INSIGHT Journal of Applied Research in Education,
Vol. 29, No. 1, 2024
ISSN **0975-0665**

TEACHING IN THE AI ERA: INTEGRATING DIGITAL COMPETENCE AND TPACK FOR THE FUTURE

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Abstract

Technological advancements are progressing at a pace much faster than our ability to adapt and acquire the necessary knowledge, skills and competencies. Therefore, the effective use of technology in the educational system relies on how well we stay updated with emerging trends. In response to the ongoing Digital Transformation, our education system needs a fundamental overhaul. This transformation extends beyond mere technological adoption; it encompasses rethinking our study methods and the content of what we learn. Embracing digital tools and strategies is essential to prepare students for the dynamic and interconnected world they will navigate. Education has made notable use of artificial intelligence (AI) as a result of breakthroughs in computer and information processing capabilities. The integration of artificial intelligence in education (AIEd) offers fresh possibilities, challenges, and prospects for learning approaches. AI has the capability to tackle some of the most pressing issues in education today and to create innovative instructional methods. In our study, we sourced articles from databases such as Science Direct, Scopus, and Google Scholar, focusing on English-language publications between 2019 and 2023. We collected data using keywords like 'Digital Competence,' 'TPACK,' and 'Artificial Intelligence.' Initially, all qualitative research articles were gathered, and those containing the specified keywords in their abstracts were included in the preliminary list. Subsequently, we employed a checklist to document relevant findings. Our initial search yielded 250 articles—100 from Scopus, 105 from Google Scholar, and 45 from Science Direct. We further refined our selection, including only articles directly related to our study. Ultimately, 11 relevant articles were carefully analyzed to identify the Digital Competence (DC) and the integration of technology, framed as TPACK and the Artificial Intelligence.

Keywords: Digital Competence, TPACK, Artificial Intelligence, Teaching and Learning

Introduction

Despite significant technological and cultural advancements and rapid lifestyle

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changes, many people still lack the necessary skills to effectively navigate life's challenges, leading to increased vulnerability to stress and difficulties. Technological advancements are progressing at a pace much faster than our ability to adapt and acquire the necessary knowledge, skills and competencies. Therefore, the effective use of the technology in the educational system hinges on how well we stay updated with emerging trends. One of the most impacted areas within higher education by technology integration is the quality of teaching and learning. Technology not only fosters personal growth but also aids in the development and enhancement of knowledge societies. To achieve this, we require educators who can design enriched and innovative learning environments that enable students to explore through technology (Blair, 2012)

As technology becomes increasingly integrated into teaching and learning, various approaches have emerged, such as "flipped classrooms, ubiquitous learning, Gamification, and personal learning environments" (Castellanos et al., 2017). This shift requires teachers in training to acquire the knowledge, skills and competencies needed to effectively use technology, enabling them to incorporate it logically and pedagogically into their daily practices. Research shows that the level of digital competence among both (pre-service and in-service teachers) strongly predicts how well ICT is integrated into the teaching (Aslan & Zhu, 2016). Additionally, there is a close connection between teaching performance and student learning, indicating a relationship between teachers' self-efficacy in teaching the 21st-century skills and the quality of students' learning experiences in the classroom.

Our Prime Minister envisioned a digitally empowered India where quality education reaches even the most remote corners through digital learning. The New National Education Policy 2020, issued by the Ministry of Education, places strong emphasis on digital and online learning, aiming to revolutionize the Indian education system. By leveraging modern technology, NEP 2020 aspires to position India as a 'Global Knowledge Superpower' by 2030. To achieve this, research on disruptive technologies, assessing the current state of ICT in educational institutions, and developing strategies for content-ICT-pedagogy integration are essential according to the new pedagogical and curricular recommendations."

