Technological Pedagogical Content Knowledge (TPACK) in Practice: Measuring Teachers' Proficiency at Public and Private Universities of Lahore, Pakistan

Sadia Saeed[1] and Irfana Rasul[2]

https://doi.org/10.62345/jads.2023.12.3.25

Abstract

This study addresses the critical issue of Technological Pedagogical Content Knowledge (TPACK) implementation among teachers at public and private universities in Lahore, Pakistan. In an era marked by rapid advancements in Information and Communication Technology (ICT), it becomes imperative to assess the readiness of educators to leverage these tools effectively. The research identifies a profound gap in current teaching practices, where teachers. However, well-versed in subject matter knowledge often needs more pedagogical skills and technological proficiency to harness the full potential of ICT for meaningful content delivery. The study involved 48 teachers from Information and Technology and Business Schools faculties across four universities (two private and two public). Utilizing a survey questionnaire with 82 closed-ended items, advanced statistical techniques like Pearson product-moment correlation analysis and multiple linear regression were employed to answer key research questions. Findings reveal strong correlations between various TPACK factors, emphasizing the interconnectedness of pedagogical knowledge, content knowledge, and technological competence. In light of these findings, policy recommendations include requiring higher education institutions to prioritize professional development opportunities, encouraging collaborative learning among faculty, and revisiting curriculum designs to incorporate TPACK principles. Furthermore, ensuring robust technology infrastructure, facilitating ongoing assessments of technology integration's impact, and fostering a culture of continuous improvement are essential steps in bridging the TPACK proficiency gap among educators. The study underscores the importance of equipping teachers with the necessary skills to navigate the evolving landscape of education, ultimately leading to more effective pedagogy and content delivery in higher education settings in Lahore, Pakistan.

Keywords: Technological Pedagogical Content Knowledge (TPACK), Teachers' Proficiency.

Introduction

Technology integration in education is a global phenomenon, reshaping the teaching and learning landscape (Kanwal et al., 2023). In Pakistan, as in many countries, technology adoption in higher education has been accelerated by the Information and Communication Technology (ICT) revolution. However, the effective utilization of technology in the educational process remains a significant challenge, requiring educators to possess subject matter expertise, pedagogical skills, and technological proficiency. This challenge is at the heart of the Technological Pedagogical Content Knowledge (TPACK) framework (Soomro et al., 2018).

[1] *Research Scholar, University of Education, Lahore*
[2] *Assistant Professor, University of Education, Lahore*

Compliance with ethical standards: There are no conflicts of interest (financial or non-financial). This study did not receive any funding.

The theme of this study revolves around the critical need to assess and enhance TPACK proficiency among educators at public and private universities in Lahore, Pakistan. TPACK, as a conceptual framework, emphasizes the seamless integration of technological, pedagogical, and content knowledge in the teaching and learning process. It recognizes that more than the mere availability of technology is required; educators must be competent to wield it effectively. Pakistan's educational landscape has undergone significant transformations in recent years, with a growing emphasis on higher education institutions to adapt to the evolving digital era. The COVID-19 pandemic further accelerated the reliance on technology for remote learning. However, while the push for technology adoption is evident, the preparedness of educators to harness its potential is a matter of concern.

Pakistan's educational institutions, both public and private, grapple with the challenge of equipping teachers with the requisite skills to navigate this digital shift. In a country with diverse socio-economic backgrounds and varying levels of access to technology, the effective integration of ICT in education becomes a matter of equity and quality (Al-Zaidiyeen, Lai Mei, & Fook, 2010; Prestridge, 2012).

