Journal of Policy Research, 8(2), 67-83
https://jprpk.com
https://doi.org/10.5281/zenodo.7243207

Understanding Why Teachers' Beliefs About TPACK Weaves Influence Transformative Learning: A Mediation Analysis of TPACK Based Teaching Practices

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Abstract

The current research study proposes that teachers' beliefs about TPACK are positively related to TPACK-based teaching practices. Furthermore, TPACK-based teaching practices positively enhance transformation learning. The study also proposes that the teachers' beliefs about TPACK positively influence transformative learning via TPACK-based teaching practices. The study collected survey data from 433 teaching professionals working in 12 universities including six public and six private sector universities from Punjab, Pakistan. Analyzing data using SPSS 28 and AMOS 28, the results reveal that all the proposed hypotheses were supported. The study contributes to the different streams of literature and offers valuable insights for government, policymakers, and higher education institutions' management guiding them to implement and promote TPACK-related beliefs, TPACK-based practices, and transformative learning environments.

Keywords: TPACK, teachers' beliefs about TPACK, TPACK-based teaching practices, transformative learning, structural equation modeling

1. Introduction

Over the years, technology has gained enormous attention as it has affected and changed the economic and social patterns of human beings and played an important role in economic and social development. Cunningham, Lachapelle, & Lindgren-Streicher, (2006) explained that technology has become a necessary part of human life because people consume 95% of their time interacting with the technological world. The effective and efficient use of technology can create potential benefitting opportunities. For instance, in organizational settings, the use of technology can facilitate the transfer of valuable knowledge that may lead to an innovative approach to handling procedural and administrative issues (Picciano, 1998). Similarly, the use of digital technologies in classroom settings has positively contributed to shaping and developing the teaching and learning process (Martin, Diaz, Sancristobal, Gil, Castro, & Peire, 2011).

Technology plays an imperative role in the basic structure of the educational setting for the transformation of the system to fit the needs of the changing society (Bates, 2010; Kimmons & Hall, 2016). It has been recognized that the education of our children and the educational institutes should experience a great digital transformation to be able to fulfill the requirements of the new generation and their digitalized future. Prior research has highlighted that integrating technologies in the classroom can profoundly enhance the effectiveness of the teaching and learning process as it can motivate teachers and students to explore and approach learning in innovative ways (Castaneda, Bindman, & Divanji, 2021; Niaz, Akram, & Bahoo, 2021; Song, 2021). Furthermore, Celik, Sahin, and Akturk, (2014, p.2) noted that "Technology usage in the teaching-learning process may result in increased student writing, enhanced cooperative learning, enhanced integration of curriculum, greater application of learning style strategies, increased applications of cross-age tutoring, increased teacher communication, enhanced community relations, and enhanced global learners".

Although technology can play an instrumental role in enhancing the effectiveness of the teaching-learning process, however integrating technology into classrooms is a complex and difficult task as it requires sufficient knowledge and a specific skill set for the smooth functioning of the digital technological tools (Cheng & Xie, 2018; Xie & Luthy, 2017). To address this issue, Mishra, and Koehler (2006) proposed a comprehensive framework based on content, pedagogical and technological knowledge that is known as TPACK. Mishra and Koehler (2006) noted that "a nuanced understanding of the complex relationships between technology, content, and pedagogy" (p. 1029) which clearly indicates that effectively integrating the technology into pedagogy requires skill and knowledge and TPACK shed light on the kind of knowledge a teacher should acquire for the successful integration of technology in teaching (Mishra, 2019).

Prior literature explained although providing access to the technologies and developing basic skills to use these technologies is important, however, it does not guarantee to shape and develop teachers' abilities to integrate technologies into their teaching rather values, competencies, and beliefs are considered critical factors that can inspire and motivates teachers to integrate technologies into their teaching (Cheng & Xie, 2018; Xie & Hawk, 2017). Past research studies have explored how teachers' values and belief can affect their abilities to integrate technology into their teaching in relation to TPACK For instance, Hsu, Tsai, Chang, and Liang (2017) provided empirical evidence of

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the positive correlation between teachers' knowledge about gamed based instruction and their beliefs about using digital games in classrooms. Furthermore, Cheng and Xie, (2018) conducted multiple studies to explore the relationship between TPACK and teachers' values and beliefs. The results of both intervention and nonintervention studies confirmed the positive relationship between teachers' values and beliefs with TPACK.

Despite the important role digital technologies can play in reforming the teaching and learning process (Hammond, 2014), prior research has pointed out that the exclusive focus remained on enhancing pedagogy through digital technologies rather than creating a transformative learning environment through the use of digital education-related technologies. For instance, Tondeur, Braak, Ertmer, and Ottenbreit-Leftwich (2017) have urged scholars to explore the influence of digital technologies on the transformative learning process which has been glossed over by the prior literature due to its focus on enhancing pedagogy through digital technologies. Similarly, Blundell, Lee, and Nykvist (2020) in their study explained that digital technologies can play an imperative role in shaping and developing transformative learning that needs to be focused on and explored in order to contribute to this nascent yet growing literature. To respond to these research calls and plug in these knowledge gaps, the present study proposed and empirically tested a model that explored the direct influence of teachers' beliefs about TPACK on transformative learning.

Transformative learning refers to the "learning that transforms problematic frames of reference—sets of fixed assumptions and expectations (habits of mind, meaning perspectives, mindsets)—to make them more inclusive, discriminating, open, reflective, and emotionally able to change" (Mezirow, 2003, p.58). Furthermore, the existing literature explained that the frame of reference plays a vital role in shaping and developing opinions and belief that guides individuals' actions (Mezirow, 2003; 2012). From the teaching perspective, teachers require professional learning opportunities that motivate and help them handle challenges created by their attitudes and beliefs that initiate a transformative learning process (Ertmer et al., 2012; Prestridge, 2012).

Given the untapped nature of the inquiry, the present study attempts to explore the intervening mechanism in the relationship between teachers' beliefs about TPACK and proposed teaching practices as an important underlying mechanism through which teachers' beliefs about TPACK transform its influence on transformative learning. Teaching practice is mean of dispensing knowledge, skill, and capabilities to students using different traditional and advanced methods (Beinert et al., 2021; Chen, Brown, Hattie, & Millward, 2012; Trabelsi et al., 2021) Past research has highlighted that teaching practices shape and develop students' knowledge, skill, and learning. Furthermore, it enhances students' involvement in the learning process (Chen et al., 2012; Zhao, 2007). The theoretical model is presented in Figure 1.

