

**RESEARCH PAPER****Investigating the Relationship between Pre-Service Teachers' Cognitive Flexibility and Techno-Pedagogical Competencies: A Pathway to Effective Teaching in the Digital Age****¹Dr. Tariq Hussain* and ²Ifrah Jamil**

1. Assistant Professor, Institute of Education and Research, University of the Punjab, Lahore, Punjab, Pakistan
2. M.Phil, Scholar, Institute of Education and Research, University of the Punjab, Lahore, Punjab, Pakistan

Corresponding Author

tariq.ier@pu.edu.pk

ABSTRACT

The study aimed to investigate the relationship between pre-service teachers' cognitive flexibility and their techno-pedagogical competencies, comparing influencing factors such as program enrollment and access to technology. Incorporating technology in education requires adaptability and competence. Understanding how cognitive flexibility affects techno-pedagogical skills is vital for enhancing teacher preparation programs. A correlation research design with a quantitative approach was utilized. Data were collected from students enrolled in BS, B.Ed., and pre-service teacher training programs using a self-developed 45-item instrument with a 5-point Likert scale. The sample was selected through multistage sampling, and the instrument's reliability (Cronbach's alpha: 0.861) was validated. The findings showed significant differences in cognitive flexibility and techno-pedagogical competencies based on program type, computer access, and internet availability. A positive correlation between cognitive flexibility and techno-pedagogical skills was observed. Enhancing access to technology and fostering adaptability through targeted training programs can improve pre-service teachers' techno-pedagogical competencies.

Keywords: Cognitive Flexibility and Techno Pedagogical Competencies, Pre Service Teachers**Introduction**

The traditional chalk-and-talk teaching approach has transitioned into a digital pedagogical model utilizing advanced technological tools. This shift not only enhances instructors' abilities but also broadens students' knowledge bases, preparing them for global competitiveness. In the 21st century, the integration of technology with effective pedagogical principles, termed "techno-pedagogical competency" by Niess (2005), is critical. This competence involves designing, implementing, and evaluating educational processes to maximize learning outcomes, blending technology and pedagogy into the teaching environment (Lee & Tsai, 2010).

Teachers today must demonstrate cognitive flexibility and techno-pedagogical skills to meet the challenges of a rapidly evolving educational landscape. Despite progress in integrating technology into classrooms, barriers such as insufficient training, resource constraints, and resistance to change hinder the development of these competencies. In Pakistan, these challenges are further compounded by systemic limitations, highlighting the urgent need for a multimodal strategy to equip educators with the required skills.

Studies show that cognitive flexibility enables teachers to adapt to change, while techno-pedagogical competencies ensure effective technology integration in instruction (Orhaner&Tunç, 2003). Yet, in Pakistan, research in this domain remains limited, despite

significant global advancements. Addressing this gap is essential for fostering a dynamic and inclusive education system capable of meeting international standards.

Efforts to prepare pre-service teachers for technology use have encountered obstacles, revealing that technical skills alone do not guarantee effective classroom integration (Lambert, 2010). Training programs must therefore emphasize a balance between technical expertise, cognitive adaptability, and pedagogical strategies.

In conclusion, enhancing cognitive flexibility and techno-pedagogical competencies is vital for developing capable educators who can navigate the demands of modern education. Future studies should inform policymakers and educational institutions to optimize training programs, improve system effectiveness, and elevate education quality to international standards.

This research aims to investigate the extent to which cognitive flexibility (CF) in pre-service teachers—defined as their ability to adapt thinking strategies when confronted with new or unfamiliar situations—affects their proficiency in techno-pedagogical education. Specifically, this study will explore the relationship between CF and the acquisition, integration, and application of technological tools and pedagogical approaches in educational contexts.

