Exploring Teachers' Perceptions of Technology, Pedagogy, and Content Knowledge in Secondary Education in Bangladesh

Monira Jahan[1]
Moriom Akter[2]

Abstract

The study aimed to explore teachers' perceptions of technology, pedagogy, and content knowledge (TPACK) as teachers in Bangladesh is highly encouraging to follow technology based education. A total of 255 teachers were randomly selected from 20 purposefully chosen schools and madrasas located in 3 different districts of Bangladesh. Following the post-positivist and constructivist paradigms, this study used a parallel mixed-methods research design. Thus, quantitative and qualitative data were generated using a questionnaire and interview. The result indicated that teachers had mixed perceptions of TPACK, ranging from good to medium-level perception. Significant correlations, though trivial, were found among teachers' background variables (i.e., age, teaching experience, gender, educational qualifications, and computer skills) and their perception of TPACK. Moreover, the crucial factors related to the teachers' perceptions towards TPACK were also identified from the qualitative data, which include compensation, administrative support, increased workload, and curriculum. It is expected that the results of this study will lead to a better understanding of the real scenario of teachers' perceptions of TPACK that may have policy implications to take steps and policies of TPACK and technology integration in teaching and learning activities.

Keywords: *Teachers' Perception, TPACK, Technology Integration, Mixed Method.*

1. Introduction

In recent years, education has extended beyond the four walls of the classroom, and there has been a lot of focus on 21st century skills (Valtonen, et al., 2017). Online learning and technology-based education, in particular, are used more

[1] Professor, Institute of Education and Research (IER), Jagannath University, email: jahannottingham@yahoo.co.uk
[2] Technical Coordinator-VET, Child Protection Project, COAST Foundation, collaboration with UNICEF, email: moriomela.jnu@gmail.com

frequently than before, especially since the start of the COVID-19 pandemic. To keep pace with rapid technological advancements, teachers must be well-versed in a variety of pedagogical methods and the effective use of ICT (Information and Communication Technology). In addition to technological knowledge, teachers should also be equipped with diverse teaching approaches to ensure efficient and effective teaching, thereby preparing their students to become global citizens in the 21st century (Valtonen, et al., 2017; Ansari, 2013).Therefore, the integration of technology, pedagogy, and content knowledge (TPACK)is essential for teachers (Cetin-Berber & Erden , 2015).In many countries, including Bangladesh, this transition poses unique challenges as teachers must learn to effectively utilize devices such as, laptops, computers, smartphones, tablets, and other devices. Without a comprehensive understanding of TPACK, teachers may face difficulties in effectively integrating technology into their teaching and learning activities, limiting their ability to promote critical 21st century skills such as creativity, critical thinking, and problem-solving (Shafie, 2021). Thus, it is crucial for teachers to be digitally proficient and skilled in integrating technology into their pedagogy to deliver high-quality education and adequately prepare students to be competent global citizens (Ansari, 2013).This article, therefore, seeks to explore secondary school teachers' perceptions of TPACK.

2. Theoretical Underpinning of the Study

The TPACK framework, as shown in Figure 1 and Figure 2, proposed by Koehler & Mishra (2006), is an extension of Shulman (1987) notion of Pedagogical Content Knowledge (PCK). In fact, the Technological Pedagogical and Content Knowledge (TPACK) framework provides a theoretical underpinning for teachers, supporting the integration of technology into teaching and learning activities (Koehler & Mishra, 2006).

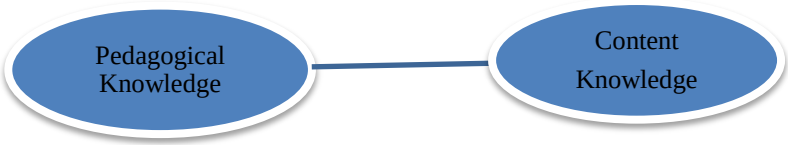

Figure 1: Two Circle of Pedagogical Knowledge and Content Knowledge

(Source: Shulman, 1987: p.7, 8)

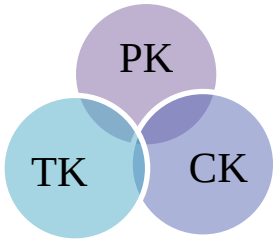

Figure 2: Three Circles of TK, CK, and PK

(Source: Koehler & Mishra, 2006)

Figure 2 depicts the three circles of pedagogical and content knowledge, now joined by pedagogical content knowledge (Koehler & Mishra, 2006). To better understand teachers' knowledge of effective technology integration, Koehler & Mishra (2006) extended PCK by incorporating Technological knowledge (TK) into the framework. As a result, a new framework is introduced containing Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), and Technological Pedagogical Content Knowledge (TPACK) (Koehler & Mishra, 2006). The authors further added that these three categories of knowledge are essential for teaching and emphasize the importance of leveraging rapidly advancing technological resources. The TPACK framework has been adopted as a theoretical foundation of technological integration in teaching. TPACK consists of seven domains, as illustrated in Figure 3, that blend knowledge of technology, pedagogy, and content, ensuring that technology is used meaningfully in educational contexts.

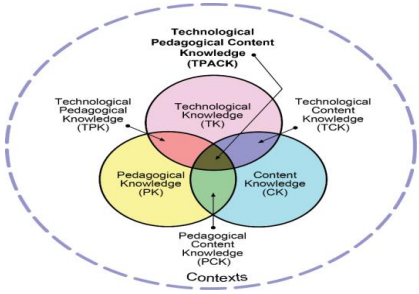

Figure 3: Complete view of Technological Pedagogical Content Knowledge (TPACK)

(Source: From TPACK.org. website)

The concise explanation of TPACK is illustrated as follows:

- Technological Knowledge (TK) refers to the understanding of various technology tools.
- Content Knowledge (CK) refers to the knowledge of the foundation of the subject taught as well as relevant facts and evidence in a particular field (Koehler & Mishra, 2006).
- Pedagogical Knowledge (PK) refers to the extensive knowledge of educational goals and objectives, principles and standards as well as teaching and learning procedures (Koehler & Mishra, 2006).
- Knowledge of concepts, educational strategies, and prior knowledge of students is referred to as Pedagogical content knowledge (PCK).
- Technological Pedagogical Knowledge (TPK) refers to the understanding of how to use technology to apply teaching methods.
- Technological Content Knowledge (TCK) is the knowledge of the relationships between technology and content knowledge as well as how these relationships affect and constrain each other.
- Lastly, TPACK combines the knowledge and skills of the other essential components. TPACK refers to the knowledge of using the appropriate technological tools to impart a specific topic by utilizing effective pedagogical techniques.

In a nutshell, TPACK offers an integrated framework of teacher knowledge that clarifies the crucial factors affecting the improvement of the teaching and learning process through the use of digital technology.

