

Techno-Pedagogical Competencies: Empowering Teachers in the 21st Century

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ABSTRACT:

The 21st-century educational landscape has undergone an extreme paradigm shift due to the rapid advancement of technology. In this evolving scenario, teachers are expected to possess not only content and pedagogical knowledge but also the ability to effectively leverage digital tools for curriculum delivery, student engagement, and assessment. Today's techno-pedagogical competencies are a primary requirement for modern teachers. It enables teachers to create an interactive, inclusive and effective learning environment. In the present study, researchers explore the existing literature on techno-pedagogical competencies for teachers. For this purpose, the study follows a systematic review approach. The study mainly explored five aspects: its importance in classrooms, different levels of education, teachers' performance and professional development, challenges, and Ways to navigate challenges to implementing techno-pedagogical competencies among teachers.

Keywords: Techno-Pedagogy, Techno-pedagogical competency, Teaching-Learning

INTRODUCTION

In the contemporary era, digital transformation is growing worldwide and has significantly reshaped how societies think, work, communicate, and learn. Over the past decade, technological advancements like artificial intelligence, cloud computing, innovative technologies, and digital learning platforms have advanced rapidly and transformed every domain of our society (Miah & Parhi, 2024), including the education system. In this era, education is no longer just textbooks and the classroom; now it happens in a digital environment, where teaching and learning increasingly depend on technology. However, this transformation not only changed the classroom dynamic but also signifies a paradigm shift in pedagogical approaches, teachers' roles, student engagement, and institutional management (Warpade, 2012). Additionally, it changes the way education is delivered, the way teaching materials are created and distributed, and also the way teachers interact with the students (Jain & Mittal, 2020). The integration of technology into the educational landscape has fundamentally changed the roles and responsibilities of teachers worldwide. It reshaped the traditional teaching-learning paradigm and offers new opportunities for both teachers and learners (Ali, 2018). Therefore, the teachers' roles and responsibilities have been completely transformed from instructor to facilitator (Dabbeeru & Gannavaram, 2024). They have to acquire new competencies for using blended technological tools with pedagogical strategies to meet the growing demands of 21st-century education (Koehler & Mishra, 2009). So, today, teachers must possess not only content knowledge but also the skills to use digital tools effectively, from curriculum planning to the evaluation stage (Asad et al., 2021; Qurashi & Jan, 2022). These changes in teachers' roles and responsibilities due to technology integration in the education sector have given rise to a new concept, Techno-Pedagogical competencies, which refers to teachers' ability and skills to integrate technology into teaching to achieve learning goals and outcomes effectively (Chauhan, 2024; Sathiyaraj & Rajasekar, 2013).

It is observed that the COVID-19 pandemic has raised the urgency of digital transformation in the education sector, which compelled educational institutions to adopt technology-mediated learning environments

worldwide instead of face-to-face instruction (Safyari et al.,2024; Mondal,2024). During that time, along with the globe, India also rapidly adopted online platforms like videoconferencing, Google Meet, Zoom, etc., to provide education. Before the pandemic, virtual teaching was uncommon in India, but it not only changed the scenario of education but also highlighted the potential of technology to sustain the teaching-learning process during a crisis. Additionally, it exposed the massive gap in teachers' preparedness, emphasising the need for ongoing professional development in techno-pedagogy (Safyari et al., 2020).

In the rapidly evolving digital landscape, techno-pedagogical competencies are recognised as foundational for effective teaching. It not only empowers teachers to design and deliver meaningful learning experiences but also helps them create a dynamic and interactive learning environment to meet the needs of digital native learners (Jana & Chattopadhyay, 2026; Thappa & Baliya, 2022; Parkash & Hooda, 2021). In 2006, Mishra & Koehler developed a framework which was Technological Pedagogical Content Knowledge (TPACK) that integrates technology, pedagogy, and content knowledge holistically. This framework was an extension of Shulman's Pedagogical Content Knowledge (Deb, 2026; Sena et al., 2018). It describes how teachers can use technology more successfully in the teaching-learning process (Karmakar et al.,2025). This model emphasises the interplay between three core knowledge domains: Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK).