As Akpınar (2003) emphasized, it is crucial for teachers not only to keep pace with technological advancements but also to effectively utilize technology in the planning of learning activities. Tinio (2003) further argued that successful integration of technology in education depends on various factors, including teaching and curriculum design, educators' teaching abilities, long-term funding, institutional preparedness, and the fostering of lifelong learning skills. Techno-pedagogical competence (TPC) encompasses a wide range of skills and knowledge areas essential for the effective integration of technology in instruction. This study seeks to deepen our understanding of how teacher training programs for prospective educators can be designed to improve both student learning outcomes and teaching effectiveness in the 21st century. By examining the relationship between cognitive flexibility and techno-pedagogical abilities, the research aims to identify how these factors can be leveraged to enhance teaching practices and learning experiences.

Literature Review

Cognitive flexibility is increasingly recognized as a crucial skill for educators in the 21st century, enabling them to respond to diverse teaching scenarios and adapt instructional methods to suit varied learning environments. Cognitive flexibility allows teachers to manage complexity, switch between multiple teaching strategies, and apply creative solutions to classroom challenges. This adaptability is linked to improved learning outcomes, as teachers can better align their practices with students' evolving needs (Spalding, Klecka, Lin, Wang, & Odell, 2010). Moreover, it supports teachers in navigating digital learning environments, which often require multitasking and rapid adjustment to technological tools and platforms (Dajani & Uddin, 2015).

Research has highlighted that fostering cognitive flexibility among pre-service teachers significantly impacts their ability to integrate technology effectively into pedagogy. For instance, individuals with higher cognitive flexibility are better equipped to embrace innovative teaching technologies and adapt their lesson plans to include interactive and digital tools (Braem & Egner, 2018). Developing this skill during teacher education programs ensures that teachers are not only competent but also resilient in facing educational shifts (Diamond, 2013).

The Role of Techno-Pedagogical Competencies in Modern Classrooms

Techno-pedagogical competencies play a crucial role in bridging the gap between traditional pedagogical methods and the innovations brought about by modern technology. These competencies are not merely about the use of digital tools but also involve the thoughtful integration of content knowledge with the appropriate technological tools to enhance student learning outcomes. Teachers with strong techno-pedagogical skills can design lessons that effectively incorporate technological resources, ensuring that educational strategies remain relevant and engaging in today's digitized and interconnected education systems (Mishra & Koehler, 2006). This combination of technological and pedagogical knowledge allows educators to provide more dynamic, interactive, and effective teaching experiences, tailored to the needs of 21st-century learners. Several studies have emphasized the importance of these techno-pedagogical competencies in creating a positive and effective learning environment. For instance, Koehler, Mishra, and Cain (2013) highlight the Technological Pedagogical Content Knowledge (TPACK) framework as a fundamental model for teachers to blend technology seamlessly with subject-specific pedagogy. This framework provides a holistic approach, where educators are not just experts in their content area, but also proficient in selecting and implementing technological tools that align with their teaching objectives. These competencies empower teachers to create interactive lessons, utilize online assessment tools, design multimedia-rich content, and encourage collaborative learning through digital platforms, making learning more engaging and accessible for all students.

The increasing emphasis on e-learning and blended learning models further underscores the need for educators to be proficient in using virtual learning environments, digital content creation, and online communication tools (Chai, Koh, & Tsai, 2011). As digital classrooms continue to evolve, educators are expected to leverage a wide variety of technologies to enhance instruction and provide students with diverse learning opportunities. These may include video lectures, online discussions, real-time feedback, and interactive simulations, which foster greater student engagement and participation.

Furthermore, educators with well-developed techno-pedagogical competencies are better equipped to address the diverse learning needs and preferences of students. This enables them to tailor lessons to accommodate different learning styles, making education more inclusive and student-centered. Jeyaraj and Ramnath (2018) assert that techno-pedagogical competencies allow educators to move away from the "one-size-fits-all" approach and toward personalized, differentiated instruction, ensuring that every student can learn in the way that suits them best. By integrating technology thoughtfully, teachers can create more flexible and responsive learning environments that engage students, cater to their individual needs, and ultimately improve educational outcomes.