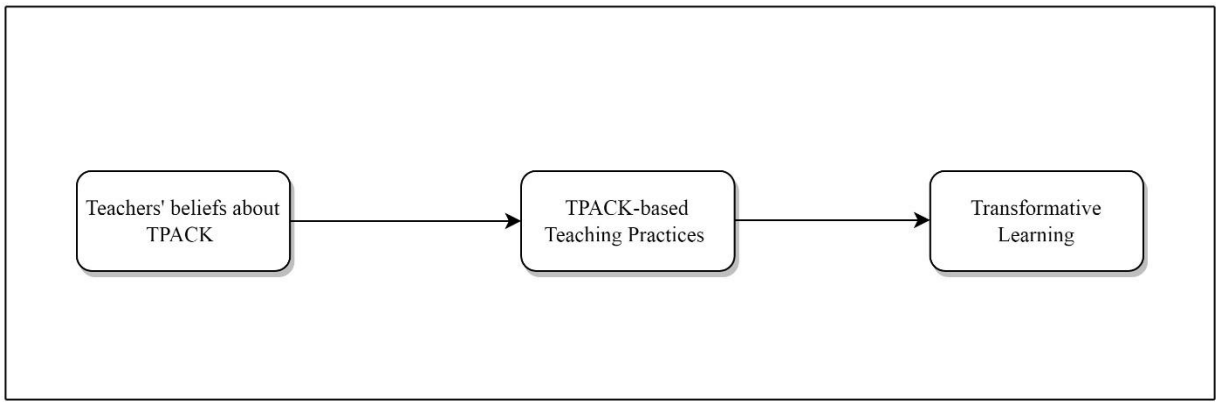

Figure 1: Theoretical Model

2. Theory and Hypotheses Development

2.1. TPACK an Overview

The TPACK framework provides a pattern to be followed by the teachers of higher education institutions for the integration of technology with pedagogy and content knowledge. TPACK (technological pedagogical and content knowledge) model is the addition of the PCK (pedagogical content knowledge) model. The first model of PCK was recommended by Gudmundsdottir and Shulman in 1987 and was further reorganized by Mishra and Koehler in 2006 and resulting in TPACK. Koehler and Mishra (2009) explained the seven dimensions of TPACK as follows i) "Content knowledge (CK) is teachers' knowledge about the subject matter to be learned or taught" (Koehler & Mishra, 2009, p. 63).ii) "Pedagogical knowledge (PK) is teachers' deep knowledge about the processes and practices or methods of teaching and learning" (Koehler & Mishra, 2009, p. 64).iii) "Technological knowledge (TK) enables a person to

accomplish a variety of different tasks using information technology and to develop different ways of accomplishing a given task" (Koehler & Mishra, 2009, p. 64).

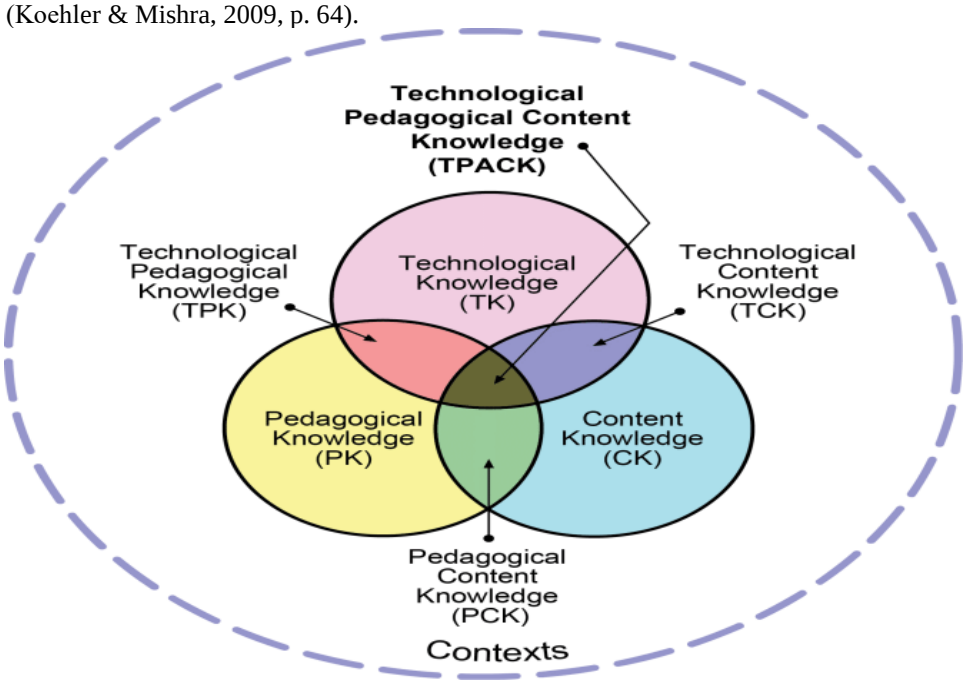

Figure 2: TPACK Framework (Koehler & Mishra, 2009; p.63)

iv)"Pedagogical content knowledge (PCK) covers the core business of teaching, learning, curriculum, assessment and reporting, such as the conditions that promote learning and the links among curriculum, assessment, and pedagogy" (Koehler & Mishra, 2009, p. 64).v) "Technological pedagogical knowledge (TPK) is an understanding of how teaching and learning can change when particular technologies are used in particular ways. This includes knowing the pedagogical affordances and constraints of a range of technological tools as they relate to disciplinarily and developmentally appropriate pedagogical designs and strategies" (Koehler & Mishra, 2009, p. 65).vi) "Technological content knowledge (TCK) is an understanding of how technology and content influence and constrain one another" (Koehler & Mishra, 2009, p. 65).vii) "Technological pedagogical content knowledge (TPACK) is an understanding that emerges from interactions among content, pedagogy, and technology knowledge" (Koehler & Mishra, 2009, p. 66). The TPACK framework tends to explain what knowledge and skills teachers should have and what professional growth they need to achieve in order to get better and more efficient use of technology in transforming teaching and learning (Koehler & Mishra, 2008; Mishra & Koehler, 2006; Mishra et al., 2020).

2.2. Relationship between Teachers' Belief About TPACK and TPACK-Based Teaching Practices

Teachers' beliefs are central to their practices and the acceptance of new technologies and practicing these technologies in their classrooms for transformative teaching (Kim, Lee, Spector, DeMeester; 2013). These beliefs can be classified into six sets: The construction of knowledge; the source of knowledge; the stability of knowledge; the speed of learning; the capability of learning; and the activities to support teaching and learning (Chan & Elliott, 2004). These beliefs are associated with practices determined by the teacher's behaviors, attitudes, and efforts (Schommer, 1990), and are the most valued elements influencing the teacher's acceptance (Kim et al., 2013). For example, if a teacher discovers it is easy to learn about the usage of the latest instruments, he/ she would try to practice in his / her teachings. In the same way, if an instructor considers teaching is all over the reproduction of what they have acquired knowledge in the classroom; subsequently they are more expected to practice lesson reflection methodology during instructions.

Research on the beliefs of teachers on technological use indicate that the scope of beliefs about technology looks insufficient as compared to the general beliefs of teachers. Researchers frequently test only beliefs associated with technology and not the general beliefs of teachers related to the teaching-learning process that might affect the adoption of technology (Kim et al., 2013). Teachers with greater self-efficacy, probably discover new technologies easily and are useful in teaching to practice (Celik & Yesilyurt, 2013). Likewise, teachers with positive approaches to using new technology in teaching are expected to practice the technology in their classrooms (Orlando, 2014). This indicates that teachers' faith and viewpoint can influence the acceptance of new technologies in education. So, we can say teachers' views are observed through the greatest forecaster of their teaching practices regarding technology

incorporation (Miller & King, 2003). The beliefs of teachers' regarding the incorporation of technology involve three parts: self-efficacy beliefs regarding the incorporation of technology; pedagogical beliefs about technological incorporation and beliefs regarding the importance of technology for the learners. All three elements were connected all together and considered the key forecasters of teachers' practices of technology in the classroom (Miranda & Russell, 2012; Bebell & Kay, 2010). Building on the aforementioned discussion, the present study proposes the following hypothesis.