The TPACK framework, introduced by Mishra and Koehler (2006), offers a theoretical lens to examine the confluence of technology, pedagogy, and content knowledge. It posits that effective technology integration requires not only technical know-how (Technological Knowledge - TK) but also a deep understanding of how technology interacts with pedagogical practices (Pedagogical Knowledge - PK) and subject matter expertise (Content Knowledge - CK). This theoretical framework underscores that technology should not be viewed in isolation but as an integral component of the educational process. Educators must be proficient in their respective subjects and adept at selecting and employing appropriate technological tools and strategies to enhance learning outcomes (Kamran et al., 2022). In the context of Pakistan's higher education institutions, the TPACK framework offers a structured approach to addressing the digital divide among educators. It provides a roadmap for professional development initiatives to enhance teachers' TPACK proficiency, ultimately leading to more effective pedagogy and content delivery in the digital age. This study seeks to delve deeper into the current state of TPACK proficiency among educators in Lahore, Pakistan, and to provide insights and policy recommendations to bridge the existing gaps in technology integration in higher education.

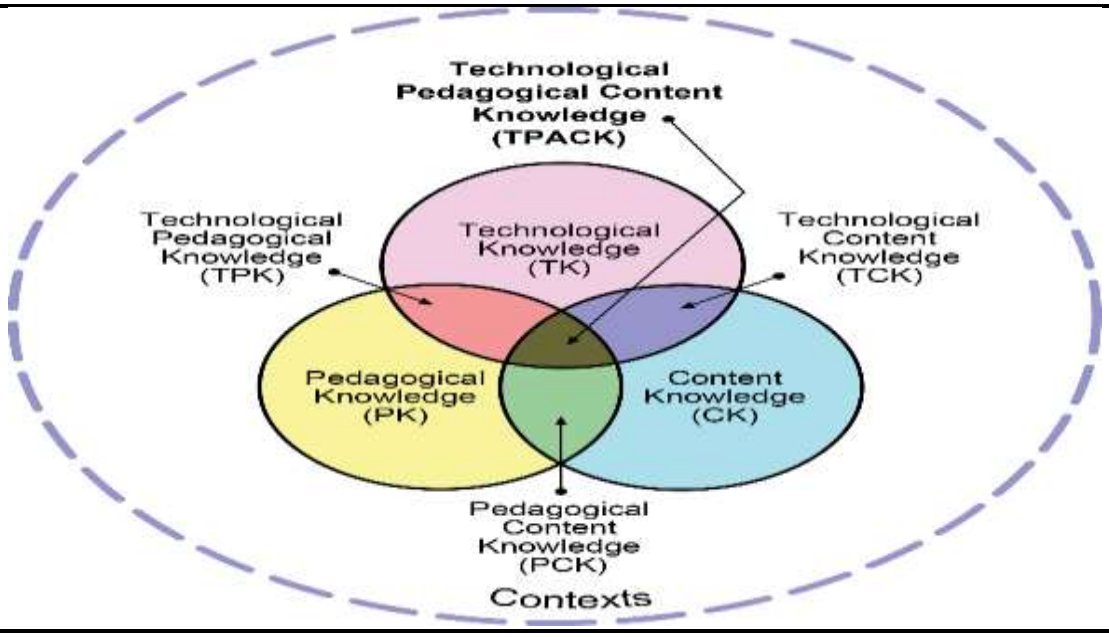
A successful teaching-learning method depends upon the transmission and transformation of knowledge to the learner in an effective way. Since the start of the 21st century, Information and Communication Technology (ICT) has provided a novel approach to get and process knowledge in every field. In education, teachers also started using ICT to transfer their knowledge to the students in their particular context (Omar et al., 2020). Institutes of Higher Education are one hub where this evolution takes place quickly. Due to these ongoing changes, the faculty members of higher education institutions are also supposed to meet up with all these challenges in their specific field of subject. The technological Pedagogical Content Knowledge (TPACK) framework defines how technology can be merged with pedagogical and content knowledge (Koh et al., 2014; Soomro et al., 2018; Omar & Arif, 2020) to affect the teaching-learning process.

