Journal of Social Sciences Review (JSSR) DOI: https://doi.org/10.54183/jssr.v3i1.212

How to Cite This Article: Ali, Z., Azam, R., & Saba, F. (2023). Technological Pedagogical and Content Knowledge of Pre-Service Elementary School Teachers in Karachi, Pakistan: A Quantitative Study. *Journal of Social Sciences Review*, 3(1), 678-688. https://doi.org/10.54183/jssr.v3i1.212

Technological Pedagogical and Content Knowledge of Pre-Service Elementary School Teachers in Karachi, Pakistan: A Quantitative Study

Zahid Ali	Associate Professor, School of Education, American International Theism University, Florida, USA.
Rizwan Azam	Lecturer in English, College Education and Literacy Department, Govt. of Sindh, Pakistan.
Farukh Saba	M.Phil. Scholar, Department of Education, Benazir Bhutto Shaheed University, Lyari, Karachi, Sindh, Pakistan.

Vol. 3, No. 1 (Winter 2023)

Pages: 678 – 688

ISSN (Print): 2789-441X

ISSN (Online): 2789-4428

Key Words

Pre Service Teacher’s Perceptions, Teachers Teaching Practices, Teachers TPACK

Corresponding Author:

Zahid Ali

Email: drzahid.aly@aituedu.org

Abstract: *This study examined how aspiring educators describe technological pedagogical content knowledge, how its components relate to one another, and how far along the competency spectrum elementary school teachers are in their capacity to integrate technology into their classes. The 21st century has unified curricula, cutting-edge technologies, and comprehensive comprehension. To achieve educational excellence and student achievement in a rapidly modernizing society, teachers must learn new instructional methods and technologies. "Technological pedagogical and content knowledge" (TPACK) is a framework of collective and composite knowledge needed by teachers in technology-integrated classrooms. This study assessed pre-service teachers' technology integration knowledge and behaviors. This cross-sectional survey assessed future educators' TPACK and associated expertise. This survey uses questionnaire-based purposeful sampling. Surveys assessed technology, content, instructional techniques, and pedagogy. Each series of questions established a 5-point Likert scale, with 1 representing strongly disagreed and 5 representing strongly agreed. Smart PLS and SPSS analyzed data. Future educators are confident and able to use technology to fulfil student needs, according to the study. All three predictions were proven when all prospective educators surveyed understood TPACK. This shows that they understood the role of technology in each allegory or were confident in combining all three TK, PK, and CK structures. Findings determined implications.*

Introduction

Teachers' credentials, subject knowledge, high level of proficiency, pedagogical expertise, and willingness were all crucial components that made a big difference in the success of the classroom experience. An outstanding educator who believes education can broaden horizons and inspire lasting change in pupils can make a significant impact on the progress of society. It implies that one should gain preparation before commencing a career in the teaching profession in order to attain teaching quality and a dedication to one's professional development. Doing so is crucial for becoming a responsible adult. While a teacher's presence is essential for the education of children, technology plays a crucial role. This ensures that students continue to be engaged in the learning process (Kuzu & Günüc, 2014) and is thus a key expectation for educators. Virtual classrooms and other forms of online education are not supported by a national infrastructure in Pakistan, as stated by Abid, Zahid, Shahid, and Bukhari (2021). There is only one major public university that offers distance education, and it is not enthusiastic about using online teaching methods. Plans to run online programs during an emergency remained inadequate because face-to-face schooling is still the norm. There's no doubt that the 21st century won't be like the centuries before it. Pakistan's educational system is designed to prepare educators to deal with the unique challenges that their students of all ages may face (Ali, Thomas, & Hamid, 2020). Pre-service teachers' technology pedagogical content knowledge (TPACK) is becoming increasingly important, as noted by Wang, & Zhao (2021).

To survive in the twenty-first century, we had to adopt technological means of interaction with one another and with the world around us, means that would allow for more effective and contextualized modes of communication and information sharing (Alayyar, Fisser, & Voogt, 2012). These goals required the employment of technical resources for the purposes of both education and training. On the premise that digital technology has altered our daily routine across most fields, Mishra and Koehler (2006) developed some useful next steps. These proactive measures stem from the realization that modern digital technology has altered the way we usually go about our jobs. It was in light of this idea that these procedures were developed. The same thing has happened in the field of education, and the use of technology in its many forms has become integral to the process. If you're going to make a case for technology, you should hold the view that it helps make the connections between the natural world and the organisms that live in it, and that it makes the teaching of science more accessible in general. The two most vital points are these. In the same vein, the argument was made for integrating technology into classrooms on the grounds that its inherent capacity for holistic development accounts for every aspect of any given system. Because of this, technology may be implemented in a wide range of classroom contexts, and its effect can be maintained in a way that is helpful in encouraging specific student behaviors over time. The conception of the technical skills and knowledge students need to succeed in the contemporary environment was produced as a result of the research undertaken by Niess et al. (2009) on the issues that were presented to educators by the International Society for Technology and Education.

