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Research Article

From Theory to Practice: Examining Self-Efficacy and TPACK Among Future Educators

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ABSTRACT

This study explored the relationship between Technological Pedagogical Content Knowledge (TPACK) and self-efficacy (SE) among future educators using a descriptive research design with simple random sampling. The sample included 300 future educators from government-aided education colleges in Punjab, categorized by gender and geographical background. Data collection involved the TPACK Scale developed by Schmidt et al. (2009) and the Self-Efficacy Scale by Schwarzer and Jerusalem (1995). Results indicated a strong positive correlation between TPACK components and self-efficacy, underscoring the significance of confidence in managing technology-integrated teaching. Additionally, ANOVA analysis showed notable main effects of gender and locale on TPACK, along with a significant interaction between the two, suggesting that these variables jointly influence technological-pedagogical capabilities. These outcomes highlight the importance of focused professional development, especially for future educators in rural areas, to improve their skills in integrating technology into pedagogy. Future studies could investigate other contributing factors, such as institutional backing and teaching practice, to further support TPACK development.

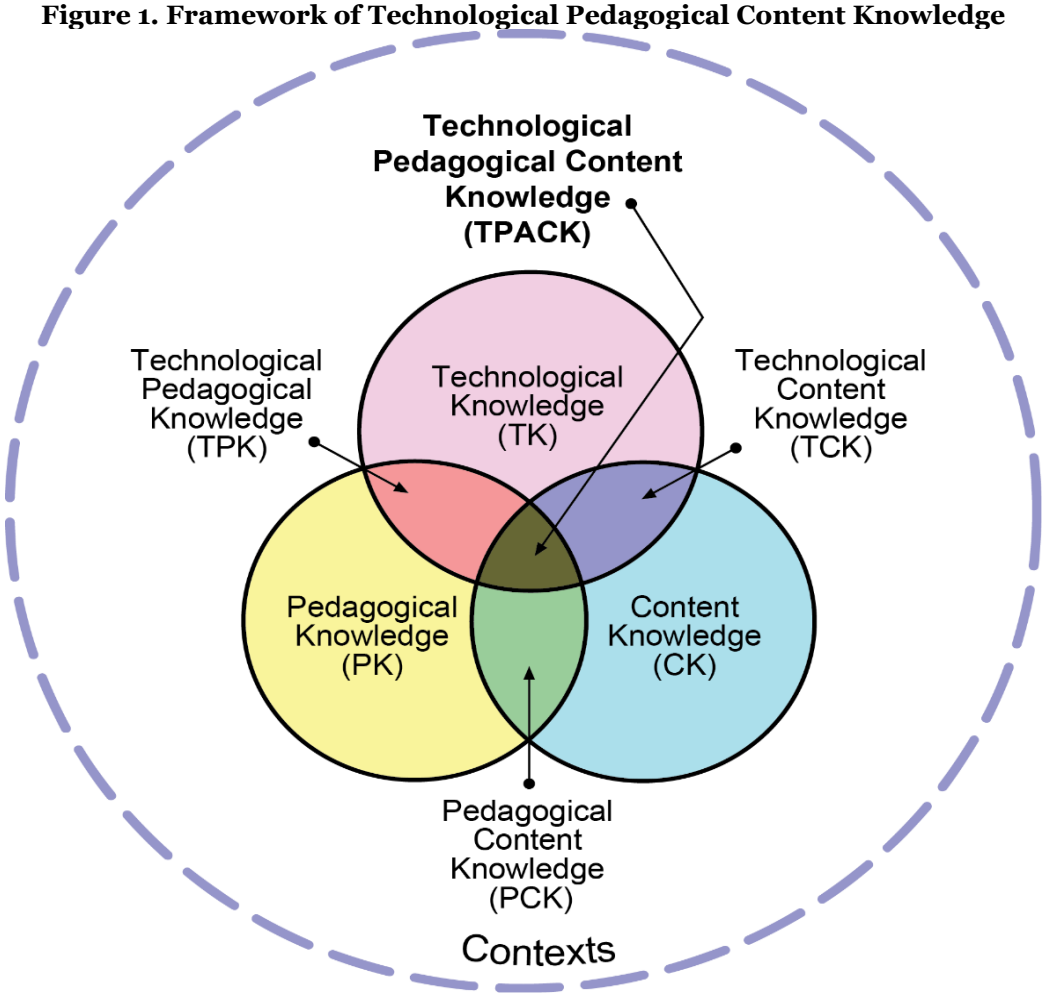
Keywords: TPACK (Technological pedagogical content knowledge), Technological knowledge (TK), Pedagogical knowledge (PK), Content Knowledge (CK), Self-efficacy (SE), Future educators