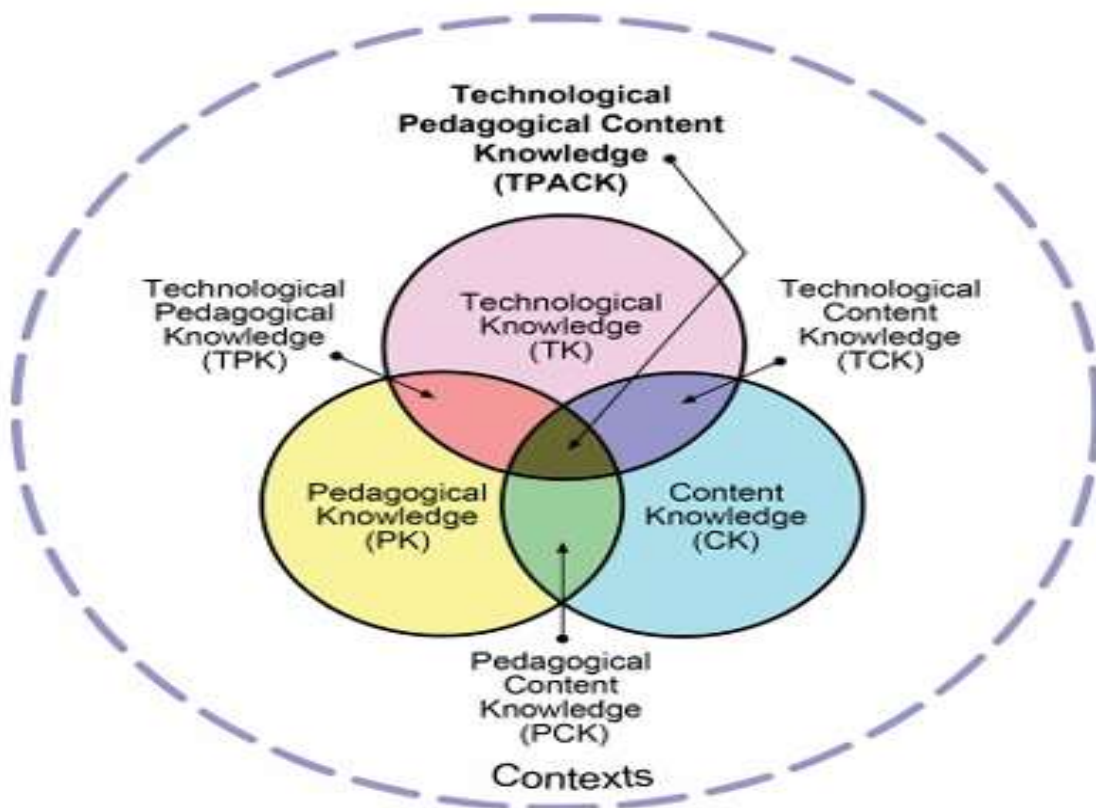


Figure 1: Mishra& Koehler, 2006, TPACK framework

Table No. 1: Terms of the TPACK framework

Terms	Definition
Content Knowledge (CK)	It refers to what to teach. This category concerns a teacher's deep understanding of the subject matter they teach.
Pedagogical Knowledge (PK)	It refers to how to teach. It is the knowledge and skills related to the art and science of teaching.
Technological Knowledge (TK)	It refers to the teacher's knowledge and understanding of using various technologies, tools, devices, and resources in the process of teaching and learning.

Pedagogical Content Knowledge (PCK)	It refers to the intersection of content knowledge (CK) and pedagogical knowledge (PK).
Technological Content Knowledge (TCK)	It refers to the reciprocal relationship between technology and content (Agustini et al.,2019). It involves teachers' understanding of how technology and content can both influence one another.
Technological Pedagogical Knowledge (TPK)	It refers to the teacher's knowledge and understanding of how particular technologies can change both the teaching and learning process.
Technological Pedagogical Content Knowledge (TPACK)	It refers to the integration of all three, enabling teachers to develop context-specific, technology-enhanced teaching strategies (Mishra & Koehler,2006).

Techno-Pedagogy

The word techno-pedagogy is derived from a combination of two words, techno and pedagogy. Pedagogy refers to the art and science of teaching, and techno means weave or construct. Therefore, "Techno-pedagogy refers to weaving the techniques of teaching into the learning environment itself" (Gloria & Benjamin, 2014). It is a hybrid approach of teaching in which information and communication technology is used to create an effective learning environment (Bansal,2022). It helps the teachers to make the teaching-learning process joyful and interesting. Bala & Tao (2018) declared that techno-pedagogy refers to the effective use of different technological tools and resources to provide inclusive and high-quality learning experiences. Also, Bhuyan & Tripathy (2021) stated that techno-pedagogy comprises the applicability of ICT in the teaching process; ultimately, it ensures the quality of teaching and learning by designing lesson plans, instructional delivery and assessment. Techno-pedagogy is a process of weaving digital tools into the instructional process, empowering communication and fostering a learning environment rather than just the use of technology (Jayaraj & Ramnath,2018; Fullan,2012).

Techno-pedagogical competency

Techno-pedagogical competency refers to the capabilities of teachers to effectively integrate pedagogy and technology for their teaching (Guru & Beura,2019). According to Chauhan (2024), techno-pedagogy is the capability and efficiency of teachers to enhance the performance of teaching tasks by successfully integrating technology with content and subject matter in the teaching-learning process. Teachers who have this competency are better able to bring the entire world into the classroom, and it helps the teachers to make their teaching very interesting to the students, no matter which subject they teach (Lyonga & Nkeng,2022). In techno-pedagogy, teachers need to plan, implement, and evaluate the teaching process by using knowledge of technology, pedagogy, and content, which helps the teachers stay updated on their skills and adopt various tools in teaching (Guru & Beura,2019; Gloria & Benjamin,2018; Setua,2020). Nowadays, teachers must require techno-pedagogical competencies to enhance student engagement and active learning (Dangwal & Srivastava, 2016), and it refers to the skill set of the teachers to use different technological tools in the teaching process (Rao & Jalajakshi,2021)

Objective Of The Study

- To study the importance of techno-pedagogical competencies for classroom teachers.
- To study the teachers' techno-pedagogical competencies at different levels of education.
- To understand the role of techno-pedagogical competencies towards teachers' performance and professional development.
- To identify the challenges faced by the teachers in using techno-pedagogy in the teaching and learning process.
- To identify the ways to enhance techno-pedagogical competencies among teachers.

METHODOLOGY

The present study is mainly descriptive in nature and based on secondary sources of data. A systematic review approach is employed to understand and analyse teachers' techno-pedagogical competencies. Studies published between 2013 and 2025 were selected as relevant papers through databases such as Google Scholar, ResearchGate, Web of Science, JSTOR, PubMed, and Scopus etc.

Selection Process and Criteria for Inclusion and Exclusion:

Initially, the literature search identified 190 articles using different databases, out of which 42 articles were found to be relevant for the study. Articles were selected based on predefined inclusion and exclusion criteria (Table No.2). Only peer-reviewed studies were included in this study. The search process exclusively focused on articles that were published in the English language. After that, selected articles were filtered with the help of the title of the study and articles that were suitable for the objective of the study.

