Department of Education, Mizoram University, 65 were selected as sample for the present study. An overall knowledge was assessed based on Likert Scale regarding content of each subject with technology and teaching approaches. Data for the present study were collected from the sample pre-service teachers who were undergoing B.Ed. programme at Department of Education, Mizoram University. The investigator personally visited the institution and administered a self-made Likert scale to the sample pre-service teacher trainee.

Analysis and Interpretation:

The data collected through the questionnaire were analysed and interpreted by finding out the percentage of the respondent's reaction for each question. In order to classify the pre-service teachers into different levels, those who scored one standard deviation below the mean were categorizes as having moderate level of competency. Those who scored one standard deviation above the mean were categorized as having

above average level of competency. Those who scored between minus one standard deviation and plus one standard deviation were categorized as having average level of competency. Comparison of pre-service teacher's perception with respect to their gender is also done by finding out their differences using the t test. Analysis and interpretation are done in accordance with the objectives of the present study as follows:

Objective no.1: To find out the competency level of pre-service teachers' professional knowledge of technology integration and its use in their teaching practices.

Table 1

Competency level of pre-service teachers' professional knowledge of technology integration and its use in their teaching practices.

Level of Competency	Respondents	Percentages
Moderate	9	13.84%
Average	50	76.92%
Above Average	6	9.23%
Total	65	100%

The above table reveals that majority (76.92%) of all the respondents had average level of competency professional knowledge of technology integration and its uses in their teaching practices while few of the respondents (13.84%) had moderate level and negligible percentages (9.23%) had above average competency level.

Objective no.2: To compare the pre-service teacher's perceptions of technological pedagogical content knowledge (TPACK) with reference to their gender.

In order to compare the perceptions of technological pedagogical content knowledge (TPACK) of male and female pre-service teachers, the mean and standard deviation of the scores of male and female were calculated. The mean difference of these two groups were testes by applying 't' test and the details are presented in the following table no2.

Table 2

Comparison of pre-service teacher's perception of TPACK with respect to their gender

Groups	Number	Mean	SD	MD	SEMD	t-Value	Sig. level
Male	23	114.17	8.45	2.07	2.44	0.07	NS
Female	42	112.10	11.00				

Table 2 reveals that the calculated 't' value of .07 is lower than the criterion 't' value at both .01 and .05 level. Therefore, it can be concluded that there is no significant difference between the male and female pre-service teacher's perception on their knowledge of TPACK. Hence, the hypothesis that there is a significant relationship in pre-service teacher's perceptions on their knowledge of technology, pedagogy and content with reference to their gender cannot be accepted.

Discussion:

From the study it can be concluded that majority of the pre-service teachers have average level of competency professional knowledge of technology integration and its uses in their teaching practices, which means that they are sufficiently aware of technology integration in teaching learning process. It was also found that the percentages of both male and female respondents had almost similar conceptual level

of knowledge of technological, pedagogical and content and there is no significant relationship. Hence, the research hypothesis which states ‘There is a significant relationship in pre-service teacher’s perceptions on their knowledge of technology, pedagogy and content with reference to their gender’ is rejected. However, average does not necessarily indicate good or desirable of core competencies of teachers such as collaboration, digital literacy, critical thinking, problems solving and the knowledge of teaching and technology to achieve the goals of quality of education and students’ achievement.

It was also found that some of the pre-service teacher’s perceptions regarding their technology knowledge and abilities were low. It also revealed that teachers do not feel that they know about many different technologies and how to use them. Respondents in this study were not confident in their knowledgeable of different types of technology, especially for educational purposes. Teachers’ implementation of technology integration into their practice is often dictated by their feelings of confidence with using technology in every-day instruction. Teachers’ technology knowledge can be defined as teachers’ knowledge of technology that is accessible for classroom use, such as technological tools, applications (apps), websites and devices. Many respondents were familiar with technology for personal use but were less likely to know how to incorporate the technology into classroom instruction.

Recommendations and suggestions

Based on the findings, the following recommendations are suggested for consideration. These recommendations could help achieve the education policy objectives that have been linked with the overall developments in the education sector. The recommendations are:

- TPACK should be included in the basics of the teacher’s education programs. Curriculum should have a positive approach of teaching with technology of the subject.
- The TPACK should be processed in such way through which student learning could be improved the ultimate goal of teaching.
- For proper implication, more research is required in urban and rural as well as public and private sector to assess other contextual issues during the practical application of TPACK.
- Content, technological and pedagogical skills should teach and modelled together in an integrated manner. Pre-service teachers did not receive adequate training for technological education during the courses of their study. It is necessary that effectiveness and efficiency that resources other than human and human power are handled in a more realistic way.
- The teaching process should be developed with latest technology as an add-on and in such a way that should be taken into consideration the classroom contexts.

Conclusion

It was clear from the respondents’ perspectives and the information that was discussed above, both from the findings, integration of digital technology has often been a topic of debate and its key users, the students and teachers, were ready to use it for their everyday. However, there were some points that needed policy level attention to enable easy integration, such as, there should be a curriculum level approach towards digital technology integration. Also, there should be content and technical workshops focused on updating teachers about latest mobile technology trends, new approaches in mobile learning, or learning through mobiles. Information technology infrastructure should be enhanced at school level and dedicated programs specifically designed both for students, teachers, and support staff as part of the overall integrated technology program of the school environment because, unless there was a trained technical

support staff available, there was no viable way to sustain teachers' development of their technological, pedagogical and content knowledge.

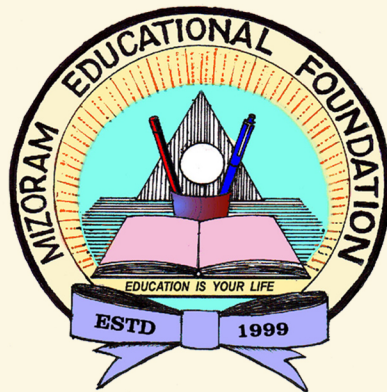
References

1. Bindu, Joseph. (2016). *Development of a package for enhancing pedagogical content knowledge of secondary school teachers*. Published Doctoral Thesis. Mahatma Gandhi University.
2. Mishra, P., & Koehler, M. J. (2006). *Technological pedagogical content knowledge: A framework for teacher knowledge*. Teachers College Record, 108(6):1017-1054
3. Sharma, Leena. (2017). *Effectiveness of an ICT programme on technological pedagogical and content knowledge tpack teacher self-efficacy and teaching effectiveness among pre-service teacher educators*. International Journal of Research in Social Sciences, Vol.8 Issue 6(1), June 2018.
4. Stoilescu, Dorian. (2011). *Technological pedagogical content knowledge: Secondary school mathematics teachers' use of technology*. Published Doctoral Thesis. University of Toronto.
5. Knolton, V Davin. (2014). *Technological, pedagogical, content knowledge (TPACK): An exploratory study of adjunct faculty technology proficiency*. Published Doctoral Thesis. Kansas State University.
6. Hardisky, Michael. (2018). *TPACK: Technology integration and teacher perceptions*. Published Doctoral Thesis. Drexel University.
7. B.W. Melissa. (2013). *The influence of teacher beliefs and knowledge on planning for technology integration in technology-rich classrooms*. Published Doctoral Thesis. University of North Carolina.
8. Wang, Jennifer Gee Huei. (2020). *Developing teachers technological, pedagogical, and content knowledge (TPACK) through design thinking and community of practice*. Published Doctoral Thesis. San Jose State University.

ISSN 2395-731X

Mizoram Educational Journal

(A National Refereed Journal)



Vol. X, Issue 3, September, 2024

Technological, Pedagogical and Content Knowledge (TPACK): Technological Integration and Teaching Effectiveness

H. Lalbiakzuali *
Lokanath Mishra**

Abstract

Technological Pedagogical Content Knowledge (TPACK) was first introduced by Punya Mishra and Matthew J. Koehler of Michigan State University in 2006. This framework identifies three domains of knowledge needed to successfully integrate educational technology: Content Knowledge (CK), Pedagogical Knowledge (PK), Technological Knowledge (TK). Each domain also intersects with the other domains. The knowledge, skills, and abilities developed where all three domains overlap and integrate cohesively is referred to as TPACK and forms the basis for effective technology integration. TPACK serves as a useful conceptual framework for thinking, analyzing, and evaluating what teachers must know to integrate technology into teaching, but ultimately it must be understood as a framework for ways in which teachers might best develop this integrated knowledge. TPACK is a technical framework of collective and composite knowledge required for teachers teaching practices in the classrooms with technology integration.