INTRODUCTION

Scientific and technological progress has significantly reshaped the landscape of education in recent years. Conventional teaching strategies, such as the use of chalkboards and the chalk-and-talk approach, are gradually being replaced by digital tools and technology-driven instructional methods. The growing emphasis on Information and Communication Technology (ICT) highlights the necessity for educators to incorporate technology seamlessly into their teaching practices (Graham et al., 2009). This integration has redefined the teacher's role in the classroom. Modern educators are now expected to function as techno-pedagogues—professionals who adeptly combine technology with instructional strategies to improve student learning outcomes. It is essential for today's teachers to be competent not only in operating technological tools but also in integrating them effectively with pedagogical strategies and subject matter content. To create meaningful and impactful learning environments, teachers in the 21st century must possess Technological Pedagogical Content Knowledge (TPACK), a comprehensive understanding that enables them to merge technology, pedagogy, and content to deliver effective and engaging instruction. The TPACK framework equips future educators with the necessary competencies to plan and implement technology-integrated learning experiences, ensuring their readiness for digital teaching environments.

The TPACK framework builds upon Shulman's concept of Pedagogical Content Knowledge (PCK), originally proposed in 1986, by incorporating the technological dimension. Introduced by Mishra and Koehler in 2006, the TPACK model provides a structure that supports teachers in thoughtfully integrating technology into their pedagogical and content knowledge. It encompasses seven interconnected domains: Technological Knowledge (TK), Pedagogical Knowledge (PK), Content Knowledge (CK), Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK), and the integrative core of Technological Pedagogical Content Knowledge (TPACK), as illustrated in Figure 1.

Figure 1. Framework of Technological Pedagogical Content Knowledge



Source: https://tpack.org/wp-content/uploads/2024/02/TPACK.png

Technology Knowledge (TK)

Technology Knowledge refers to a teacher's understanding and competence in using digital tools within a technology-supported learning environment. This includes knowledge of devices such as laptops, the Internet, and various software applications. TK extends beyond simple digital proficiency and encompasses the ability to adapt and innovate with existing technologies to enhance instructional effectiveness in educational contexts.

Content Knowledge (CK)

Content Knowledge signifies a teacher's thorough understanding of the academic subject they teach. This involves deep insight into key concepts, theories, principles, and structures of the discipline. It enables teachers to communicate complex subject matter effectively, promote critical thinking, and support meaningful student learning. Educators with strong content knowledge are well-versed in the standards of evidence and inquiry unique to their discipline and understand how knowledge is generated and validated within the field.

Pedagogical Knowledge (PK)

Pedagogical Knowledge involves a teacher's in-depth understanding of the processes of teaching and learning. It covers educational goals, values, and strategies for managing classrooms, designing instructional plans, and evaluating student performance. Teachers with substantial PK comprehend how learners develop and how to support this development through theories of learning, including cognitive, developmental, and social perspectives. Such knowledge helps them create inclusive, engaging, and productive learning environments that encourage academic growth and student motivation.

Technological Pedagogical Knowledge (TPK)

Technological Pedagogical Knowledge requires educators to skillfully select and use technological tools that align with specific pedagogical goals. TPK is about matching appropriate technology with effective teaching strategies to improve learning outcomes. It demands flexibility and creativity from teachers as they explore innovative applications of technology to enhance instruction, ensuring that the selected tools genuinely support learning objectives rather than serve as mere add-ons.