3. Literature Review

The perception of teachers regarding the relevance of a task for achieving future goals strongly influences pre-service teachers' motivation to use technology (Anderson, Graulx, & Maninger, 2011). Teachers who view technology as less significant and are not particularly motivated to improve their technology, pedagogy, and content knowledge tend to integrate technology less into teaching and learning (Çelik, 2009; Cedillo, 2003). In contrast, teachers who believe that integrating technology into the classroom will benefit students' learning are more enthusiastic to integrate technology in their teaching (Sarhandi, Bajnaid, & Elyas, 2017). Similarly, it is evident that teachers are interested in incorporating technology only when they believe it will benefit students' learning (Mumtaz, 2000).According to Kortrlik & Redmann (2005), significant problems remain with the integration of technology into educational curricula and classrooms, along with many issues derived from the findings of Mumtaz (2000).

Furthermore, literature on TPACK revealed that obstacles, for example, time for lesson planning, scheduling internet research, technology accessibility, administrative support, and teacher anxiety, affect teachers' perceptions of TPACK (Cetin-Berber & Erden , 2015). Successful integration of technology into teaching and learning depends largely on alignment with teachers' perceptions (Ertmer, 2012). A number of studies underscore the importance of teachers' perceptions for effective technology integration and the need for effective teaching strategies (Ertmer, 2012; Cope, 2002; Eshet-Alkakay, 2011; Lee & Tsai, 2010; Sarhandi, Bajnaid, & Elyas, 2017; Cheng 2017) conducted a study on Taiwanese native language teachers' TPACK, which showed that while teachers were generally satisfied with their TPACK, they lacked confidence in CK, TK, and TPK. The teachers' perceptions of CK, PK, and PCK were also positively correlated with their teaching experience. As a result, investigating teachers' perceptions of TPACK may help determine their inclination to integrate technology into their classrooms (Cetin-Berber & Erden , 2015).

In the context of a developing country, a Pakistani study highlights TPACK and ICT, the new hope for Pakistan's education system, indicating teachers in Pakistan have a positive perception and attitude towards ICT and TPACK (Hussain, Fakhar-Ul-Zaman, Kanwal, Nawaz, & Thaheem, 2024). Another study on Pakistani teachers examined the correlation among six TPACK domains for pre-service teachers of BEd. (Honors) Program, which found positive correlations across all domains (Rahim, Jalani, Ur Rahim, Bano, & Hussain, 2024). Additionally, a study in the context of Indonesia highlights the perspective physics teachers show strong competence in integrating technology into teaching, with excellent performance in TK, TPACK, and related areas. However, their CK and PK were rated as sufficient, signaling a need for improvement in subject mastery and pedagogy (Bani, 2024). The study of Ahsan, et al. (2022) explored the relationship between technology-Enhanced Teaching and Learning (TPACK) and demographic factors in Bangladesh, aiming to understand the complex interplay between TPACK and demographics. The study revealed that male teachers had better perceptions of overall classroom management and technology integration compared to female teachers (Ahsan, et al., 2022).

The research by Rouf & Mohamed, (2016) on teachers' technological skills in secondary education in Bangladesh resulting teachers exclusively used technology for PowerPoint. For record-keeping, evaluation, and feedback, no teacher used technology. Despite having the ability to create and utilize PowerPoint presentations, the majority of teachers preferred getting pre-made digital content (DC) from various sources, such as Teacher Batawan of the

Ministry of Education, and using them in Microsoft PowerPoint. Unfortunately, Bangladesh faces a shortage of technologically qualified teachers, many of whom are uncomfortable in using technology in the classroom due to a lack of technology (computer) literacy (Khan, Hassan, & Clement, 2012).On the other hand, positive teacher perceptions regarding technology are considered crucial for effective teaching and learning (Çelik & Keskin, 2009).

It is evident from the literature of TPACK that many studies have explored various aspects of TPACK and technology integration in education (Alayyar, Ghaida, Fisser, & Voogt, 2012; Archambault & Barnett, 2010; Banu, 2012; Braun & Clarke, 2006; Fereday & Muir-Cochrane, 2006; Lin, Tzu, Tsai, Chai, & Lee, 2013; Jimoyiannis, 2010; Celik, 2023; Eshet-Alkakay, 2011; Cetin-Berber & Erden , 2015; Chuang & Ho, 2011; Shin et al., 2009; Cox & Graham, 2009). However, there are few studies that can be found related to teachers' perception levels of TPACK in secondary education in Bangladesh. This study aims to explore the level of teachers' perceptions toward TPACK. It is anticipated that the findings of the current study may provide a better understanding of the scenario of teachers' perceptions regarding TPACK in Bangladeshi settings and assist authorities and the government in developing policies for TPACK and technology integration in teaching and learning. The scarcity of similar studies in secondary education in Bangladesh highlights the importance of this research in addressing this gap in the literature.

4. Research Objectives

The aim of this study is to explore teachers' perceptions of TPACK (Technological Pedagogical Content Knowledge) in secondary education in Bangladesh, focusing on the following objectives:

1. To assess the level of teachers' perceptions of TPACK in secondary education in Bangladesh.
2. To examine the relationship between teachers' background factors and their perceptions of TPACK.
3. To identify key factors influencing teachers' perceptions of TPACK.

5. Methodology of the Study

This study adopted a mixed methods research design to generate both qualitative and quantitative data. As the study was conducted on secondary teachers, therefore, all the teachers of secondary education in Bangladesh were the population of the study. To achieve the aim of this study, the sample of this study

was chosen through both probability and non-probability sampling methods, as shown in Table 1.

Table 1: Sample and Sampling Techniques used in the Study

Institutions and sample		**Number**	**Sampling Techniques**
Districts and Areas		3	Purposive Sampling
Schools	Rural	5	Convenience Sampling
	Urban	5	
Madrasahs	Rural	5	
	Urban	5	
Total Secondary Schools and Madrasas		20	
Teachers (Questionnaire Survey)		235	Simple Random Sampling
Head Teachers/ Assistant Head Teachers and Supers (Interview)		20	Purposive Sampling
Total		**255**	

A survey questionnaire and an in-depth interview schedule for teachers were used to generate in-depth information to collect data. Survey questionnaires were used to collect quantitative data, while qualitative data was gathered using prescheduled in-depth interviews. The data sets were managed and analyzed using the statistical packages for quantitative and qualitative data. For example, SPSS and MS Excel were used to analyze quantitative data generated by the questionnaire. Besides, qualitative data was analyzed following thematic analysis procedures.

6. Findings of the study

6.1. Teachers' Perceptions level of TPACK

A pre-scheduled scale was developed to measure teachers' perceptions of TPACK that contained 9 items. The scale reliability, i.e., the Cronbach's alpha value, was detected as given in Table 2 and showed an acceptable level of internal consistency ($\alpha = 0.693$), implying the scale could be used in the final analysis (Clark & Watson, 2019) for measuring the perception level of teachers towards TPACK.