In conclusion, as educational landscapes continue to evolve with technology, the role of techno-pedagogical competencies becomes increasingly important. Educators must not only keep up with technological advancements but also be skilled in using these tools to enhance teaching and learning. By fostering these competencies, schools can ensure that their teaching staff is prepared to meet the challenges and opportunities of modern education, providing students with the skills they need to succeed in a digital world.

Synergy between Cognitive Flexibility and Techno-Pedagogical Competencies

The interplay between cognitive flexibility and techno-pedagogical competencies creates a robust framework for addressing the challenges of contemporary education. Teachers with these combined attributes can effectively implement differentiated instruction and cater to a variety of learning preferences, ensuring equity in education (Hommel & Colzato, 2017).

Recent studies highlight that cognitive flexibility enhances teachers' willingness to experiment with new technologies, fostering an innovative mindset. This dynamic enables educators to stay updated with technological advancements and integrate them meaningfully into their teaching (Eshet-Alkalai, 2004). Conversely, the acquisition of techno-pedagogical competencies can promote cognitive flexibility by encouraging teachers to engage in lifelong learning and adapt to evolving educational technologies (Goschke, 2003).

Moreover, technology-driven teaching environments, such as flipped classrooms and online courses, provide opportunities for educators to refine their cognitive flexibility while enhancing their techno-pedagogical skills. These environments demand multitasking, problem-solving, and quick decision-making, all of which are facilitated by cognitive flexibility (Meiran et al., 2011).

Theoretical Framework

Instructors are the primary agents responsible for integrating technology into teaching processes within schools. As a result, the topic of techno-pedagogical competencies has garnered significant attention from scholars and has been extensively examined across various countries since the early 21st century. Consequently, it is imperative for pre-service and in-service teachers to stay current with technological advancements while continuously refining their professional knowledge, skills, and perspectives. Additionally, they must possess the competencies required to apply technological tools effectively at various levels of instruction (Akgün, 2013). This study is grounded in two key theoretical frameworks: Cognitive Flexibility Theory and Constructivist Theory of Learning. Cognitive Flexibility Theory emphasizes the importance of promoting diverse cognitive strategies and perspectives within learning environments to foster deeper understanding and flexible thinking. This theory advocates for the ability to shift between different problem-solving approaches and adapt to novel, unpredictable situations.

On the other hand, Constructivist learning theories, rooted in educational psychology, stress the active construction of knowledge by learners. According to constructivism, learning is a dynamic, interactive process in which individuals engage with new information, link it to their existing knowledge, and develop a coherent worldview. In the context of teaching, constructivist approaches advocate for student-centered, inquiry-based learning experiences that promote exploration, collaboration, and reflection. Both of these theories are pivotal in understanding how teachers' cognitive flexibility and techno-pedagogical competencies can be nurtured. By exploring these theories, we can gain a clearer understanding of how the integration of technology in education requires flexibility on the part of teachers to foster active, engaged learning. These frameworks provide valuable insights into how teachers can adapt to changing educational landscapes and effectively incorporate technology to enhance learning outcomes.

Material and Methods

The research methodology of this study was employed to investigate the relationship between pre-service teachers' cognitive flexibility (CF) and techno-pedagogical competencies (TPC). A quantitative correlation research design was adopted, targeting pre-service teacher programs in Lahore. Using a multi-stage sampling technique, a sample of 450 students was selected from the University of Punjab, Government University, and the University of Lahore.

The research instrument was self-developed, drawing from established scales such as the Cognitive Flexibility Scale (CFS) by Martin & Rubin (1995) and the TPACK-Deep Scale by KabakciYurdakul et al. (2012). The modified instrument included 45 items

divided into sub-factors like self-awareness, self-willingness, self-efficacy for CF, and instructional design, content organization, technology integration, and proficiency for TPC. Validity was confirmed by experts, while reliability testing showed an overall Cronbach Alpha value of 0.861, indicating high reliability.