Digital Competence, Technological Pedagogical Content Knowledge (TPACK), And Artificial Intelligence (AI)

There is a pressing need to provide quality education to everyone, anytime and anywhere, and technology offers a powerful means to overcome barriers of time and space. The integration of technology enables the creation of various digital resources such as e-content, digital libraries, OERs, and MOOCs. This study is conceptualized

around Digital Competence (DC) and the integration of technology, framed as TPACK. "TPACK primarily focuses on teaching with the use of technology; DC extends to the use of digital technologies both inside and outside the professional context" (Instefjord & Munthe, 2017; Starkey, 2020). A teacher proficient in digital skills can foster creativity, critical thinking and scientific inquiry among students, transforming them into continuous learners and innovators. Continuous training and retraining are essential for teachers to fulfill their roles effectively and meaningfully. This study is crucial for achieving the expected learning outcomes, which include a blend of knowledge, values, attitudes, and skills, particularly those related to "creativity, critical thinking, communication and collaboration". As the world rapidly moves into an era of Artificial Intelligence, it is imperative to embrace new and effective approaches that will enhance the quality of education, a challenge currently facing teachers and the educational system.

The European Commission (2019) emphasizes that teacher training programs must ensure that educators possess digital skills that enable them to seamlessly incorporate ICT into their teaching methods. This is underscored by the fact that (4 out of 5) "European Member States" recognize "DC" as a crucial skill that teachers need to incorporate into their instruction. In Norway, digital competence has been a key focus in the national education agenda for years. In 2006, digital skills were officially recognized as a core competency for all students, alongside basic knowledge of reading, writing and arithmetic" (Ministry of Education and Research, 2014). The outline for basic competence, which covers grades 1 through 13, outlines the development of skills in five key areas: use and understanding, searching and processing, production, communication, and the digital responsibility (The Norwegian Directorate for Education and Training, 2017). These areas represent the essential components of digital competence that Norwegian teachers are expected to integrate into their teaching.

Digital competence is a dynamic concept that covers a wide array of skills and capabilities. It includes not only technical skills for effectively using digital tools and technologies in various aspects of life, such as studying, working, communicating, and leisure activities, but also the capacity to critically evaluate digital technologies and online information. Additionally, it encourages active participation in the digital culture. Over the past few decades, educators, much like other professionals, have enjoyed greater access to digital tools, media, and resources. Numerous national and international organizations have highlighted the importance of digital competence in the training of future teachers as a vital component in improving the quality of education in the 21st century. This topic has been widely explored from various angles within the scientific literature (Lazaro et al., 2019; Almas & Krumsvik, 2007).

Fig. 2. (Digital Competence Areas). Source: EU Science Hub

Recent literature highlights numerous studies on the training and development of early childhood and primary school teachers in ICT, emphasizing the essential role of teacher education in tackling the educational challenges of a digitized society (Ananiadou & Rizza, 2010; Cabero, 2014; Casillas et al., 2020; Prendes & Gutierrez, 2013; Tondeur et al., 2017).These studies stress the importance of providing comprehensive initial training in ICT, covering various dimensions such as instrumental, curricular, pragmatic, design, evaluation, organization, and attitudes. Technological Pedagogical Content Knowledge (TPACK) (Mishra & Koehler, 2006) has emerged as a highly relevant framework in teacher training. It emphasizes the necessity of cultivating teachers' skills in three key areas: Content Knowledge (CK), Pedagogical Knowledge (PK), and Technology Knowledge (TK), while highlighting the essential interactions among these domains. The more these three domains intersect, the stronger the foundation for effective teaching with digital tools (Koehler et al., 2013).

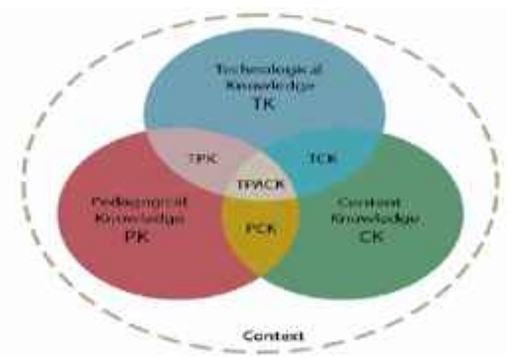

Fig.1 TPACK (Source: graphic adapted from.)

The interaction between technological knowledge and pedagogical knowledge demonstrates how teachers can utilize technology for educational purposes.

Meanwhile, the interaction between technological knowledge and content knowledge illustrates the integration of technology into specific subject content. Lastly, the intersection of pedagogical knowledge and content knowledge underscores how teachers can effectively combine content with subject-specific teaching strategies in their practice.