Table 2: Items Descriptions and Scale Reliability of Teacher's Perception Level towards TPACK

Variable	Item No	Item Descriptions	Scale Reliability
Teachers' Perceptions towards TPACK	1	Technology helps to increase academic performance (e.g. grades).	0.693
	2	TPACK helps teachers to feel more competent as educators.	
	3	TPACK enhances my professional development.	
	4	TPACK eases the pressure on me as a teacher.	
	5	Makes classroom management more difficult.	
	6	TPACK helps accommodate students' individual learning style.	
	7	Technology integration motivates students to get more involved in participation.	
	8	TPACK promotes the development of communication & interpersonal skills.	
	9	TPACK helps to demonstrate critical concept and ideas of content.	

In the next step, teachers' perception level towards TPACK was identified, categorizing the scale values into three levels explaining low, moderate, and good levels of perception. Figure 4 indicates good level to moderate levels of perception possessed by the teachers, implying their positive perception of using and integrating TPACK that is expected to accelerate the teaching and learning process and make teachers more technically efficient, which is the demand of the rapid change of the 21st century.

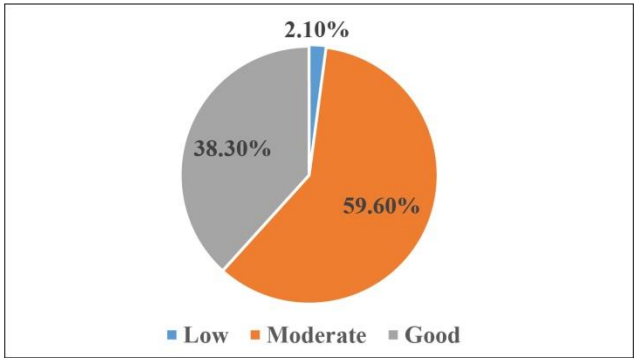

Figure 4: The Level of Perceptions towards TPACK
(Source: Primary data collected from field work)

The pie chart (Figure 4) depicts the findings of teachers' perceptions of TPACK. Most of the teachers (59.60%) had moderate levels of perceptions towards TPACK. Very few participants (2.1%) were found who negatively perceived TPACK and had low perceptions regarding TPACK. The good perception level towards TPACK possessed 38.30% teachers.

6.2. Relation between Teachers' Background Factors and Their Perceptions towards TPACK

Relationships between teachers' perceptions of TPACK and their background factors were measured using linear regression, which is shown in Table 3 and Table 4. The model summary of regression analysis reveals that 10.6% of the variation in teachers' perception of TPACK can be explained by their background factors.

Table 3: Model Summary of Linear Regression

Model Summary					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Sig. F Change
1	.326[a]	.106	.066	4.27164	.004
a. Predictors: (Constant), Computer Access, Gender, Teaching subject, Experience, Professional degree, Qualification, Source of skill acquisition, Age, Subject specialization, Computer skill					

Table 4 represents the coefficients of the background factors implying that only teachers' age and their access to computer have statistically significant association with teachers' perception of TPACK.

Table 4: Coefficients of Teachers' Background Factors

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.(p)
		B	Std. Error	Beta (β)		
1	(Constant)	27.975	1.775		15.758	.000
	Age	0.898	0.374	0.216	2.400	.017
	Computer access	2.347	0.726	0.266	3.233	.001
a. Dependent Variable: Perception score						

According to Table 4, significant association between teachers' perceptions of TPACK and their age suggests that younger teachers tend to have more favorable

perceptions towards the use of technology in the classroom compared to older teachers and this group of teachers is more interested in applying their technological knowledge and skills in their teaching. Significant association is observed between the teachers' access to own computer and their perceptions of TPACK explaining that teachers' prior technological knowledge ameliorate them in using and integrating TPACK.

6.3. Key Factors Identified from Qualitative Data Influencing Teachers' Perceptions of TPACK

Teachers were interviewed to obtain more in-depth information identifying influencing factors of teachers' perception towards TPACK. Four different themes were identified from the analysis of qualitative data as interpreted below.

Theme 1: Teachers' Workload

Workload is identified as a crucial factor from the qualitative data, implying more than half of the teachers' perception of TPACK was not very positive. The teachers express their view toward TPACK, acknowledging-

Table 5: Increased Workload is one of the Reasons that Lower Teachers' Perceptions of TPACK

Views	N (%)
Integrating technology increases teachers' workload.	N = 12 (60%)
It requires more time to prepare technological materials compared to traditional classes.	N = 12 (60%)
Teachers are too busy with everyday classwork to consider incorporating technology into their daily lessons.	N = 10(50%)
Teachers face difficulties in using the technology and choosing particular teaching content to teach with technology.	N = 12 (60%)
They argued they need more preparation time.	N = 12 (60%)

It is, therefore, clear from Table 5 that teachers from both schools and madrasahs concurred that utilizing technology resulted is a greater workload for them, and they also claim that they faced less workload in traditional one way teaching and learning methods. This is the key reason teachers possess a low perception towards TPACK. Although 2.1% teachers had comparatively low perception toward TPACK according to the quantitative result, the qualitative result shows different findings, almost 60% teachers acknowledge that integrating technology added to their workload and requires them to prepare technological materials more thoroughly than they did traditional ones. That is why they have low

perception towards TPACK as they faced less workload in traditional one way teaching learning method. A few of teachers reported that they were too busy to consider incorporating technology into their daily lessons. The 12 teachers who faced difficulties while choosing the technology that would be used in the classroom for particular content. They argued they should have given the more preparation time. Teachers from both school and madrasah concurred that utilizing technology in a greater workload. Two of the head teachers from Urban Madrasah said,

"The most frequent issue mentioned by all of the teachers is the lack of time they have to use technology to organize content, explore numerous websites on the Internet, and require work load." (Teacher, Rural Madrasah)
"It took longer to prepare the teaching materials that it did to prepare traditional classes". (Urban School Head Teacher)

Regarding using technology in teaching another teacher said,

"Every time I try incorporating technology, I feel like I'm adding another full-time job to my plate. Preparing lesson with technology takes so much longer than my usual planning. I want to, but there just aren't enough hours in the day". (Urban School Teacher)

Theme 2: Curriculum

Curriculum (10%) is identified as a robust factor that is influencing teachers' perceptions towards TPACK. The following crucial points originated about curriculum from the in-depth interviews with teachers.

Table 6: Curriculum is one of the Factors Behind Teachers' Perceptions of TPACK

Views	N (%)
Proper instruction of technology integrating for teachers should be included in the curriculum.	10%(N=2)
Flexibility or self-paced instruction should be allowed in the curriculum.	10%(N=2)
Proper instruction about technology integration in teaching needs to be included in the teacher training curriculum.	10%(N=2)

The theme indicates that teachers' perceptions towards TPACK can be boosted if the curriculum is developed considering the above key points. One of the teachers' views is illustrated below echo similar foresight.