Keywords: *Technological, Pedagogical and Content Knowledge, Technological integration, Teaching effectiveness.*

Introduction

Technology has become an increasingly important part of students' lives beyond school, and even within the classroom it can also help increase their understanding of complex concepts or encourage collaboration among peers. Because of these benefits, current educational practice suggests that teachers implement some form of technology in their classrooms – but many teachers face difficulties in doing so. Cost, access, and time often form considerable

* H. Lalbiakzuali, Research Scholar, Department of Education, Mizoram University, Aizawl. Email: beeziehmar@gmail.com

** Prof. Lokanath Mishra, Professor & Head, Department of Education, Mizoram University, Aizawl. Email: munumishra7@gmail.com

barriers to classroom implementation, but another obstacle is a lack of knowledge regarding how technology can best be used to benefit students across diverse subject matter.

What is the TPACK Framework?

TPACK stands for Technological Pedagogical Content Knowledge. It is a theory that was developed to explain the set of knowledge that teachers need to teach their students a subject, teach effectively, and use technology.

Technological Pedagogical Content Knowledge (TPACK) was introduced to the educational research field as a conceptual framework for understanding teacher knowledge that is required for technology integration. TPACK evolved from Shulman's (1986) theory of pedagogical content knowledge (PCK) and focuses on the need for teachers to skilfully demonstrate their ability to integrate technology within the constructs of content and pedagogical domains. TPACK can be perceived as a teacher's intuitive understanding for teaching subject-specific content with appropriate pedagogical methods and selected technologies. It is well understood that teaching is a complex cognitive activity that requires teachers to draw upon several types of knowledge (Koehler & Mishra, 2009). TPACK serves as a useful conceptual framework for thinking, analyzing, and evaluating what teachers must know to integrate technology into teaching, but ultimately it must be understood as a framework for ways in which teachers might best develop this integrated knowledge. To date, researchers have stressed the importance of teachers having a solid conceptual understanding of the interactions that occurs among technology, pedagogy, and content when planning instruction. This framework provides a critical perspective with which to view technology integration in classroom settings.

Historical Context

The most recognized version of the TPACK framework was conceptualized and first reported in 2005 by Matthew Koehler and Punya Mishra, who were both faculty at Michigan State University. This was not a completely original construct as scholars since 1998 had discussed how to better understand and explain how educators should conceptualize the role of technology in education. It was becoming clear that an emphasis on technology (and the educational possibilities it engendered) was not adequate to explain what was happening in actual educational settings; adding technology into an educational process did not lead to change. In particular, it was recognized that teachers needed to understand the relationships between users, technologies, and practices, including how technologies can support the teaching and learning of educational concepts. Later work added the importance of context to the mix.

As previously mentioned, Koehler and Mishra built the TPACK framework by extending Shulman's (1986, 1987) Pedagogical Content Knowledge framework to include technology

(Koehler & Mishra, 2005). Other scholars had proposed similar ideas, but it was Mishra and Koehler's (2006) description and representation of TPACK, with minor tweaks over the next few years, that became widely adopted.

After its initial introduction, TPACK scholarship was expanded through two handbooks (AACTE Committee on Innovation and Technology, 2008; Herring et al., 2016), a monthly newsletter, journal articles, conference presentations, and other publications. The newsletter and a bibliography of TPACK scholarship can be found at tpack.org. To illustrate the impact of TPACK, prior to 2021 there had been 1418 articles, 318 chapters in books, 28 books, and 438 dissertations that used it as a conceptual framework to guide their work. More important has been the impact of TPACK on practice, with schools and colleges of education across the world incorporating the TPACK framework in teacher professional development and teacher education.

The Conceptual Framework

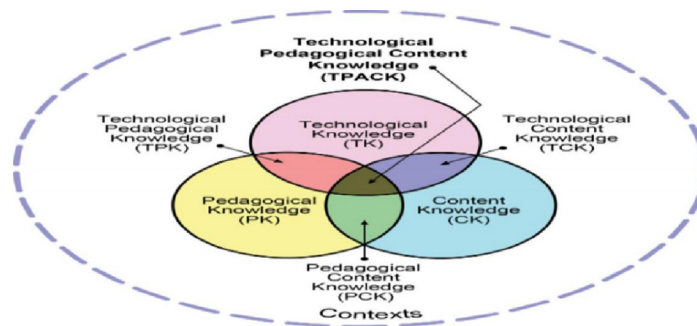


Figure1: This image was reproduced with permission of the publisher,
© 2012 by tpack.org from <http://tpack.org>.

The TPACK framework was first introduced by Mishra and Koehler (2006). The framework builds on Shulman's (1986, 1987) Pedagogical Content Knowledge (PCK)—the idea that teacher knowledge is more than mere knowledge of content and of general pedagogical principles. Shulman suggested that teachers possess a special form of knowledge that has to do with processes and techniques for transforming content in ways that are pedagogically viable. The TPACK framework extended PCK to include technological knowledge as being an important component of the kinds of knowledge teachers need to possess, and similar to PCK, TPACK is conceived as being more than individual pieces of knowledge.

Technological Pedagogical Content Knowledge Framework

The understanding of fundamental elements is what technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK). TPACK facilitates teachers in

making technology selections and incorporating them into the teaching and learning process by taking into account the pedagogical components and the nature of the content. Thus, TPACK includes the following portions or elements:

Components or Elements of TPACK

Content Knowledge (CK): Content knowledge (CK) is teachers' knowledge about the subject matter to be learned or taught. The content to be covered in middle school science or history is different from the content to be covered in an undergraduate course on art appreciation or a graduate seminar on astrophysics.

This describes teachers' own knowledge of the subject matter. CK may include knowledge of concepts, theories, evidence, and organizational frameworks within a particular subject matter; it may also include the field's best practices and established approaches to communicating this information to students

Pedagogical Knowledge (PK): It provides a definition of the methods, techniques, and approaches employed in teaching and learning so that teachers are aware of them. Pedagogical knowledge can be applied in more focused contexts, such as lesson planning, assessment, and the understanding of students' learning preferences/styles, classroom management skills in addition to covering the aims, principles, and purposes of education.

Technological Knowledge (TK): Technological Knowledge (TK) – This describes teachers' knowledge of, and ability to use, various technologies, technological tools, and associated resources. TK concerns understanding edtech, considering its possibilities for a specific subject area or classroom, learning to recognize when it will assist or impede learning, and continually learning and adapting to new technology offerings.

Pedagogical Content Knowledge (PCK): This describes teachers' knowledge regarding foundational areas of teaching and learning, including curricula development, student assessment, and reporting results. PCK focuses on promoting learning and on tracing the links among pedagogy and its supportive practices (curriculum, assessment, etc.), and much like CK, will also differ according to grade level and subject matter. In all cases, though, PCK seeks to improve teaching practices by creating stronger connections between the content and the pedagogy used to communicate it.

Technological Content Knowledge (TCK): This describes teachers' understanding of how technology and content can both influence and push against each other. TCK involves understanding how the subject matter can be communicated via different edtech offerings, and considering which specific edtech tools might be best suited for specific subject matters or classrooms.

Technological Pedagogical Knowledge (TPK): This describes teachers' understanding of how particular technologies can change both the teaching and learning experiences by introducing new pedagogical affordances and constraints. Another aspect of TPK concerns understanding how such tools can be deployed alongside pedagogy in ways that are appropriate to the discipline and the development of the lesson at hand.

Technological Pedagogical Content Knowledge (TPACK): A growing body of knowledge called TPACK goes beyond the three "core" components (content, pedagogy, and technology). Technological pedagogical content knowledge is an understanding that is the result of interactions between content, pedagogy, and technological knowledge. TPACK strengthens deeply skilled and highly relevant teaching with technology, which is distinct from individual knowledge of any of the three principles (Mishra & Koehler, 2009)

TPACK is the end result of these various combinations and interests, drawing from them – and from the three larger underlying areas of content, pedagogy, and technology – in order to create an effective basis for teaching using educational technology. In order for teachers to make effective use of the TPACK framework, they should be open to certain key ideas, including:

1. concepts from the content being taught can be represented using technology,
2. pedagogical techniques can communicate content in different ways using technology,
3. different content concepts require different skill levels from students, and edtech can help address some of these requirements,
4. students come into the classroom with different backgrounds – including prior educational experience and exposure to technology – and lessons utilizing edtech should account for this possibility,
5. educational technology can be used in tandem with students' existing knowledge, helping them either strengthen prior epistemologies or develop new ones.

Because it considers the different types of knowledge needed and how teachers themselves could cultivate this knowledge, the TPACK framework thus becomes a productive way to consider how teachers could integrate educational technology into the classroom. Then too, TPACK can also serve as a measurement of instructor knowledge, potentially impacting both training and professional development offerings for teachers at all levels of experience. Finally, the TPACK framework is useful for the ways in which it explicates the types of knowledge most needed in order to make technology integration successful in the classroom. Teachers need not even be familiar with the entire TPACK framework as such in order to benefit from it: they simply need to understand that instructional practices are best shaped by content-driven, pedagogically-sound, and technologically-forward thinking knowledge.