Table No.2: Criteria for inclusion and exclusion

Criteria	Inclusion	Exclusion
Year	From 2013 to 2025	Before 2013
Language	Studies published in English	Studies published in non-English
Articles	Only peer-reviewed articles	Abstract without full text, magazine, etc.

Table No. 3: Themes related to the review of literature

SL. No	Themes
1	Importance of techno-pedagogical competencies for classroom teachers
2	Teachers' techno-pedagogical competencies at different levels of education
3	Role of techno-pedagogical competencies towards teachers' performance and professional development
4	Challenges to using techno-pedagogy for teachers in the teaching and learning process
5	Ways to navigate challenges to implementing techno-pedagogical competencies among teachers

Importance of techno-pedagogical competencies for classroom teachers

In the present global landscape, the rapid advancement of technology is reshaping and transforming the dynamics of human existence, affecting our day-to-day lifestyles, social relations and interactions (Vernyuy, 2024). Similarly, the education sector has been influenced by new advancements in technology, which offer unique opportunities to enrich teaching and learning (Mena-Guacas et al.,2025). Therefore, teachers' competencies in using technology in the classroom are increasingly recognised as an essential aspect for teachers that enables them to meet evolving educational standards and prepare for a technology-driven world (Perumal & Saravanakumar, 2020). These techno-pedagogical competencies of teachers enable them to design, deliver, and assess more effectively (Mishra & Koehler, 2006).

The growing emphasis on technology in classrooms has led to significant changes, not only improving the teaching and learning process but also influencing the way how students learn. It also fulfils the diverse needs of each student by creating student-centred, interdisciplinary and self-paced learning experiences, which are facilitated by the teachers (Gangmei & Thomas, 2025). It also helps students acquire higher-order thinking skills like analyzing, synthesizing, applying, and creating, which are essential to prepare students to navigate today's competitive environment (Hota,2024). Therefore, teachers must know the application of techno-pedagogy in the teaching process. They should understand how to incorporate techno-pedagogy into their course while planning and offering learning experiences (Miah & Parhi,2024). Additionally, teachers' techno-pedagogical competencies help to create a conducive learning environment and offer user-centred instruction to meet the needs and demands of students (Sachan & Dwivedi,2023). In the same way, integration of technology into teaching significantly improves students' learning outcomes (Bihari,2024). So, teachers who have adequate

techno-pedagogical competencies are better able to make learning more interesting by using technological resources such as multimedia content, interactive software and virtual simulation.

Teachers' techno-pedagogical competency at different levels of Education

In our education system, teachers play a central role in imparting knowledge to students. Teachers are responsible for introducing and integrating various digital technologies in front of students to support and enhance their learning experiences. However, teachers' roles and responsibilities are not the same at all stages of education. Similarly, teachers' techno-pedagogical competencies vary significantly depending on the level of education they teach. The uses of digital tools, pedagogical requirements, and expectations are not the same for primary, secondary, and higher education teachers.

At the primary level of education, teachers generally use technology for simple classroom activities and make it effective and interesting, and their techno-pedagogical competencies are at a moderate level. Usually, teachers can use digital tools like videos, smart boards, apps, etc. Zhakiyanova et al. (2023), primary teachers are generally strong in content and pedagogy, but their use of technology in the classroom is mostly at a basic level. At this level, teachers frequently use digital tools primarily for presentation and content delivery, but their use in data management, collaborative learning, assessment, and digital creation remains limited due to insufficient technological proficiency and time constraints (Alptekin & Taneri, 2025).

In modern classrooms, teachers must be knowledgeable not only in their subject matter and pedagogy but also in how to effectively utilise technology to make learning more engaging and effective. As students at the secondary level are familiar with digital tools and online learning environments, teachers must incorporate technology to enhance students' learning outcomes. In light of this, techno-pedagogical competency is now crucial for teachers at the secondary education level. Many studies revealed that secondary school teachers demonstrate a moderate to high level of competencies (Guru & Beura, 2019; Sarkar et al., 2014; Alegre & Galado, 2023; Ering & Ering, 2025). This means that they are able to pick suitable digital tools and use them effectively to support lessons and explain concepts more clearly. However, the level of competencies is not the same everywhere. Teachers in urban schools exhibited higher proficiency in techno-pedagogy due to better access to technological and training opportunities than rural school teachers (Bala & Tao, 2018). Similarly, private school teachers tend to possess higher levels of techno-pedagogical competencies than their counterparts in government schools (Qurashi & Jan, 2022; Erring & Ering, 2025; Revati, 2025).

In higher education, techno-pedagogical competencies signify a teacher's ability to blend technology effectively into teaching, transforming conventional teaching practices into innovative, research-driven and learner-oriented experiences. At this level, teachers generally demonstrate an average level of techno-pedagogical competencies (Anand, 2019). Most of the faculty members possess strong subject matter expertise and sound pedagogical knowledge, but their technological skills and capability to integrate digital tools remain limited due to a lack of resources, improper infrastructure, and institutional support, etc (Thakur, 2015; Moreira et al., 2023; Marak & Dwivedi, 2025).

Role of techno-pedagogical competencies towards teachers' performance and professional development

The integration of techno-pedagogical competencies into teaching has become a key determinant in improving teacher performance and facilitating professional growth in the digital era (Ghavifekr & Rosdy, 2022). As the evolving demands of the 21st century classroom, teachers must be able to effectively integrate technology with pedagogy, which is crucial for delivering, engaging and student-centred instruction (Mishra & Koehler, 2006). In the classroom, teachers enhance instructional delivery with the help of techno-pedagogical competencies, which not only improve students' learning outcomes but also develop teachers' self-efficacy (Kumari & Rani, 2020) and skills of classroom management (Alayyar et al., 2021). Most importantly, it also helps teachers to build their confidence in using modern tools, relieve their workload, and encourage creativity and innovation in teaching. Moreover, teachers who have gained proficiency in techno-pedagogical competency can use this knowledge in a way to deliver an easier and more efficient learning experience to students (Bansal, 2022). Additionally, several studies consistently showed that teachers who have a high level of techno-pedagogical competencies tend to demonstrate greater confidence, better adaptability in every situation, and job satisfaction

(Borah & Das,2024). Furthermore, these competencies also help to promote inclusive teaching practices, enabling them to use varied instructional strategies and address the diverse needs of students (Alayyar et al.,2021).