"I think the TPACK approach should be considered while designing an ICT curriculum. Proper instruction regarding the integration of technology should be

incorporated into teacher curriculum too. How teachers use technology effectively in classrooms that should be instructed in the curriculum, and master trainers must explain it clearly in their training sessions" (Urban Madrasah Super).

This comment indicates that if the curriculum is developed with proper instruction of integrating technology for teachers and teacher educators, the perception of teachers about TPACK can be boosted. Although the curriculum should have the proper instruction about technology integration, Self- paced instruction should be allowed. The research identified an identifiable feature in all of the participant responds to the open- ended questions: Self-paced instruction. Two of the participants in urban school opined,

"I like the flexibility (self-paced instruction) to adjust my lessons to meet the needs of my learners" (Head Teacher, Urban School).

"Every teacher has a different teaching style. Allowing for self-paced instruction would help us feel more comfortable with the technology". (Head Teacher, Rural School)

Theme 3: Teachers' Expectations and Beliefs

Teachers' expectations from authority and their beliefs are also recognized as robust factors, as teachers' perceptions of TPACK vary to some extent based on their expectations and religious beliefs. It is observed from the interview that 55% (N = 11) teachers expect the following necessary administrative supports for integrating technology in teaching that can boost up their technological knowledge and skills, motivation, and positive perception towards TPACK.

- Adequate ICT-based materials that include multimedia, contents, video lectures, and tutorials.
- Proper infrastructure for effective use of ICT in teaching.
- Technical supports that include uninterrupted internet, electricity, a classroom with a proper arrangement of ICT-related equipment, help desk support, and onsite support to fix hardware issues with printers, servers, or networking equipment.
- Administrative supports, for example, head teachers' prompt action, resource management, budget, support service.
- Training for continuous professional and skill development is not adequate to integrate technology in teaching and learning activities.
- Administrative factors can affect the perceptions of teachers to use their TPACK.

A lack of support in providing technological supplies and materials from the administration may contribute to teachers' negative perception of TPACK. The following narrations highlight teachers 'views about their expectations.

"If the required resources of ICT are not available, technology integration in teaching will be challenging. Teachers have to arrange or buy materials on their own initiative, which certainly makes it difficult for them and loses their motivation." (Head Teacher, Rural School)

"A sufficient number of full-time technical and administrative supports are essential components for effective integration of technology in class. It helps to amplify teachers' positive perceptions of TPACK." (Assistant Super of Urban Madrasah).

Teachers' perception of TPACK is also influenced by their religious beliefs and values. Many madrasah teachers claim that their madrasah authorities discourage them from using technology, as it may impact their religious practices. The view is reflected in the following narration.

"Sometimes the madrasa authorities discourage teachers from using certain types of technology due to concerns about religious issues. For example, displaying images of people, showing videos that feature women in front of male students or teachers, and using music is strictly prohibited. To adhere to these guidelines, some teachers choose not to use technology in their teaching" (Rural Madrasah Super).

The above discussion clearly portrays that teachers' expectations for administrative support and their religious beliefs can be regarded as influential factors in shaping their perceptions of TPACK.

Theme 4: Teachers' Remuneration

Teachers' remuneration was identified as one of the robust factors that hinder teachers' positive perception toward TPACK. Sharply half of the participants (50%, N = 10) have claimed that their perception of TPACK has become lower because:

- Educational institutes pay them low-level remuneration, which lowers teachers' satisfaction and causes hardship to maintain their living standard with this minimum range of remuneration.
- Despite receiving this little amount of remuneration, teachers are expected to put forth a lot of effort, have a pleasant attitude, and attend to the needs of learners.

- As their income from teaching is very minimal, they spend their after-school time in other jobs like private tutoring, shop keeping, or farming to generate extra income.

One of the supers of a madrasah in urban area said,

"*Teachers work a lot longer hours than the general public thinks. We work twelve hours a day, at the very least, and sometimes on the weekends as well. Honestly, a 60-80 hour workweek is not worth the little amount of pay. I believe my value to be far higher than that. So I have to do another work parallelly like tutoring, farming, etc. This is why I can't get more time to prepare technological materials for class next day."(Urban Madrasah Super)*

Teachers require breaks to grow professionally, and prepare themselves for next day class to integrate technology, yet because their income from teaching is very poor, they utilize their free time to look for job elsewhere in order to supplement their income, which lowers their perception toward TPACK implication. Two of the teachers' voices are illustrated below in favor of the above points.

"*Honestly, 60-80 hours work in a week is not worth the little amount of pay. I believe my value to be far higher than that. So I have to do other work simultaneously, like tutoring, farming, etc. This is why I can't get more time to prepare technological materials for everyday class." (Rural madrasah assistant super)*

"*Higher compensation will undoubtedly attract teachers more to work in improving their skills related to teaching that automatically improve their insight of TPACK*" *(Teacher, Rural School).*

To support the idea, one head teacher from a rural school urged,

"The government would like to build a smart nation for a future smart Bangladesh. For building a smart nation, smart teachers are essential. Smart teachers cannot be made without a suitable amount of remuneration. Good students may not be willing to join the teaching profession if the compensation is not given in a proper way." (Rural School Head Teacher)

Thus, there is no denying this conviction that upgrading teachers' remuneration has a direct impact on their perceptions towards TPACK. A flowchart, as shown in Figure 5, is created to present the factors at a glance that have direct impact on teachers' perceptions of TPACK.