Applications: TPACK in the Classroom

Implementing meaningful technology within any classroom can be a daunting task. Thorough evaluation of a tech-based tool that seamlessly integrates into a predetermined curriculum must be justifiable and provide an elevated learning experience without feeling cumbersome or irrelevant (Earle, 2002).

Selecting Technology: In order to integrate technology into the classroom, it is important to remember that less can be more. Rather than attempting to incorporate a new and innovative technology that claims to tick off all of the items on your tech-tool wish list, it is advisable to use tried and tested technologies that have proven payoffs. From a teacher's perspective, using an easy to learn and intuitive technology is key to success. Aside from learning and mastering the technology themselves, they must consider their students' diverse needs, accommodations, and affordances. Using a tool like TEDED is an efficient way to include multimedia, assessment, and customization in order to heighten student engagement. The platform is easily accessible and does not include fees thereby being accessible to all educators and learners.

Keeping technology as a separate knowledge set causes problems, but when we understand the framework of TPACK, we can integrate technology into the content and pedagogy of our classrooms. The integration will help our students learn more effectively. Mishra and Koehler suggest that TPACK should guide curriculum development and teacher education. To apply TPACK to our classrooms now, it should change the way we plan our daily lessons. First, by planning process where we first choose the learning outcomes that we will be working on that day or during that class session. The learning outcomes are the content. The second step is choosing an activity type. The activity type is the pedagogy or how are the students going to learn the content. Finally, we can choose technologies that will support the activity type and aid the students in learning. For this, our instructional planning should include each part of the TPACK framework and allow us to create and develop the overlapping knowledge to make the best learning environment for our students. The simplest idea at play in TPACK is that a person who is a world-renowned expert in a subject might not be a great teacher because they lack the pedagogical knowledge to make the subject accessible and understandable. To be a great teacher, we have to combine our knowledge of the subject with our knowledge of how to teach. With the increasing focus on technology, we need to also learn how to combine technology with our content and pedagogy to create an effective learning environment.

Examples:

A language teacher chooses to conduct an interactive teaching-learning session for teaching articles using her pedagogical knowledge (PK). She selects to use an

interactive whiteboard and applies her pedagogy content knowledge (PCK), technology knowledge (TK), and technology content knowledge to generate statements that are grammatically incorrect (TCK). She motivates her students to bring out the mistakes and uses her knowledge of the subject to help them construct appropriate statements (CK). She divides her class into small groups and provides computer systems to each group. She does formative evaluation and notes the grades as the groups discuss, reach an understanding, and rectify the grammatically incorrect sentences on their computers that are connected to the computer.

Recommendations for educational institutions on the use of TPACK

As it is considered a serious problem to see technology, pedagogy, and content differently from each other, teachers have to improve themselves in the fields of technology, pedagogy, and content in order to have a successful professional career. In teaching and learning process, it is important not only how teachers teach (pedagogy) and what they teach (content), but it is also important which materials (technology) they use while teaching. A teacher who can navigate between these interactions acts as an expert who is different than only a subject matter, pedagogy, or teaching expert. Instead of being treated content knowledge and pedagogical knowledge as separated domains of teacher knowledge bases, they should be considered to have mutual relationships with each other (Shulman, 1987).

It is important to recognize that the TPACK model represents an ideal scenario. In order to meet this ideal or come close to achieving this within a classroom, the standards for integration have to be attainable. Incorporating technologies that are inexpensive or free to the user, as well as ones that are intuitive and easy to learn, are the cornerstone of successful integration of tech-tools within the classroom. It is important for educators to vet and evaluate technology-based tools before implementing them into their classroom to ensure that learning is optimized through the use of technology rather than simply acting as a hollow expectation.

Simply adding technology or ICT as a required subject in schools and teacher preparation programs did not result in better teaching. In order to effectively integrate technology in the classroom, teachers must combine TPACK competencies for the particular subject matter to be taught. Because they help future teachers and prepare them to become techno-pedagogues, the TPACK competences are now critically important for teacher-educators and teachers. Therefore, possibilities for teachers to gain practical and pedagogical skills through the use of current technology during their teaching-learning process should be made available.

References:

- Bindu, J. (2016). *Development of a package for enhancing pedagogical content knowledge of secondary school teachers*. Doctoral Dissertation. Mahatma Gandhi University.
- Mishra, P., & Koehler, M. J. (2006). *Technological pedagogical content knowledge: A framework for teacher knowledge*. Teachers College Record, 108(6):1017-1054
- Sharma, L. (2017). Effectiveness of an ICT programme on technological pedagogical and content knowledge tpack teacher self-efficacy and teaching effectiveness among pre-service teacher educators. *International Journal of Research in Social Sciences*, 8(6-1), 2018.
- Stoilescu, D. (2011). *Technological pedagogical content knowledge: Secondary school mathematics teachers' use of technology*. Doctoral Dissertation. University of Toronto.
- 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. (2018). What is technological pedagogical content knowledge? In R. E. West (Ed.), *Foundations of learning and instructional design technology*. EdTech.Books. <https://edtechbooks.org/lidtfoundations/tpack>
- Warr, M. & Mishra, P. (2022). TPACK: The TPACK Technology Integration Framework. *The open encyclopedia of educational technology*. EdTechnica <https://edtechbooks.org/encyclopedia/tpack>
- Kurt Serhat (2018). *PACK: Technological Pedagogical Content Knowledge Framework*. <https://educationaltechnology.net/technological-pedagogical-content-knowledge-tpack-framework/>
- Alshehri, K.A. (2012). *The Influence of mathematics teachers' knowledge in technology, pedagogy and content (tpack) on their teaching effectiveness in Saudi public school*. Doctoral Dissertation. University of Kansas.
- Wei, W. (2016). *Development of technological pedagogical content knowledge (tpack) in pre k-6 teacher preparation programs*. Doctoral Dissertation. Iowa State University.
- Bas, G. & Senturk, C. (2018). An evaluation of technological pedagogical content knowledge (tpack) of in-service teachers: A study in Turkish public schools. *International Journal of Educational Technology*, 5(2), 46-58.
- Hardisky, M. (2018). *TPACK: Technology integration and teacher perceptions*. Doctoral Dissertation. Drexel University.
- Melissa, B.W. (2013). *The influence of teacher beliefs and knowledge on planning for technology integration in technology-rich classrooms*. Doctoral Dissertation. University of North Carolina.
- Wang, J.G.H. (2020). *Developing teachers technological, pedagogical, and content knowledge (TPACK) through design thinking and community of practice*. Doctoral Dissertation. San Jose State University.



NATIONAL SEMINAR ON CONTEMPORARY ISSUES IN EDUCATION SERIES III



This is to certify that

Lalbiakzuali

Research Scholar, Department of Education, MZU

presented a paper on the topic
*Pre-Service Teacher's Perceptions on Technological Pedagogical
and Content Knowledge (TPACK)*

on 18th November, 2022, held at Conference Hall,
Institute of Advanced Studies in Education, Aizawl, Mizoram.

(Dr. LALRINTLUANGI)
Convener

(Prof. LALBIAKDIKI HNAME)
President, M.E.F

(Dr. VANLALRUATFELA HLONDO)
Convener

ORGANISED BY :
MIZORAM EDUCATIONAL FOUNDATION
IN COLLABORATION WITH ALL INDIA EDUCATION FORUM



NATIONAL SEMINAR ON MODERN EDUCATIONAL TRENDS AND CHALLENGES

This is to certify that

H. Lalbiakzuali

Research Scholar, Dept. of Education, MZU

presented a paper on the topic

"ICT in Teaching Learning Process of Higher Secondary Schools:

Understanding the Technological Aspect of the TPACK Model "

on 28th January, 2025 held at Seminar Hall, Pachhunga University College.

(Dr. LALTHANKUNGI)

HOD

(Prof. H. LALTHANZARA)

Principal

(Dr. LALCHHUANMAWII)

Convener

ORGANISED BY : DEPARTMENT OF EDUCATION, PACHHUNGA UNIVERSITY COLLEGE

chapter 1-5.docx

-  My Files
-  My Files
-  Mizoram University

Document Details

Submission ID

trn:oid:::10015:122854103

Submission Date

Nov 26, 2025, 12:23 PM GMT+5:30

Download Date

Nov 26, 2025, 12:35 PM GMT+5:30

File Name

chapter 1-5.docx

File Size

1.4 MB

185 Pages

51,792 Words

308,703 Characters

9% Overall Similarity

The combined total of all matches, including overlapping sources, for each database.

