

Original Article

Technology and Teacher Education: Enhancing Teaching Competencies in the Digital Era

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**Abstract**

The rapid development of digital technologies has significantly transformed the education sector. The integration of technology into teaching practices has created new opportunities for improving learning outcomes and enhancing student engagement. Teacher education programs play a crucial role in preparing educators to effectively use technology in classrooms. This paper examines the role of technology in teacher education and explores how digital tools, online learning environments, and educational technology frameworks contribute to improving teaching competencies. The study also analyzes models such as the Technological Pedagogical Content Knowledge (TPACK) framework and the SAMR model for technology integration. A qualitative research approach based on literature analysis is used to examine recent studies related to technology integration in teacher education. The findings indicate that technology enhances teaching effectiveness, promotes collaborative learning, and provides access to global educational resources. However, challenges such as lack of technological infrastructure, insufficient teacher training, and resistance to technological change still exist. The paper concludes that teacher education programs must focus on developing digital literacy and technological competencies among educators to effectively integrate technology into teaching and learning processes.

Keyword: Teacher education, educational technology, TPACK model, SAMR model, digital learning, ICT in education

Introduction

The integration of technology into education has transformed traditional teaching and learning practices across the world. Digital technologies such as learning management systems, multimedia tools, and online collaboration platforms have become essential components of modern classrooms. These technologies enable teachers to deliver content more effectively and improve student engagement in learning activities [4]. Teacher education programs play a significant role in preparing teachers to integrate technology into classroom instruction. Educators must develop technological competencies that allow them to design innovative teaching strategies and create interactive learning environments [3]. The use of digital tools helps teacher's present complex concepts in more engaging ways and encourages students to actively participate in learning activities.

Recent developments in educational technology have also introduced new learning opportunities through online learning platforms and virtual classrooms. These technologies provide flexible learning environments that support personalized learning experiences for students [5]. As a result, teacher education institutions are increasingly incorporating technology training into their curriculum. Despite the benefits of technology integration, many teachers face challenges when using digital tools in classrooms. Limited access to technological infrastructure, lack of professional development opportunities, and insufficient digital literacy skills are major barriers to effective technology integration [7]. Therefore, it is essential to examine how teacher education programs can prepare teachers to effectively use technology in their teaching practices.

This paper aims to explore the role of technology in teacher education and examine the frameworks and strategies used to integrate technology into teaching practices.

Objectives of the Study

The main objectives of this research are:

1. To examine the role of technology in teacher education.

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2. To analyze the impact of technology on teaching and learning practices.
3. To study technology integration models such as TPACK and SAMR.
4. To identify challenges faced in integrating technology in teacher education.

Literature Review

Several researchers have examined the role of technology in education and its impact on teaching practices. The integration of digital technologies in classrooms has been shown to enhance student engagement and improve learning outcomes [5]. The TPACK framework provides a theoretical foundation for understanding how teachers integrate technology into their teaching practices. The model explains the relationship between technological knowledge, pedagogical knowledge, and content knowledge in effective teaching [1], [2]. Recent studies emphasize that teachers must develop competencies in all three domains to effectively integrate technology into classroom instruction [3]. Teachers who possess strong technological pedagogical knowledge are better able to design innovative learning activities and promote student-centered learning. Another widely used model for technology integration is the SAMR model, which describes four levels of technology use in education: substitution, augmentation, modification, and redefinition [6]. The model helps teachers evaluate the effectiveness of technology integration in their classrooms.

The COVID-19 pandemic further accelerated the adoption of digital technologies in education. Many educational institutions shifted to online learning platforms, which required teachers to quickly adapt to new teaching methods and technologies [4]. Recent research also highlights the role of emerging technologies such as artificial intelligence, virtual reality, and augmented reality in education. These technologies provide immersive learning experiences and support personalized learning environments [9]. However, several challenges still exist in implementing technology in education. Limited technological infrastructure and insufficient training opportunities often prevent teachers from effectively using digital tools in classrooms [7].

Conceptual Framework

A. TPACK Model

The **Technological Pedagogical Content Knowledge (TPACK)** model is a framework that explains how teachers integrate technology into teaching and learning processes. The model was introduced by **Punya Mishra and Matthew J. Koehler** and highlights the relationship between three key knowledge domains required for effective teaching: **Content Knowledge (CK)**, **Pedagogical Knowledge (PK)**, and **Technological Knowledge (TK)** [1].

The TPACK framework emphasizes that teachers must not only understand the subject content and teaching methods but also know how to use technology effectively in the classroom. The interaction between these three types of knowledge enables teachers to design meaningful and technology-enhanced learning experiences for students.