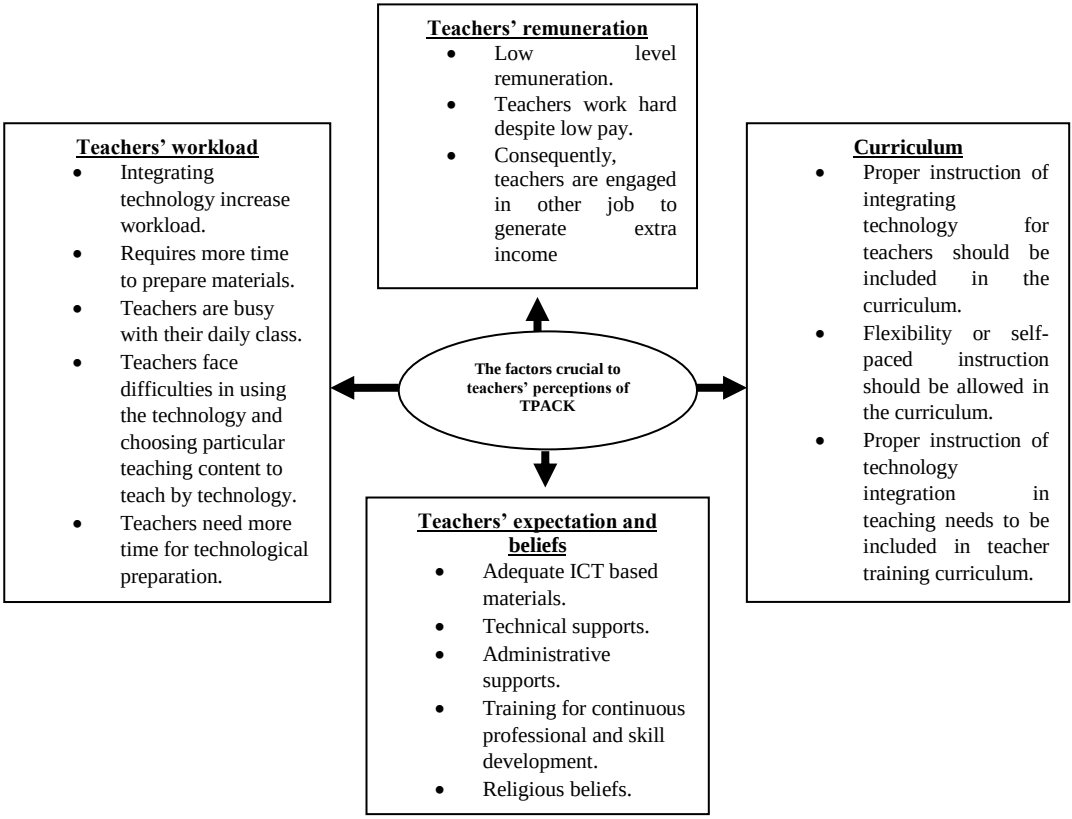

Figure 5: Flowchart of Influential Factors of Teachers' Perception of TPACK

7. Discussion

This study aimed to explore teachers' perceptions of technology, pedagogy, and content knowledge (TPACK) in secondary education in Bangladesh. Teachers of secondary schools and madrasahs (religious-based schools) participated in this study. The findings indicate that the majority of teachers had a moderate level of perceptions of TPACK. Just over a third of teachers have a good level of perception regarding TPACK. Conversely, we found that a very small percentage of teachers had low perceptions of TPACK. It is evident that positive teacher perceptions of technology integration are considered indispensable for effective teaching (Çelik, 2009). Teachers who perceive technology as less significant and

are not engaged in developing their Technological, Pedagogical, and Content Knowledge (TPACK) tend to utilize it less frequently in their teaching (Cedillo, 2003). Conversely, those teachers were willing to incorporate technology in their teaching activities, who believe that technology has a positive impact on their teaching and students learning (Sarhandi, Bajnaid, & Elyas, 2017; Mumtaz, 2020).

The findings of the study indicate that 10.6% of the variation in teachers' perceptions of TPACK can be attributed to their background factors (i.e. age and access to the computer). Trivial statistically significant associations were found between teachers' perception level, and their age, and computer access. A similar finding was observed for teacher age in Lee & Tsai's (2010) study, although reverse findings were derived in other studies (e.g., Cetin-Berber & Erden, 2015; Mai & Hamzah, 2016), where no significant correlation was found between the two variables. Teachers' perceptions of technology-enhanced instruction (i.e., TPACK, encompassing Technological Pedagogical Knowledge, Technological Content Knowledge, and Technical Knowledge) vary significantly according to their age(Fahadi & Khan, 2022). This implies that younger teachers with limited conventional knowledge are less likely to acquire high levels of TPACK than older teachers, who tend to have stronger conventional knowledge. Further, findings indicate that teachers' perceptions of TPACK were positively impacted by having their own personal computer or laptop (computer access). It is crucial to note that all teachers in Bangladesh are required to own a personal computer and possess strong computer skills for effective integration of technology, which certainly can accelerate their confidence and positive perception of TPACK.

The qualitative results of the study suggest that several factors influence teachers' perceptions of TPACK. More than half of the teachers surveyed believed that their workload and remuneration significantly affected how they perceived and implemented TPACK in practice. A substantial number of teachers emphasized that adequate remuneration was essential in fostering positive perceptions of TPACK. Without sufficient remuneration, it is challenging to cultivate effective teachers. Adequate remuneration is necessary to attract good teachers. Therefore, the government should consider increasing teacher salaries to allow them to focus fully on classroom instruction and effectively integrate technology, making classes both enjoyable and productive. Teachers also expressed that using technology increased their workload compared to traditional one-way teaching methods, where they feel less work pressure. Their negative perceptions of TPACK and technology integration reflect this attitude. This finding aligns with

the research of (Khan, Hassan, & Clement, 2012) indicating that a shortage of teachers in Bangladesh forces teachers to manage heavy workloads, leaving them little time to design, develop, and integrate technology into their teaching. A similar view is expressed by Strickland (2014), who concluded that teachers felt that incorporating technology required more planning and class time. The findings of the research also support the notion of the research done by Jimoyiannis (2010) that lesson preparation time for technology integration significantly impacts their use of technological pedagogical scientific knowledge in instruction. Many teachers perceived technology integration as time-consuming and demanding, which significantly influenced their perceptions of integration of technology following the TPACK format in teaching. Based on in-depth interviews of teachers, it is observed that teachers' expectation of institutional support plays a crucial role in enhancing teachers' technological skills (Kotrlik & Redmann, 2005; Robertson et al., 1996). Teachers need adequate support from the administration for integrating technology to foster positive perceptions of TPACK (Technological Pedagogical Content Knowledge). As many of the teachers claimed that they do not receive proper support from the administration, which consequently lowers their perceptions of TPACK. Teachers want to implement their technological skills and knowledge and also need to acquire more knowledge through professional training. One challenge teachers usually face is the need to purchase their resources for technology-based teaching, which lowers their interest and makes it difficult to apply the TPACK concept effectively when these tools are unavailable.

Additionally, an interesting finding was derived from the study that the madrasah administration occasionally discourages teachers from using technology due to conflicts with religious beliefs that include images of people, videos featuring women in front of male students due to the Purdah (covering) system, and certain types of music are strictly forbidden. To adhere to these religious standards, some teachers are unwilling to use technology in the classroom. This situation demonstrates how administrative factors of some educational institutes can influence teachers' perceptions of TPACK. Along with that, cultural and religious resistance significantly impacts the use of technological pedagogical content knowledge in instruction, highlighting the specific TPACK characteristics in particular contexts (Jimoyiannis, 2010).