Filtered from the Report

- Bibliography
- Quoted Text
- Cited Text
- Small Matches (less than 10 words)

Match Groups

-  **223 Not Cited or Quoted 9%**
Matches with neither in-text citation nor quotation marks
-  **0 Missing Quotations 0%**
Matches that are still very similar to source material
-  **0 Missing Citation 0%**
Matches that have quotation marks, but no in-text citation
-  **0 Cited and Quoted 0%**
Matches with in-text citation present, but no quotation marks

Top Sources

- 5%  Internet sources
- 4%  Publications
- 4%  Submitted works (Student Papers)

Integrity Flags

0 Integrity Flags for Review

No suspicious text manipulations found.

Our system's algorithms look deeply at a document for any inconsistencies that would set it apart from a normal submission. If we notice something strange, we flag it for you to review.

A Flag is not necessarily an indicator of a problem. However, we'd recommend you focus your attention there for further review.

ANNEXURE - I

MIZORAM UNIVERSITY (A Central University)

Ph. D. Thesis Certificate on Plagiarism Check

Name of Research Scholar/Student	H. Lalbiakzuali	
Ph. D. Registration Number	MZU/Ph.D./1630 of 21.10.2020	
Title of Ph. D. thesis	Technological Pedagogical and Content Knowledge of Higher Secondary School Teachers and Teaching Effectiveness: A Critical Study	
Name & Institutional Address of the Supervisor	Prof. Lokanath Mishra, Department of Education, Mizoram University, Aizawl	
Name of the Department and School	Department of Education, School of Education	
Date of submission	28.11.2025	
Date of plagiarism check	26.11.2025	
Name of the software used	Turnitin	
Percentage of similarity detected by the TURNITIN software	Core areas	9%
	Non-Core areas	9%
Percentage of similarity permissible under MZU regulations	Core areas	A common knowledge or coincidental terms and/or up to fourteen (14) consecutive words, if option is available in the software.
	Non-Core areas	Up to 10%

I hereby declare/certify that the Ph. D. Thesis submitted by me is complete in all respect, as per the guidelines of the Mizoram University (MZU) for this purpose. I also certify that the Thesis (soft copy and print version) has been checked for plagiarism using TURNITIN similarity check software. Copy of the Report generated by the TURNITIN software is also enclosed.

Place: Aizawl

Date : 26.11.2025

(Name & Signature of the Scholar)

Name & Signature of the Supervisor:
with seal

Name & Signature of the DRC Chairperson/Head:
with seal

Annexure – II

Plagiarism Verification Certificate

(This certificate should be submitted to the Examination Department at the time of submission of the Thesis)

This is to certify that the plagiarism check has been performed for Ph. D. Thesis *Technological Pedagogical and Content Knowledge of Higher Secondary School Teachers and Teaching Effectiveness: A Critical Study* submitted by **H. Lalbiakzuali** under the Supervision of Prof. Lokanath Mishra Department of Education, School of Education, Mizoram University. The check performed by the Scholar is found correct/adheres to MZU regulations and authentic software **TURNITIN** has been used for the similarity check.

Name, Signature & Seal of the Dean of the School:

(PROF. LOKANATH MISHRA)
Dean, School of Education,
Mizoram University



Connecting research and researchers



H. Lalbiakzuali ▾



English ▾

Search the ORCID registry...



iD

[https://orcid.org/
0009-0009-1760-3135](https://orcid.org/0009-0009-1760-3135)

[Preview public record](#)

Emails & domains



Email addresses

beeziehmar@gmail.com



Lalbiakzuali29@gmail.com



Verified email domains

No verified email domains

Websites & social links



Keywords



Countries



Help

PARTICULARS OF THE CANDIDATE

NAME OF THE CANDIDATE:	H. LALBIAKZUALI
DEGREE:	DOCTOR OF PHILOSOPHY
DEPARTMENT:	EDUCATION
TITLE OF THE THESIS:	TECHNOLOGICAL, PEDAGOGICAL AND CONTENT KNOWLEDGE OF HIGHER SECONDARY SCHOOL TEACHERS AND TEACHING EFFECTIVENESS: A CRITICAL STUDY
DATE OF ADMISSION:	21.10.2020
APPROVAL OF RESEARCH PROPOSAL:	
1. DRC:	30 & 31. 03. 2021
2. BOS:	16.04.2021
3. SCHOOL BOARD:	20.05.2021
MZU REGISTRATION NO:	4717 OF 2011
PH. D REGISTRATION NO & DATE:	MZU/PH.D./1630 OF 21.10.2020
EXTENSION (IF ANY):	No extension

HEAD

DEPARTMENT OF EDUCATION

ABSTRACT

TECHNOLOGICAL, PEDAGOGICAL AND CONTENT KNOWLEDGE OF HIGHER SECONDARY SCHOOL TEACHERS AND TEACHING EFFECTIVENESS: A CRITICAL STUDY

**AN ABSTRACT SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF
PHILOSOPHY**

H. LALBIAKZUALI

MZU REGISTRATION NO: 4717 of 2011

PH.D. REGISTRATION NO: MZU/Ph.D./1630 OF 21.10.2020



DEPARTMENT OF EDUCATION

SCHOOL OF EDUCATION

NOVEMBER, 2025

ABSTRACT

**TECHNOLOGICAL, PEDAGOGICAL AND CONTENT KNOWLEDGE OF
HIGHER SECONDARY SCHOOL TEACHERS AND TEACHING
EFFECTIVENESS: A CRITICAL STUDY**

BY

H. LALBIAKZUALI

DEPARTMENT OF EDUCATION

SUPERVISOR

PROF. LOKANATH MISHRA

Submitted

**In partial fulfillment of the requirement of the Degree of Doctor of Philosophy in
Education of Mizoram University, Aizawl**

INTRODUCTION

Technology has become an increasingly important part of students' lives beyond school, and even within the classroom it can also help increase their understanding of complex concepts or encourage collaboration among peers. Because of these benefits, current educational practice suggests that teachers implement some form of technology in their classrooms – but many teachers face difficulties in doing so. Cost, access, and time often form considerable barriers to classroom implementation, but another obstacle is a lack of knowledge regarding how technology can best be used to benefit students across diverse subject matter.

According to Yang and Liu (2004), faculty must become involved in continued learning in order to be more effective teachers. Support mechanisms should be designed for lifelong learners, in this case teachers, to hone existing skills and develop new knowledge and skills that can be translated into effective learner-centered instructional strategies. However, instructional technology tools have a negative connotation with some teachers. Some research has suggested that teachers' autonomy, workload, and pedagogical interest are jeopardized when the use of technology as a learning mechanism is introduced. Technology as instructional mechanisms do not replace the role of the teacher. Instead, it is an integral component to the learning process just as pedagogy and subject content. A challenge of incorporating technology into pedagogy revolves around the need to understand how and in what capacity to implement technology as an instructional tool. An initial approach to finding a solution would be to assess the technological knowledge of teacher, which would aid in analyzing the type of academic support necessary for successful implementation of the technology (Austin, 2003; Hearn & Anderson, 2002; Jones, 2011).

Since the typical pedagogical boundaries in low and high consensus educational disciplines consist of limited technological usage, teachers are reluctant to develop instructional technology competencies without performance incentives (Austin, 2003; Golde & Dore, 2001). This suggests that the inclusion of instructional technology tools could impose a major change to teachers' workload and autonomy. As a result, this highlights the need for academic support for continuous developmental training in addition to performance incentives to encourage the successful implementation of technology with existing pedagogy and content for student learning.

The TPACK framework provides an essential lens through which to examine teachers' competencies in technology integration. Measuring teachers' self-perceived TPACK levels offers insight into their preparedness to teach effectively in technology-rich environments and helps identify areas needing targeted support and training.

Therefore, this study seeks to examine the self-perceived TPACK of higher secondary school teachers in Mizoram and explore how various demographic factors influence their technological, pedagogical, and content knowledge. By doing so, it aims to contribute to the broader understanding of teachers' technology integration competencies within the Indian educational context and provide evidence-based recommendations for future teacher training and policy implementation.

RATIONALE OF THE STUDY

As one considers the impact that technology has had on society as a whole, one might also question these changes as they pertain to the teaching and learning environment. The transformative nature of educational technologies has profoundly changed pedagogical thinking and looks to revolutionize our educational system. However, an important question remains—are teachers really utilizing these technologies to their full potential in classroom practice? The Technological Pedagogical and Content Knowledge (TPACK) framework provides a basis for examining this issue by considering three distinct areas in a teacher's ability to integrate technology and improve instructional effectiveness: content, which refers to the subject matter to be taught; pedagogy, which represents the method and practice of teaching; and technology, the digital tools or resources through which pedagogical strategies are. By emphasizing the dynamic relationship between these three domains, the TPACK framework highlights that effective teaching with technology requires not only technical proficiency but also a deep understanding of how technology interacts with pedagogy and content to enhance student learning outcomes.