Technological Content Knowledge (TCK)

Technological Content Knowledge focuses on the intersection between subject content and technology. It involves understanding how to use technological tools to present subject matter in engaging and accessible ways. TCK enables teachers to determine the most effective technologies for teaching specific content and to understand how the nature of the subject matter affects the choice and application of digital tools. It reflects an awareness of how technological developments influence how content can be understood and communicated.

Pedagogical Content Knowledge (PCK)

Pedagogical Content Knowledge represents the integration of a teacher's pedagogical skills with their content expertise. It reflects a teacher's ability to apply the most appropriate teaching strategies for delivering specific subject matter. PCK involves understanding how students learn particular topics and how best to teach them, combining what to teach with how to teach it. This enables educators to select and adapt instructional methods that align with the subject's nature and students' learning needs.

Technological Pedagogical Content Knowledge (TPACK)

Technological Pedagogical Content Knowledge (TPACK) represents the harmonious convergence of three essential knowledge components: TK (Technological Knowledge), PK (Pedagogical Knowledge), and CK (Content Knowledge). Educators with TPACK understand how to effectively deliver content by combining pedagogical strategies with technology. TPACK represents the comprehensive knowledge required for teachers to incorporate technology into their specific subject areas. It involves using suitable technologies to deliver content effectively by understanding the interplay between pedagogical methods and subject content.

Due to TPACK's comprehensive nature, many teachers face challenges in integrating advanced technology due to inadequate pre-service preparation (Heitink et al., 2016). Novice and future educators often lack the necessary skills (Tondeur et al., 2018). Studies have examined TPACK with variables like technology anxiety (Ajith Kumar, 2017) and self-assessment (Max et al., 2022). Teachers' beliefs significantly influence ICT integration (Angeli & Valanides, 2009); unprepared teachers may experience diminished self-assurance. A pre-service teacher's confidence in their ability to effectively integrate technology, pedagogy, and content (TPACK) is likely intertwined with their overall sense of self-efficacy.

SELF-EFFICACY (SE)

Self-efficacy, as conceptualized by Bandura, refers to an individual's belief in their ability to execute specific actions and achieve particular outcomes successfully (Bandura, 1997). It centers on a person's internal confidence in their potential to succeed. Pajares (2002) further defines self-efficacy (SE) as an individual's assessment of their own capability to reach designated goals. This belief significantly influences one's actions, motivational levels, and cognitive processes (Bandura, 1997).

Bandura identified four key psychological processes that contribute to self-efficacy and its role in human functioning:

a) Cognitive processes involve setting ambitious goals and preparing for potential setbacks, guided by one's belief in personal competence.

b) Motivational processes inspire sustained effort and persistence, driven by thoughts of future accomplishments.

c) Affective processes enhance one's ability to manage emotional challenges like stress and depression, thereby fostering greater confidence in difficult circumstances.

d) Selection processes guide the choices individuals make and the activities they engage in, often opting for challenges they believe they can manage, shaped by environmental and social influences.

Self-efficacy plays a vital role in both personal and social spheres by promoting self-assurance, resilience, and the determination needed to overcome barriers and achieve desired objectives.

In his 1977 work, Bandura also detailed four principal sources of self-efficacy:

a) Mastery experiences—Confidence is built through repeated successes and learning from failures.

b) Vicarious experiences—Observing the achievements of others can reinforce one's own belief in their capabilities.

c) Verbal persuasion—Receiving encouragement and affirmative feedback can strengthen an individual's confidence.

d) Emotional and physiological states—A person's physical and emotional condition can affect self-efficacy; positive states enhance confidence, while negative states can diminish it.

In professional settings, self-efficacy is essential for navigating career progression and facing professional obstacles. It significantly affects motivation and cognitive development. Among future educators, their perceptions and understanding of inclusive practices strongly predict their overall sense of efficacy (Isarawi &

Sukonthaman, 2021). Moreover, teachers' self-efficacy concerning the integration of technology directly affects their actual use of digital tools in educational settings (Lee & Lee, 2014; Sharma & Sharma, 2019).