Curriculum is an integral part of teaching, which guides teachers on how to teach and what to teach. The curriculum is identified as a key factor from the study that affects teachers' perceptions of TPACK. Teachers opined that the TPACK approach should be considered in curriculum design, allowing for self-paced

teaching while ensuring that the curriculum includes necessary guidance on technology integration. It is imperative to bring up that focusing this century as the era of science and modern technologies (Shaha & Rahman, 2015), the subject ICT was introduced at all levels of education in Bangladesh, i.e., government and non-government secondary schools, madrasahs, and technical education institutions equally since 2012 (Jabbar, 2015). To facilitate effective integration of ICT in the teaching process, the government of Bangladesh introduced an updated ICT curriculum for all levels of education with detailed instructions for teachers. However, teachers are still struggling to integrate ICT into their teaching due to a lack of proper training and insufficient administrative support at both school and government levels. In a nutshell, findings derived from the study will offer timely guidelines for policymakers, researchers, and educators.

8. Conclusion

The TPACK framework emphasizes that the foundation of successful ICT integration lies in the content (what is being taught) and pedagogy (how the content is delivered). This study explores teachers' perceptions of TPACK in Bangladeshi settings and their perceived challenges in adopting it. The findings reveal that these teachers have mixed perceptions, both positive and negative, toward TPACK. This underscores the importance of ensuring that teachers, students, policymakers, and other stakeholders recognize the value of technology in this rapidly changing globe and its potential to transform traditional teaching methods. Consequently, these results may provide a knowledge base to understand teachers' perceptions of TPACK in the context of Bangladesh. However, the study has limitations regarding sample size, context, the lack of diverse participants, and a non-longitudinal design to assess the progress of integrating the TPACK framework. Additionally, the research was conducted within a specific geographical and educational context, which may not translate to other regions with varying cultural and institutional factors. To gain deeper insights, future research should employ other types of research designs or methods, for example, longitudinal studies, diverse samples, and comprehensive measurement tools to explore the reciprocal effects of the development of different knowledge dimensions (Schmidt, 2009).

9. Recommendation of the Study

- The government should allocate extra funds for the purchase, maintaining materials, and infrastructure development for technology integration.
- Teachers in Bangladesh require a personal computer to use their ICT knowledge and skills in their teaching. Policymakers should take the step to

make a policy requiring all teachers to have access to personal computers, along with support for acquiring these devices (e.g., subsidies or low internet fees).

- The government should organize regular and effective hands-on training to improve teachers 'interest and motivation to use TPACK.
- Curriculum developers should work with educators to design curriculum and teachers' guides that incorporate specific and practical examples necessary for technological integration in the classroom.
- A massive campaign, workshops, and seminar should be arranged to understand the value of technology integration for effective teaching and students' learning.
- Establish a system for regular monitoring and evaluation of teachers' use of the TPACK, with feedback mechanisms to promote best practices.
- The Government should introduce a reward system where teachers receive financial assistance or bonuses for successful technology integration in their classrooms, along with increasing base salaries.

References

Ahsan, S., Hossen, A., Jahan, I., Mahmood, A., Mim, M. R., Sohely, S. J., . . . Begum, H. A. (2022). Teachers' perceived level of TPACK and the influence of demographic factors: the context of higher education in Bangladesh. *International Journal of Smart Technology and Learning, 3*, 1-25.

Alayyar, Ghaida, M., Fisser, P., & Voogt, J. (2012). Developing technological pedagogical content knowledge in pre-service science teachers: Support from blended learning. *Australasian journal of educational technology, 28*.

Anderson, S., Graulx, J., & Maninger, R. (2011). Relationships among preservice teachers' technology-related abilities, beliefs, and intentions to use technology in their future classrooms. *Journal of Educational Computing Research, 45*, 321-338.

Ansari, U. & Malik, S.K. (2013). Image of an effective teacher in 21st century classroom. *Journal of Educational and Instructional Studies in the World, 3(4)*, 61-68. Retrieved from Ansari, U. & Malik, S. K. (2013). Image of an effective teacher in 21st century classroom. Journal of Educational and Instructional Studies in The World, 3(4), 61-68.

Archambault, L., & Barnett, J. (2010). Revisiting technological pedagogical content knowledge: Exploring the TPACK framework. *Computers & Education, 55*, 1656-1662.

Bachy, S. (2014). TPDK, a New Definition of the TPACK Model for a University Setting. *European Journal of Open, Distance and E-Learning (EURODL), 17*, 15-39.

Bani, M. (2024). Analysis of the Ability of Prospective Physics Teachers In Developing Tpack-Based Learning Tools (Technolgical, Pedagogical, and Content, Knowledge). *Pegem Journal of Education and Instruction, 14*, 347-354.

Banu, S. (2012). Teachers readiness for computer education classes in the secondary schools of Bangladesh. *Bangladesh education journal, 11*, 39-50.

Berthiaume, D. (2007). What is the nature of university professors' discipline-specific pedagogical knowledge?: a descriptive multicase study. Retrieved from Berthiaume, D. (2007). What is the nature of university professors' discipline-specific pedagogical knowledge?: a descriptive multicase study.

Bingimlas, K. (2018). Investigating the level of teachers' Knowledge in Technology, Pedagogy, and Content (TPACK) in Saudi Arabia. *South African Journal of Education, 38*.

Braun, & Clarke. (2006). Using thematic analysis in psychology. *Qualitative research in psychology, 3*, 77-101.

Cedillo, T. & Kieran, C. (2003). Initiating students into algebra with symbol-manipulating calculators. *Computer Algebra Systems in Secondary School Mathematics Education*, 219-239. Retrieved from Cedillo, T., & Kieran, C. (2003). Initiating students into algebra with symbol-manipulating calculators. Computer Algebra Systems in Secondary School Mathematics Education, 219-239.

Çelik & Keskin, M. (2009). The effects of the primary class teachers 'information technology literacy skill level on students' achievement: The case of afyonkarahisar. *Procedia-Social and Behavioral Sciences, 1,* 1167-1171. Retrieved from Çelik, L., & Keskin, M. (2009). The effects of the primary class teachers 'information technology literacy skill level on students' achievement: The case of afyonkarahisar. Procedia-Social and Behavioral Sciences, 1(1), 1167-1171.

Celik, I. (2023). Towards Intelligent-TPACK: An empirical study on teachers' professional. *Elsevier, 138*. Retrieved from Celik, I. (2023). 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, 107468.

Çelik, L. &. (2009). The effects of the primary class teachers 'information technology literacy skill level on students' achievement: The case of afyonkarahisar. *Procedia-Social and Behavioral Sciences, 1*, 1167-1171. Retrieved from Çelik,

L., & Keskin, M. (2009). The effects of the primary class teachers 'information technology literacy skill level on students' achievement: The case of afyonkarahisar. Procedia-Social and Behavioral Sciences, 1(1), 1167-1171.

Cetin-Berber, D., & Erden , A. R. (2015). An investigation of Turkish pre-service teachers' technological, pedagogical and content knowledge. *Computers, 4*, 234-250.

Chai, C. S., Koh, J. H., & Tsai, C.-C. (2010). Examining the technological pedagogical content knowledge of Singapore pre-service teachers with a large-scale survey. *Journal of Computer Assisted Learning, 26*, 563-573.