Artificial intelligence (AI) is revolutionizing education by "personalizing learning experiences, streamlining administrative tasks, and enhancing student engagement". Through adaptive learning systems, AI tailors content to individual needs, providing real-time feedback. While challenges exist, AI's benefits in education far outweigh drawbacks, making it a powerful force in shaping the future of learning.

Fig. 3: Artificial Intelligence (Source: Unsplash)

Literature Review

In any research process, reviewing the related literature is crucial as it helps to identify and avoid repeating previous studies. It also offers valuable insights that can enhance the significance of the research outcomes.

Portillo et al. (2020) assessed "the self-perception of digital competence among educators during the COVID-19 pandemic", focusing on their ability to deliver emergency remote teaching. The results, based on responses from 4,586 in-service teachers across all educational levels in the Basque Country, revealed that teachers generally perceived themselves as only partially competent in digital skills. They felt more confident in using digital tools for general communication than in using specific tools for teaching-learning processes. Notably, primary and secondary school teachers rated their digital competence lower than university teachers. The systematic review examined the digital competence of teachers in higher education by analyzing literature from 2000 to 2021. The review found that many studies focused on teachers' self-assessment of their digital competencies, revealing that higher education instructors often rated their digital skills as low or medium-low. The findings also highlighted a significant gap in competencies, particularly those related to evaluating educational practices (Basilotta et al., 2020).

Galimullina et al. (2022) explored the "digital competence requirements for future teachers", emphasizing the need for a comprehensive model that reflects the dynamic technological landscape and the specificities of Russian education. Their study revealed gaps in existing models of digital competence, particularly in assessing the digital skills of future educators. Through empirical research involving surveys of practicing teachers and teacher-training students, the study identified the most critical digital competencies needed for future teachers, leading to the development of a theoretical model tailored to these needs. The findings underscore that current approaches do not fully address the assessment and development of digital competence in teacher education.

Cebi et al. (2022) and Elen et al. (2017) examined the "development of digital competencies in pre-service teachers". They found that training based on the Dig Comp framework significantly enhanced participants' techno- pedagogical content knowledge (TPACK) and digital competence, highlighting a positive correlation between the two. They showed that while there are weak positive correlations between institutional support and digital competence, stronger correlations exist between self-efficacy and digital competence among teacher educators. Additionally, Falloon (2020) emphasized the importance of expanding teacher education to include competencies necessary for operating effectively and ethically in digitally-mediated environments. He introduced a digital competence framework aimed at better preparing teachers for future classrooms, suggesting that its implementation should be a collective responsibility across educational faculties.

Hector and Maria (2021) explored the "digital competence of pre-service early childhood and primary school teachers", finding that these future educators generally possess a medium level of digital competence, with particular challenges in content creation. The study revealed that digital competence improves significantly over time and through coursework, though no significant differences were observed based on the type of university or gender. These findings suggest the need for curriculum design and teacher training programs to focus more on enhancing digital competence among pre-service teachers.

Lisbeth A. et al. (2019) found that teacher educators in higher education often do not utilize digital technologies for pedagogical purposes and identified a significant gap in digital competence between educators (high and low self-reported competence). Study highlighted the inadequacies in initial teacher education (ITE) regarding ICT training, with newly qualified teachers reporting poor quality and contributions from their ITE in developing professional digital competence (PDC). Studies underscore the need for continuous improvement in digital competence training for educators, particularly in integrating the digital tools effectively into teaching practices.

Moreno et al. (2019) analyzed the development of the TPACK model through a review of 37 publications from 2014 to 2017. Their study categorized the research based on public education levels, topics, main results, and methodological designs. They found that the majority of studies focused on integrating technology with the TPACK model, professional development related to TPACK, and educators' attitudes towards ICT. Most studies used questionnaires and involved multiple authors, with a predominance of English-language publications. The review highlighted that daily practice in TPACK integration often lagged behind current research.
Gonzalez et al. (2017) investigated the "Digital competence" of university students, examining the impact of gender and age on their ICT skills. Their findings indicated that students rated their ICT knowledge negatively but their management of devices and attitudes towards technology positively. Significant differences were noted, with men generally scoring higher in knowledge, management, and attitude, while older students had more positive attitudes. Basilotta et al. (2020) conducted a "systematic review of literature" on digital competence in higher education, revealing that many studies focus on instructors' self-assessment and the gaps in their digital skills, particularly in evaluating educational practices. Mannila et al. (2018) assessed teachers' self-efficacy and training needs, identifying key areas for professional development based on responses from 530 teachers, thus providing insights for future training initiatives.