Hypothesis 1: Teachers' beliefs about TPACK are positively related to TPACK-based teaching practices

2.3. Relationship between TPACK-Based Teaching Practices and Transformative Learning

Teaching practices can shape transformative learning in many ways. First, teaching practices through the effective management of the class and lending social and emotional support to the students creates a comfortable environment for the learners that allows students/learners to share their thoughts and point of view on the subject matter. Further, it would encourage them to challenge the stated assumptions about the instructors' viewpoints based on critical thinking and logical reasoning (Praetorius, Fischer, & Klieme 2020a, 2020b; Zhu & Kaiser, 2022). Second, the discourse a key element of teaching practices would encourage teaching professionals to allow two strong communications between teachers and students, which would help students to put forward their perspectives without any fear of strong arguments. It will also inspire teaching professionals to rethink their point of view on the particular subject matter (Praetorius et al., 2020a, 2020b; Zhu & Kaiser, 2022). Past research has highlighted that accepting students' perspectives and revising his/her points of view are the fundamental constituents of cultivating transformative learning (Walker, 2018). Building on these arguments, it can be suggested that Blending TPACK-based practices into teaching practices would encourage transformative learning. Thus, the present informed the following hypothesis.

Hypothesis 2: TPACK-based teaching practices are positively related to transformative learning.

2.4. TPACK-Based Teaching Practices as A Mediator in The Relationship Between Teachers' Beliefs About TPACK and Transformative Learning

Proceeding further, as depicted in Hypothesis 2 that teachers' beliefs about TPACK are positively related to TPACK-based teaching practices suggesting that the teachers' beliefs about TPACK have significant theoretical relevance in shaping and developing TPACK-based teaching practices. Similarly, Hypothesis 2 demonstrated that TPACK-based teaching practices are positively related to transformative learning, suggesting that TPACK practices have significant theoretical relevance in shaping and cultivating transformative learning. It can be inferred from the aforementioned arguments that teachers' beliefs about TPACK positively enhance TPACK-based teaching practices that in turn positively nurture transformative learning. Thus, the present study proposed a mediation hypothesis.

Hypothesis 3: TPACK-based teaching practices mediate the relationship between teachers' beliefs about TPACK and transformative learning.

3. Methodology

3.1. Data Collection Procedures

Cross-sectional survey data were collected from 433 teaching professionals working in 12 universities including six public and six private sector universities. Furthermore, the present study selected three high-ranked and three low-ranked universities from each of the public and private sector universities. In sum, the present study collected data from six high-ranked and six low-ranked universities to test the hypothesized relationships. Initially, the present study randomly selected 600 respondents from all 12 universities and distributed fifty questionnaires to each of the universities to accomplish equal representation from each of the universities and received 513 filled responses. After analyzing the data for outliers and missing values. The missing value analysis revealed that 48 responses had missing data and were excluded from the sample. Furthermore, the present study used the Mahalanobis distance square test to find the outliers in the data. Mahalanobis distance refers to calculating how much an observation deviates from the mean of the distribution (Tabachnick & Fidell, 2013). It is a widely accepted test to detect outliers and it is one of the fundamental requirements to proceed with multivariate data analysis (Hodge & Austin, 2004). The results of the Mahalanobis distance test highlighted those 32 responses were not appropriately filled by the respondents thus called outliers. To clean the data the present study removed 32 responses and obtained a usable sample of 433 to test the hypothesized relationships.

3.2. Measures and Variables

3.2.1. Teachers' Beliefs About TPACK

Teachers' beliefs about TPACK were measured using a multidimensional scale having seven correlated dimensions. The respondents recorded their responses on a six-point Likert scale ranging from 1 (need a lot of additional knowledge) to 6 (have strong knowledge). All dimensions along with their respective sample items are given below.

Teachers' Beliefs About Pedagogical Knowledge

Teachers' beliefs about pedagogical knowledge were assessed using an eight-item scale developed and validated by Valtonen et al. (2017). Sample items include "I can support students' critical thinking" and "I can guide students to make use of each other's thoughts and ideas during group work".

3.2.2. Teachers' Beliefs About Technological Knowledge

Teachers' beliefs about technological knowledge were assessed using a five-item scale developed and validated by Valtonen et al. (2017). Sample items include "I can solve ICT-related problems" and "I can use new technologies".

3.2.3. Teachers' Beliefs About Content Knowledge

Teachers' beliefs about content knowledge were assessed using a four-item scale developed and validated by Valtonen et al. (2017). Sample items include "I know the basic theories and concepts of my subject" and "I am familiar with recent research in my subject".

3.2.4. Teachers' Beliefs About the Interaction Between Pedagogical and Content Knowledge (PCK)

Teachers' beliefs about the interaction between pedagogical and content knowledge (PCK) were assessed using a six-item scale developed and validated by Valtonen et al. (2017). Sample items include "In my subject, I know how to guide students to make use of each other's thoughts and ideas in group work" and "In my subject, I know how to guide students in planning their own learning".

3.2.5. Teachers' Beliefs About the Interaction Between Technological and Pedagogical Knowledge (TPK)

Teachers' beliefs about the interaction between technological and pedagogical knowledge (TPK) were assessed using a six-item scale developed and validated by Valtonen et al. (2017). Sample items include "I know how to use ICT in teaching as a tool for sharing ideas and thinking together" and "I know how to use ICT in teaching as a tool for students' problem-solving in groups".

3.2.6. Teachers' Beliefs About the Interaction Between Content and Technological Knowledge (TCK)

Teachers' beliefs about the interaction between content and technological knowledge (TCK) were assessed using a four-item scale developed and validated by Valtonen et al. (2017). Sample items include "I know ICT applications which I can use to better understand the contents of my subject" and "I know technologies which I can use to illustrate difficult contents in my subject".

3.2.7. Teachers' Beliefs About Interaction Between Pedagogical, Technological, and Content Knowledge (TPACK)

Teachers' beliefs about the interaction between pedagogical, technological, and content knowledge (TPACK) were assessed using a four-item scale developed and validated by Valtonen et al. (2017). Sample items include "In teaching my subject, I know how to use ICT as a tool for students' creative thinking" and "In teaching my subject, I know how to use ICT as a tool for students to plan their own learning".

All the above-mentioned dimensions of teachers' beliefs about TPACK were highly correlated, and confirmatory factor analysis (CFA) was used to examine whether all the dimensions load on a single latent factor. All the dimensions demonstrated satisfactory levels of loading onto a single latent factor, with fit indices – $\chi^2(695) = 1828.98$, $\chi^2/df = 2.63$, IFI = .92, TLI = .91, CFI = .92, and RMSEA = .06-. Thus, it was appropriate to use teachers' beliefs about TPACK as a second-order composite construct.