Chuang, H.-H., & Ho, C.-j. (2011). An investigation of early childhood teachers' technological pedagogical content knowledge TPACK in Taiwan. *Ahi Evran Üniversitesi Kırşehir Eğitim Fakültesi Dergisi, 12*, 99-177.

Clark, L. A., & Watson, D. (2019). Clark, L. A., & Watson, D. (2019). Constructing validity: New developments in creating objective measuring instruments. Psychological assessment, 31(12), 1412. *Psychological assessment, 31*, 1412.

Cope, C. & Ward, P. (2002). Integrating learning technology into classrooms: The importance of teachers' perceptions. *Journal of Educational Technology & Society, 5*, 67-74. Retrieved from Cope, C., & Ward, P. (2002). Integrating learning technology into classrooms: The importance of teachers' perceptions. Journal of Educational Technology & Society, 5(1), 67-74

Cox, S., & Graham, C. (2009). Using an elaborated model of the TPACK framework to analyze and depict teacher knowledge. *TechTrends, 53*, 60-69.

Creswell, J. W., & Cresswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches.* Sage publications. Retrieved from Creswell, J. W., & Creswell, J. D. (2017). Research design: Qualitative, quantitative, and mixed methods approaches. Sage publications.

Day, C. & Smethem, L. (2009). The effects of reform: Have Teachers Really Lost their Sense of Professionalism? *Journal of Educational Change, 10*, 141-157. Retrieved from Day, C., & Smethem, L. (2009). The effects of reform: Have Teachers Really Lost their Sense of Professionalism?. Journal of Educational Change, 10, 141-157.

Dockstader, J. (1999). Teachers of the 21st century know the what, why, and how of technology integration. *The Journal, 26*, 73-74.

Ertmer, P. A.-L. (2012). Teacher beliefs and technology integration practices: A critical relationship. *Computer& education, 59*, 423-435. Retrieved from Ertmer, P. A., Ottenbreit-Leftwich, A. T., Sadik, O., Sendurur, E., & Sendurur, P. (2012). Teacher beliefs and technology integration practices: A critical relationship. Computers & education, 59(2), 423-435.

Eshet-Alkakay, O. A.-U. (2011). Teachers' knowledge and attitude towards Inmplementation of Innovative Technology. *JELLO special series of Chais Conference 2011, 7*, pp. 1-13. Raanana,Israel. Retrieved from Avidov-Ungar, O., & Eshet-Alkalai, Y. (2011). [Chais] Teachers in a World of Change: Teachers' Knowledge and Attitudes towards the Implementation of Innovative Technologies in Schools. Interdisciplinary Journal of E-Learning and Learning Objects, 7(1), 29

Fahadi, M., & Khan, M. S. (2022). Technology-Enhanced Teaching in Engineering Education: Teachers' Knowledge Construction Using TPACK Framework. *International Journal of Instruction, 15*, 519-542.

Fereday, J., & Muir-Cochrane, E. (2006). Demonstrating rigor using thematic analysis: A hybrid approach of inductive and deductive coding and theme development. *International journal of qualitative methods, 5*, 80-92.

Harris, J., & Hofer, M. (2011). Technological pedagogical content knowledge (TPACK) in action: A descriptive study of secondary teachers' curriculum-based, technology-related instructional planning. *Journal of Research on Technology in Education, 43*, 211-229.

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

Hussain, S., Fakhar-Ul-Zaman, D. K., Kanwal, M., Nawaz, I., & Thaheem, M. I. (2024). TPACK and ICT, the new hope for Pakistan's education system: analysis of the perception of prospective teachers. *Remittances Review, 9*, 743-754.

Instefjord, E. J. (2017). Educating digitally competent teachers: A study of integration of professional digital competence in teacher education. *Teaching and teacher education*, 37-45. Retrieved from Instefjord, E. J., & Munthe, E. (2017). Educating digitally competent teachers: A study of integration of professional digital competence in teacher education. Teaching and teacher education, 67, 37-45.

Islam, M. (2020). Exploring teachers' self-efficacy towards ICT integration in government primary schools in Bangladesh. *International Journal of Advance Research and Innovative Ideas in Education, 6*, 1703-1714.

Jamil, M. G. (2015). Technology enhanced teacher-learning in rural Bangladesh: a critical realist inquiry with secondary teachers of English. Retrieved from Jamil, M. G. (2015). Technology enhanced teacher-learning in rural Bangladesh: a critical realist inquiry with secondary teachers of English (Doctoral dissertation, University of Southampton).

Jimoyiannis, A. (2010). Designing and implementing an integrated technological pedagogical science knowledge framework for science teachers professional development. *Computers & Education, 55*, 1259-1269.

Khan, A., Shahazada, S., & Khan, I. (2017). Comparison of Rural and Urban Teachers' Institutional Quality in Context of Availability OF AV AIDS. 22-37. Retrieved from Khan, A. A., Ghazi, S. R., Shahzada, G., & Khan, I. U. Comparison of Rural and Urban Teachers' Institutional Quality in Context of Availability OF AV AIDS

Khan, M. S., Hassan, M., & Clement, C. K. (2012). Barriers to the introduction of ICT into education in developing countries: The example of Bangladesh. *International Journal of Instruction, 5*.

Koehler, & Mishra. (2006). TPACK: A framework for teachers' knowledge. *sagepub.con*. Retrieved from Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. Teachers college record, 108(6), 1017-1054.

Koehler, M., & Mishra, P. (2009). Teachers' technological pedagogical content knowledge and learning activity types: Curriculum-based technology integration reframed. *Journal of research on technology in education, 4*, 393-416. Retrieved from 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.

Kohen, Z., & Kramarski, B. (2012). . Developing a TPCK-SRL assessment scheme for conceptually advancing technology in education. *Studies in Educational Evaluation, 38*, 1-8.

Kotrlik, J., & Redmann, D. (2005). Extent of technology integration in instruction by adult basic education teachers. *Adult Education Quarterly, 55*, 200-219.

Lee, & Tsai. (2010). Exploing teachers perceived selp efficency and technologica content knowledge. *38*, 1-21. Retrieved from Lee, M. H., & Tsai, 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, 38, 1-21.

Lin, Tzu, C., Tsai, C.-C., Chai, C. S., & Lee, M.-H. (2013). dentifying Science Teachers' Perceptions of Technological Pedagogical and Content Knowledge (TPACK). *Journal of Science Education and Technology, 22*, 325-336.

Mai, M. Y., & Hamzah, M. (2016). Primary science teachers' perceptions of technological pedagogical and content knowledge (TPACK) in Malaysia. *European Journal of Social Science Education and Research, 3*, 167-179.