Some educational research has also established that techno-pedagogical competency is a key requirement for improving teachers' performance. As John & Rexlin Rose (2023) revealed that teachers with better techno-pedagogical competencies perform their duties in a professional way. It also helps to promote the continuous professional development of teachers by introducing emerging educational technologies, new teaching methodologies, and reflective practices. But a lack of proper training in using techno-pedagogy may hamper teachers' ability to adopt innovative teaching methods, which can negatively impact both teachers' performance and opportunities for professional development (Thakur,2015; Sharma & Saarsar,2020). Ndongfack (2015) developed a model for teachers' professional development for techno-pedagogy, whose name was Mastery of Active and Shared Learning Processes for Techno-Pedagogy (MASLEPT). The MASLEPT model emphasises collaborative learning, continuous improvement of techno-pedagogical content knowledge, and reflective practices. This model mainly integrates three key aspects, such as the lesson study approach, techno-pedagogical content knowledge, and the social constructivist framework.

Challenges to using techno-pedagogy for teachers in the teaching-learning process

In the modern education system, the integration of techno-pedagogy into the teaching-learning process is indispensable, but teachers face some significant challenges in its implementation. One of the major issues is a lack of proper training (Beegum,2022). Roy (2022) and Sarkar & Sharma (2026) highlighted that today's teacher education institutions lack the provisions of techno-pedagogy skills or knowledge, and in-service teacher education does not train in the development and use of techno-pedagogical skills. Similarly, a study found that "teachers must receive ongoing training in digital technology skills in order for them to be fully prepared and knowledgeable of how to use these tools" (Moses et al.,2022). Additionally, many teachers face troubles as a result of technological knowledge and confidence in using digital tools. However, Limited knowledge and lack of confidence give rise to technostress, anxiety, and reduced self-efficacy in teaching (Ardi & Nugraha et al., 2022; Darsih et al.,2024). Another major challenge is a lack of proper infrastructure, particularly in rural and underdeveloped areas (Sarkar & Sharma, 2026). Many institutions do not have proper facilities to incorporate technologies into classrooms, such as insufficient internet connectivity, outdated computers, absence of projectors, smart classrooms, unreliable electricity, etc (Beegum, 2022; Moses et al.,2022; Setua, 2023; Atabek,2019). Without its foundational support, technology use in the classroom remains impractical. Teachers are expected to use technology on their own, but many teachers are not able to solve technological problems independently. According to Roy (2022), a single teacher cannot handle all technical aspects of hardware and software, and due to a lack of help, they often feel discouraged. Johnson et al. (2016) emphasizes that without technological support, teachers find it difficult to use ICT tools in the classroom. Low English proficiency is another barrier. Singh & Gupta (2022) point out that language difficulty affects teachers' ability to use and adapt online materials, especially teachers from non-English backgrounds. Despite the availability of technology, many teachers are afraid or unwilling to adopt new methods due to fear of failure or lack of confidence (Asad et al.,2022). Last but not least, the gap between the curriculum and digital pedagogical practices is a major barrier to effective implementation. According to Atabek (2019) and Muneer et al. (2023), there is often no clear guideline or curriculum framework for integrating technology into teaching.

Ways to improve techno-pedagogical competencies among teachers

Although integrating techno-pedagogy into teaching offers numerous opportunities for positive changes in the classroom. But several studies consistently showed that teachers faced a lot of challenges in integrating it into the classroom. Therefore, addressing these challenges is essential. There is a need to adopt specific strategies and measures for the successful integration of techno-pedagogy.

There is a need to establish a proper infrastructure and institutional support system to strengthen techno-pedagogical competencies among teachers. Every institution must ensure that it has appropriate accessibility in techno-pedagogy-supporting labs, various technological tools such as a cable network with internet connection, computer system, radio, television, phones, etc (Singh,2022; Singh & Gupta,2022). A continuous professional

development program is another effective way to enhance techno-pedagogical competencies among teachers (Sarkar & Sharma, 2026; Mittal & Dubey, 2025). Therefore, every institution should organise regular workshops, discussion sessions, and hands-on training, which help teachers to acquire the necessary updated knowledge, technical skills and build confidence to adopt new tools and techniques in their teaching. Additionally, a positive attitude and strong motivation are indispensable qualities for every teacher. Teachers with positive attitudes are more comfortable to using technology into their teaching activities (Beegum,2022).

A well-established research and development culture is crucial for the successful integration of techno-pedagogy in education; without this, it is impossible to enhance the efficiency of techno-pedagogical competencies among teachers and address the emerging challenges. Moreover, English is the most common language on the internet (Singh,2022; Thakur,2015). In this context, most of the digital tools and software are available in English. It helps teachers to access global resources, engage in international webinars and effectively utilize various technological tools in the teaching and learning process. Therefore, improving teachers' proficiency in English is crucial to strengthening techno-pedagogical competency. However, the awareness of existing techno-pedagogical services is a major concern. Teachers who are unaware of the availability of digital resources face several problems in effectively integrating techno-pedagogy in the classroom. Therefore, it is important to develop awareness of existing techno-pedagogical resources, which help to teachers equip the necessary knowledge and improve the quality of teaching (Thakur,2015).