In the context of TPACK, mastery experiences are particularly relevant. When future educators successfully apply technology in their instructional practice, they not only gain valuable experience but also enhance their confidence, reinforcing their belief in their ability to integrate technology effectively in the future. Additionally, emotional and physiological states—such as anxiety about using technology—can impact self-efficacy, thereby influencing TPACK development. Negative emotions like technology-related anxiety may reduce both confidence and the effectiveness of technology use in teaching.

Many aspiring teachers still lack the necessary skills to integrate technology effectively into their instructional practices (Tondeur et al., 2016). Despite its significance, limited research has focused on the relationship between TPACK and self-efficacy, particularly within the context of Punjab, India. The state's educational environment presents distinct challenges, such as inconsistent digital infrastructure and variations in teacher training quality between urban and rural regions (Dheva Rajan & Fajlul Kareem, 2023). Gaining insight into this relationship is vital for developing robust and effective teacher preparation programs. Therefore, it is posited that greater levels of self-efficacy will be positively associated with higher TPACK proficiency among future educators.

OBJECTIVES

1. To examine differences in TPACK and self -efficacy among future educators based on locale.
2. To examine the relationship between TPACK domains and self-efficacy among pre-service educators.
3. To examine the interaction effect of gender and locale on TPACK among future educators.

HYPOTHESES

1. There is a significant difference in TPACK and self-efficacy among future educators based on locale.
2. There is a significant relationship between TPACK domains and self-efficacy among future educators.
3. There is a significant interaction effect of gender and locale with TPACK among future educators.

RESEARCH METHODOLOGY

Sample

A descriptive survey approach was employed to collect quantitative data. A simple random sampling method was used to select a sample of 300 future educators from government-aided colleges in Punjab, enrolled in the second year of the Bachelor of Education (B.Ed.) program during the 2023–24 academic session. Among the participants, 130 (43.3%) were male and 170 (56.7%) were female. Additionally, 167 (55.7%) resided in urban areas, while 133 (44.3%) were from rural areas. Participants were recruited through official college communication channels, where invitations containing a Google Forms link were shared via WhatsApp groups. The form included clear instructions, the study's objectives, and details about voluntary participation. Confidentiality was ensured by anonymizing responses and restricting data access exclusively to the researcher. Participants were informed that their data would be used solely for research purposes, and informed consent was obtained before participation.

Data Collection Tools

- *TPACK (Technological Pedagogical Content Knowledge) Scale*: The scale, developed by Schmidt, D. A. et al. (2009), was utilized to assess the technological pedagogical content knowledge (TPCK) of future educators. The scale encompasses seven domains: Technological Knowledge (TK), Pedagogical Knowledge (PK), Content Knowledge (CK), Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK), and Technological Pedagogical Content Knowledge (TPCK). The overall TPACK score is calculated by summing the scores of these seven domains. The scale consists of 51 items, each rated on a 5-point Likert scale, ranging from 1 ("Strongly Disagree") to 5 ("Strongly Agree"). It demonstrates excellent reliability, with a Cronbach's Alpha coefficient of 0.88.
- *The Generalized Self-Efficacy Scale (GSES):* The Generalized Self-Efficacy Scale (GSES), developed by Schwarzer and Jerusalem (1995), is a widely used psychological instrument designed to measure an individual's belief in their ability to handle challenging situations and achieve goals. This scale comprises 10 statements that evaluate the confidence of a person in their capacity to handle novel or challenging situations, as well as their ability to navigate any obstacles or setbacks that may arise. It employs a 4-point Likert scale, ranging from 1 "Not at all true" to 4 "Exactly true". The score measures the degree of an individual's belief in their own competence and ability to succeed. A higher score reflects a higher individual's generalized self-efficacy and vice-versa.

DATA ANALYSIS AND RESULTS

Data processing and analysis were facilitated by SPSS version 22.0. Descriptive analysis and correlation analysis were employed for the statistical treatment of the data. The analysis is shown in various sections: (i) Descriptive Analysis and (ii) Correlation Analysis (iii) Univariate Analysis of Variance

(i) Descriptive Analysis: - The mean (M) and standard deviation (SD) of TPACK and Self-efficacy among future educators is presented in Table 1.