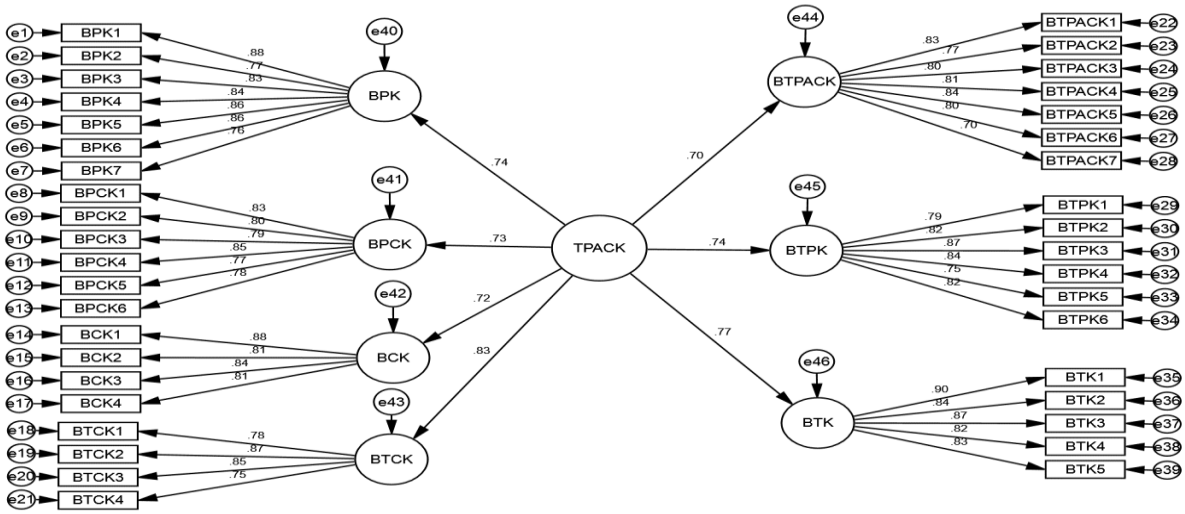

Figure 3: Higher Model of All the Dimensions of Teachers' Beliefs About TPACK

3.3. TPACK-Based Teaching Practices

TPACK-based teaching practices were measured using a multidimensional scale having seven correlated dimensions. The respondents recorded their responses on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). All dimensions along with their respective sample items are given below.

3.3.1. Pedagogical Knowledge-Based Teaching Practices

Pedagogical knowledge-based teaching practices were assessed using an 11-item scale developed and validated by Graham et al. (2009). Sample items include "I apply different learning theories and approaches (ex, Constructivist Learning, Multiple Intelligence Theory, Project-based Teaching)" and "I use the best instructional strategy and method for teaching a particular concept".

3.3.2. Technological Knowledge-Based Teaching Practices

Technological knowledge-based practices were assessed using an 11-item scale developed and validated by Graham et al. (2009). Sample items include "I use strategies that combine content, technologies, and teaching approaches in my classroom." and "I use different software in the instructional environment. (e.g., MS Office, Email, Paint, Online resources, etc.)".

3.3.3. Content Knowledge-Based Teaching Practices

Content knowledge-based teaching practices were assessed using a 13-item scale developed and validated by Graham et al. (2009). Sample items include "I use various ways and strategies for solving problems." and "I follow up-to-date resources (e.g., books, journals, etc.) in my content area.".

3.3.4. Interaction Between Pedagogical and Content Knowledge (PCK) Based Teaching Practices

Interaction between pedagogical and content knowledge (PCK) based teaching practices were assessed using a nine-item scale developed and validated by Graham et al. (2009). Sample items include "I teach my classes in accordance with the theoretical foundations of the curriculum." and "I help students associate my subject or a particular concept with other subjects or concepts."

3.3.5. Interaction Between Technological and Pedagogical Knowledge (TPK) Based Teaching Practices

Interaction between technological and pedagogical knowledge (TPK) based teaching practices were assessed using a nine-item scale developed and validated by Graham et al. (2009). Sample items include "I use digital technologies to motivate learners." and "I choose technologies appropriate for my teaching/learning approaches and strategies."

3.3.6. Interaction Between Content and Technological Knowledge (TCK) Based Teaching Practices

Interaction between content and technological knowledge (TCK) based teaching was assessed using a ten-item scale developed and validated by Graham et al. (2009). Sample items include "I use digital technologies that allow myself / students to speed up the understanding of my subject." and "I use digital technologies that allow myself / students to organize and see patterns in their work that would otherwise be hard to see.".

3.3.7. Interaction Between Pedagogical, Technological and Content Knowledge (TPACK) Based Teaching Practices

Interaction between pedagogical, technological, and content knowledge (TPACK) was assessed using an 11-item scale developed and validated by Graham et al. (2009). Sample items include "I help students use digital technologies that extend their ability to observe and critically evaluate various phenomena, models, and theories in my subject." and "I take a leadership role among my colleagues in the integration of content, pedagogy, and technology knowledge."

All the above-mentioned dimensions of TPACK-based teaching practices were highly correlated, and confirmatory factor analysis (CFA) was used to examine whether all the dimensions load on a single latent factor. All the dimensions demonstrated satisfactory levels of loading onto a single latent factor, with fit indices – $\chi^2(1645) = 3086.04$, $\chi^2/df = 1.87$, IFI = .94, TLI = .94, CFI = .94, and RMSEA = .04-. Thus, it was appropriate to use TPACK-based teaching practices as a second-order composite construct.

3.4. Transformative Learning

Transformative learning was measured using a six-item scale developed and validated by Walker (2018) Sample items include "I encourage students to challenge my assumptions" and "I respect and value students' perspectives". The respondents recorded their responses on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