Table 4: Authors and thematic discussions

Authors	Themes
Vernyuy (2024), Mena-Guacas et al. (2025), Perumal & Saravanakumar (2020), Mishra & Koehler (2006), Gangmei & Thomas (2025), Hota (2024), Miah & Parhi (2024), Sachan & Dwivedi (2023), Bihari (2024).	Importance of techno-pedagogical competencies for classroom teachers
Zhakiyanova et al. (2023), Alptekin & Taneri (2025), Guru & Beura (2019), Sarkar et al. (2014), Alegre & Galado (2023), Ering & Ering (2025), Qurashi & Jan (2022), Revati (2025), Bala & Tao (2018), Thakur (2015) Moreira et al. (2023)	Teachers' techno-pedagogical competency at different levels of Education
Ghavifekr & Rosdy (2022), Mishra & Koehler (2006), Alayyar et al. (2021), Bansal (2022), Kumari & Rani (2020), Borah & Das (2024), John & Rexlin Rose (2023), Thakur (2015), Sharma & Saarsar (2020), Ndongfack (2015),	Role of techno-pedagogical competencies towards teachers' performance and professional development
Roy (2022), Moses et al. (2022), Setua (2023), Atabek (2019), Johnson et al. (2016), Singh & Gupta (2022), Asad et al. (2022), Muneer et al. (2023), Beegum (2022), Sarkar & Sharma (2026), Ardi & Nugraha et al. (2022), Darsih et al. (2024)	Challenges to using techno-pedagogy for teachers in the teaching-learning process
Singh (2022), Singh & Gupta (2022), Thakur (2015), Sarkar & Sharma (2026), Mittal & Dubey (2025), Beegum (2022).	Ways to improve techno-pedagogical competencies among teachers

DISCUSSION

In the era marked by rapid digital transformation, techno-pedagogical competencies are essential for teachers. In the last few decades, the expectations and standards of education has undergone a profound transformation due to the emergence of innovative technologies, digital tools and platforms, etc. It has fundamentally reshaped

how learning is designed, delivered, and experienced across educational contexts (Arifani et al.,2025). Additionally, this transformation redefined the role of teachers (Dochia, 2025). Now, teachers are no longer merely transmitters of knowledge but rather act as facilitators who are responsible for designing interactive digital environments that enhance critical thinking, creativity, and innovation (Abdeslam et al.,2025). Therefore, to meet the evolving standards of 21st-century education, teachers must develop techno-pedagogical competencies (Perumal & Saravanakumar, 2020). The findings of the study also demonstrate that teachers' techno-pedagogical competencies are significantly different across educational level and context, because each level of education is designed to achieve distinct goals, curriculum expectations, pedagogical principles, and intended learning outcomes. However, the review of related literature also revealed that techno-pedagogical competencies play a significant role in teachers' performance and professional development. Ansari (2025) highlight that techno-pedagogical competence has become a foundational pillar of teachers' professional development. Several studies consistently showed that teachers with strong techno-pedagogical competence are more confident, creative and proactive in seeking professional development opportunities (Safyari, 2024; Singh & Indian, 2024). It not only enhances their expertise in teaching but also helps in long term job satisfaction and greater adaptability (Chauhan, 2024). Further, the findings of the study also highlighted substantial challenges in developing techno-pedagogical competencies among teachers. Lack of proper training, limited knowledge about technology, lack of an institutional support system, inadequate infrastructure, low confidence in using technology, and lack of proper guidelines are the prominent barriers. Moreover, addressing these challenges is crucial for strengthening teachers' techno-pedagogical competence and ensuring the effective integration of technology in the teaching-learning process. Each and every educational institution must prioritise institutional support and infrastructure, ensure continuous professional development, nurture a positive attitude and motivation towards technology, and build a collaborative entail learning environment, etc are essential for enhancing techno-pedagogical competencies among teachers. Additionally, the development of techno-pedagogical competencies must remain a priority for policymakers, educators, and stakeholders.

CONCLUSION

It can be concluded that techno-pedagogical competencies are vital for meeting the evolving standard of education. As education increasingly shifts towards digital, hybrid, personalised learning models, the importance of these competencies is crucial for empowering teachers and enhancing the teaching-learning outcome (Mishra & Koehler, 2006). It is key for teachers to effectively plan, execute, and manage classes well in today's world. By mastering these competencies, teachers can create an interactive, inclusive and effective learning environment. Additionally, it helps teachers to make informed decisions about when, how, and why technology should be used in the classroom.

REFERENCES

1. Ali, M. (2018). Techno-pedagogical competency of teachers: An area of concern in the 21st century higher education. *REVIEW OF RESEARCH*, 7(11), 1–5. <https://oldror.lbp.world/UploadedData/5578.pdf>
2. Asad, M. M., Aftab, K., Sherwani, F., Churi, P., Moreno-Guerrero, A. J., & Pourshahian, B. (2021). Techno-pedagogical skills for 21st-century digital classrooms: An extensive literature review. *Education Research International*, 1-12. <https://doi.org/10.1155/2021/8160084>
3. Atabek, O. (2019). Challenges in integrating technology into education. *Turkish Studies-Information Technologies and Applied Sciences*, 14(1), 1–19. <https://doi.org/10.7827/TurkishStudies.14810>
4. Bansal, S. (2022). Role of techno-pedagogical skills for enhancing teaching and learning. *Journal of Positive School Psychology*, 6(2), 3785–3793. <https://journalppw.com/index.php/jpsp/article/download/2471/1576/2857>
5. Bihari, S. (2024). Exploring the techno-pedagogical competency of senior secondary school teachers. *Innovation Insights*, 1, 29–37. https://innovationinsights.in/wp-content/uploads/2025/05/Manuscript_4.pdf
6. Borah, D., & Das, P. (2024). Exploring teacher characteristics and participation in TPACK-related online teacher professional development in Assam, India. *Computers and Education Open*, 7, 1-14. <https://doi.org/10.1016/j.caeo.2024.100227>