In recent years, the technological pedagogical content knowledge (TPCK) framework has emerged to meet the challenges of the teaching-learning method; however, the evidence (Mishra & Koehler, 2006; Koehler & Mishra, 2009) brings forth a lack of technological orientation and skills of the teachers in the professional growth for improvement in qualitative terms. In the present era of the 21st century, teachers are still using technology in the traditional ways, and meaningful integration to affect the content delivery for quality pedagogy is absent in the practices of most teachers (Al-Zaidiyeen, Lai Mei, & Fook, 2010; Prestridge, 2012; Tsai & Chai, 2012; 2013; Prestridge, 2017; Omar, & Chaudhry, 2019) Since technology has been

an emerging trend in the field of education and children are growing up with ICT, the use of ICT by the teachers in the teaching-learning process has become a significant concern for authorities (Jimoyiannis, 2010; Polly, Mims, Shepherd, & Inan, 2010; Chai, Koh & Tsai, 2013; Kamran, Kanwal, Afzal & Rafiq, 2023).

The emphasis on technological knowledge to enhance teacher competency in technology integration has shifted recently to a concentration on the critical ties among pedagogy, technology, and content information (Koehler, 2009; Chai et al., 2013). Several recent surveys (Baran et al., 2009; Lee, Tsai, & 2013) have supported the theory legitimacy of the TPACK (Technological et al. Knowledge) framework. In recent years, methods for improving teachers' ability to integrate technology have placed less emphasis on technical expertise and more on the critical links among technology, pedagogy, and content knowledge—TPACK (Mishra & Kohler, 2006; Chai & Tsai, 2013 Chai et al., 2013). **Koehler and Mishra's Framework** demonstrates the complete integration process and highlights the critical aspects of a teacher's content, pedagogical, and technological knowledge (Mishra & Koehler, 2008).

Figure 1: Framework



According to Kohler (2006), technical, pedagogical, and content information are intricately intertwined, mentioned as TPACK. It refers to the knowledge of students' prior understanding, conceptions of epistemology, knowledge of how technologies can be employed, and pedagogical strategies that leverage technologies to teach the material as prerequisites for effective technology-assisted instruction. Regarding TPACK's structure, Mishra and Koehler are supported by other researchers (Niess, 2005; McCormick & Thomann, 2007; Cox, 2008; Fath & Genalo, 2008) with a viewpoint that TPACK is a way of thinking about the dynamic relationships between technology, pedagogy, and a particular subject matter in order to help students understand that topic matter restored (Afzal et al., 2023).

Problem Statement

Current practices of the teachers at higher education institutes evidence that the focus is only on what to teach, the content, and how to teach; pedagogy is the missing ingredient (Afzal & Rafiq, 2022). Though the teachers are equipped with the subject knowledge they teach, pedagogical knowledge on how to deliver the content needs to be improved. (Mishra et al., 2010.) (Koehler et al., 2011; Figg & Jaipal, 2012). Based on the skillset, i.e., possessing subject

knowledge only, the teachers cannot transform and internalize the knowledge, and each session ends merely with the simple transfer of the knowledge.

Moreover, technological knowledge as the basis of a digital learning environment is the need of the hour. The teacher needs more technical competency to integrate technology into the lessons for maximum output (Scardamalia et al., 2012). Teachers need to be proficient in technological and pedagogical knowledge to make content delivery effective in the teaching-learning environment (Rafiq et al., 2022).