The educator's role may be that of facilitator, advisor, or mentor in making this information accessible to students. Technological advancements make knowledge more accessible, and it is the obligation of those involved to make this information available. A teacher's role is to foster an environment in which they may effectively direct their students; when they succeed, their students learn a great deal. Hence, scholars concur that educators must have the capacity to integrate technological proficiency with pedagogical experience and subject-matter knowledge (Chai et al., 2010; Mishra & Koehler, 2006; Otrel-Cass et al., 2010). There is a common assumption that teachers can help their pupils succeed more in life if they combine their knowledge of current technological trends with the methods they already employ in the classroom. This outlook results from the common notion that providing children with more opportunities to use technology will help them succeed academically. Each of its constituent parts—pedagogical knowledge, mechanical understanding, and content mastery—works together to build a coherent whole. Koehler and Mishra's (2005) expansion of Shulman's PCK cognition idea to the realm of creativity is notable. Innovative pedagogical content knowledge (TPCK) is a sort of PCK that has recently gained a lot of attention. Educators use the term "innovative pedagogical substance information" to describe this type of PCK. Originally written as TPCK, the term has been shortened to TPACK to facilitate easier speech (Thompson and Mishra, 2008).

The study's goal is to determine how well-informed aspiring educators are about how technology may be used to improve teaching and learning. The overarching goals of this research are to gain a better understanding of how pre-service teachers perceive the value of their own technological pedagogical content knowledge (TPACK), how they relate to one another, and how well they understand the professional implications of integrating technology into the classroom.

Literature Review

Successful integration of technological tools into pedagogical practices necessitates a set of skills and knowledge known as technological pedagogical and content knowledge (TPACK for short). Instructive performance is enhanced by a number of factors, including pedagogy and content, both of which are grounded in knowledge. TPACK allows for more efficient and widespread use of technology in schools. Recent years have seen a surge in empirical studies examining the impact of educators' perspectives on the use of technology in the classroom (Scherer, 2018). Koehler and Mishra (2009) state that any digital device in technology can be considered "technology," including those that could be used to teach science in the classroom. In this context, "technology" refers specifically to means of electronic communication and storage. According to (McCrory, 2008). Note that it has been observed that pre-service teachers have advanced levels of digital and TPACK competence, making it easier to use the latter in practice and the former in future research. (Chai, 2018; Yurdakul, 2018). Koehler and Mishra's (2009) reiteration that technologies mostly undertaken in consideration are novel ideas in recent literature that would be challenging to implement in any other way clearly settles the mind of the readers. They do this by arguing that the idea that technologies that are largely undertaken in consideration are significant for practical purposes is a new one in the most recent literature. According to Shulman (1986), there used to be a clear separation between the pedagogical approach taken in the classroom and the topics covered. The pedagogical substance information framework was proposed by Shulman (PCK). Shulman argues, in light of this development, that teachers' subject-matter knowledge and their training in pedagogy are intertwined.

Pre-service teachers at traditional institutions would benefit from real-world experiences that help them understand the potential of technology and, in particular, boost their confidence in using technology in the classroom, according to the available literature (Wang, & Zhao, 2021). Hall, Lei, and Wang (2020) found that pre-service teachers' confidence in themselves and their ability to apply TPACK had significantly increased over the course of the study. The research by Lyublinskaya and Du (2022) suggests that using an interactive online platform, placing an emphasis on high-impact teaching strategies, and incorporating cycles of immersion, theoretical analysis, and digital content development may all contribute to the sustained development of students' TPACK as a group. Each student's TPACK learning trajectory showed a unique pattern that was influenced by their engagement, the teachers' encouragement, and their own familiarity with the use of technology in the classroom. Linear regression analysis establishes a connection between pedagogical content knowledge (TPACK) and classroom practices for future teachers (Baran, Canbazoglu Bilici, Albayrak Sari, & Tondeur, 2019). Reflection on one's own teaching practices and using one's own teacher educators as models were found to be the two most common types of strategies used in teacher education programs across all of the programs analyzed in this study. Questions about how to best foster the development of TPACK in pre-service teachers through different approaches to teacher education were raised by the findings, which should inform future research.