7. Chauhan, D. (2024). Techno-pedagogical competency among teachers in relation to their attitude towards teaching. *Forum for Education Studies*, 2(2), 1-8. <https://doi.org/10.59400/fes.v2i2.566>
8. Dangwal, K. L., & Srivastava, S. (2016). Digital pedagogy in teacher education. *International Journal of Information Science and Computing*, 3(2), 67-72. <https://www.renupublishers.com/images/article/15152386043.pdf>
9. Fullan, M. (2012). A review of stratosphere: Integrating technology, pedagogy and change knowledge. *Alberta Journal of Educational Research*, 62(4), 429-432. DOI:10.55016/ojs/ajer.v62i4.55489
10. Gangmei, N., & Thomas, K. A. (2025). Teachers' technology proficiency for quality learning and teaching- A scoping review. *Journal of Educational Technology Systems*, 1-23. <https://doi.org/10.1177/10567879251316213>
11. Ghavifekr, S., & Rosdy, W. A. W. (2022). Teachers' professional development through ICT: Barriers and enablers in developing countries. *International Journal of Instruction*, 15(3), 119-134. <https://doi.org/10.29333/iji.2022.1537a>
12. Gloria, R., & Benjamin, A. E. W. (2018). Attitude of teachers towards techno-pedagogy. *International Journal of Engineering Technologies and Management Research*, 5(4), 87-89. <https://doi.org/10.29121/ijetmr.v5.i4.2018.212>
13. Guru, N., & Beura, M. K. (2019). Techno-pedagogical competency of higher secondary school teachers in relation to students' academic achievement in science. *International Journal of Applied Research*, 5(12), 362-370. www.allresearchjournal.com
14. Hota, S. (2023). Techno-pedagogical skills for 21st century teachers: Contextual enabler. *IOSR Journal of Research & Method in Education*, 13(5), 42-46. <https://www.iosrjournals.org/iosr-jrme/papers/Vol-13%20Issue-5/Ser-1/F1305014246.pdf>
15. Jeyaraj, I., & Ramnath, R. (2018). Techno pedagogical skills among teacher educators in relation to certain select variables. *Review of research*, 7(12), 1-4. www.lbp.world
16. John Lings, V., & Rexlin Jose, G. (2023). Influence of techno-pedagogical skills on professional effectiveness of prospective teachers. *ShodhKosh: Journal of Visual and Performing Arts*, 4(2), 4055-4062. <https://doi.org/10.29121/shodhkosh.v4.i2.2023.4599>
17. Johnson, A. M., Jacovina, M. E., Russell, D. E., & Soto, C. M. (2016). Challenges and solutions when using technologies in the classroom. In S. A. Crossley & D. S. McNamara (Eds.), *Adaptive educational technologies for literacy instruction* (1st Ed., pp. 13-29). Taylor & Francis. <https://doi.org/10.4324/9781315647500>
18. Miah, M. H., & Parhi, R. K. (2024). Techno-pedagogical competency: A hybrid teaching method in 21st-century classroom. *Educational Administration: Theory and Practice*, 30(1), 1276-1281. <https://doi.org/10.53555/kuey.v30i1.6150>
19. Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, 108(6), 1017-1054. <https://doi.org/10.1111/j.1467-9620.2006.00684.x>
20. Mondal, P. K. (2024). Investigating the impact of techno-pedagogical competence on teacher effectiveness and student outcomes across diverse educational contexts. *Preprints.org*, 1-6. doi:10.20944/preprints202412.1622.v1
21. Moses, C., Nghipandulwa, L. L. T., & Shikusho, S. P. (2022). Investigating the challenges faced by teachers in the implementation of digital technology in secondary schools in Rundu Circuit, Kavango East Region Namibia. *Open Journal of Social Sciences*, 10(9), 286-301. <https://doi.org/10.4236/jss.2022.109018>
22. Muneer, R., Ibrahim, M., & Begum, R. (2023). Examining the challenges and factors affecting technology integration in the learning process. *Pakistan Journal of Educational Research*, 6(4), 247-250. <https://pjer.org/index.php/pjer/article/view/990>
23. Ndongfack, M. N. (2015). Teacher profession development on technology integration using the mastery of active and shared learning for techno-pedagogy (MASLEPT) model. *Creative Education*, 6(3), 295-308. <https://doi.org/10.4236/ce.2015.63028>
24. Parkash, J., & Hooda, S. R. (2018). A study of techno-pedagogical competency among teachers of government & private schools of Haryana state. *International Journal of Current Advanced Research*, 07(1), 9301-9306. <http://dx.doi.org/10.24327/ijcar.2018.9306.1532>