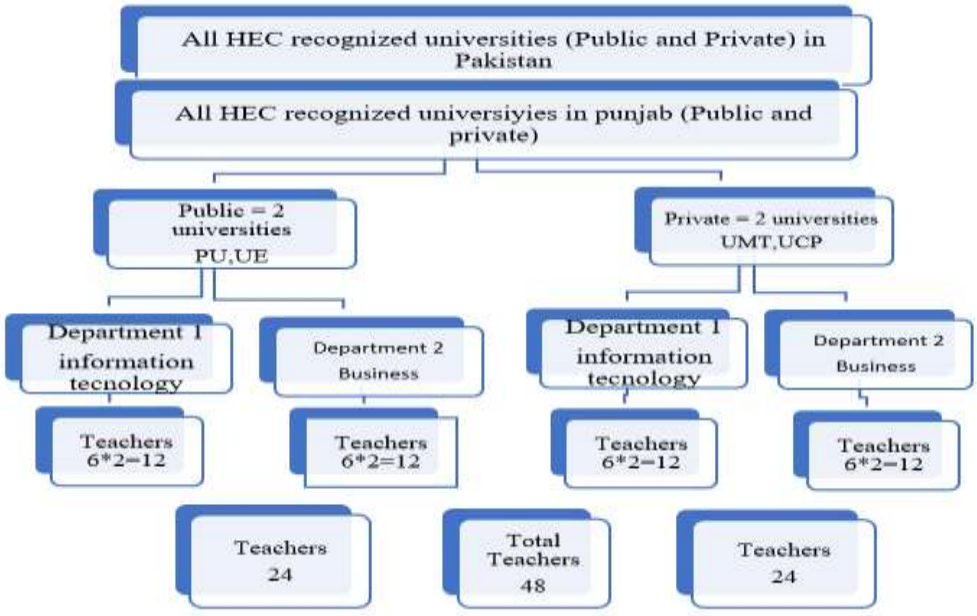
Research Questions

- What is the interactive effect of foundation- and intermediate-level variables to ensure effective TPACK practices as perceived by the teachers of public and private universities in Pakistan?
- What is the predictive value of foundation-level variables leading to effective TPACK practices as perceived by the teachers of public and private universities in Pakistan?
- What is the predictive value of intermediate-level variables leading to effective TPACK practices as perceived by the teachers of public and private universities in Pakistan?

Methodology

This research employed a survey method to investigate the implementation of Technological Pedagogical Content Knowledge (TPACK) among teachers at public and private universities in Lahore, Pakistan. The study utilized a cross-sectional survey design, collecting data from a diverse group of participants at a specific point in time to assess TPACK proficiency. The target population included all male and female teachers teaching in public and private universities in Punjab, Pakistan. A multi-stage sampling technique was employed (Alvi, 2016), ensuring an equal chance of selection for all private and public universities in Punjab. Two specific faculties, Information and Technology, and Business Schools, were selected based on established criteria such as offering professional education programs (Steven,1977; 2014; Cochran). Within these faculties, random sampling was used to select teachers, including 12 teachers from each faculty in four universities (two private and two public), resulting in a total sample size of 48 teachers.

Figure 2: Sampling Frame



Data was collected through a structured survey questionnaire consisting of 82 closed-ended items. The questionnaire aimed to capture information related to various facets of TPACK, including technological knowledge (TK), pedagogical knowledge (PK), content knowledge (CK), and their interconnectedness. Participants responded based on their perceptions and experiences. Data analysis involved advanced statistical techniques, including Pearson product-moment correlation analysis and multiple linear regression. These methods were used to answer the research questions, exploring the relationships between different TPACK factors. The research examined correlations between foundation-level variables (TK et al.), intermediate-level variables (PCK, TPK, TCK), and TPACK proficiency. Multiple linear regression was employed to determine the predictive value of foundation-level and intermediate-level variables on TPACK proficiency among educators.

Throughout the research process, ethical considerations were paramount. Informed consent was obtained from all participants, ensuring they were aware of the research's purpose, their rights, and the confidentiality of their responses. Measures were in place to protect participant identities and ensure anonymity. The research upheld strict ethical standards, emphasizing confidentiality and voluntary participation (Yilmaz, 2013). By employing a survey method, this research sought to provide valuable insights into the current status of TPACK implementation among higher education teachers in Lahore, Pakistan. The findings contribute to a deeper understanding of the challenges and opportunities in technology integration in higher education, offering valuable information for policy recommendations and strategies to enhance pedagogy and content delivery.

Data Analysis and Findings

Q1. What is the interactive effect of foundation- and intermediate-level variables to ensure effective TPACK practices as perceived by the teachers of public and private universities in Pakistan?