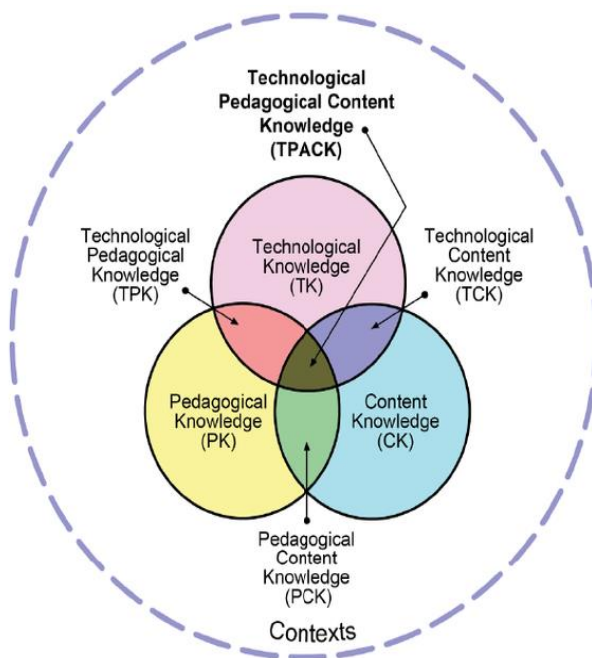


Fig1. TPACK Model

1. Content Knowledge (CK)

Content knowledge refers to the teacher's understanding of the subject matter being taught. It includes knowledge of concepts, theories, and principles related to a particular discipline. For example, a mathematics teacher must have knowledge of algebra, geometry, and calculus.

2. Pedagogical Knowledge (PK)

Pedagogical knowledge refers to knowledge about teaching methods, classroom management strategies, and instructional techniques. It includes the ability to design lesson plans, manage classroom activities, and assess student learning.

3. Technological Knowledge (TK)

Technological knowledge refers to the understanding of digital tools and technologies used in education. It includes knowledge of computers, educational software, multimedia tools, learning management systems, and online learning platforms.

4. Pedagogical Content Knowledge (PCK)

Pedagogical Content Knowledge refers to the understanding of how to teach specific subject content effectively using appropriate teaching strategies.

5. Technological Content Knowledge (TCK)

Technological Content Knowledge refers to the understanding of how technology can be used to represent and explain subject content. For example, using simulations to demonstrate scientific experiments.

6. Technological Pedagogical Knowledge (TPK)

Technological Pedagogical Knowledge refers to the understanding of how technology supports teaching methods and instructional strategies.

7. Technological Pedagogical Content Knowledge (TPACK)

At the center of the model is **TPACK**, which represents the integration of content, pedagogy, and technology. Teachers with strong TPACK competencies can effectively design technology-supported lessons that enhance student learning and engagement. The TPACK model is widely used in teacher education programs to help teachers develop digital competencies and improve their ability to integrate technology into teaching practices.

B. SAMR Model

This framework helps teachers evaluate how effectively technology is integrated into classroom instruction. The **SAMR Model** is a framework used to understand how technology can be integrated into teaching and learning. It was developed by Ruben R. Puentedura to help educators evaluate the impact of digital technologies on classroom practices. The model describes four levels of technology integration that range from basic substitution of traditional tools to the transformation of learning activities. It is widely used in teacher education programs to guide teachers in effectively integrating technology into their instructional practices [1].

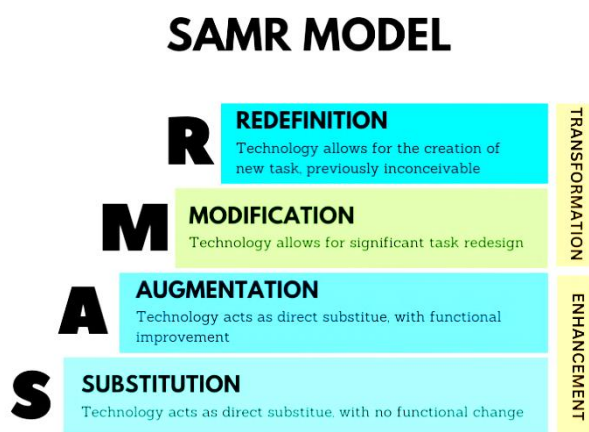


Fig2: SAMR Model

The acronym SAMR stands for Substitution, Augmentation, Modification, and Redefinition. These four stages represent increasing levels of technology integration in education.

1. Substitution

Substitution is the first and most basic level of the SAMR framework. At this stage, technology acts as a direct substitute for traditional tools, with no significant change in the learning task. For example, students may type assignments using Microsoft Word instead of writing them by hand. The task remains the same, but the medium changes from paper to digital format [1]. Although substitution does not transform the learning process, it introduces students and teachers to digital tools and helps them become comfortable with using technology in the classroom.