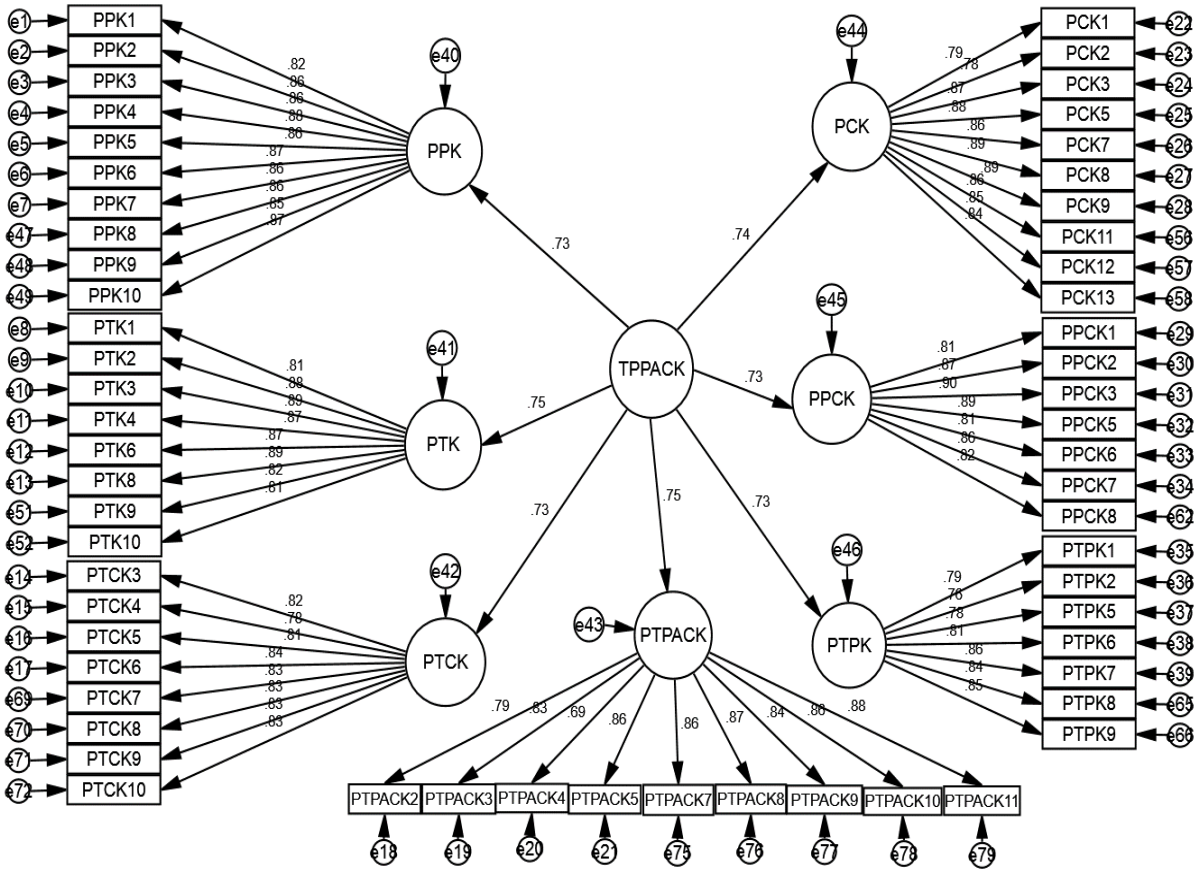

Figure 4. Higher Model of All the Dimensions Of TPACK-Based Teaching Practices

4. Results and Analysis

4.1. Demographic Analysis

In this section description of the demographic of the sample and different variables are presented.

Table 1: Distribution of The Sample in Terms of Gender

Respondents	Frequency	Percentage %
Male	237	54.7
Female	196	45.3
Total	433	100.0

Table 1 highlighted that in terms of gender 237(54.7%) respondents were males and 196(45.3%) respondents were females.

Table 2: Distribution of The Sample in Terms of Institution Type

Respondents	Frequency	Percentage %
Public	239	55.2
Private	194	44.8
Total	433	100.0

Table 2 demonstrated that in terms of institution type 239(54.7%) respondents were belonged to public sector universities and 194(44.8%) respondents belonged to private sector universities.

Table 3: Distribution of The Sample in Terms of Ranking

Respondents	Frequency	Percentage %
High	222	51.3
Low	211	48.7
Total	433	100.0

Table 3 demonstrated that in terms of ranking 222(54.7%) respondents belonged to high-ranked universities and 194(44.8%) respondents belonged to low-ranked universities.

4.2. Means and Correlations

Table 4. Means and Correlations

Construct	Means	SD	1	2	3	4	5	6	7	8
1. TBTPACK	2.97	0.89	-							
2. TPTPACK	3.26	0.92	.29**	-						
3. TL	3.03	1.22	.22**	.31**	-					
4. Age	36.23	7.71	.00	-.09	-.04	-				
5. Gender	1.45	0.50	.04	.07	.04	-.07	-			
6. Tenure	3.07	1.40	.09	.05	.05	.01	-.03	-		
7. Experience	6.16	3.73	.01	.04	-.07	.00	-.08	.00	-	
8. Institution type	1.44	.49	-.07	.05	.00	-.04	.03	.04	-.43**	-
9. Ranking	1.48	.50	-.07	.26**	-.03	-.10*	.04	-.04	.23**	.05

Note. N=433. * p <.05. ** p <.01 level (2-tailed). TBTPACPK = Teachers' beliefs about TPACK, TPTPACK = Teachers' TPACK based teaching practices, TL = Transformative learning, SD = standard deviation. Gender: 1 = male, 2 = female, Institution type: 1 = Public, 2 = Private. Ranking: 1 = High, 2 = low.

Table. 4 posited that correlations among the understudy constructs are consistent with the theory. For instance, teachers' belief about TPACK is positively correlated with the teachers' TPACK-based teaching practices and transformative learning and is in the expected theorized direction. Similarly, teachers' TPACK-based teaching practices are positively correlated with transformative learning which is also akin to the proposed theorized direction.

4.3. Measurement Model

The measurement model is a covariance-based analysis that provides insight into the fitness of data with a proposed model including the goodness and badness of the fit. Furthermore, it helps establish the reliability and validity of the measuring scales (Hair et al., 2010). The present study conducted CFA using structural equation modeling in Amos 24 to assess consisted of teachers' beliefs about TPACK, teachers' TPACK-based teaching practices, and transformative learning. The fit indices – $\chi^2(167) = 412.64$, $\chi^2/df = 2.47$, RMSEA = .06, IFI = .95, CFI = .95, TLI = .94 –showed that the measurement model has an acceptable fit with the data.

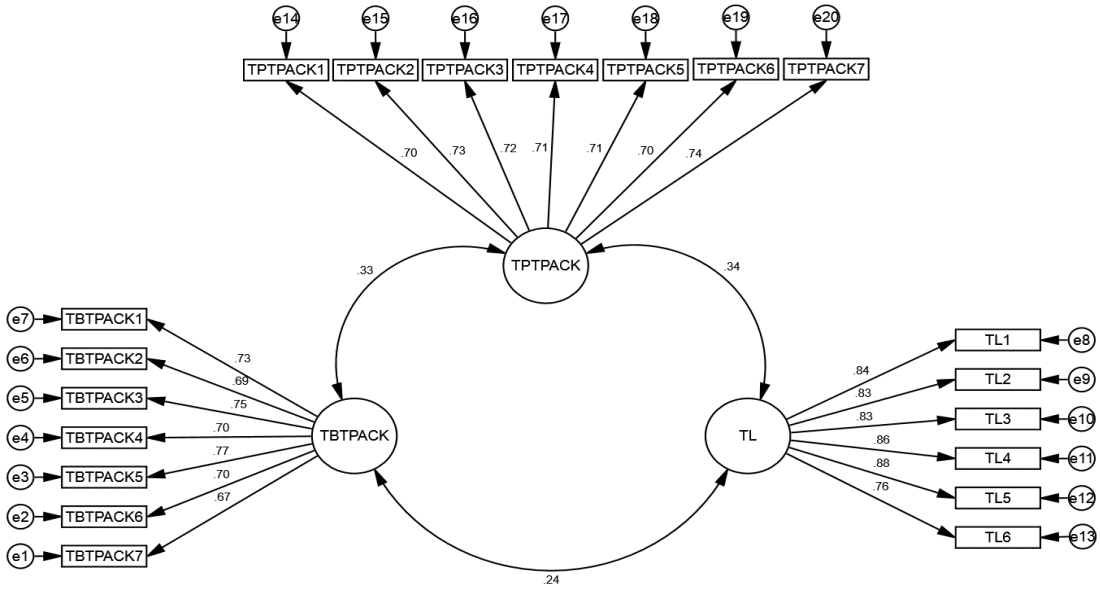

Figure 5: Measurement Model

Notes. N = 433, TBTPACPK = Teachers' beliefs about TPACK, TPTPACK = Teachers' TPACK based teaching practices, TL = Transformative learning,