25. Qurashi, G. U. D., & Jan, T. (2022). Techno-pedagogical competence of private and government secondary school teachers of Kashmir- A comparative study. *International Journal of Indian Psychology*, 10(3), 944-953. DOI:10.25215/1003.101
26. Roy, A. (2022). Various criteria of techno-pedagogy in teaching-learning process. *International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)*, 2(1), 327–332. <https://doi.org/10.48175/IJARSCT-5683>
27. Sachan, M., & Dwivedi, S. (2023). Study of digital competence and techno-pedagogical skills of secondary school teachers. *Quest Journals: Journal of Research in Humanities and Social Science*, 11(5), 263–274. <https://www.questjournals.org/jrhss/papers/vol11-issue5/1105263274.pdf>
28. Setua, C. (2023). Challenges faced by secondary school teachers of West Bengal board in implementing techno-pedagogy as an innovative process in remote areas. In Mridha, D., & Bera, S (Eds.), *Innovation in education* (pp. 55-66). Crescent Publishing Corporation. <https://www.researchgate.net/publication/378942941>
29. Sharma, H. L., & Saarsar, P. (2020). Techno-pedagogy skills in teacher education. In *Paradigm shift and evolving teacher education* (1st Eds., pp. 97–105). Eureka Publications. <https://www.researchgate.net/publication/344308714>
30. Sharma, M., & Sharma, R.R. (2021). Techno-pedagogical skills of teacher trainees belonging to arts and science academic streams. *Towards Excellence*, 13(2), 907-916. DOI: 10.37867/TE130276
31. Singh, R., & Gupta, S. (2022). Techno-pedagogical competence: Challenges and resolving measures for teachers. *International Journal of Creative Research Thoughts (IJCRT)*, 10(2), 330-336. <https://ijcrt.org/papers/IJCRT2202276.pdf>
32. S. Rajasekar, K. Sathiyaraj. (2013). The relationship between the techno-pedagogical competency of higher secondary school teachers and their anxiety towards the use of instructional aids in teaching. *International Journal of Teacher Educational Research (IJTER)* 2(12), ISSN: 2319-4642.
33. Thakur, N. (2015). A study on implementation of techno-pedagogical skills, its challenges and role to release at higher level of education. *American International Journal of Research in Humanities, Arts and Social Sciences*, 9(12),182-186. <http://www.iasir.net>
34. Thappa, S. R., & Baliya, J. N. (2024). Effect of technological pedagogical and content knowledge framework-based capacity building programme module (CBPM) on teaching aptitude of pre-service teachers. *MIER Journal of Educational Studies Trends & Practices*, 14(2), 511–531.DOI:10.52634/mier/2024/v14/i2/276
35. Revati, N. (2025). A study on techno-pedagogical skills among teachers of government and private secondary schools. *International Journal for Research Trends and Innovation*, 10(3), 7-14. <https://www.ijrti.org/papers/IJRTI2503002.pdf>
36. Alptekin, Z., & Taneri, A. (2025). Technology integration in pedagogical processes: Digital competence and teaching practices of primary school teachers in Turkey. *Discover Education*, 1-22.<https://doi.org/10.1007/s44217-025-00646-9>
37. Zhakiyanova, Z., Zhaitapova, A., Orakova, A., Baizhekina, S., Shnaider, V., & Nametkulovala, F. (2023). Investigation of primary school teachers' professional competencies and technological pedagogical content knowledge (TPACK) competencies. *International Journal of Education in Mathematics, Science, and Technology*, 11(5), 1154-1172. <https://doi.org/10.46328/ijemst.3604>
38. Alegre, E. M., & Galado, J. (2023). Technological competence and pedagogical content knowledge practices of junior high school science teachers. *International Journal of Membrane Science and Technology*, 10(2), 566-579. <https://doi.org/10.15379/ijmst.v10i2.1266>
39. Ering, O., & Ering, M. (2025). Techno pedagogical competency of secondary school teachers in East Siang district of Arunachal Pradesh. *International Journal of Multidisciplinary Research in Arts, Science and Technology (IJMRAST)*, 3(7), 82-93. <https://doi.org/10.61778/ijmrast.v3i7.157>
40. Moreira, M. A., Arcas, B. R., Sánchez, T. G., García, R. B., Melero, M. R., Cunha, N. B., Viana, M. A., & Almeida, M. E. (2023). Teachers' pedagogical competences in higher education: A systematic literature review. *Journal of University Teaching & Learning Practice*, 20(1), 90-123. <https://doi.org/10.53761/1.20.01.07>
41. Bhuyan, S., & Tripathy, M. K. (2021). Techno-pedagogical skills of Bachelor of Education students of Odisha. *Scholarly Research Journal for Interdisciplinary Studies*, 8(62), 14554–14564.