To find the answers to the question, Pearson product-moment correlation was applied to determine the relation among all three variables:

Foundation-Level Variable (Pedagogical et al.), Intermediate-Level Variable (Pedagogical and Content Knowledge-PCK), Technological and Pedagogical Knowledge-TPK), Content and Technological Knowledge-TCK), and Technological, Pedagogical, and Content Knowledge-TPACK Practices. Seven factors and sub-factors (TK et al., PCK, TPK, TCK, and TPACK) were extracted. Most of the factors demonstrated a positive and significant correlation. The details are explained below.

Table 4: Correlation Matrix of Factors

	PK	*TK*	*CK*	*PCK*	*TCK*	*TPK*	*TPACK*
PK	1	.061	.457	.750	.532	.419	.546
TK		1	.206	.165	.375	.289	.114
CK			1	.584	.502	.482	.497
PCK				1	.581	.529	.668
TCK					1	.586	.639
TPK						1	.585
TPACK							1

The strongest favorable association was found between Pedagogical Content Knowledge (PCK) and Pedagogical Knowledge (PK) with the value r=.750**; p<.0.01, which revealed that it is imperative to update the pedagogical knowledge of the teachers along with subject matter knowledge. Teachers shall be aware of how to deliver parallel with what to deliver. Moreover,

a moderate correlation was found between Technological Pedagogical Content Knowledge (TPACK) and Pedagogical Content Knowledge (PCK) with the value r=.668**; p<.0.01, which complemented the previous findings spotlighting the supportive role of content-specific pedagogic methods, strategies, and approaches for effective delivery of the content. Similarly, a high correlation was found between Technological pedagogical Content Knowledge (TPACK) and Technological Content Knowledge (TCK) with the value r=.639**; p<.0.01; however, a moderate correlation was found between Technological Pedagogical Knowledge (TPK) and Technological Content Knowledge (TCK) with the value r=.586**; p<.0.01 which demonstrates the importance of technological knowledge of teachers in using the tools and software within a discipline to access and generate technology-oriented content in offering enriched subject matter to the students. The merge of content and technology also supports scientific inquiry and self-directed learning among the students. Technological Content Knowledge (TCK) also had a moderate relationship with Pedagogical Content Knowledge (PCK) with the value r=.581**; p<.0.01. A moderate correlation between Content Knowledge (CK) and Pedagogical Knowledge (PK) with the value r=.457**; p<.0.01 was also demonstrated. Moreover, a moderate correlation between Technological Pedagogical Content Knowledge (TPACK) and Technological Pedagogical Knowledge (TPK) was also found with the value r=.585**; p<.0.01. Generally, the results align with the studies (Graham et al., 2009; Önal, 2016). Valtonen, Sointu, Kukkonen, Kontkanen, Lambert, & Mäkitalo-Siegl, 2017), as more significant correlations were found between foundational factors and intermediate factors. Similarly, five (PK, CK, PCK, TPK, TCK) out of the six (TK et al., PCK, TPK, TCK) factors demonstrated a strong and significant correlation with the core variable TPACK.

Q2. What is the predictive value of foundation-level variables leading to effective TPACK practices as perceived by the teachers of public and private universities in Pakistan?

As the correlation analysis reflected that most of the factors were positively and significantly correlated, step-wise regression was applied to identify the strong predictors of TPCK. The conceptual framework specified seven significant variables, out of which six variables—TK, PK, CK, PCK, TPK, TCK—were treated as independent variables, and one variable—TPACK—was treated as the dependent variable. In order to generate models, dependent variables were further sub-categorized at Foundation-level (TK et al.) and intermediate level (PCK, TPK, TCK). Seven factors and sub-factors— TK, PK, CK, PCK, TPK, TCK, and TPACK—were added to the model to manipulate the results further.

For answering question 2, step-wise regression was applied to identify the predictive value of foundation-level variables leading to effective TPACK practices.