Technology's impact on the teaching and learning environment has changed not only the way students process new concepts and achieve learning objectives, but it has also modified the way in which instruction is delivered. Students' needs are diverse, and the forms of technology that they encounter in their learning environment may not fit those needs of every student or subject. The educational technologies that

a teacher may use in the teaching and learning environment may not adapt to every diverse need; rather, it is the responsibility of the teacher to creatively apply these tools to meet the needs of individual learners. How a teacher chooses to use technology in the classroom is dependent upon that teacher's expectations in each grade level, subject, and class, as well as past experiences and training. Examining different applications of technology in the classroom—specifically how a teacher adapts technology to best fit the lesson—may also reveal the way a teacher perceives technology and its role in supporting effective teaching and learning.

Teachers in the 21st century must not only be familiar with the operation of instructional technologies but also with their application within the curriculum and their classroom. Topper (2004) suggests that "for teachers to use technology in support of their teaching, and see it as a pedagogically useful tool, they must be confident and competent with the technology they are planning to use". As the successful use of technology continues to gain attention and becomes more ubiquitous in our society, novice and veteran teachers may possess the pedagogy but lack a technological base from which to adapt the device.

In the context of Mizoram, the integration of technology into teaching and learning has been growing, particularly after the COVID-19 pandemic, which accelerated the adoption of digital tools in schools and higher education institutions. However, despite the increasing availability of technological resources, many teachers still face challenges in effectively incorporating these tools into their pedagogical practices due to limited training, inadequate infrastructure, and varying levels of digital literacy. This gap underscores the need to examine teachers' self-perceived Technological Pedagogical and Content Knowledge (TPACK) and their ability to connect technology, pedagogy, and subject content meaningfully in their classrooms. Understanding teachers' TPACK levels can provide valuable insights for policymakers, teacher educators, and school administrators to design targeted professional development programs and support systems that enhance technology integration in Mizoram's education system. Hence, this study is significant as it seeks to assess and strengthen teachers' technological competencies, ultimately contributing to improved teaching practices and better student learning outcomes in the state.

The findings of this study may enrich the theoretical knowledge about Technological Pedagogical and Content Knowledge (TPACK), provide considerable ideas and suggestions for developing higher secondary school teachers' TPACK and their teaching effectiveness, and help educational policymakers, administrators, teacher educators, and other stakeholders in reformulating and improving strategies for the successful implementation of digital technologies in teaching.

Hence, this study will take the established Technological Pedagogical and Content Knowledge (TPACK) framework and employ it in a manner that will help illuminate how the use of technology in educational classroom activities is influenced by higher secondary school teachers' perceptions, teaching effectiveness, and the barriers they face in Mizoram. Based on the above rationale, several research questions emerged in the mind of the investigator, leading to the formulation of specific objectives for the present study.

1. Are the higher secondary school teachers of Mizoram expert in different components of technological pedagogical and content knowledge?
2. Is there a significant difference in higher secondary school teachers of Mizoram self-perceived technological pedagogical content knowledge based on educational discipline, gender, age, teaching experience and ICT training?
3. Is there a significant relationship of higher secondary school teacher's self-perceived expertise in technology pedagogy and content knowledge and its effectiveness in teaching?
4. What are the problems faced by higher secondary school teachers in integrating technology in teaching?
5. What are the experiences of students in the effectiveness of teaching of higher secondary school teachers of Mizoram using technological pedagogical content knowledge?

STATEMENT OF THE PROBLEM

With the hope of revealing about the technological, pedagogical and content knowledge of higher secondary school teachers perceived competencies and their teaching effectiveness, the present study is formulated as below:

“Technological, Pedagogical and Content Knowledge of Higher Secondary School Teachers and Teaching Effectiveness: A Critical study”

OBJECTIVES OF THE STUDY

1. To assess the self-perceived level of technological pedagogical and content knowledge (TPACK) of higher secondary school teachers in Mizoram.
2. To compare the differences in self-perceived TPACK among higher secondary school teachers with reference to their educational discipline, gender, age, teaching experience and ICT training.
3. To examine the relationship of higher secondary school teachers self-perceived expertise in TPACK and its effectiveness in teaching.
4. To find out the problems faced by the higher secondary school teachers of Mizoram in integrating technology in teaching
5. To investigate the perceived experience of students on the effectiveness of teaching of higher secondary school teachers of Mizoram using TPACK.

HYPOTHESES OF THE STUDY

1. There is no statistically significant difference in higher secondary school teachers of Mizoram on self-perceived technological pedagogical content knowledge based on educational discipline.
2. There is no statistically significant relationship in higher secondary school teachers of Mizoram on self-perceived technological pedagogical content knowledge based on gender.
3. There is no statistically significant relationship in higher secondary school teachers of Mizoram on self-perceived technological pedagogical content knowledge based on age.
4. There is no statistically significant relationship in higher secondary school teachers of Mizoram on self-perceived technological pedagogical content knowledge based on teaching experience.

5. There is no statistically significant relationship in higher secondary school teachers of Mizoram on self-perceived technological pedagogical content knowledge based on ICT training.
6. There is no statistically significant relationship in higher secondary school teachers self-perceived expertise in TPACK and its effectiveness in teaching.

REVIEW OF RELATED LITERATURE:

A total of 123 reviews had been incorporated in the study. There were 23 studies done in India and 100 studies done abroad. The review period ranges from 2006 to 2025.

METHOD OF THE STUDY:

The present study is descriptive in nature. Therefore, descriptive survey method has been employed.

POPULATION:

The population of the study comprised of all the higher secondary schools' teachers and students in Mizoram.

SAMPLE:

For the present study, out of 73 higher secondary schools in Aizawl district, 21 schools offering both science and arts were selected as a representative sample. The final sample consisted of 200 higher secondary school teachers in Aizawl District, comprising 100 male and 100 female teachers, with 100 teachers from the science stream and 100 from the arts stream. Teachers from the Commerce stream were not included, as this stream is not offered in every school and was unavailable in most institutions. The student sample consisted of 152 Arts students and 155 Science students and a sum of 307 students constitutes the sample of the study.

The samples were selected following Convenience Sampling Technique. The name of schools and sample distribution of the teachers and students is presented in the following Table no 1

Table no. 1**Name of schools and sample distribution**

Sl No.	Name of School	Number of Respondent					
		Teachers				Students	
		Male	Female	Arts	Science	Arts	Science
1	Govt. K.M HSS	7	7	5	9	10	10
2	Sihphir HSS	1	2	-	3	-	6
3	Ch. Chhunga HSS	3	5	-	8	-	16
4	Govt. Mizo HSS	6	1	2	5	-	20
5	Greenland HSS	4	3	3	4	10	-
6	Staine's Memorial School	5	4	4	5	-	11
7	Govt. JL HSS	5	5	10	-	10	-
8	Govt. Mamawii HSS	4	6	10	-	12	-
9	Boston HSS	5	4	3	6	-	11
10	Mount Carmel School	8	9	6	11	10	10

11	Govt. Chaltlang HSS	2	3	2	3	20	-
12	Public HSS	3	3	6	-	11	-
13	Modern English HSS	5	3	4	4	10	-
14	Govt. Centrsl HSS	3	5	8	-	10	-
15	Govt. Zemabawk HSS	6	5	11	-	20	-
16	Home Mission HSS	5	4	4	5	-	20
17	St. Joseph HSS	14	10	9	15	16	20
18	Synod HSS	5	6	4	7	-	10
19	Dawrpui School of Science and Teachnology	2	3	-	5	-	5
20	St. Paul's HSS	5	9	4	10	4	16
21	Lengpui HSS	2	3	5	-	9	-
TOTAL		100	100	100	100	152	155

Out of the 73 higher secondary schools in Aizawl district, 21 schools offering both Science and Arts streams were selected as the representative sample. The final sample included 200 teachers (100 males and 100 females), with an equal distribution of 100 Arts and 100 Science teachers, along with 307 students—bringing the total number of respondents to 508. The student sample comprised 152 Arts students (49.5%) and 155 Science students (50.5%), reflecting an almost equal representation of both streams.

TOOLS FOR DATA COLLECTION:

The following tools were used for the present study

1. The Perception Scale on TPACK for teachers developed by researcher.
2. Observation schedule for assessing the effectiveness of teaching.
3. Structured questionnaire to study the problems faced by the higher secondary school teacher in integrating technology in teaching.
4. Evaluation schedule for assessing Teachers' Effectiveness for students.

ADMINISTRATION OF TOOLS AND COLLECTION OF DATA:

Data were collected using a structured survey questionnaire with two main sections. The first section obtained demographic details—gender, age, subject taught, ICT training status, and years of teaching experience for teachers, and stream of study and school name for students. The second section consisted of two parts: a five-point Likert scale assessing teachers' TPACK (SD to SA) and a “yes/no” checklist identifying challenges faced in technology integration. Students also rated teacher effectiveness using a three-point scale: Poor/Low (30%), Average/Moderate (50%), and Good/High (above 50%).