Table 1. ***Descriptive analysis of TPACK and SE among future educators***

Variables	Mean	Std. Deviation
TK	25.65	5.43
PK	31.88	5.91
CK	23.07	4.66
TPK	29.96	6.62
TCK	21.97	4.86
PCK	31.18	5.40
TPCK	29.83	6.69
TPACK	192.74	36.78
Self-efficacy	33.29	5.88

Table 1 displays the mean scores and standard deviations of various variables related to Technological Pedagogical Content Knowledge (TPACK) and Self-Efficacy among future educators. The mean scores for the TPACK components range from 25.65 (TK) to 29.83 (TPCK), with the overall TPACK mean at 192.74 and standard deviation 36.78. The mean score for self-efficacy is 33.29, with a standard deviation of 5.88.

Table 2 ***The t-Values testing the significance of locale-wise mean differences in TPACK and self-efficacy among future educators***

Variable	Urban (N=167)	Rural (N=133)	t-value	Significance Level
TPACK	199.66 (33.78)	184.04 (38.63)	3.678*	$p < 0.05$
Self-Efficacy	34.72 (5.19)	31.50 (6.21)	4.78*	$p < 0.05$

* Significant at 0.05 level.

Table 2 presents the t-values for locale-wise differences in both TPACK and self-efficacy among future educators. The mean TPACK score for urban future educators (M = 199.66, SD = 33.78) is significantly higher than that of their rural counterparts (M = 184.04, SD = 38.63), with a t-value of 3.678 ($p < 0.05$). This suggests that urban future educators demonstrate greater competence in integrating technology, pedagogy, and content knowledge, Similarly, in terms of self-efficacy, urban future educators (M = 34.72, SD = 5.19) report higher confidence in their teaching abilities compared to rural future educators (M = 31.50, SD = 6.21), with a t-value of 4.78 ($p < 0.05$). This finding suggests that urban future educators feel more capable and prepared to handle teaching challenges.

Thus, the hypothesis "There is a significant difference in TPACK and self-efficacy among future educators based on locale" fails to be rejected.

(ii) Correlation Analysis

A Pearson correlation coefficient was calculated to evaluate the association between TPACK (Technological Pedagogical Content Knowledge) and self-efficacy. The results of the correlation analysis are presented in Table 4, which presents the correlation coefficient values between TPACK and self-efficacy.

Table 3 ***Correlation between TPACK domains & SE across gender among future educators***

	TK	PK	CK	TPK	TCK	PCK	TPCK	TPACK	Self-efficacy
TK	1	.635**	.627**	.668**	.628**	.552**	.609**	.760**	.553**
PK	.635**	1	.783**	.794**	.675**	.750**	.752**	.862**	.641**
CK	.627**	.783**	1	.864**	.810**	.792**	.766**	.905**	.699**
TPK	.668**	.794**	.864**	1	.867**	.836**	.882**	.953**	.712**
TCK	.628**	.675**	.810**	.867**	1	.765**	.868**	.905**	.760**
PCK	.552**	.750**	.792**	.836**	.765**	1	.807**	.885**	.651**
TPCK	.609**	.752**	.766**	.882**	.868**	.807**	1	.918**	.772**
TPACK	.760**	.862**	.905**	.953**	.905**	.885**	.918**	1	.785**
Self-efficacy	.553**	.641**	.699**	.712**	.760**	.651**	.772**	.785**	1