2. Augmentation

Augmentation is the second level of the SAMR model. At this stage, technology still substitutes a traditional tool but provides functional improvements that enhance the learning task. For example, when students use Google Docs, they can take advantage of features such as spell check, grammar suggestions, and commenting tools. These features improve the quality of work and make the learning process more efficient [1].

Thus, augmentation adds value to the learning activity by providing additional digital capabilities that are not available in traditional methods.

3. Modification

The modification stage represents a significant shift in teaching and learning. At this level, technology allows teachers to **redesign** learning tasks. Students can collaborate on projects in real time using digital tools like Google Docs or create multimedia

presentations using Microsoft PowerPoint. Multiple students can work on the same document simultaneously, which encourages teamwork and collaborative learning [1].

This stage demonstrates how technology can transform classroom activities by enabling new forms of interaction and collaboration.

4. **Redefinition**

Redefinition is the highest level of the SAMR model. At this stage, technology enables the creation of **entirely new learning activities** that were previously impossible without digital tools. For example, students can create videos, podcasts, or digital presentations and share them with a global audience through platforms like YouTube or learning platforms such as Google Classroom [1].

Redefinition encourages creativity, innovation, and global collaboration among students, making learning more interactive and engaging.

The SAMR model plays an important role in teacher education because it helps teachers understand how to integrate technology meaningfully into their teaching practices. By progressing through the four levels of SAMR, teachers can move from simply replacing traditional tools with digital ones to transforming the learning experience through innovative instructional strategies [1]. The model also supports the development of digital literacy, collaborative learning, and student engagement, which are essential skills in modern education systems.

Role of Technology In Teacher Education

Technology has significantly influenced **teacher education programs** by providing innovative tools and digital resources that improve both teaching and learning processes. In modern education systems, technology helps teachers access a wide range of learning materials, develop interactive lessons, and communicate with students more efficiently. The integration of technology in teacher education ensures that future educators are prepared to teach in digitally advanced classrooms and support students' learning through modern instructional strategies [1].

1. **Digital Learning Platforms**

Digital learning platforms, also known as Learning Management Systems (LMS), play an important role in teacher education. These platforms allow teachers to manage and organize educational content in a systematic way. Teachers can upload lecture notes, videos, assignments, and other learning materials so that students can easily access them anytime and anywhere.

Popular learning management systems such as Moodle, Google Classroom, and Canvas enable teachers to create online courses, distribute study materials, conduct quizzes, and monitor student progress. These platforms also allow teachers to evaluate assignments digitally and provide feedback quickly.

In teacher education programs, trainees learn how to use these platforms to design structured courses and manage classroom activities effectively. Digital learning platforms also support blended learning, which combines traditional classroom teaching with online learning resources. This approach improves flexibility in education and helps students learn at their own pace [2].

2. **Virtual Classrooms**

Virtual classrooms have become an important component of modern education. They allow teachers and students to interact in real time through online video conferencing tools. Virtual classrooms enable teachers to deliver lectures, conduct discussions, and answer student questions without requiring physical presence in a traditional classroom.

Platforms such as Zoom, Microsoft Teams, and Google Meet provide features like screen sharing, chat, recording, and breakout rooms that enhance online teaching. These tools make it possible for teachers to present slides, share videos, and engage students in interactive activities during live sessions. The importance of virtual classrooms increased significantly during the COVID-19 pandemic, when many educational institutions shifted to online teaching. As a result, teacher education programs now focus on training teachers to manage virtual classes effectively, maintain student engagement, and use digital communication tools for teaching [3].

3. **Multimedia Teaching Tools**

Multimedia teaching tools are widely used in teacher education to make lessons more interesting and effective. Multimedia refers to the use of different forms of media such as text, images, audio, video, animations, and simulations in the teaching process. Teachers can use presentation software such as Microsoft PowerPoint or video platforms like YouTube to explain concepts visually. Educational videos and animations help students understand complex topics more easily than traditional lecture-based teaching methods. Simulations and interactive software allow students to explore real-life situations and experiments in a virtual environment. Multimedia tools also support different learning styles. For example, visual learners benefit from diagrams and videos, while auditory learners can understand concepts through recorded lectures or podcasts. Teacher education programs train future teachers to create multimedia presentations and integrate these tools into lesson plans to improve teaching effectiveness and student engagement [4].