Methodology

This quantitative investigation was carried out by making use of an appropriate questionnaire for a survey, which allowed for its successful completion. In order to achieve this goal, a survey was designed, the questions for which were taken from an existing survey titled "Survey of Pre-service Teachers' Knowledge of Teaching and Technology," and the survey itself was developed in order to collect the necessary data (Schmidt et al., 2009). Because of the high statistical results it generates, this survey is utilized in the majority of TPACK research that can be found in the literature. This is owing to the fact that it produces these results. In order to assess the pre-service teachers' level of comprehension in relation to a variety of TPACK-related concepts, survey questionnaires were distributed to 165 pre-service teachers at three educational institutions. Of those pre-service teachers, 150 teacher candidates responded to the surveys. Mishra and Koehler (2006) put the TPACK model to the test by carrying out an investigation into the ways in which educators adapt their pedagogical strategies in order to make effective use of technological tools in the classroom. In light of the necessity, the method of purposive sampling was applied to this study in order to obtain representative samples from the entire study population that shared the same parameters. This was done in order to ensure the accuracy of the results. (Experience in a variety of fields, including but not limited to education and technology, as well as current and specific abilities and expertise.) The researcher briefed the participants about the consciousness of multiplicity and consent norms, as well as concerns regarding privacy and confidentiality. This was done in the context of discussing ethical considerations with the participants. Regarding the research field activity that was going to take place in three different educational institutes in the city of Karachi, formal approval to do so was granted. In addition, participants in the study had the option to drop out of the investigation at any time during the process in which it was being conducted. In addition to this, researchers gave them the assurance that their names and any other information that could be used to identify them would not be disclosed to any third party for any other purpose. Data were analyzed using Smart PLS and SPSS.

Data Analysis and Results

In this study, researchers looked into the TK, PK, CK, and TPACK frameworks, along with their associated 22 items. Loadings between 0.40 and 0.60, however, are considered appropriate and should be kept in the final product. This is in accordance with the recommendation made by Hair, Ringle, and Sarstedt (2013), which states that items with loadings greater than 0.60 are suitable for use in research pertaining to the social sciences. On the other hand, values that are lower than 0.40 will be discarded. Hence, TK=1 and 4, CK=5, and PK=6 and 7 were omitted, as were items whose loadings were lower than 0.60; however, all other items with an appropriate loadings value that was greater than 0.60 were taken into consideration for the subsequent analysis (See Table 5).

Demographic Results

In this study, we enlisted the help of one hundred fifty future teachers-in-training who volunteered to take part in the research. There were a total of 139 girls (92.7% of the total), and 11 males (7.3% of the total). The age group distribution showed that the majority, or 33.3% of the population, was between the ages of 20 and 25 years old. Just 2.7% of participants were older than 40 years old at the time of the study. When it came to the marital status of the participants, the bulk of the subjects (76.0% to be exact) were single, while the other participants were married. 47.6% of the participants had already earned their bachelor's degree, while the aggregate percentage of participants who were still in school was 54.7%. As can be seen in the table1.

Table 1

Demographic information

	Demographics	Frequency	Percent	Valid Percent	Cumulative Percent
Gender	Female	139	92.7	92.7	92.7
	Male	11	7.3	7.3	100.0
	Total	150	100.0	100.0	
Age group	20-25 years	50	33.3	33.3	33.3
	26-30 years	51	34.0	34.0	67.3
	31-35 years	35	23.3	23.3	90.7
	36-40 years	10	6.7	6.7	97.3
	40 > years	4	2.7	2.7	100.0
	Total	150	100.0	100.0	
Marital status	Married	36	24.0	24.0	24.0
	Unmarried	114	76.0	76.0	100.0
	Total	150	100.0	100.0	
Academic Qualification	Undergraduate	38	25.3	25.3	25.3
	Graduate	70	46.7	46.7	72.0
	Postgraduate	42	28.0	28.0	100.0
	Total	150	100.0	100.0	
Currently Pursuing Degree	BS / B.Ed. 4 Years	82	54.7	54.7	80.7
	B.Ed. 2.5 Years	39	26.0	26.0	26.0
	B.Ed. 1.5 Years	29	19.3	19.3	100.0
	Total	150	100.0	100.0	