**. Correlation is significant at the 0.01 level

The correlation matrix presented in Table 3 illustrates the relationships between different components of Technological Pedagogical Content Knowledge (TPACK) and self-efficacy. All correlations are significant at the $p < .01$ level, indicating strong interconnections among the variables. Notably, TPACK exhibits the highest correlations with its subcomponents, particularly with Technological Pedagogical Knowledge (TPK) ($r = .953$) and Content Knowledge (CK) ($r = .905$), demonstrating its integrative nature. Among the subcomponents, CK and TPK also show a strong correlation ($r = .864$), emphasizing the interdependence of content knowledge and pedagogical applications of technology. Additionally, self-efficacy is positively correlated with all components, with the strongest associations observed with TPACK ($r = .785$) and TPCK ($r = .772$), highlighting the importance of confidence in handling technology-related aspects of teaching. These results indicate that future educators with higher self-efficacy are more likely to embrace innovative teaching strategies and integrate digital tools effectively. Therefore,

The hypothesis "There is a statistically significant association in TPACK domains and self-efficacy among future educators" fails to be rejected.

(iii) Two Way Analysis of Variance

To study the main and interaction effects of the categorical variables gender (male and female) and locale (urban and rural) on TPACK, Two-Way Analysis of Variance was applied using SPSS 27.0. The assumptions of normality and homogeneity of variance were tested and met, ensuring the validity of the ANOVA results. The findings of the **2×2** ANOVA are presented in Table 4.

Table 4 ***Table 5 ANOVA Table: The Effects of Gender and Locale on the TPACK***

Tests of Between-Subjects Effects					
Dependent Variable: TPACK					
Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	31789.200[a]	3	10596.400	8.414	.000
Intercept	10763289.499	1	10763289.499	8546.624	.000
Gender	5018.852	1	5018.852	3.985	.047
Locale	14749.857	1	14749.857	11.712	.001
Gender * Locale	10071.143	1	10071.143	7.997	.005
Error	372770.997	296	1259.361		
Total	11548787.000	300			
Corrected Total	404560.197	299			
a. R Squared = .079 (Adjusted R Squared = .069)					

The Tests of Between-Subjects Effects table 4 presents the results of two-way analysis of variance (ANOVA) examining the effects of gender, locale, and their interaction on TPACK scores among future educators. The results indicate that gender, locale, and their interaction significantly influence TPACK scores among future educators. While the model is significant ($F = 8.414$, $p = .000$), the R-squared value (.079) suggests that only 7.9% of the variance in TPACK is explained by these factors, implying the influence of other unexamined variables.

Gender differences reveal those male future educators ($M = 196.440$) score significantly higher level of TPACK than females ($M = 188.135$) ($F = 3.985$, $p = .047$). Similarly, urban future educators ($M = 199.406$) outperform rural counterparts ($M = 185.169$) ($F = 11.712$, $p = .001$).

A significant interaction effect ($F = 7.997$, $p = .005$) shows that gender differences vary across locales. Urban females ($M = 201.135$) have the highest TPACK scores, surpassing even male future educators, while rural females ($M = 175.135$) score the lowest. Rural males ($M = 195.203$) perform better than rural females but slightly lower than urban males ($M = 197.676$). Overall, urban future educators outperform rural ones, and males generally score higher than females.

Hence, the hypothesis, "There is a significant interaction effect of gender and locale on TPACK among future educators", fails to be rejected.

DISCUSSION

This research explored the interrelationship between TPACK and self-efficacy among future educators, examining differences across geographic location (locale). The study found significant differences in both TPACK and self-efficacy levels based on locale, with urban future educators demonstrating higher levels in both constructs compared to their rural counterparts. These findings align with previous studies highlighting disparities in technology access and training opportunities between urban and rural areas (Tondeur et al., 2016). In contrast, research by Brown (2022) found that most high school teachers in rural districts reported high self-efficacy in implementing blended learning. These findings emphasize the need for targeted interventions, such as enhancing digital infrastructure, implementing teacher training programs, and introducing mobile learning solutions to support rural teacher education programs effectively.