4. **Online Collaboration Tools**

Technology has also introduced **online collaboration tools** that allow students and teachers to work together more efficiently. These tools support collaborative learning by enabling students to share ideas, work on projects, and communicate with each other in real time. Digital platforms such as Google Docs, Microsoft Teams, and Slack allow multiple users to edit documents simultaneously, discuss topics, and complete group assignments. Discussion forums and shared workspaces help students participate actively in group learning activities even when they are not physically present in the classroom. In teacher education programs, future teachers are trained to use collaborative tools to design group projects, encourage teamwork, and facilitate communication among students. These tools help develop important skills such as teamwork, problem-solving, communication,

and critical thinking, which are essential for modern education [5]. Technology has transformed teacher education by providing advanced digital tools and resources that support effective teaching and learning. Digital learning platforms help teachers manage courses and assessments efficiently, while virtual classrooms enable real-time online teaching. Multimedia teaching tools make lessons more interactive and engaging, and online collaboration tools encourage teamwork and communication among students. By integrating these technologies into teacher education programs, educational institutions can prepare teachers to meet the challenges of modern digital classrooms and improve the overall quality of education [6].

Benefits Of Technology in Teacher Education

The integration of technology in teacher education has brought significant improvements to the teaching and learning process. Digital tools and online resources help teachers deliver lessons more effectively and provide students with engaging and interactive learning experiences. The following are some important benefits of technology in teacher education.

1. Improved Teaching Effectiveness

Technology helps teachers present information in a clearer and more organized manner. Tools such as Microsoft PowerPoint and digital learning platforms like Google Classroom allow teachers to use presentations, videos, and digital materials during lessons. These tools make it easier for teachers to explain complex topics and improve the overall quality of instruction. As a result, teachers can deliver lessons more effectively and help students understand concepts better [8].

2. Enhanced Student Engagement

Technology makes learning more interesting and interactive. Multimedia resources such as educational videos, animations, and interactive quizzes help capture students' attention and encourage active participation in the classroom. Platforms like YouTube provide educational content that supports visual learning and improves student motivation. When students actively participate in technology-based activities, their interest and involvement in learning increase [8].

3. Access to Global Educational Resources

Technology provides teachers and students with access to a vast amount of information and educational resources from around the world. Through the internet, teachers can use digital libraries, research articles, and online courses to enhance their knowledge. Educational platforms such as Coursera and edX offer courses and learning materials from international universities, helping teachers stay updated with modern teaching methods [8].

4. Flexible Learning Environments

Technology enables flexible learning environments where teaching and learning can occur anytime and anywhere. Online learning platforms and virtual classrooms allow teachers to conduct classes and share materials remotely. Tools such as Zoom and Google Meet support online lectures and discussions, making education more accessible for students who cannot attend traditional classroom sessions [8].

5. Development of Digital Skills among Teachers and Students

The use of technology in teacher education helps develop important digital skills for both teachers and students. Teachers learn how to use digital tools, create online content, and manage virtual classrooms. Students also gain experience using technology for research, communication, and collaboration. These digital skills are essential for success in modern education and future professional environments [8].

Overall, technology plays a vital role in teacher education by improving teaching effectiveness, increasing student engagement, providing access to global resources, enabling flexible learning, and developing digital skills. These benefits help create a more modern, interactive, and effective educational environment [8].

Challenges In Technology Integration

While technology has transformed teacher education, several challenges hinder its effective integration in classrooms:

1. Lack of Digital Infrastructure:

Many educational institutions do not have adequate computers, smart devices, or digital labs, making it difficult for teachers and students to access and use technology effectively.

2. Limited Internet Connectivity:

Poor or unreliable internet access can prevent teachers from using online learning platforms, virtual classrooms, and digital resources, especially in remote or rural areas.

3. Insufficient Teacher Training:

Teachers may not receive adequate training in using technology tools, learning management systems, or digital teaching methods, which limits their ability to integrate technology effectively into their instruction.

4. Resistance to Technological Change:

Some educators are hesitant to adopt new technologies due to fear of change, lack of confidence, or preference for traditional teaching methods. This resistance can slow down the adoption of technology in education.

Addressing these challenges requires investment in infrastructure, reliable internet access, professional development programs, and support systems to help teachers embrace technology in teaching and learning.

Discussion

Technology has the potential to transform education by enabling innovative teaching practices and improving learning outcomes. Teacher education programs must focus on developing digital competencies among educators to prepare them for technology-rich classrooms. Emerging technologies such as artificial intelligence and immersive learning environments are expected to play a significant role in the future of education.

Conclusion

Technology integration has become an essential component of modern education. Teacher education programs must prepare educators to effectively use digital technologies in their teaching practices. The TPACK and SAMR models provide useful frameworks for understanding how technology can be integrated into teaching and learning processes. Although several challenges remain, proper training, institutional support, and technological infrastructure can help educators successfully integrate technology into education systems.

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Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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