Pilot testing involved 50 students to ensure clarity and ease of response. Data were collected through personal visits and online forms. Analysis was conducted using SPSS, employing descriptive and inferential statistics, including Pearson correlation, to explore the relationship between CF and TPC among pre-service teachers.

Results and Discussion

Table 1
Pre-service teachers' cognitive flexibility in terms of program

	program	N	Mean	SD	T-value	Sign.
Cognitive flexibility	BS (hons)	311	71.9035	9.52638	.860	.188
	B.Ed	138	73.1739	9.17463		

Table above show the finding of independent sample t-test to identify the mean difference in the CF of the respondents in term of their programs. The results of independent sample t-test shows that the significance is statistically difference, $t(\text{sign}.188) = .860$, $p > 0.05$. It is conclude that BS Hons students have high cognitive flexibility as compare to the B.Ed students. The majority of the respondents were from BS Hons program and show that they have much cognitive flexibility as compared to B.Ed students.

Table 2
Pre-service teachers' cognitive flexibility in terms of computer availability

	Computer Availability	N	Mean	SD	T-value	Sign.
Cognitive flexibility	Yes	384	72.8880	9.48190	.167	.001
	No	65	68.7846	8.33759		

Table show the the value t-test for evaluating the mean comparison in the cognitive flexibility of the participants in term of computer availability. The analysis depicts that there is significance difference with t value, $t(\text{sign}=.001) = .167$, $p > 0.05$. The students who have computer facility shows high cognitive flexibility as the participants who don't have the computer facility show low cognitive flexibility.

Table 3
Pre-service teachers' cognitive flexibility in terms of Internet access

	Internet Access	N	Mean	SD	T-value	Sign.
Cognitive flexibility	Yes	376	72.8670	9.38074	.766	.002
	No	72	69.1667	9.11430		

Above table shows the analysis of mean comparison among the respondents who have internet access. The analysis of the above statistics shows the significance difference with value $t(.002) = .766$, $p > 0.05$ that clearly shows the participants with internet facility were much more cognitive flexible than the participants who don't have internet were less cognitively flexible while handling or facing uncertain conditions.

Table 4
Pre-service teachers' techno-pedagogical competencies in terms of program

	Program	N	Mean	SD	T-value	Sign.
Techno pedagogical Competencies	BS (Hons)	311	87.7299	12.885	.647	.524
	B.Ed	138	86.9130	11.695		

Table above show the results of independent sample t-test to identify the mean difference in the techno pedagogical competencies of the respondents in term of their programs. The results of independent sample t-test shows that the significance is statistically difference , $t(\text{sign}.524) = .647, p > 0.05$. It is conclude that BS Hons students have more competencies as compare to the B.Ed students. The majority of the respondents were from BS. Hons program and show that they have much more techno-pedagogical competencies than B.Ed students.

Table 5
Pre-service teachers' techno-pedagogical competencies in terms of Computer availability

	Computer availability	N	Mean	SD	T-value	Sign.
Techno pedagogical Competencies	Yes	383	88.2846	11.824	.034	.001
	No	66	82.8030	15.277		

Table show the result of independent sample t-test for analysis the mean comparison in the techno pedagogical competencies of the participants in term of computer availability. The analysis depicts that there is significance difference with t value , $t(\text{sign}.001) = .034, p > 0.05$. The students who have computer facility were much more competent that the students who don't have the computer facility.

Table 6
Pre-service teachers' techno-pedagogical competencies in terms of Internet Access

	Internet Access	N	Mean	SD	T-value	Sign.
Techno pedagogical Competencies	Yes	375	88.2800	11.90264	.420	.002
	No	73	83.2192	14.72644		

Above table shows the analysis of mean comparison among the respondents who have internet access. The analysis of the above statistics shows the significance difference with value $t(\text{sign}.002) = .446, p > 0.05$ that clearly shows the participants with internet facility have the more competency than the participants who don't have internet.