The investigator personally visited the selected schools, obtained permission from headmasters, explained the purpose of the study, and administered the questionnaires to available teachers and students. Respondents were assured of confidentiality and encouraged to answer honestly. Completed questionnaires were collected and checked for accuracy and completeness.

For the observation component, the investigator again sought permission and briefed teachers on the study's objectives and ethical considerations. Teachers first completed the TPACK perception scale, after which classroom observations were scheduled with minimal disruption. Using a structured observation schedule, the investigator systematically recorded how teachers integrated technology, applied pedagogical strategies, and connected content knowledge during regular classroom teaching.

ANALYSIS OF DATA:

Quantitative analysis was done for the present research. Quantitative analysis of data was done by making use of descriptive and inferential statistics like measures of central tendency, percentages and z-score, along with Pearson product moment correlation, Spearman rank correlation coefficient and t-test.

MAJOR FINDINGS OF THE STUDY:

The following are the major findings of the study:

1. Findings regarding the self-perceived level of TPACK of higher secondary school teachers in Mizoram.

- The analysis of data highlights teachers' self-perceived levels of knowledge across the seven domains of the TPACK framework, revealing notable variations in their competencies. In the Technological Knowledge (TK) domain, teachers reported a mean score of 13.72 (SD = 1.99), indicating a moderate level of technological proficiency. Most teachers (68%) perceived their technological knowledge as average, while 15.5 percent and 16.5 percent rated themselves as having good and poor knowledge, respectively.
- In the Pedagogical Knowledge (PK) domain, the mean score was 17.51 (SD = 2.56), reflecting a relatively strong understanding of teaching strategies. The majority (78.5%) assessed themselves at an average level, with (9%) and (12.5%) reporting good and poor knowledge, respectively. For Content Knowledge (CK), teachers obtained a mean score of 17.58

(SD = 2.33). While (61.5%) rated themselves as average, (17.5%) reported good knowledge, and (21%) fell into the poor category, indicating some inconsistency in subject-matter confidence.

- Regarding the integration domains, Technological Pedagogical Knowledge (TPK) had a mean of 17.70 (SD = 2.44), showing moderate competence in combining technology with pedagogy. Most teachers (71.5%) considered themselves average, (9.5%) good, and (19%) poor in this domain. Technological Content Knowledge (TCK) recorded a mean of 13.86 (SD = 1.87), with 74 percent at an average level, 16.5 percent good, and 9.5 percent poor, suggesting a fairly stable but moderate understanding of the relationship between technology and subject content. In Pedagogical Content Knowledge (PCK), the mean score was 13.78 (SD = 2.06); 67 percent of teachers were average, while 19 percent and 14 percent demonstrated good and poor knowledge, respectively, indicating a moderate ability to connect pedagogy with content.
- The overall TPACK score revealed a mean of 23.17 (SD = 3.35), with the vast majority of teachers (85%) perceiving themselves as having average integrated knowledge. Only (2.5%) rated themselves as having good TPACK, whereas 12.5 percent reported poor levels.
- An examination of individual statement means identified the highest and lowest rated items across domains. The highest mean ($M = 4.49$, $SD = 0.68$) was observed in the TCK domain, suggesting that most teachers were proficient in using technology to demonstrate subject concepts. Conversely, the lowest mean ($M = 3.30$, $SD = 1.11$) appeared in the TPK domain, indicating limited ability among teachers to engage students in higher-order thinking—such as problem-solving, critical thinking, and decision-making—through technological tools.

2. Findings regarding the self-perceived TPACK of higher secondary school teachers in Mizoram with reference to educational discipline.

- The comparison of higher secondary school teachers' self-perceived TPACK across Science and Arts disciplines revealed that both groups generally perceive themselves at a moderate level in all domains, with science teachers reporting slightly higher mean scores across the board. Science teachers showed greater confidence in integrating technology into teaching, particularly in TPK ($M = 17.91$) and TCK ($M = 14.59$), compared to arts teachers ($M = 16.64$ and 13.66 , respectively). A higher proportion of science teachers fell into the high-level category, while arts teachers had more respondents in the low-level category, especially in TPK, TCK, and PCK, indicating weaker integration of technology and pedagogy. Overall TPACK scores were also higher for science teachers ($M = 22.10$) than arts teachers ($M = 21.86$). Statistical analysis confirmed a significant difference between the two groups at the 0.05 level ($t = 2.48$), supporting the hypothesis that educational discipline influences teachers' self-perceived TPACK.

3. Findings regarding the self-perceived TPACK of higher secondary school teachers in Mizoram with reference to their gender.

- The comparison of male and female higher secondary school teachers' self-perceived TPACK revealed that both groups generally fall within the moderate level across all domains, though some differences are evident. Male teachers recorded slightly higher mean scores in most domains, including TK ($M = 13.55$), PK ($M = 19.21$), and TPK ($M = 19.25$), compared to female teachers ($M = 12.70$, 18.35 , and 17.81 , respectively). Similar trends were found in TCK and PCK, suggesting that male teachers perceive themselves as more confident in technological and pedagogical aspects of teaching. In contrast, female teachers obtained a slightly higher mean score in the overall TPACK domain ($M = 22.10$) than males ($M = 21.91$), reflecting comparable overall integration of technology, pedagogy, and content.

- A higher proportion of male teachers were found in the high-level category, particularly in TK, PK, and PCK, while most female teachers remained within the moderate range across all domains. This indicates that male teachers tend to show greater confidence in technology use, whereas female teachers demonstrate more consistency and balance across domains. The calculated t-value (2.24) exceeded the critical value at the 0.05 level, confirming a statistically significant difference in self-perceived TPACK between male and female teachers. Therefore, Hypothesis 3 was accepted, establishing that gender significantly influences self-perceived TPACK among higher secondary school teachers in Mizoram.

4. Findings regarding the self-perceived TPACK of higher secondary school teachers in Mizoram with reference to their age.

- The findings indicate that teachers below 40 years of age have higher mean scores across all TPACK domains compared to those above 40 years. In the Technological Knowledge (TK) domain, younger teachers achieved a higher mean ($M = 14.08$, $SD = 1.66$) than older teachers ($M = 13.22$, $SD = 2.18$). This pattern continues across other domains, including Pedagogical Knowledge (PK) ($M = 18.91$ vs. 16.13), Technological Pedagogical Knowledge (TPK) ($M = 18.51$ vs. 15.92), and Technological Pedagogical and Content Knowledge (TPACK) ($M = 23.16$ vs. 20.88), indicating greater confidence and integration of technology among younger teachers.
- In terms of knowledge levels, most teachers in both age groups fell within the moderate range; however, a higher proportion of younger teachers were represented in the high-level category across all domains. For instance, 17.6 percent of teachers below 40 years reported high TK, compared to only 9.3 percent of those above 40 years. Similarly, in the overall TPACK domain, 18.3 percent of younger teachers rated themselves high, while only 3.1 percent of older teachers did so. Conversely, a larger

percentage of teachers above 40 years fell into the low-level category, particularly in technology-related domains such as TK, TPK, and TCK—for example, 26.5 percent of older teachers demonstrated low TK compared to 11 percent among younger teachers.

- Statistical analysis revealed a t-value of 6.09, which exceeds the critical value at both 0.05 and 0.01 significance levels, confirming a significant difference in self-perceived TPACK between age groups. Consequently, Hypothesis 4, which states that “there is a statistically significant relationship in self-perceived TPACK among higher secondary school teachers of Mizoram based on age,” was accepted. Teachers below 40 years recorded a higher overall mean score ($M = 17.41$) compared to those above 40 years ($M = 15.40$), indicating that younger teachers possess significantly higher self-perceived technological, pedagogical, and content integration skills.

5. Findings regarding the self-perceived TPACK of higher secondary school teachers in Mizoram with reference to their teaching experience.

- The comparison of self-perceived TPACK based on teaching experience revealed that teachers with less than 10 years of experience scored higher across all domains than those with more than 10 years. Less-experienced teachers demonstrated stronger technological and integrative abilities, particularly in TK ($M = 13.43$ vs. 11.68), TPK ($M = 19.53$ vs. 17.67), and TCK ($M = 13.08$ vs. 11.51). This suggests that newer teachers are more confident in using technology in their teaching practices. Although both groups predominantly fell within the moderate category, a greater proportion of teachers with fewer years of experience were represented in the high-level category across domains.
- For example, 15.2 percent of less-experienced teachers reported high TPK compared to 12 percent among more-experienced teachers. The overall

TPACK mean was also higher for teachers with less than 10 years of experience ($M = 17.38$) than those with more than 10 years ($M = 15.74$). This difference may reflect younger teachers' greater exposure to ICT training and digital tools during their professional preparation. The calculated t-value (4.43) exceeded the critical values at both 0.05 and 0.01 levels, confirming a statistically significant difference. Therefore, Hypothesis 5 was accepted, indicating that teachers with less teaching experience possess significantly higher self-perceived TPACK than their more-experienced counterparts.