Table 5: Factor Loadings

Constructs	Factor Loadings	Criteria
1. Teachers' beliefs about TPACK		
TBTPACK1	.668	Factor Loading > .60 Hair et al. (2010)
TBTPACK2	.697	
TBTPACK3	.775	
TBTPACK4	.698	
TBTPACK5	.749	
TBTPACK6	.668	
TBTPACK7	.727	
2. Teachers' TPACK-based teaching practices		
TPTPACK1	.702	Factor Loading > .60 Hair et al. (2010)
TPTPACK2	.734	
TPTPACK3	.719	
TPTPACK4	.708	
TPTPACK5	.706	
TPTPACK6	.698	
TPTPACK7	.742	
3. Transformative learning		
TL1	.843	Factor Loading > .60 Hair et al. (2010)
TL2	.827	
TL3	.830	
TL4	.864	
TL5	.882	
TL6	.756	

4.4. Validity and Reliability

Table 6 Discriminant Validity, Convergent Validity, and Internal Consistency

Construct	1	2	3	α	CR	AVE	MSV	ASV
1. TBTPACK	**.71**			.87	.87	.51	.10	.08
2. TPTPACK	.32	**.71**		.88	.88	.51	.13	.11
3. TL	.24	.35	**.83**	.93	.93	.70	.12	.09

Notes. N = 433, TBTPACPK = Teachers' beliefs about TPACK, TPTPACK = Teachers' TPACK based teaching practices, TL = Transformative learning, MSV = Maximum shared variance. ASV = Average shared variance. AVE = Average variance extracted. CR = Composite Reliability. Bolded values on the diagonals of columns 2 to 3 are the square root values of AVE. α = Cronbach alpha.

There are three fundamental conditions to claim discriminant validity, and convergent validity of the understudy constructs i) The values of Cronbach alpha should be greater than .70 ii) ASV should be less than from MSV for all the understudy constructs iii) AVE should be greater than .50 iv) The square root value of AVE was greater than its inter-construct correlations for all the understudy constructs. To claim furthermore the internal consistency can be claimed if Cronbach alpha should be greater than .70. Table 6 highlighted that all the understudy constructs fulfill the aforementioned conditions for discriminant validity, and convergent validity as well as for internal consistency. Thus, the measuring instruments used to collect data demonstrate adequate discriminant validity, convergent validity, and internal consistency for all the understudy constructs.

4.5. Structural Model

The structural models were performed to test the proposed relationship using structural equation modeling in Amos 28. First, to test the direct influence of teachers' beliefs about TPACK on transformative learning, the present study performed a path analysis. The fit indices – $\chi^2(64) = 176.05$, $\chi^2/df = 2.75$, IFI = .97, TLI = .96, CFI = .97, and RMSEA = .06 - displayed that the direct structural model had confirmed a satisfactory fit with the data. Bootstrapping specifying a sample size of 2000 where the confidence interval did not cross zero was used to test the level of significance for the direct path.

The results reported in Table 7 revealed a significant positive relationship between teachers' beliefs about TPACK and teachers' TPACK-based teaching practices *(β = .34, SE* = .06, *p < .01,* CI = *[.21, .45])*, suggesting that teachers' beliefs about TPACK enthuse and stimulate them to demonstrate and practice TPACK based teaching practices during the teaching process. Thus hypothesis 1 was supported. The results also elucidated that a one-unit positive change in teachers' beliefs about TPACK account for a 34% change in their TPACK-based teaching practices which empirically established teachers' beliefs about TPACK plays an important role in shaping developing teachers' TPACK-based teaching practices.

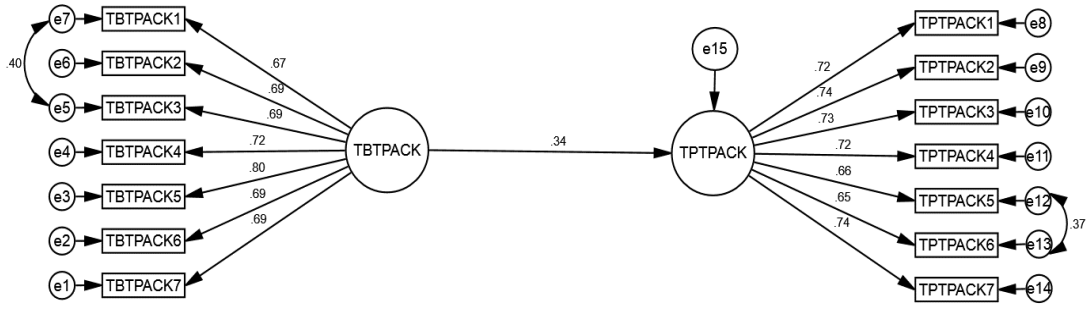

Figure 6: Structural Model for Direct Paths

Notes. N = 433, TBTPACPK = Teachers' beliefs about TPACK, TL = Transformative learning

Finally, to test the direct influence of teachers' TPACK-based teaching practices and their transformative learning, the present study accomplished a path analysis. The fit indices – $\chi^2(64) = 163.28$, $\chi^2/df = 2.55$, IFI = .97, TLI = .96, CFI = .97, and RMSEA = .06 - displayed that the direct structural model had confirmed a satisfactory fit with the data. Bootstrapping specifying a sample size of 2000 where the confidence interval did not cross zero was used to test the level of significance for the direct path. The results reported in Table 7 highlighted a significant positive relationship between teachers' TPACK-based teaching practices and their transformative learning *(β = .34, SE* = .05, *p < .01,* CI *= [.24, .44])*, suggesting that teachers' TPACK-based teaching practices enthuse and inspire them to promote transformative learning. Thus hypothesis 2 was supported. The results also elucidated that one-unit positive change in teachers' TPACK-based teaching practices accounts for 34% change in their transformative learning experience which empirically established teachers' TPACK-based teaching practices play an imperative role in shaping and developing their transformative learning.

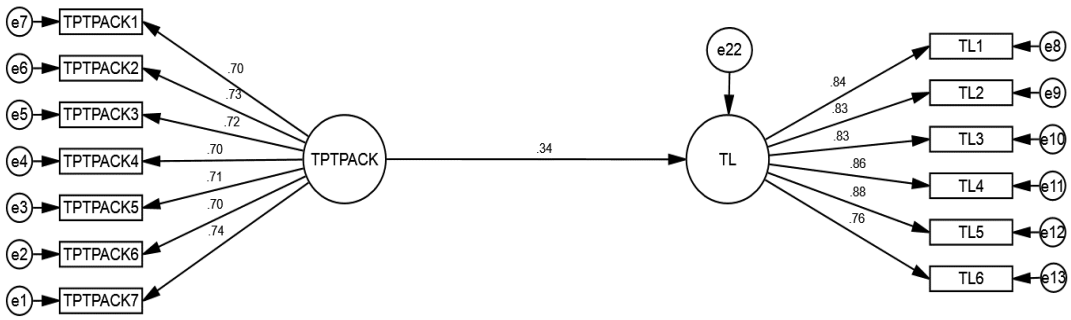

Figure 7. Structural Model for Direct Paths

Notes. N = 433, TBTPACPK = Teachers' beliefs about TPACK, TL = Transformative learning

4.6. Mediation Analysis

To examine the mediated paths of the structural model, the present study performed a mediation analysis. To undertake this, the present study incorporated TPACK-based teaching practices as a mediator in the association between teachers' beliefs about TPACK and transformative learning. The fit indices – $\chi^2(167) = 412.64$, $\chi^2/df = 2.47$, IFI = .95, TLI = .94, CFI = .95, and RMSEA = .06 revealed that the mediation model had a satisfactory fit with the data. Bootstrapping specifying a sample size of 2000 where the confidence interval did not cross zero was used to test the level of significance for the indirect path.