The current study presents a strong positive correlation between TPACK and self-efficacy among future educators, indicating that as self-efficacy improves, so does their ability to apply the TPACK framework. This

finding aligns with Bandura's (1997) social cognitive theory, which suggests that confidence in one's abilities influences performance in specific domains. In this context, future educators who believe in their capability to integrate technology into pedagogy while considering content requirements are more likely to develop and apply TPACK competencies. This study's findings are consistent with previous research highlighting the positive correlation between self-efficacy and TPACK. Zeng et al. (2022) and Birisci and Kul (2019) both demonstrated that teachers with higher self-efficacy in technology integration exhibited stronger TPACK competencies, reinforcing the role of confidence in effective techno-pedagogical application. Given these correlations, self-efficacy emerges as a key determinant in how effectively future educators acquire and apply TPACK skills, underscoring the importance of fostering confidence in their ability to integrate technology into teaching.

The results of the two-way analysis of variance (ANOVA) indicate that gender, locale, and their interaction significantly influence TPACK scores among future educators. The findings reveal that both gender and locale independently affect TPACK, highlighting demographic differences in technological pedagogical competence. Additionally, a significant interaction effect suggests that the influence of gender on TPACK varies depending on locale, with urban females demonstrating the highest TPACK scores, while rural females score the lowest. This indicates that gender differences in TPACK are more pronounced in rural settings, emphasizing the need to address contextual disparities in teacher preparation programs. Consistent with Ma & Baek (2020), gender had a significant effect on Technology Knowledge (TK) and interacted with teacher type (pre-service vs. in-service). Additionally, the results support Alshehri (2012), who found a significant effect of locale on TPACK, with urban teachers reporting higher self-perceived TPACK scores compared to their rural counterparts. Addressing urban-rural disparities requires equitable access to digital infrastructure and professional development. Expanding high-speed internet, interactive tools, and mobile-based training can empower rural future educators. Collaboration between policymakers, institutions, and ed-tech companies can bridge the digital divide, ensuring all educators develop the technological competencies needed for innovative and future-ready teaching.

The general findings highlight the need for teacher education programs to enhance future educators' self-efficacy and TPACK through hands-on technology training, peer collaboration, and mentorship. Structured mentorship, digital learning projects, and simulated teaching experiences can strengthen their technological pedagogical confidence, fostering essential 21st-century skills like digital literacy, problem-solving, and adaptability.

Limitations and Future Research Directions

While this study provides valuable insights, several limitations must be acknowledged. The reliance on self-reported measures introduces the possibility of response bias, as participants may overestimate or underestimate their self-efficacy and TPACK levels. Future studies could incorporate performance-based assessments or classroom observations to provide more objective evaluations. Additionally, the study focused solely on government-aided colleges in Punjab, limiting the generalizability of findings. Expanding the sample to include diverse institutional settings, such as private universities and teacher training centers, would enhance the applicability of results.

Further, the correlational nature of this study prevents causal inferences. While strong associations were found between TPACK and self-efficacy, longitudinal or experimental designs would be necessary to determine whether increases in self-efficacy directly led to improved TPACK outcomes. Comparative studies across different cultural and educational contexts could also offer deeper insights into how self-efficacy shapes TPACK development in varying learning environments.

Finally, future research should explore additional moderating factors, such as prior exposure to technology, teacher training curricula, and institutional support mechanisms, to better understand the nuanced influences on TPACK and self-efficacy. Examining these constructs among in-service teachers and across specific subject disciplines could provide further insights for targeted professional development initiatives. Investigating how policy-level interventions—such as state-funded technology training programs or school-based digital literacy initiatives—impact teacher self-efficacy and TPACK adoption could also yield valuable findings.

CONCLUSION

The study highlights the significant role of self-efficacy in shaping TPACK among future educators, reinforcing its importance in developing technological pedagogical competence. Significant locale disparities were observed, with urban future educators exhibiting higher levels of Technological Pedagogical Content Knowledge (TPACK) and self-efficacy compared to their rural counterparts. The strong positive correlations between TPACK and self-efficacy further underscore their interconnectedness, suggesting that enhancing self-efficacy can be a strategic approach to strengthening TPACK development among future educators.

These findings underscore the need for structured interventions that enhance future educators' confidence in technology use while simultaneously bridging the digital divide between urban and rural learners. Future research should continue exploring these relationships through longitudinal studies, experimental designs, and cross-cultural comparisons, ultimately contributing to more effective teacher preparation models for the digital age.

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