Table 1: Model Summary: Foundation-Level (TPACK as Dependent Variable)

Model	*R*	*R Square*	*Adjusted R Square*	*Std. Error of the Estimate*
1	.613[a]	.376	.334	.43149

a. Predictors: (Constant), CK, TK, PK

Overall, the model was significant as a 37.6% change in TPACK can be accounted for the Foundation-level variables (PK, TK, CK). To assess the significance of each factor, multiple linear regression using stepwise methods was applied.

Table 2: Multiple Linear Regression using stepwise Methods: Foundation-Level (TPACK as Dependent Variable)

	Model	*B*	*t-value*	*p-value*
1	(Constant)		.701	.487
	PK	.404	3.017	.004
2	(Constant)		.701	.487
	PK	.404	3.017	.004
	TK	.026	.214	.832
3	(Constant)		.701	.487
	PK	.404	3.017	.004
	TK	.026	.214	.832
	CK	.307	2.249	.030

Model 1 illustrated that the PK relationship was surprisingly reliable for 40% of the variation in Pedagogical Knowledge (r=.404; P =.004). Model 2 explained that the factors PK and TK collectively influenced 42% (PK: r=.404; P=.004; TK: r=.026; P=.832). Model 3 explained that PK, TK, and CK were collectively responsible for a 72% variation (PK: r=.404; P=.004; TK: r=.026; P=.832; TK: r=.307; P=.030) in the dependent variable TPACK. The findings demonstrated that the teachers' pedagogical and technical knowledge contribute significantly to the quality of the subject matter offered.

Q3. What is the predictive value of intermediate-level variables leading to effective TPACK practices as perceived by the teachers of public and private universities in Pakistan?

To answer question 3, step-wise regression was applied to identify the predictive value of Intermediate-level variables leading to effective TPACK practices.

Table 3: Model Summary: Intermediate-Level (TPCK as Dependent Variable)

Model	*R*	*R Square*	*Adjusted R Square*	*Std. Error of the Estimate*
1	.754[a]	.568	.539	.35909

a. Predictors: (Constant), PCK, TPK, TCK

Overall, the model is significant as a 56.8% change in TPACK can be accounted for the intermediate-level variables (PK, TK, CK). To assess the significance of each factor, multiple linear regression using stepwise methods was applied.

Table 4: Multiple Linear Regression using stepwise Methods: Intermediate-Level (TPACK as Dependent Variable)

	Model	*B*	*t-value*	*p-value*
1	(Constant)		.016	
	PCK	.389	3.063	.004
2	(Constant)		.016	
	PCK	.389	3.063	.004
	TCK	.290	2.179	.035
3	(Constant)		.016	
	PCK	.389	3.063	.004
	TCK	.290	2.179	.035
	TPK	.210	1.644	.107

Model 1 illustrated that the PCK relationship was surprisingly reliable for 38% of the variation in Pedagogical Content Knowledge (r=.389; P =.004). Model 2 explained that the factors PCK and TCK collectively influenced 68% (PCK: r=.389; P=.004; TCK: r=.290; P=.035). Model 3 explained that PCK, TCK, and TPK were collectively responsible for an 89% variation (PCK: r=.389; P=.004; TCK: r=.290; P=.035; TPK: r=.210; P=.107) in the dependent variable TPACK. The Intermediate-Level model demonstrated that the interaction of pedagogical knowledge and content knowledge contributes the most to predicting variables to ensure effective TPACK practices. The findings correlate with the Foundation-level model as pedagogical knowledge (PK) contributes the most, with 40% variance, thus reflecting the strongest predictor. Thus, teachers should be knowledgeable about the pedagogic modalities for transformational teaching.

Discussion and Conclusion

The study delves into the critical issue of implementing Technological Pedagogical Content Knowledge (TPACK) among teachers in higher education institutions in Lahore, Pakistan, against the backdrop of the rapidly evolving digital landscape (Al-Zaidiyeen et al., 2010; Prestridge, 2012). The research reaffirms the core premise of the TPACK framework, emphasizing the intertwined nature of technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK) in effective technology integration (Mishra & Koehler, 2006). The study underscores the significance of pedagogical knowledge as a substantial predictor of TPACK proficiency (Soomro et al., 2018), highlighting that educators' proficiency in employing effective teaching strategies alongside technological tools is imperative (Koh et al., 2014). Additionally, it underscores the importance of content knowledge, indicating that teachers must robustly grasp the subject matter they teach to integrate technology (Afzal et al., 2023) effectively.