Table 7. Hypothesis Testing Results

Direct Paths	β	SE	CI
TB about TPACK → TPTPACK	.34**	.06	.21, .45
TPTPACK → Transformative learning	.34**	.06	.24, .44
Indirect Paths			
TB about TPACK → TPTPACK→ Transformative learning	.10**	.03	.06, .16

Notes: N 433, β =Standardized coefficient, SE= Standard error, Bootstrapping specified at 2000 with 95% confidence interval, TB= teachers' beliefs, TPTPACK= Techers' TPACK based teaching practices

The results reported in Table 7 underlined a significant indirect link between teachers' beliefs about TPACK and transformative learning via TPACK based teaching practices *(β = .10, SE = .03, p < .01, CI = [.06, .16]).* This suggests that TPACK-based teaching practices act as a vital mediatory mechanism through which teachers' beliefs about

TPACK transform their influence on transformative learning. Thus, hypothesis 4 was supported. However, after the inclusion of TPACK-based teaching practices as a mediator between the relationship between teachers' beliefs about TPACK and transformative learning, the direct relationship between teachers' beliefs about TPACK and transformative learning remains significant which highlight that TPACK-based teaching practices partially mediates the relationship between teachers' beliefs about TPACK and transformative learning.

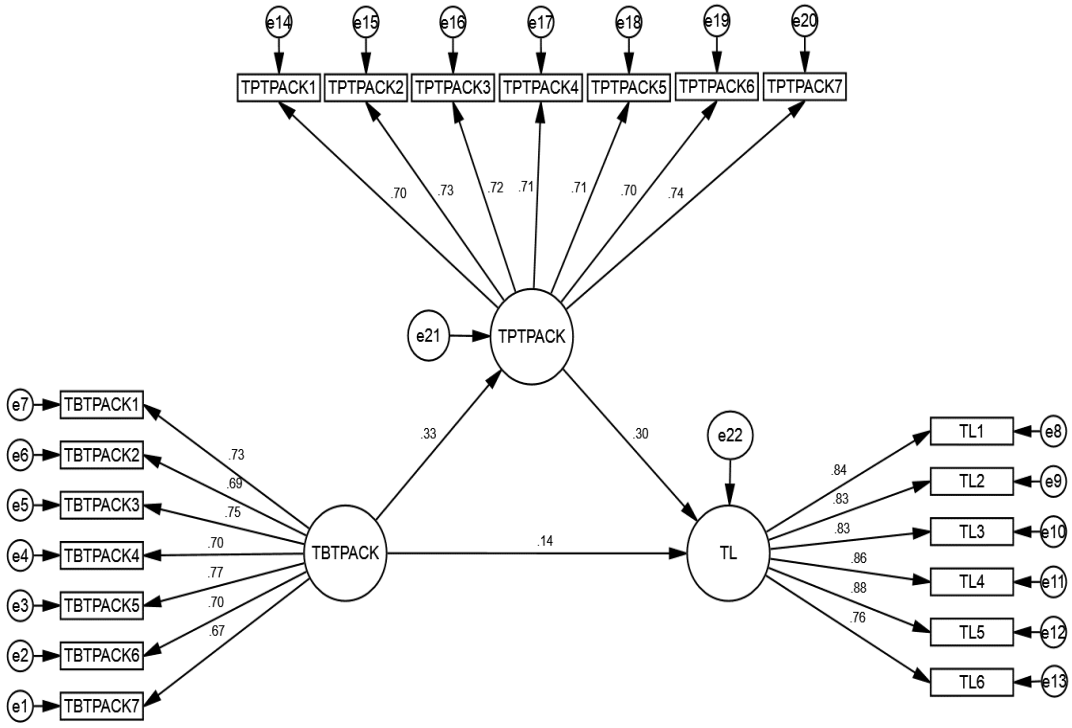

Figure 8: Structural Model for the Mediation Model

Notes. N = 433, TBTPACPK = Teachers' beliefs about TPACK, TPTPACK = Teachers' TPACK based teaching practices, TL = Transformative learning,

5. Discussion

The digital transformation due to the emergence of new technologies has affected all walks of human life including education, business, and social development. It is acknowledged that technological instruments can play an important role in learning and development in classroom settings as well as out-of-classroom settings (Bates, 2010; Kimmons & Hall, 2016). Furthermore, it is affirmed that the use of technological instrumentation for teaching purposes can positively contribute to the effectiveness of the teaching-learning process. Celik, Sahin, and Akturk, (2014) noted that "Technology usage in the teaching-learning process may result in increased student writing, enhanced cooperative learning, enhanced integration of curriculum, greater application of learning style strategies, increased applications of cross-age tutoring, increased teacher communication, enhanced community relations, and enhanced global learners". TPACK is one of the important comprehensive frameworks, which clearly indicates that effectively integrating technology into pedagogy requires skill and knowledge and TPACK shed light on the kind of knowledge a teacher should acquire for the successful integration of technology in teaching (Mishra, 2019).

To address these important issues, the present study proposes the following hypotheses. First teachers' beliefs about TPACK are positively related to TPACK-based teaching practices. Second, TPACK-based teaching practices are positively related to transformative learning. Finally, TPACK-based teaching practices mediate the relationship between teachers' beliefs about TPACK and transformative learning. The present study tested all the hypothesized relationships using cross-sectional survey data collected from 433 university teaching professionals from high and low-ranked universities. To test the hypothesized relationships, the present study used AMOS 28 and assessed the measurement model for gauging fitness indices, reliability, and validity. Furthermore, the present study conducted a structural path analysis for path-by-path significance for the proposed model.

5.1. Theoretical Contributions

The present study makes serval theoretical contributions and extends the different streams of literature. First, by revealing a significant positive relationship between teachers' beliefs about TPACK and TPACK- based teaching practices, the present study contributes to the literature on integrating technologies in teaching practices and processes (Major, Warwick, Rasmussen, Ludvigsen, & Cook, 2018; Marcelo & Yot-Domínguez, 2019). Furthermore, it shed light on the extensively researched relationship between beliefs and teaching practice using a different technology-based perspective (Ding, Ottenbreit-Leftwich, Lu, & Glazewski, 2019; Li, Garza, Keicher, & Popov, 2019). The finding is in line with past research (Cheng & Xie, 2018; Roussinos & Jimoyiannis, 2019) and adds empirical evidence from a South Asian country. Furthermore, the replication of the finding based on a large sample size from higher education institutions in Pakistan not only enhances the generalizability of the teachers' beliefs and teaching practices links but also adds different contextual empirical evidence to the existing literature (Civitillo, Juang, & Schachner, 2018; Wilson, Woolfson, & Durkin, 2022).