Methodology

This study provides a comprehensive and descriptive review of the snowball sampling method, drawing from articles published in national and international journals. Snowball sampling, or chain-referral sampling, is a non-probability technique often employed in qualitative research to reach difficult-to-access or hidden populations. This method enables you to uncover relevant papers by utilizing existing networks and connections, which may reveal resources that traditional random sampling could overlook. Despite this, the in-depth and contextually rich data gathered from these sources can offer significant insights for the review (Naderifar and Ghaljaie, 2017). The selected articles were sourced from databases such as Science Direct, Scopus, and Google Scholar, covering English languages between 2019 and 2023. Data collection involved English keywords like 'Digital Competence,' 'TPACK,' and 'Artificial Intelligence,' initially, all qualitative research articles were gathered, and those containing the specified keywords in their abstracts were included in the preliminary list. Subsequently, a checklist was employed to document the relevant findings.

The initial search yielded 250 articles 100 articles from the Scopus, 105 from the Google Scholar, and 45 from the Science Direct. In the next step, all articles related to study were gathered. We included articles that contained the specified keywords in their abstracts, while excluding the rest. To document our findings, we utilized a checklist."Ultimately, 11 articles were deemed relevant and selected for the review. Various snowball sampling methods can enhance scientific research, support community-based data collection, and facilitate health education programs. This technique enables researchers to reach populations that might otherwise be difficult to access. Therefore, incorporating snowball sampling strategies is recommended when working with participants in educational programs or research studies (Naderifar and Ghaljaie, 2017).

Digital Competence and TPACK in the age of Artificial Intelligence

Digital Competence and TPACK have crucial role in shaping effective teaching and learning experiences, especially in the context of AI education. Digital competence stands out as a frequently encountered skill within educational frameworks. It encompasses an educator's ability to effectively use digital tools, navigate online resources, and integrate technology into teaching practices. In the age of AI, digital competence extends beyond basic computer literacy. Educators need to understand AI concepts, applications, and ethical implications to prepare students for an AI-driven world.

TPACK Framework provides a holistic perspective on effective teaching. It emphasizes the interplay between three essential components: Content Knowledge (CK) refers to subject-specific expertise, Pedagogical Knowledge (PK) encompasses teaching strategies, instructional design, and classroom management, and Technological Knowledge (TK) relates to the effective use of technology in teaching and learning. TPACK recognizes that effective teaching involves integrating these three domains seamlessly. When applied to AI education, TPACK becomes AI-TPACK, emphasizing the unique challenges and opportunities related to teaching AI.

Educators need a solid understanding of AI concepts, including machine learning, neural networks, natural language processing, and robotics. They should be aware of AI's impact on various fields (e.g., healthcare, finance, transportation) and its ethical implications. Effective AI teaching involves designing engaging learning experiences that demystify AI for students. Project-based learning, real-world applications, and problem-solving activities can enhance AI education. Educators must be comfortable using AI tools and platforms. They should explore AI-driven educational technologies, adaptive learning systems, and AI-powered assessment tools (Kim et al., 2021).

Among various digital technologies, artificial intelligence (AI) is increasingly being utilized in education to enhance the management and tracking of educational systems. The TPACK model acknowledges that the competencies required by teachers extend beyond traditional discipline-specific knowledge, technological skills, and pedagogical techniques. Instead, it emphasizes a new type of literacy—one that encompasses AI knowledge and readiness. This updated form of literacy involves a more integrated approach, blending technological proficiency with professional competencies in a way that is inclusive and adaptable. In the context of digital and online learning, a thorough understanding of TPACK will be most effective when teachers incorporate AI knowledge, skills, and literacy into their teaching practices. This integration not only enhances the learning experience but also ensures that educators are well-equipped to navigate and leverage the evolving digital landscape (Karan, 2022).