Table 7
Relationship between the pre-service teachers' cognitive flexibility with techno pedagogical education competencies

	Cognitive flexibility (n=448)	Techno pedagogical competencies (n=448)
Person coefficient	.825(**)	.910(**)
Overall	1	

Table show the statistical analysis of the correlation between pre-service teachers CF with TPC. The correlational analysis revealed significant positive connection between pre-service teacher cognitive flexibility with techno pedagogical competencies. The positive association suggest that the pre-service teachers have higher cognitive development were much more competent while integrating technology in their teaching environment. The relationship is significantly positive ($r=1, p < 0.01$). The techno pedagogical competency with ($r=.991$) were much more positively related to the cognitive flexibility with ($r=.825$). The overall value of coefficient of both variables clearly show the positive relationship among them with ($r=1$).

Conclusions

The study aimed to explore the relationship between pre-service teachers' cognitive flexibility (CF) and techno-pedagogical competencies (TPC). The findings reveal a

significant connection between these two constructs, with pre-service teachers demonstrating higher levels of cognitive flexibility also exhibiting stronger techno-pedagogical competencies. Cognitive flexibility, defined as the ability to adapt thinking strategies in response to new or unfamiliar situations, was found to positively influence the ability of teachers to effectively integrate technology into their teaching practices. This relationship underscores the importance of developing cognitive flexibility as a foundational skill for teachers who are navigating the increasingly complex and technology-driven educational environment. A key insight from the study is that certain factors—such as the type of teacher education program, the availability of computers, and access to the internet—play a critical role in shaping both cognitive flexibility and techno-pedagogical competencies. Significant differences were identified between pre-service teachers enrolled in different types of programs, particularly between those in Bachelor of Education (B.Ed.) programs and those in Bachelor of Science in Education (BS Ed) programs. It was found that students enrolled in the BS Ed program exhibited higher levels of cognitive flexibility and technological competency compared to their counterparts in the B.Ed. program. This suggests that the curriculum or pedagogical approach of the BS Ed program may better support the development of these skills, possibly due to a stronger focus on integrating technology and fostering adaptive learning strategies.

Moreover, access to technology played a pivotal role in enhancing both cognitive flexibility and techno-pedagogical skills. Pre-service teachers who had ready access to computers and the internet demonstrated significantly higher levels of both cognitive flexibility and technological competency. This finding highlights the importance of providing technology infrastructure in educational settings, as it not only supports the development of technical skills but also facilitates the cognitive flexibility required for adapting to new educational tools and methodologies. Teachers who have access to these resources are more likely to engage with technology in ways that enhance their teaching practices, creating more interactive and dynamic learning environments for their students.

Further analysis revealed a strong positive correlation between cognitive flexibility and techno-pedagogical competencies. This correlation suggests that teachers who possess higher cognitive flexibility are more adept at integrating technology into their teaching practices. In other words, teachers who are better at adjusting their thinking and problem-solving strategies in the face of new challenges are more likely to successfully adopt and implement technological tools in their classrooms. The relationship between these two competencies emphasizes the need for teacher education programs to not only focus on the technical aspects of technology but also on cultivating the cognitive flexibility that allows teachers to make the most effective use of these tools in diverse classroom settings. In conclusion, the study highlights the significant role that cognitive flexibility plays in enhancing pre-service teachers' ability to integrate technology into their teaching practices. The findings suggest that teacher education programs, particularly those with a focus on technology, can benefit from incorporating strategies that promote both cognitive flexibility and techno-pedagogical competencies. Additionally, ensuring that pre-service teachers have access to the necessary technological resources is crucial for developing these competencies and preparing teachers to thrive in the digital age of education.

Recommendations

- **Replication of Study:** Future research should replicate this study with a larger and more diverse sample across different regions in Pakistan to confirm the findings.
- **Study of In-Service Teachers:** It would be valuable to investigate the cognitive flexibility and techno-pedagogical competencies of in-service teachers, as they bring practical experience that could offer new insights.