The Measurement Model

Researchers checked the measuring model's construct validity, convergent validity, and discriminant validity to ensure it was reliable and valid. This helped them test the model's construct validity and see if it was adequate. Factor loadings reported in Table 5 above 0.6 substantiated the current study's content validity. The research was done by four people (Hair, Hult, Ringle, and Sarstedt, 2013). According to Hair, Risher, Sarstedt, and Ringle, the study model has internal consistency reliability no lower than that indicated by Cronbach's alpha (2018). Yet, it was established that composite reliability represents the limit of acceptability (CR). Cronbach's alpha values in Table 2 are above the minimum threshold of 0.7. As for CR, its values are greater than 0.7 and less than 0.95. Hence, once internal consistency has been established, there is no such thing as indicator redundancy. Two separate measures taken during the course of this investigation lent credence to the idea that the items in this set were all measuring the same underlying notion or structure (Hair, Hult, Ringle, & Sarstedt 2013). Table 5 displays that all factor loadings are larger than 0.6, and the average variance extracted (AVE) is greater than 0.05 (Hair, Rishe, Sarsted, and Ringle) (2018). Three results were examined to provide evidence that a set of items can be used to separate one variable from a broader set of factors. As can be seen in Table 5, when all of the items were compared in terms of their cross-loadings, each item loaded strongly against its own specific construct. Second, as can be seen in Table 3, the values shown in the diagonal bold cells for each construct are greater than the values presented in the rows and columns for that construct because they represent the square roots of the AVE values for that construct. No matter the framework one uses, this holds true. Overall, as indicated in Table 4, all of the HTMT ratios are less than 0.85.

Table 2

Construct Reliability and Validity

Constructs	Cronbach's Alpha	rho_A	Composite Reliability	(AVE)
CK	0.750	0.763	0.841	0.570
PK	0.805	0.824	0.861	0.555
TK	0.717	0.741	0.823	0.540
TPACK	0.748	0.760	0.841	0.572

Table 3

Discriminant Validity (Fornell-Larcker Criterion)

Construct	CK	PK	TK	TPACK
CK	0.755			
PK	0.337	0.745		
TK	0.247	0.447	0.735	
TPACK	0.462	0.472	0.553	0.756

Table 4

Heterotrait-Monotrait Ratio (HTMT)

Constructs	CK	PK	TK	TPACK
CK				
PK	0.432			
TK	0.337	0.533		
TPACK	0.595	0.575	0.741	

Table 5

Outer Loadings

Items of the constructs	CK	PK	TK	TPACK
CK_item3	0.710			
CK_item4	0.813			
CK_item2	0.721			
CK_item1	0.773			
PK_item1		0.783		
PK_item2		0.754		
PK_item3		0.826		
PK_item4		0.733		
PK_item5		0.612		
TK_item2			0.806	
TK_item3			0.793	
TK_item5			0.676	

TK_item6	0.651	
TPACK_item1		0.729
TPACK_item2		0.832
TPACK_item3		0.660
TPACK_item4		0.793

Table 6

R Square and Q square

DV	R Square	R Square Adjusted	Q Square
TPACK	0.447	0.436	0.236

The Structural Model

Partial Least Squares- Structural Equation Modeling (PLS-SEM) in Smart PLS was then used to investigate the stated hypotheses of the study once construct validity and reliability had been confirmed. It was done so that we could test our study's hypotheses (Ringle et al., 2015). By a wide margin, PLS-SEM methodology delivers more precise estimates than other covariance-based approaches (Hair et al., 2013). Table 7 shows that there is a statistically significant relationship between pre-service teachers' levels of TK (t = 4.977, p = 0.000), PK (t = 2.256, p = 0.025), and CK (t = 4.211, p = 0.000) when it comes to their use of TPACK in the classroom. This means that all three hypotheses, labelled H1, H2, and H3, can be accepted on the basis of the data supplied here (see Table 7)