42. Safyari, S. (2024). Identifying the criteria for Techno-Pedagogical competence in higher education. *International Journal of Vocational Learning Management Studies*, 5(3), 112–124.
43. Singh, A., & Indian, R. (2024). The role of Techno-Pedagogical skills in teacher training. *Knowledge University Educational Journal*, 6(1), 10148–10171.
44. Dochia, I. (2025). The changing role of teachers in the digital age: From knowledge transmitter to learning facilitator. *International Journal of Social and Educational Innovation (IJSEIro)*, 12(23), 109–118. <https://doi.org/10.5281/zenodo.14956342>
45. Abdeslam, S., Boussakra, A., & Boukheit, S. (2025). The digital transformation in education and its impact on the role of the teacher. *Al-MIEYAR Journal*, 16(2), 1214–1229. <https://doi.org/10.54191/2320-016-002-084>
46. Arifani, Y., Suryanti, S., Raja Harun, R. N. S., Wahi, W., & Susanto, S. (2026). Editorial: Redefining learning in the digital age: Pedagogical strategies and outcomes. *Frontiers in Education*, 11. <https://doi.org/10.3389/feduc.2026.1811393>
47. Rao, S. N., & Jalajakshi, B. N. (2021). Techno-pedagogical skill: An indispensable skill for a 21st century classroom teacher. *International Journal of Creative Research Thoughts*, 9(3), 1264–1267. <https://www.ijcrt.org/papers/IJCRT2103164.pdf>
48. Ansari, A. B. (2025). The need and importance of techno-pedagogical competency in the digital age. *Journal of Advance and Future Research*, 3(11), 546–550. <https://rjwave.org/jaafr/papers/JAAFR2511188.pdf>
49. Lyonga, N. A. N., & Nkeng, A. J. (2022). Development of techno-pedagogical skills among teacher educators: The case of Higher Technical Teachers' Training College of the University of Buea, Cameroon. *Innovare Journal of Education*, 10(4), 17–23. <https://doi.org/10.22159/ijoe.2022v10i4.45589>
50. Dabbeeru, R. S., & Gannavaram, K. (2024). Digital transformation in education: Adoption trends of digital technologies in contemporary education sectors. *International Journal of Innovative Research in Technology*, 10(8), 563–572. <https://ijirt.org/Article?manuscript=167380>
51. Jain, A., & Mittal, A. (2020). Digitalization of higher education in India: Constructive aspects and challenges. In *Virtual teaching in India during lock down* (pp. 27–42). Red'Shine Publication. ISBN 978-93-89522-41-9.
52. Vernyuy, A. (2024). Impact of technological advancements on human existence. *International Journal of Philosophy*, 3(2), 54–66. <https://doi.org/10.47941/ijp.1874>
53. Mena-Guacas, A. F., López-Catalán, L., Bernal-Bravo, C., & Ballesteros-Regaña, C. (2025). Educational transformation through emerging technologies: Critical review of scientific impact on learning. *Education Sciences*, 15(3), 368. <https://doi.org/10.3390/educsci15030368>
54. Warpade, S. A. (2022). Digital transformation in higher education sector in India. *International Journal of Food and Nutritional Sciences*, 11(11), 3256–3272.
55. Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)? *Contemporary Issues in Technology and Teacher Education*, 9(1), 60-70.
56. Jana, T., & Chattopadhyay, K. N. (2026). Techno-pedagogical competencies: Empowering educators in the digital age. *International Research Journal of Education and Technology*, 9(3). https://www.irjweb.com/user_upload/TechnoPedagogical%20Competencies%20Empowering%20Educators%20in%20the%20Digital%20Age.pdf
57. Deb, J. P. (2026). Technological pedagogical content knowledge (TPACK) framework in pre-service teacher education: A comprehensive review of two decades of research (2006–2026). *International Journal of Emerging Voices in Education*, 2(2), 1–22. <https://doi.org/10.59828/ijeve.v2i2.31>
58. Karmakar, I., Behera, S. K., & Mohalik, R. (2025). A study on techno pedagogical skills of college teachers in West Bengal. *Indian Journal of Educational Technology*, 7(1), 277–288. <https://journals.ncert.gov.in/IJET/article/view/851>
59. Bala, P., & Tao, I. (2018). An examination of techno-pedagogical competence and anxiety towards the use of instructional aids in teaching among senior secondary school teachers. *Chetana Quarterly*, 3(3), 95–114. <https://echetana.com/wp-content/uploads/2018/10/14.-Preeti-Bala.pdf>
60. Perumal, M. N., & Saravanakumar, A. R. (n.d.). Importance of techno pedagogic skills for effective teachers in today classroom. Conference paper, Alagappa University, Karaikudi.

61. Sarkar, M., Shrivastava, N., & Sharma, P. (2024). Influence of techno-pedagogical competency on teacher effectiveness of higher secondary school teachers. *International Research Journal of Commerce Arts and Science (CASIRJ)*, 15(9), 100–108.
62. Kumari, P., & Rani, M. (2022). Techno-pedagogical skills of teacher educators with special reference to e-learning. *International Journal for Research in Applied Science & Engineering Technology (IJRASET)*, 10(4), 550–552. <https://doi.org/10.22214/ijraset.2022.41287>
63. 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), 1298–1316. <https://doi.org/10.14742/ajet.773>
64. Sana, S., Adhikary, C., & Chattopadhyay, K. N. (2018). Exploring teacher's techno-pedagogical competency to achieve process-oriented skills of learners: A multimedia context. *Inquisitive Teacher*, 5(2), 174–188.
65. Mittal, R., & Dubey, P. (2025). A study of techno-pedagogical content competency among government and private secondary school teachers. *International Journal of Research - GRANTHAALAYAH*, 13(8), 89–94. <https://doi.org/10.29121/granthaalayah.v13.i8.2025.6349>
66. Darsih, E., Agustiana, V., Rahmatunisa, W., & Hanggara, A. (2024). Factors affecting preservice English teachers' technological pedagogical content knowledge (TPACK). *Indonesian Journal of Learning and Instruction*, 7(2). <https://doi.org/10.25134/ijli.v7i2.10943>
67. Sarkar, K., & Sharma, A. (2026). Techno-pedagogical competency in pre-service teachers: Challenges and strategies. *International Journal of Social Science and Education Research*, 8(4), 78–83. <https://doi.org/10.33545/26649845.2026.v8.i4a.605>
68. Nugraha, C. A., Kuswandi, D., & Praherdhiono, H. (2022). Teacher professional development to train digital skills with technological pedagogical content knowledge (TPACK). *JTP – Jurnal Teknologi Pendidikan*, 24(3), 330–340. <https://doi.org/10.21009/jtp.v24i3.31019>
69. Beegum, R. M. S. (2022). Importance of techno-pedagogical skill for 21st century classroom teacher. *International Journal of All Research Education and Scientific Methods*, 10(7), 2641–2644.
70. Marak, R., & Dwivedi, A. (2025). A study on techno-pedagogical skills among teachers of higher education. *EPRA International Journal of Multidisciplinary Research (IJMR)*, 11(8), 873–878. <https://doi.org/10.36713/epra23868>
71. Anand, S. (2019). Techno pedagogical competency of faculty members: The present need of higher education. *Journal of Current Science*, 20(1), 61–64.
72. Singh, N. (2025). An investigation of the role of techno-pedagogical skills implementation, their difficulties, and their release at the higher education level. *Journal of Emerging Technologies and Innovative Research*, 12(8), f476–f482. <https://www.jetir.org/papers/JETIR2508564.pdf>