6. Findings regarding the self-perceived TPACK of higher secondary school teachers in Mizoram with reference to ICT training.

- The comparison between teachers with and without ICT training revealed that those who had undergone ICT training demonstrated higher self-perceived TPACK across all domains. Teachers with ICT training ($n = 107$) scored higher mean values in Technological Knowledge ($TK = 15.40$, $SD = 1.05$), Technological Pedagogical Knowledge ($TPK = 19.40$, $SD = 1.30$), Pedagogical Content Knowledge ($PCK = 15.36$, $SD = 1.19$), and overall TPACK ($M = 25.32$, $SD = 0.78$), compared to teachers without ICT training ($n = 93$) who scored $TK = 12.26$ ($SD = 1.37$), $TPK = 19.06$ ($SD = 1.75$), $PCK = 11.97$ ($SD = 1.16$), and overall TPACK = 20.70 ($SD = 3.47$).
- The overall mean difference (trained = 18.45, $SD = 3.35$; untrained = 16.87, $SD = 3.45$) was found to be statistically significant, as indicated by the calculated t-value (3.43) exceeding the critical values at both 0.05 (1.97) and 0.01 (2.60) levels. Hence, the hypothesis stating that there is a statistically significant difference in self-perceived TPACK of higher secondary school teachers of Mizoram based on ICT training was accepted.
- These findings clearly suggest that ICT training substantially enhances teachers' technological, pedagogical, and content integration abilities. Teachers who received ICT training not only possessed stronger

technological knowledge but also demonstrated improved capacity to integrate technology with pedagogy and subject content effectively. The training likely contributed to greater confidence in selecting and applying appropriate technological tools to enrich classroom instruction.

- Furthermore, ICT-trained teachers exhibited higher Pedagogical Content Knowledge, indicating that the training may have helped them organize and present content more efficiently and adopt diverse instructional strategies. Thus, ICT training appears to play a pivotal role in developing teachers' holistic professional competence by strengthening their understanding and application of technology in teaching and learning.

7. Findings regarding the effectiveness of higher secondary school teachers in Mizoram in their classroom teaching.

- The findings of the study revealed that in terms of teacher planning, a majority of teachers (65%) exhibited planning that was apparent, while (35%) demonstrated strong planning, and none failed to display this skill. Regarding knowledge and understanding, most teachers (65%) showed a strong level of subject knowledge, whereas (35%) displayed it at an apparent level, reflecting good mastery of the subject matter. In relation to the medium of instruction, the majority of teachers (82.5%) used the language of instruction at an apparent level, (7.5%) showed strong proficiency, while (10%) were found to be less effective in their language use.
- The findings indicated that more than half of the teachers (55%) employed teaching methods at an apparent level, while 45 percent demonstrated strong use, suggesting moderate variation in their teaching strategies. With regard to classroom management, a very high proportion (82.5%) exhibited apparent performance, whereas only 17.5 percent showed strong management skills, indicating that overall management was adequate but not exceptional.

- The findings further revealed that more than half of the teachers (57.5%) applied assessment practices at an apparent level, (37.5%) demonstrated strong application, while (5%) did not display any assessment during observation. In terms of homework and assignments, 60% provided them strongly, and (37.5%) at an apparent level, indicating that assigning homework and related tasks is a well-established and consistently practiced aspect of their teaching.

8. Findings regarding the relationship between self-perceived expertise in TPACK and teaching effectiveness of higher secondary school teachers in Mizoram.

- The analysis of the relationship between self-perceived expertise in TPACK and teaching effectiveness of higher secondary school teachers revealed a correlation coefficient (R value) of 0.77, which indicates a high and positive relationship between the two variables. When compared with the critical values of r (0.325 at the 0.05 level of significance and 0.418 at the 0.01 level), it is evident that the obtained value is substantially higher than both. Hence, it can be concluded that there exists a significant positive correlation between self-perceived expertise in TPACK and teaching effectiveness among higher secondary school teachers. In other words, teachers who perceive themselves as more competent and knowledgeable in integrating technology, pedagogy, and content are likely to be more effective in their classroom teaching practices. This implies that as teachers' self-perceived TPACK expertise increases, their teaching effectiveness also tends to improve.

9. Findings on problems faced by the higher secondary school teachers of Mizoram in integrating technology in teaching

- The adoption of new technological tools in classroom settings emerged as the most significant challenge (69%), indicating that teachers struggle most with incorporating new devices into daily teaching.
- Shortage of time to practice and update technological skills was reported by 64.5 percent of teachers, highlighting workload and scheduling limitations.
- Preparing technology-integrated lessons was seen as time-consuming by 59.5 percent, reinforcing time constraint as a persistent issue.
- Regarding infrastructure and access Issues, 52 percent of teachers reported that computers and other digital devices were not available in their classrooms and 28 percent lacked access to devices or stable internet at home, and 40.5 percent indicated that their schools lacked adequate network infrastructure to support digital instruction.
- In terms of training and professional support, only 38.5 percent of teachers received adequate technical training and support, and 46.5 percent felt that professional workshops had effectively prepared them for technology use and just 42.5 percent reported receiving timely guidance on technology integration, indicating insufficient institutional support.
- In teacher attitudes and practices, 53.5 percent of teachers engaged students in technology-based learning activities. Only 24.5 percent expressed fear or hesitation toward using new technologies, suggesting that resistance is not widespread and a strong 93.5 percent agreed that using technology enhances their comfort and teaching effectiveness, showing high willingness despite practical barriers.
- The findings reveals that regarding institutional readiness, 57 percent of teachers stated that schools are making efforts to help students collaborate using digital tools, though 43 percent reported limited engagement, revealing inconsistency in institutional preparedness. 51.5 percent believed that sufficient funds are available for sustaining technology-based teaching, though utilization may vary by school.

10. Findings regarding the perceived experience of students on the effectiveness of teaching of higher secondary school teachers of Mizoram using TPACK.

- **The perceived experience of students on the effectiveness of teaching of higher secondary school teachers revealed the following:**
- 51.46 percent of students rated teachers' teaching methods as average or moderate, while 46.57 percent found them good or high, and only 1.95 percent rated them as poor.
- In terms of knowledge of the content taught, 61.56 percent of students rated teachers high, 41.69 percent moderate, and only 3.25 percent low, showing that teachers were generally well-versed in their subject matter.
- Regarding effective use of technology, 48.2 percent perceived it as moderate, 39.73 percent as low, and only 12.05 percent as high, indicating a comparatively weaker area among teachers.
- On initiative and strategies, 71.98 percent rated teachers moderate, 19.86 percent high, and 7.81 percent low, suggesting that most teachers were average in adopting new strategies.
- Concerning creativity, 58.63 percent of students rated teachers moderate, 29.96 percent high, and 11.4 percent low.
- In terms of enthusiasm, 59.6 percent rated teachers moderate, 31.27 percent high, and 9.44 percent low.
- For ability to work with supervisors or heads, 51.14 percent rated teachers high, 42.34% moderate, and 6.84 percent low, indicating good professional relationships.
- Regarding ability to work with peers, 47.55 percent rated teachers moderate, 46.9 percent high, and 5.53 percent low, showing healthy collegial interactions.
- On rapport with parents, 56.02 percent rated teachers moderate, 29.31 percent high, and 14.65 percent low, reflecting a need for improvement in parent–teacher communication.

- For rapport with students, 49.83 percent rated teachers moderate, 42.67 percent high, and 10.74 percent low, suggesting generally positive teacher–student relationships.
- Regarding classroom planning, 46.57 percent rated teachers moderate, 34.85 percent high, and 18.56 percent low, indicating scope for better planning.
- On ability to maintain discipline, 62.21 percent rated teachers high, 32.57 percent moderate, and only 5.21 percent low, highlighting this as a strong area.
- For willingness to improve professionally, 48.53 percent rated teachers high, 45.92 percent moderate, and 5.53 percent low, indicating a generally positive attitude toward professional growth.
- Finally, overall teaching success was rated high by 53.09 percent of students, moderate by 44.29 percent, and low by only 2.6 percent, reflecting overall effective teaching performance among higher secondary teachers.