Furthermore, the study brings to light the pivotal role played by intermediate-level variables, particularly the synergy between pedagogical and content knowledge (PCK) and the combination of technological and pedagogical knowledge (TPK), in enhancing TPACK practices (Baran et al., 2009; Lee, Tsai, & 2013). Teachers who can effectively bridge pedagogical strategies with content-specific approaches and employ technology to facilitate this fusion are likelier to excel in TPACK (Koehler & Mishra, 2009; Chai et al., 2013). These findings have substantial implications for higher education institutions in Lahore, Pakistan, and beyond, offering a roadmap for comprehensive faculty development programs (Rafiq et al., 2022). These programs should simultaneously prioritize enhancing pedagogical knowledge, content knowledge, and technological skills, promoting collaborative learning among faculty members, and revisiting curriculum designs to incorporate TPACK principles (Soomro et al.,

2018). Additionally, institutions must ensure robust technology infrastructure and facilitate ongoing assessments of technology integration's impact while fostering a culture of continuous improvement (Afzal & Rafiq, 2022). By addressing these issues, institutions can bridge the digital divide among educators, ultimately leading to more effective pedagogy and content delivery in the digital age (Prestridge, 2017).

In conclusion, this research underscores the urgency of equipping teachers with the necessary skills to navigate the evolving educational landscape in the digital age (Jimoyiannis, 2010). It highlights that by integrating pedagogical knowledge, content knowledge, and technological proficiency, higher education institutions in Lahore and beyond can work toward more effective pedagogy and content delivery (Polly et al., 2010). This research serves as a foundation for further studies and actions to address the critical issue of technology integration in education, ensuring that educators are prepared to meet the demands of the 21st century (Chai et al., 2013).

Recommendations

The TPACK (Technological et al. Knowledge) framework is valuable for effectively integrating technology in higher education institutes. Here are some recommendations for using the TPACK framework in higher education:

Professional Development: Provide faculty members professional development opportunities to familiarize themselves with the TPACK framework. Offer workshops, seminars, or online courses to help educators understand how to integrate technology, pedagogy, and content knowledge in their teaching practices.

Collaborative Learning: Encourage collaboration among faculty members to share their experiences and best practices related to technology integration. Create communities of practice or online forums where educators can exchange ideas, resources, and challenges.

Curriculum Redesign: Use the TPACK framework to guide redesigning courses and curricula. Identify opportunities to integrate technology in meaningful ways to enhance content delivery, student engagement, and learning outcomes.

Technology Infrastructure: Ensure the institution has the necessary technology infrastructure and support to facilitate effective technology integration. It includes access to reliable internet, appropriate software, and technical support for faculty and students.

Ongoing Assessment: Continuously assess the impact of technology integration on teaching and learning outcomes. Use formative and summative assessments to evaluate the effectiveness of technology use and make data-informed decisions for improvement. Digital Literacy Training: Offer students digital literacy training and resources to ensure they are equipped to navigate and use technology effectively for learning purposes. It will empower students to take ownership of their learning and engage actively in technology-rich environments.

Faculty Support: Provide ongoing support and mentorship for faculty members as they implement the TPACK framework. Offer resources, peer coaching, and opportunities for sharing success stories to build confidence in using technology for teaching.

Continuous Improvement: Emphasize a culture of continuous improvement, where faculty and administrators are open to experimentation, learning from failures, and evolving their practices based on evidence and best practices.

By implementing the TPACK framework in higher education institutes, educators can create more meaningful and compelling learning experiences that leverage the potential of technology to enhance pedagogy and content delivery.

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