Predictive Relevance of the Model

The predictive power of the various domains included in the structural model was examined using R square (Hair et al., 2013) and Stone Geisser's Cross-Validated Redundancy (Q-square) (Geisser, 1974). Table 6 shows that the TK, PK, and CK components of TPACK account for 30% (R-squared = 0.447) of the variance in TPACK. That's a lot more than the threshold of 0.10 that Falk and Miller recommended for R-squared (1992). Furthermore, the blindfolding procedure in Smart PLS yielded a Q-square value of 0.236, a non-zero integer. It's proof that everything went off without a hitch (Geisser, 1974) Not only does this show that the PLS-path model has predictive significance, but it also shows that it is significant even though Hair, Risher, Sarstedt, and Ringle only identified a very tiny degree of relevance. This is significant because it provides evidence that the PLS-path model has established predictive value (2018). According to Cohen (1988), there are three cutoff points for effect size (2): 0.02, 0.15, and 0.35. These numbers indicate small, medium, and large effects, respectively. The numeric equivalents of these three cutoffs are 0.02, 0.15, and 0.35. In Table 7, we can see the effect size (2) for each of the three variables that were found to predict TPACK in future educators. According to the effect size values, pre-service teachers' pedagogical knowledge has a moderate influence on their TPACK (effect size = 0.052), their content knowledge has a moderate influence (effect size = 0.141), while their technology knowledge has a big influence (effect size = 0.220).

Table 7

Hypothesis Testing

Hypothesis	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values	f^2	Decision
CK -> TPACK	0.299	0.301	0.071	4.211	0.000	0.141	Supported

PK -> TPACK	0.196	0.209	0.087	2.256	0.025	0.052	Supported
TK -> TPACK	0.392	0.386	0.079	4.977	0.000	0.220	Supported

Discussion

This study found that pre-service teachers' individual levels of TK, PK, and topic knowledge positively influenced the TPACK levels they held (CK). We used the Smart PLS to draw the following conclusions about TPACK among pre-service teachers: (1) technological knowledge has a significant positive impact on TPACK; (2) pedagogical knowledge has a significant positive impact on TPACK; and (3) content knowledge has a significant positive impact on TPACK. This confirms what has been found in a large body of prior studies from a variety of disciplines and locations around the globe. Prior to this, considerable research had been done (Mishra & Koehler, 2006; Koehler & Mishra, 2009; Schmidt et al., 2009; Bruce & Chiu, 2015; Harris & Hofer, 2017; Kirikcilar & Yildiz 2018; Patria, 2019; Hill & Uribe Florez, 2019; Ali, Thomas, Ahmed, Ahmed, & Ahmed, 2020; Ali, Thomas, & Hamid 2020). High levels of instructors' opinions on TPACK skills, as well as teachers' attitudes toward their own personal interests, experiences, and grasp of TPACK, were found in a study (ler, & YILDIRIM, 2018; Ali, et al., 2020). It was also shown that teachers have a high level of TPACK awareness. In addition to offering effective training in the subject area that the pre-service teachers will be teaching, they suggest that the courses offered to pre-service teachers should include technology, content, and pedagogy. The countless paths we explored, each of which led to the same result, were all fruitless. Based on their findings, the authors of a different study (Ali, Thomas, & Hamid, 2020) concluded that teachers needed to learn how to teach both content and pedagogy and that these three skills needed to be taught and modelled in tandem. Students enrolled in colleges of education did not obtain sufficient preparation in the area of technological education. Despite the importance of technical education to the jobs they hope to one day hold, a lack of resources means that aspiring teachers aren't getting the training they need.

Conclusion

This research places a large emphasis on the education of pre-service teachers; nevertheless, this education should not be segregated from the fundamental technical problems that are required to meet demand in order for it to be effective. They need to modernize the ways in which they teach by incorporating several different topics that are related to technology into each of their classes. According to Koehler and Mishra (2009), it ought to be incorporated into their method of instructing using the most recent technology as an add-on, and in such a way that ought to take into mind the specifics of the classrooms in which it will be implemented. In addition to this, it should be designed in a way that takes into account the requirements that are specific to the students. The research that we have done exposes, on the same level, all of these various qualities in a variety of ways. According to the findings that were compiled at the end of the research project, it was discovered that the educators who took part in the research project have a clearer grasp and perspective of the TPACK contents.