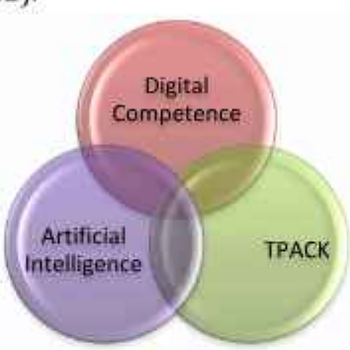

Fig. 4. Intersection of DC, AI and TPACK

Discussion

Building upon the existing findings, several critical dimensions emerge. First, Lisbeth A. et al. (2019) highlight a significant gap in how teacher educators in higher education utilize digital technologies for the pedagogical purposes. in spite of the proliferation of digital tools, there remains room for improvement in integrating them efficiently into the teaching practices. Addressing this gap requires targeted training programs that empower educators to harness technology for enhanced learning experiences. Second, Moreno et al. (2019) emphasize the "Technological Pedagogical Content Knowledge" (TPACK) model. This framework recognizes the interplay between "technological, pedagogical, and content knowledge". While research has explored TPACK integration, the translation of theoretical insights into daily classroom practices remains a challenge. Bridging this gap involves professional development initiatives that bridge theory and application, ensuring

educators can seamlessly blend technology with subject matter expertise. Third, Gonzalez et al. (2017) investigated digital competence among university students, considering gender and age differences. Their findings revealed that men generally scored higher in knowledge, management, and attitude toward technology. Older students exhibited more positive attitudes. Understanding these disparities is crucial for designing inclusive training programs that cater to diverse educator profiles. It also underscores the need to address any gender-based biases in digital competence development. Finally, Mannila et al. (2018) assessed teachers' self-efficacy and training needs. Their study provides insights for professional development. Recognizing that digital competence evolves over time, educators must engage in continuous learning. Collaborative efforts across educational faculties, institutions, and policymakers are essential. By collectively prioritizing digital competence, we can equip educators with the skills needed to navigate the ever-evolving digital landscape. In summary, these dimensions intersect to shape the landscape of digital competence in education. As we expand our understanding, we recognize the urgency of fostering a digitally competent teaching force—one that not only adapts to technological advancements but also leverages them to enhance student learning outcomes.

In recent years, research has shed light on the digital competence of educators across various educational levels. Portillo et al. (2020) revealed that teachers, particularly those in primary and secondary schools, perceived themselves as only partially competent in digital skills, emphasizing challenges in using specific tools for teaching and learning. Basilotta et al. (2020) conducted a systematic review, highlighting gaps in competencies, especially related to evaluating educational practices. Galimullina et al. (2022) emphasized the need for a comprehensive model tailored to future teachers' digital competencies. Meanwhile, Cebi et al. (2022) and Elen et al. (2017) explored digital competencies in pre-service teachers, emphasizing the positive correlation between self-efficacy and digital competence. Falloon (2020) underscored the collective responsibility of educational faculties in preparing teachers for digitally mediated environments. Additionally, Hector Galindo-Dominguez and Maria José Bezanilla (2021) found that pre-service teachers generally possessed a medium level of digital competence, with room for improvement. Lisbeth A. et al. (2019) highlighted gaps in initial teacher education (ITE) regarding ICT training, emphasizing the need for continuous improvement. Moreno et al. (2019) reviewed TPACK development, revealing that daily practice often lags behind research. Gonzalez et al. (2017) explored digital competence among university students, considering gender and age differences. Mannila et al. (2018) assessed teachers' self-efficacy and training needs, providing insights for

professional development. These studies collectively emphasize the complexities and opportunities associated with digital competence in education, calling for targeted interventions and collaborative efforts.

Conclusion

In the rapidly evolving landscape of education, digital competence and the integration of technology are pivotal. The New National Education Policy 2020 (NEP 2020) underscores the need to harness disruptive technologies and leverage digital tools to enhance pedagogy. As we step into the AI age, educators must adapt, not only mastering digital skills but also understanding the intricate interplay between "technological, pedagogical, and content knowledge" (TPACK). NEP 2020's vision of a 'Global Knowledge Superpower' hinges on our ability to seamlessly blend AI-driven innovations with effective teaching practices. By fostering continuous professional development, collaborative efforts, and research, we can empower educators to navigate this transformative journey and ensure that every child benefits from a digitally enriched education.

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