Mou, S. (2016). Possibilities and challenges of ICT integration in the Bangladesh education system. *Educational Technology*, 50-53. Retrieved from Mou, S. (2016). Possibilities and challenges of ICT integration in the Bangladesh education system. Educational Technology, 50-53.

Mumtaz, S. (2000). Factors affecting teachers' use of information and communications technology: a review of the literature. *Journal of information technology for teacher education, 9*, 319-342. Retrieved from Mumtaz, S. (2000). Factors affecting teachers' use of information and communications technology: a review of the literature. Journal of information technology for teacher education, 9(3), 319-342.

Naaz, S., & Khan, Z. (2018). Measuring the Technological Pedagogical Content Knowledge (TPACK) of Pre-service Teachers in Relation to their Gender and Streams. *Online Submission, 22*, 50-55.

Niess, M. (2011). Investigating TPACK: Knowledge growth in teaching with technology. *Journal of educational computing research, 44*, 299-317.

Niess, M. L. (2009). Mathematics teacher TPACK standards and development model. *Contemporary issues in technology and teacher education, 9*, 4-24. Retrieved from Niess, M. L., Ronau, R. N., Shafer, K. G., Driskell, S. O., Harper, S. R., Johnston, C., ... & Kersaint, G. (2009). Mathematics teacher TPACK standards and development model. Contemporary issues in technology and teacher education, 9(1), 4-24.

Rahim, M., Jalani, G., Ur Rahim, M., Bano, S., & Hussain, I. (2024). Examining the Correlation among Technological Pedagogical and Content Knowledge (TPACK) subscales: A Study of Pre-service Teachers Training Program. *Harf-o-Sukhan, 8*, 59-67.

Robertson, S., J. Calder, Fungi, P., Jonest A., O'Shea, T., & Lambrechtst G. (1996). Pupils, teachers & palmtop computers. *Journal of computer assisted learning, 12*, 194-204.

Rouf, M. A., & Mohamed, A. R. (2016). Secondary School English Language Teachers' Technological Skills in Bangladesh: A Case Study. *International Journal of Instruction, 11*, 701-716.

Sarhandi, P. S. (2016). Integration of technology with pedagogical perspectives: An evaluative study of in-house CALL professional development. *Arab World English Journal (AWEJ), 3*. Retrieved from Sarhandi, P. S., Khan, I. F., Buledi, M. H., & Asghar, J. (2016). Integration of technology with pedagogical perspectives: An evaluative study of in-house CALL professional development. Arab World English Journal (AWEJ) Special Issue on CALL, (3).

Sarhandi, P., Bajnaid, A., & Elyas, T. (2017). Impact of Smartphone Based Activities on EFL Students' Engagement. *English Language Teaching, 10*, 103-117. Retrieved from Sarhandi, P. S. A., Bajnaid, A., & Elyas, T. (2017). Impact of Smartphone Based Activities on EFL Students' Engagement. English Language Teaching, 10(6), 103-117.

Schmidt, D. A. (2009). Technological pedagogical content knowledge (TPACK) the development and validation of an assessment instrument for preservice teachers. *Journal of research on Technology in Education*, 123-149. Retrieved from 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

Shafie, H. M. (2021). 21st Century Technological Pedagogical Content Knowledge (TPACK) Level Among English Language Educators: A Pilot Study. . *Turkish Online Journal of Qualitative Inquiry*. Retrieved from Shafie, H., Majid, F. A., & Ismail, I. S. (2021). 21st Century Technological Pedagogical Content Knowledge (TPACK) Level Among English Language Educators: A Pilot Study. Turkish Online Journal of Qualitative Inquiry, 12(6).

Shin, T., Koehler, M., Mirshra, P., Schmidt, D., Baran , E., & Thompson, A. (2009). Changing technological pedagogical content knowledge (TPACK) through course experiences. *In Society for information technology & teacher education international conference* (pp. 4152-4159). Association for the Advancement of Computing in Education (AACE). Retrieved from Shin, T., Koehler, M., Mishra, P., Schmidt, D., Baran, E., & Thompson, A. (2009, March). Changing technological pedagogical content knowledge (TPACK) through course experiences. In Society for information technology & teacher education international confe

Shulman, L. S. (1986). Those Who Understand: Knowledge Growth in Teaching. *Stor, 15*, 4-14. Retrieved from Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. Educational researcher, 15(2), 4-14.

Strickland, A. & Coffland, D. (2004). Factors Related to Teacher Use of Technology in Secondary Geometry Instruction. *Journal of Computers in Mathematics and Science Teaching, 4*, 347-365. Retrieved from Strickland, A., & Coffland, D. (2004). Factors Related to Teacher Use of Technology in Secondary Geometry Instruction. Journal of Computers in Mathematics and Science Teaching, 23(4), 347-365.

Tesfaye, S. & Berhanu, K. (2015). Improving Students' Participation in Active Learning Methods: Group Discussions, Presentations, and Demonstrations: A Case of Madda Walabu University Second Year Tourism Management Students of 2014. *Journal of Education and Practice, 6*, 29-32. Retrieved from Tesfaye, S., & Berhanu, K. (2015). Improving Students' Participation in Active Learning

Methods: Group Discussions, Presentations, and Demonstrations: A Case of Madda Walabu University Second Year Tourism Management Students of 2014. Journal of Education and Practice, 6, 29-32.

Thomas, A., & Falls, Z. (2019). Rural elementary teachers' access to and use of technology resources in STEM classrooms. *Society for Information Technology & Teacher Education International Conference* (pp. 2549-2553). Association for the Advancement of Computing in Education (AACE). Retrieved from Thomas, A., & Falls, Z. (2019, March). Rural elementary teachers' access to and use of technology resources in STEM classrooms. In Society for Information Technology & Teacher Education International Conference (pp. 2549-2553). Association for the Advancement of Computing in Education (AACE).

Valtonen, T., Sointu, E., Kukkonen, J., Konkanen, S., Lambert, M., & Mäkitalo-Siegl, K. (2017). TPACK updated to measure pre service teachers' twenty first century skills. *Australasian Journal of Educational Technology, 33*.

Voogt, J. T. (2009). Science teacher learning of MBL-supported student-centered science education in the context of secondary education in Tanzania. *Journal of Science Education and Technology*, 429-238. Retrieved from Voogt, J., Tilya, F., & van den Akker, J. (2009). Science teacher learning of MBL-supported student-centered science education in the context of secondary education in Tanzania. Journal of Science Education and Technology, 18, 429-438.

Wenning, C. J. (2011). Levels of Inquiry Model of Science Teaching: Learning sequences to lesson plans. *Journal of Physics Teacher Education Online, 6*, 17-20. Retrieved from Wenning, C. J., & Khan, M. A. (2011). Levels of Inquiry Model of Science Teaching: Learning sequences to lesson plans. Journal of Physics Teacher Education Online, 6(2), 17-20.