Second, by revealing a significant positive relationship between TPACK-based teaching practices and transformative learning, the present study extends the literature on technological intervention-based teaching (Coleman et al., 2021; Lachner et al., 2021) and transformative learning (Blundell et al., 2020; Hoggan, & Kloubert, 2020; Van Schalkwyk et al., 2019). Furthermore, the present adds to the pools of the existing study on the relationship of teaching practices with adding TPACK outlook and perspective. It also highlights the importance of technological interventions in shaping and developing transformative learning. The empirical findings confirmed that technological interventions in the organized form such as TPACK can play an imperative role in enhancing transformative learning (Miguel-Revilla, Martínez-Ferreira, & Sánchez-Agustí., 2020). Third, by revealing a significant indirect relationship between teachers' beliefs about TPACK and transformative learning via TPACK-based teaching practices, the present study extends the literature on the antecedents and outcome of the teachers' beliefs about TPACK (Lai et al., 2022; Nelson & Voithofer, 2022; Voithofer, & Nelson, 2021), TPACK based teaching practices (Coleman et al., 2021; Lachner et al., 2021) and transformative learning (Blundell et al., 2020; Hoggan, & Kloubert, 2020; Van Schalkwyk et al., 2019). Furthermore, by theorizing and empirically establishing TPACK-based teaching practices as an important underlying mechanism through teachers' beliefs about TPACK transforms its influence on transformative learning, the present study extends the literature on the mediating mechanism and contributes to the existing literature on the factors that can serve as a mediatory mechanism in transforming the influence of the TPACK related beliefs on different behavioral outcomes of the teaching professionals (Cheng & Xie, 2018; Roussinos & Jimoyiannis, 2019).

Fourth, the present study conceptualized beliefs in a more specific way to gauge respondents' beliefs about all the seven dimensions of TPACK allowing for deeper insight into the beliefs regarding TPACK and enabling research to propose more specific inventions. Furthermore, it offers a more nuanced and comprehensive account of individual beliefs about all the facts of TPACK and extends the existing literature (Cheng & Xie, 2018; Roussinos & Jimoyiannis, 2019). Similarly, the present conceptualized teaching practice regarding all the seven variants of TPACK presents a more nuanced and comprehensive account of individual beliefs about all the facts of TPACK and contributes to an existing line of inquiry on TPACK-based teaching practices (Coleman et al., 2021; Lachner et al., 2021).

5.2. Strengths of the Study

The work at hand has several important strengths. The present study theorized and the empirically tested relationship between teachers' beliefs about TPACK and TPACK-based teaching practice. Furthermore, the study theorized and empirically tested the relationship between TPACK transformative learning and transformative learning. Finally, the present study theorized and empirically tested that TPACK-based practices mediated the relationship between teachers' beliefs about TPACK between TPACK and transformative learning. Instead of using basic statistical tests like t-test, ANOVA, correlation, and mean, the present study employed confirmatory factor analysis using structural equation modeling that allowed us to understand all the latent and observed constructs simultaneously and employed structural path analysis that allowed us to understand the path-by-path evaluation of the full model. The present study had a large sample size that had been employed to test the hypothesized relationships and made several valuable theoretical contributions to the existing literature. Finally, the study offered serval valuable practical implications for the government, policymakers, university management, and teaching professionals.

5.3. Limitations of the Study

The present study has some caveats that should be noted. The present study collected cross-sectional data that might cause the issue of common method variance. Although the present study employed Harman single factor test to mitigate this issue, I acknowledged this as a limitation of the study because the present design of the study precludes causality due to its cross-sectional nature and did not gauge change over time. Data were collected at the same time point which has a potential issue of social desirability. The present study has collected data from 12 universities that may have potential influences on the generalizability of the study findings.

5.4. Suggestions for Future Research

The present study offers the following important suggestions for future research scholars. Past research has highlighted that time lag data provides more robust inference as it can undermine the issues of common method variance and the data about understudy variables is collected after a considerable lag time. In the time lag data collection strategy, the data about the independent variables, moderating variables, and demographic variables are usually collected at Time 1, and data about mediators is collected at Time 2 after a considerable lag of time, and data about the dependent variables are collected at Time 3 using same time lag (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). By doing so, research can avoid common method variance and can infer more robust results as compared to self-reported cross-sectional data. Future research should collect time lag survey data to replicate our proposed model which would strengthen the present study findings. Longitudinal research design has frequently been employed in educational research and it enables researchers to gauge change over time (Rowan, Mayer, Kline, Kostogriz, & Walker-Gibbs, 2015; von Suchodoletz, Jamil, Larsen, & Hamre, 2018). As the design of the present study precludes causality, the present study invites research scholars to conduct a longitudinal research study to account for the causal relationship of the proposed model.

5.5. Implications of the Findings

The work at hand carries several practical implications for the teaching professional, university management, policymakers, and government. One of the major issues that require prime attention of the university management is to plan and invest resources for technology, the findings of the present study guide universities to plan and invest resources for technology on the beliefs and values as a focal point in mapping and investing their resources. Furthermore, considering beliefs as a focal point of planning resources will help university management to develop a pool of teaching professionals that would consider technological intervention as a fundamental part of their beliefs to enhance their teaching capabilities. The technology-related need of teaching professionals needs includes aiding classroom functions and organization, modifying classroom resources, and enhancing professional development. By focusing on developing TPACK-related beliefs through training and resource provision, the administration role that will help to teach professionals to accomplish their aforementioned technological needs. The professional accomplishment will enable them to enhance comprehension, motivation, and critical thinking among students. The management should link the technology intervention to the teaching professional beliefs to acquire their above-mentioned needs which will increase the likelihood of professional interest and involvement in learning and practicing this technology due to their close enactment with their technology-related belief system.

University administration should promote and build a supportive environment through institutional practices to explain the importance of situating technology in teaching content and strengthen their beliefs about integrating technology into their teaching practices and inspires them to experiment with new technologies. Foulger et al. (2015) explained that the promotion of technology integration programs not only shapes teaching professional beliefs about technology but also enables them to understand the crucial role of TPACK in their personal and professional development. Against this backdrop, the university management should organize formal and informal sessions and workshops to promote technology integration programs.

Second, the teaching professional's basic knowledge of technology is considered an important fundamental aspect of their capabilities and confidence in integrating technology into their classroom management and teaching practices. In this regard, the university management should develop a formal support system to enhance teaching professionals' knowledge and confidence about technology as TPACK is a comprehensive package that shed light on the pedagogical, content, and technology-related knowledge among the teaching professionals, the promotion and awareness about the TPACK would enhance teaching profession knowledge and capabilities to integrate technology in their teaching practices and improve the effectiveness of their teaching. Furthermore, university management should develop and promote a culture encouraging and welcoming technology and innovation-related teaching approaches that will enhance the skill set of the teaching professionals to effectively integrate technology-based interventions in their teaching practices.

Third, policymakers should follow fruitful approaches to innovate the instructional strategy design to meet the exponentially changing teaching paradigms. In this regard, the policymakers should adopt a professional development approach that should be based on the expanded conceptual framework to frame activities (Vosniadou, 2003), based on the proactive engagement in knowledge-seeking and dissemination through technological resources and means that would help implement new changes professionally. By doing so policymakers would be able to nurture an unlearning desire for old methods and strategies among teaching professionals a trigger a technology-based proactive approach to learning and practicing new approaches. It would also help the teaching professionals to reflect on their experience in a constructive way and motivate them to adopt more plausible and fruitful conceptions of technology-based pedagogy.

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