Recommendations

It is an absolute requirement that TPACK be incorporated into the fundamental aspects of the many different types of programs that are designed to prepare teachers. A fruitful method of instructing students that makes use of the appropriate technologies needs to be incorporated into the curriculum. The processing of TPACK should take place in such a way that it makes it possible for the learning that is taking place among students to be improved. This should be done since the improvement of student learning is the ultimate goal of teaching. It is necessary to conduct additional research in both urban and rural areas, as well as the public and private sectors, in order to evaluate other contextual difficulties that may arise during the process of putting TPACK into practice. This evaluation must be done in order to fulfil the requirements of the National Science Foundation. In order to satisfy the requirements of the Common Core State Standards for Science and technology as well as the STEM learning system, certain investigations need to be carried out.

References

Abid, T., Zahid, G., Shahid, N., & Bukhari, M. (2021). Online teaching experience during the COVID-19 in Pakistan: Pedagogy–technology balance and student engagement. *Fudan Journal of the Humanities and Social Sciences*, *14*(3), 367-391. https://doi.org/10.1007/s40647-021-00325-7

Alayyar, G. 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*(8). https://doi.org/10.14742/ajet.773

Ali, Z., Busch, M., Qaisrani, M. N., & Rehman, H. U. (2020). The influence of teachers' professional competencies on students' achievement: a quantitative research study. *American Research Journal of Humanities & Social Science*, *3*(6), 45-54.

Ali, Z., Rehman, H. U., & Ullah, N. (2022). Measuring University Teacher Educators' Knowledge and Skills Using TPACK in Teachers Education Programs. *Research Journal of Social Sciences and Economics Review*, *3*(3), 83-91. https://doi.org/10.36902/rjsser-vol3-iss3-2022(83-91)

Ali, Z., Thomas, M., & Hamid, S. (2020). Teacher Educators' perception of Technological Pedagogical and Content Knowledge on Their Classroom Teaching. *New Horizons (1992-4399)*, *14*(2).

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

Baran, E., Canbazoglu Bilici, S., Albayrak Sari, A., & Tondeur, J. (2017). Investigating the impact of teacher education strategies on preservice teachers' TPACK. *British Journal of Educational Technology*, *50*(1), 357-370. https://doi.org/10.1111/bjet.12565

Capobianco, B., & Lehman, J. (n.d.). Examining and characterizing elementary school teachers' engineering design-based instructional practices and their impact on students' science achievement. *2018 ASEE Annual Conference & Exposition Proceedings*. https://doi.org/10.18260/1-2--30465

Chai, C.S., Koh, J. H. L. & Chai, C. C. T. (2010) Facilitating Preservice Teachers' Development of Technological, Pedagogical, and Content Knowledge (TPACK). *Journal of Educational Technology & Society, 13*(4), 63-73.

Chai, C. S., Chin, C. K., Koh, J. H., & Tan, C. L. (2013). Exploring Singaporean Chinese language teachers' technological pedagogical content knowledge and its relationship to the teachers' pedagogical beliefs. *The Asia-Pacific Education Researcher*, *22*(4), 657-666. https://doi.org/10.1007/s40299-013-0071-3

Chai, C. S., Hwee Ling Koh, J., & Teo, Y. H. (2018). Enhancing and modeling teachers' design beliefs and efficacy of technological pedagogical content knowledge for 21st-century quality learning. *Journal of Educational Computing Research*, *57*(2), 360-384. https://doi.org/10.1177/0735633117752453

Cuhadar, C. (2018). Investigation of pre-service teachers' levels of readiness to technology integration in education. *Contemporary Educational*

Technology, *9*(1). https://doi.org/10.30935/cedtech/6211

Falk, R. F. & Miller, N. B. (1992). *A primer for soft modeling. Akron, OH*: University of Akron Press.

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research*, *18*(1), 39. https://doi.org/10.2307/3151312

Geisser, S. (1974). A predictive approach to the random effect model. *Biometrika*, *61*(1), 101-107. https://doi.org/10.1093/biomet/61.1.101

Graham, C. R. (2011). Theoretical considerations for understanding technological pedagogical content knowledge (TPACK). *Computers & Education*, *57*(3), 1953-1960. https://doi.org/10.1016/j.compedu.2011.04.010

Günüç, S., & Kuzu, A. (2014). Factors influencing student engagement and the role of technology in student engagement in higher education: Campus-class-Technology theory. *Turkish Online Journal of Qualitative Inquiry*, *5*(4). https://doi.org/10.17569/tojqi.44261

Hair, J. F., Ringle, C. M., & Sarstedt, M. (2013). Partial least squares structural equation modeling: Rigorous applications, better results and higher acceptance. *Long Range Planning*, *46*(1-2), 1-12. https://doi.org/10.1016/j.lrp.2013.01.001

Hair, J. F., Risher, J. J., Sarstedt, M., & Ringle, C. M. (2019). When to use and how to report the results of PLS-SEM. *European Business Review*, *31*(1), 2-24. https://doi.org/10.1108/ebr-11-2018-0203

Hall, J. A., Lei, J., & Wang, Q. (2020). The first principles of instruction: An examination of their impact on preservice teachers' TPACK. *Educational Technology Research and Development*, *68*, 3115-3142.