EDUCATIONAL IMPLICATIONS

The findings of the present study carry noteworthy educational implications for enhancing the quality of teaching and learning among higher secondary school teachers in Mizoram. The moderate level of TPACK observed among most teachers indicates that, while they possess adequate pedagogical and content knowledge, there remains a substantial need to strengthen their ability to integrate technology meaningfully into classroom practices. Hence, professional development programmes should be designed to go beyond the basic acquisition of technological skills and instead focus on pedagogically grounded applications of technology. Training should provide teachers with structured opportunities to design lessons that explicitly align technology with content and pedagogical objectives. Such programmes may include model demonstrations, co-teaching opportunities, lesson study, and reflective practice sessions that enable teachers to experiment with and refine their technology-integrated instructional strategies. Continuous in-service training and mentoring systems would

also help sustain teachers' professional growth and gradually enhance both their TPACK competencies and overall teaching effectiveness.

For teachers, the findings underscore the importance of adopting a more proactive role in enhancing their TPACK competencies. Teachers need to continuously update their digital skills, engage meaningfully in professional development activities, and embrace reflective practices that allow them to assess the effectiveness of technology-based lessons. They are encouraged to collaborate with peers through professional learning communities, share innovative instructional strategies, and participate in peer observation to improve their classroom practices. Additionally, teachers must shift toward student-centred digital pedagogies that promote higher-order thinking, problem solving, creativity, and active engagement. By integrating technology thoughtfully and purposefully, teachers can enhance learning outcomes and create more inclusive and interactive classroom environments.

At the institutional level, effective leadership is crucial for fostering a school culture that promotes and sustains technology integration. School heads and administrators should provide adequate infrastructural support, such as reliable connectivity, multimedia equipment, and access to digital learning resources. However, investment in hardware alone will not suffice; what is equally important is the establishment of professional learning communities that encourage collaboration, peer observation, and reflective dialogue focused on improving technology-supported pedagogy. School leaders can initiate mentoring systems where experienced teachers guide others in lesson planning and classroom implementation grounded in the TPACK framework. Similarly, pre-service teacher education programmes should embed the TPACK model across subject pedagogy courses so that new teachers enter the profession equipped with both conceptual understanding and practical competence in technology-integrated teaching. Such measures will ensure a sustainable and contextually relevant approach to professional capacity building in Mizoram.

At the broader policy and curriculum level, it is imperative that the higher secondary curriculum and assessment framework be aligned with digital pedagogical practices that promote innovation, critical thinking, and creativity. Policymakers

should consider integrating technology-based learning activities and formative assessments that evaluate students' analytical, problem-solving, and collaborative skills, rather than relying solely on memory-based examinations. Furthermore, to address the disparities in digital access across Mizoram, strategies for digital equity—such as the provision of offline learning materials, community learning centers, and affordable digital devices—should be prioritized. These initiatives would ensure that all learners, irrespective of their socio-economic or geographic background, benefit equally from technology-enhanced education.

Additionally, the findings highlight the need to strengthen ongoing monitoring and evaluation mechanisms to ensure that technology integration efforts are producing the desired outcomes. Regular evaluation of teachers' TPACK development—through classroom observations, digital lesson portfolios, and feedback from students—would provide valuable insights into areas requiring further improvement. Such evidence-based monitoring would enable schools and policymakers to refine professional development initiatives, allocate resources more effectively, and identify best practices that can be scaled across districts. Moreover, creating platforms where teachers can share exemplary technology-integrated lessons, innovative teaching approaches, and classroom challenges will foster a culture of continuous learning. Embedding such reflective and evaluative practices within the education system will not only enhance teachers' technological and pedagogical growth but also contribute to the overall improvement of teaching quality in Mizoram.

In conclusion, strengthening TPACK among higher secondary teachers in Mizoram requires a multi-level approach encompassing teacher training, institutional support, and systemic policy reform. When effectively implemented, such efforts can transform classroom practices, enrich students' learning experiences, and ultimately elevate the standard of secondary education in the state.

RECOMMENDATIONS

Based on the findings of the present study, the following recommendations are made to enhance the Technological, Pedagogical, and Content Knowledge (TPACK)

of higher secondary school teachers in Mizoram and thereby improve their teaching effectiveness.

- 1. Continuous and Context-Based Professional Development:** Regular professional development programs should be organized to enhance teachers' competencies in integrating technology with pedagogy and content. These training programs should be contextually designed, keeping in mind the specific challenges faced by teachers in Mizoram such as limited access to digital infrastructure and varying levels of technological literacy. Workshops should include hands-on sessions on digital lesson planning, use of interactive teaching tools, and strategies for creating locally relevant digital content. Continuous training will empower teachers to become more confident and effective in technology-enabled teaching.
- 2. Establishment of Local Learning Communities:** Schools and educational authorities should encourage the formation of Professional Learning Communities (PLCs) at the district and institutional levels. Through these communities, teachers can collaborate, share best practices, and mentor each other in technology integration. Peer collaboration is particularly valuable in remote areas of Mizoram, where collective problem-solving can overcome resource and infrastructure limitations.
- 3. Integration of TPACK Framework in Pre-Service and In-Service Teacher Education:** Teacher education institutions under the Mizoram Board of School Education (MBSE) and the Directorate of School Education should embed TPACK-based training modules into their curriculum. Both pre-service and in-service teachers should be trained not only in using ICT tools but also in aligning those tools effectively with pedagogical methods and subject content. Such integration will help teachers develop holistic technological competence.
- 4. Improvement of Technological Infrastructure and Support:** The Government of Mizoram should prioritize strengthening ICT infrastructure in higher secondary schools, particularly in rural and hilly areas. Reliable internet connectivity, access to digital devices, and smart classrooms can significantly enhance teachers' ability to implement TPACK effectively. Moreover,

appointing ICT support personnel at the school level can help teachers troubleshoot and sustain the use of technology in classrooms.

- 5. Promotion of Reflective and Innovative Practices:** Teachers should be encouraged to engage in reflective practices to evaluate their teaching strategies and identify areas for improvement. Encouraging innovation through experimentation with educational technologies, digital storytelling, online assessment tools, and AI-assisted platforms can make lessons more engaging and relevant to students. Reflective teaching journals or portfolios can also be introduced to help teachers track their TPACK development over time.
- 6. Policy and Administrative Support:** The State Education Department should formulate policies that promote technology integration and recognize teachers who demonstrate excellence in TPACK-based teaching. Incentives such as awards, professional credits, or opportunities for higher study can motivate teachers to continually upgrade their technological and pedagogical skills. Policies should also ensure equitable access to digital resources for all schools, bridging the urban–rural digital divide in Mizoram.
- 7. Development of Culturally and Linguistically Relevant Digital Content:** Since Mizoram has a distinct linguistic and cultural context, digital learning materials should be designed to reflect local culture, language, and values. Encouraging teachers to develop bilingual or vernacular digital content can enhance student understanding and engagement. Collaboration between teachers, local education experts, and digital content developers will make TPACK implementation more contextually effective and sustainable.

SUGGESTIONS FOR FURTHER RESEARCH

The following suggestions are proposed:

1. Extend the study to other districts of Mizoram or Northeastern states for a broader understanding of teachers' TPACK.
2. Conduct subject-specific studies to explore differences in TPACK across disciplines.

3. Undertake longitudinal research to examine changes in teachers' TPACK over time.
4. Design intervention-based studies to test the effectiveness of training programs in enhancing TPACK.
5. Investigate the relationship between teachers' TPACK and students' learning outcomes.
6. Use qualitative or mixed-method approaches for deeper insights into teachers' experiences and challenges.
7. Assess the impact of digital literacy programs and ICT initiatives on teachers' technological and pedagogical skills.

References

- Abbit, J. T. (2011). Investigation of the relationship between self-efficacy beliefs about technology integration and Technological Pedagogical Content Knowledge (TPACK) among pre-service teachers. *Journal of Digital Learning in Teacher Education*, 27(4), 134-145.
- 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.
- Cui, Y., & Zhang, H. (2022). Integrating teacher data literacy with TPACK: A self-report study based on a novel framework for teachers' professional development. *Frontiers in Psychology*, 13, 1-17. Doi:10.3389
- Hardisky, M. (2018). *TPACK: Technology integration and teacher perceptions* (Doctoral dissertation). <https://tpack.org/tpackrefs/archives/2075>
- Harris, J. B., 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(3), 393-416. <https://scholarworks.wm.edu/educationpubs>
- Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)? *Contemporary Issues in Technology and Teacher Education*, 9(1), 60–70.
- Lalchhuanawma, & Fanai, L. (2022). Integration of ICT in school education of Mizoram: Issues and challenges. *Journal of Educational Research and Practice*, 12(1), 45–54.
- Liang, J. C., Chai, C. S., Koh, J. H., Yang, C. J., & Tsai, C. C. (2013). Surveying in-service preschool teachers' technological pedagogical content knowledge. *Australasian Journal of Educational Technology*, 29(4), 581-594.
- Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, 108(6), 1017–1054.
- 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.