- **Comparative Study of Public vs. Private Sector:** A comparative study between public and private sector teachers would shed light on how these two sectors differ in terms of cognitive flexibility and technological competencies.
- **Gender-based Study:** Future research could explore the differences in cognitive flexibility and techno-pedagogical competencies between male and female pre-service teachers.
- **Focus on Education Quality:** Researchers should aim to focus on studies that enhance the quality of education by improving the integration of technology and fostering cognitive flexibility in teacher training programs.

References

- Akgün, A. E. (2013). The role of teachers in integrating technology in education: Competencies and challenges. *Journal of Educational Technology & Society*, 16(4), 88-98
- Braem, S., & Egner, T. (2018). Cognitive flexibility in teaching and learning: The role of educational contexts. *Learning and Instruction*, 58, 1-12.
- Chai, C. S., Koh, J. H. L., & Tsai, C. C. (2011). A review of research on technology integration in teacher education. *Educational Technology & Society*, 14(1), 38-50.
- Dajani, S., & Uddin, M. (2015). Cognitive flexibility and its role in teacher education. *International Journal of Instruction*, 8(2), 45-58.
- Diamond, A. (2013). Executive functions. *Annual Review of Psychology*, 64, 135-168.
- Erdemir, A., Bakırcı, H., & Eyduran, E. (2009). Teachers' perceptions of cognitive flexibility in the context of teaching. *Educational Studies*, 35(4), 289-304.
- Eshet-Alkalai, Y. (2004). Digital literacy: A conceptual framework for survival skills in the digital era. *Journal of Educational Multimedia and Hypermedia*, 13(1), 93-106.
- Goschke, T. (2003). Cognitive flexibility and adaptation to changing task demands. *Cognition*, 89(1), 73-90.
- Hommel, B., & Colzato, L. S. (2017). Cognitive flexibility in dynamic learning environments. *Psychological Research*, 81, 304-312.
- Jamieson-Proctor, R., Finger, G., Albion, P. R., & Kopcha, T. (2013). Teachers' perceptions of their technology use and the impact of a professional development program on the integration of technology into their teaching. *Educational Technology & Society*, 16(1), 62-75.
- Jeyaraj, A., & Ramnath, S. (2018). Techno-pedagogical competencies of teachers in technology-enhanced classrooms. *International Journal of Educational Technology*, 5(2), 44-59.
- KabakcıYurdakul, I., Cakir, M., & Keser, H. (2012). The role of technological pedagogical content knowledge in teaching. *Computers & Education*, 58(1), 1-16.
- Koehler, M. J., Mishra, P., & Cain, W. (2013). What is technological pedagogical content knowledge (TPACK)? *Journal of Educational Computing Research*, 48(1), 1-8.
- Lambert, M. (2010). Integration of technology in teacher education programs: Issues and challenges. *Educational Technology Research and Development*, 58(3), 143-167.
- Lee, M. H., & Tsai, C. C. (2010). The impact of technology on teaching and learning: A critical review of current literature. *Educational Technology & Society*, 13(4), 85-99.
- Martin, R. E., & Rubin, R. B. (1995). Cognitive flexibility: A critical dimension of classroom success. *Journal of Social Psychology*, 131(6), 727-738.
- Meiran, N., Gotler, A., & Varnava, D. (2011). The role of cognitive flexibility in task switching. *Psychological Science*, 22(1), 95-102.

- Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, 108(6), 1017-1054.
- Niess, M. L. (2005). Preparing teachers to teach science with technology: Developing a technology pedagogical content knowledge. *Teaching and Teacher Education*, 21(5), 509-523.
- Orhaner, B., & Tunç, M. (2003). Cognitive flexibility in teaching: A critical skill for educators in the 21st century. *Journal of Educational Research*, 16(3), 77-86.
- Spalding, E., Klecka, C., Lin, A., Wang, Y., & Odell, M. (2010). Cognitive flexibility and its role in teaching. *Journal of Educational Psychology*, 102(4), 723-734.