Horzum, M. B. (2013). An investigation of the technological pedagogical content knowledge of pre-service teachers. Technology, Pedagogy and Education, 22(3): 303-317.

İşler, C., & YILDIRIM, Ö. (2018). Perceptions of Turkish pre-service EFL teachers on their technological pedagogical content knowledge. *Journal of Education and Future*, (13), 145-160.

Kereluik, K., Mishra, P., & Koehler, M. J. (2011). On learning to subvert signs: Literacy, technology and the TPACK framework. California Reader, 44(2), 12-18.

Lyublinskaya, I., & Du, X. (2022). Preservice teachers' TPACK learning trajectories in an online educational technology course. *Journal of Research on Technology in Education*, 1-18. https://doi.org/10.1080/15391523.2022.2160393

Mishra, P., Koehler, M. J., & Kereluik, K. (2009). The song remains the same: Looking back to the future of educational technology. Techtrends, 53(5), 48-53. https://doi.org/10.1007/s11528-009-0325-3

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record: The Voice of Scholarship in Education*, *108*(6), 1017-1054. https://doi.org/10.1177/016146810610800610

Niess, M. L., Ronau, R. N., Shafer, K. G., Driskell, S. O., Harper S. R., Johnston, C., Browning, C., Özgün-Koca, S. A., & Kersaint, G. (2009). Mathematics teacher TPACK standards and development model. Contemporary Issues in Technology and Teacher Education, 9(1): 4-24.

Niess, M. L. (2012). Teacher knowledge for teaching with technology. *Educational Technology, Teacher Knowledge, and Classroom Impact*, 1-15. https://doi.org/10.4018/978-1-60960-750-0.ch001

Pamuk, S., Ergun, M., Cakir, R., Yilmaz, H. B., & Ayas, C. (2013). Exploring relationships among TPACK components and development of the TPACK instrument. *Education and Information Technologies*, *20*(2), 241-

263. https://doi.org/10.1007/s10639-013-9278-4

Scherer, R., Tondeur, J., Siddiq, F., & Baran, E. (2018). The importance of attitudes toward technology for pre-service teachers' technological, pedagogical, and content knowledge: Comparing structural equation modeling approaches. *Computers in Human Behavior*, *80*, 67-80. https://doi.org/10.1016/j.chb.2017.11.003

Selwyn, N. (2008). From state-of-the-art to state-of-the-actual? Introduction to a special issue. *Technology, Pedagogy and Education*, *17*(2), 83-87. https://doi.org/10.1080/14759390802098573

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, *15*(2), 4-14. https://doi.org/10.3102/0013189x015002004

Thomas, M. (2013). Teachers' beliefs about classroom teaching – Teachers' knowledge and teaching approaches. *Procedia - Social and Behavioral Sciences*, *89*, 31-39. https://doi.org/10.1016/j.sbspro.2013.08.805

Thompson, A., & Mishra, P. (2007). Breaking News: TPCK Becomes TPACK!. *Journal of Computing in Teacher Education, 24*(2), 38-64.

Voogt, J., Fisser, P., Pareja Roblin, N., Tondeur, J., & Van Braak, J. (2012). Technological pedagogical content knowledge - a review of the literature. *Journal of Computer Assisted Learning*, *29*(2), 109-121. https://doi.org/10.1111/j.1365-2729.2012.00487.x

Wang, Q., & Zhao, G. (2021). ICT self-efficacy mediates most effects of university ICT support on preservice teachers' TPACK: Evidence from three normal universities in China. *British Journal of Educational Technology*, *52*(6), 2319-2339. https://doi.org/10.1111/bjet.13141

Yurdakul, IK. (2018). Modeling the relationship between pre-service teachers' TPACK and digital nativity. *Educational Technology Research and Development*, *66*(2), 267-281. https://doi.org/10.1007/s11423-017-9546-x