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Developing digital competence for primary school teachers through interdisciplinary teaching practices

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***Abstract*---**This study explores how interdisciplinary teaching practices contribute to the development of digital competence among primary school teachers. Based on a comprehensive analysis of academic publications indexed in Scopus and Web of Science, the research synthesizes theoretical perspectives, practical models, and international experiences that link digital competence with interdisciplinary pedagogy. The findings reveal that digital competence is most effectively developed in authentic and collaborative teaching environments, where technology is integrated across multiple subject areas. Interdisciplinary approaches encourage teachers to use digital tools for communication, creativity, and problem solving, while promoting inclusive and student-centered learning. The study concludes that professional development programs should embed digital competence training into interdisciplinary practice rather than treat it as a separate component. Such an integrated approach enhances teachers' innovation, adaptability, and reflective capacity, ultimately preparing students for active participation in a digitally connected world.

***Keywords*---**digital competence, interdisciplinary teaching, primary education, teacher professional development, educational innovation.

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1. Introduction

The rapid advancement of digital technologies has profoundly transformed the educational landscape worldwide. In the context of the Fourth Industrial Revolution, the integration of digital tools into teaching and learning has become a critical aspect of educational reform, shaping how teachers design, deliver, and assess learning experiences. For primary school teachers, who play a fundamental role in shaping the learning foundations of young students, digital competence has emerged as an essential component of professional practice. It enables teachers not only to use technology efficiently but also to apply it critically, creatively, and ethically to enhance learning outcomes.

Digital competence is increasingly recognized as a multidimensional construct that extends beyond technical proficiency. According to Falloon (2020), it involves cognitive, pedagogical, and ethical dimensions that reflect a teacher's ability to evaluate, select, and apply digital tools to meet educational goals. Teachers with high digital competence can design interactive learning environments, use digital platforms to support student collaboration, and adapt teaching methods to diverse learning needs. More importantly, digital competence promotes reflective teaching and continuous professional growth, aligning with the global shift toward lifelong learning and digital citizenship in education.

In primary education, where learning is inherently holistic and experiential, interdisciplinary teaching offers a natural platform for integrating digital competence into everyday practice. Interdisciplinary approaches encourage teachers to connect ideas, concepts, and methods across different subject areas, fostering creativity and problem solving among students. When digital tools are embedded into interdisciplinary lessons, they become not merely instruments of instruction but catalysts for deeper understanding and collaborative inquiry. For example, a teacher who integrates mathematics, science, and art in a project that uses digital design applications helps students see the interconnectedness of knowledge while simultaneously improving their own digital fluency.

However, despite the growing emphasis on digital transformation, many primary school teachers continue to face significant challenges in developing and applying digital competence in interdisciplinary contexts. Studies have reported barriers such as limited access to resources, insufficient professional training, and lack of confidence in integrating technology into teaching (Johannesen and Øgrim, 2020; Dele Ajayi et al., 2021). Moreover, traditional teacher education programs often focus on discrete subject instruction rather than fostering interdisciplinary collaboration and digital pedagogical skills. This gap between policy aspirations and classroom realities highlights the need for new frameworks and approaches that support teachers in developing digital competence through interdisciplinary practice.

Globally, educational systems are moving toward competency based teaching models, where interdisciplinary learning and digital literacy are seen as complementary pillars of 21st century education. According to Wang and Sang (2024), interdisciplinary competence enhances teachers' adaptability, collaboration, and reflective thinking, all of which are essential for navigating the

complexities of digital education. Similarly, Huang and Pan (2023) emphasize that digital literacy empowers teachers to design innovative and engaging learning experiences that transcend subject boundaries. When these two competencies intersect, they create a powerful synergy that prepares teachers to educate digitally fluent and globally minded learners.

This paper seeks to explore this intersection by synthesizing recent research on the development of digital competence among primary school teachers through interdisciplinary teaching practices. It examines how interdisciplinary approaches contribute to building teachers' professional digital competence, identifies the challenges they encounter, and outlines strategies and models that have been effective in supporting such development.

The objectives of the study are threefold. First, it aims to analyze existing conceptual frameworks of digital competence and their relevance to interdisciplinary pedagogy in primary education. Second, it seeks to identify empirical evidence from international research that demonstrates effective integration of digital tools into interdisciplinary teaching. Third, it aims to discuss implications for teacher professional development and institutional policies that can foster a culture of innovation and digital readiness in primary schools.

By focusing exclusively on peer reviewed sources indexed in Scopus and Web of Science, this study provides a comprehensive and evidence based synthesis of current trends and insights. The findings are expected to contribute to theoretical understanding as well as practical implications for policymakers, teacher educators, and school leaders seeking to promote digital competence through interdisciplinary approaches. Ultimately, enhancing teachers' digital competence within interdisciplinary teaching not only strengthens their professional capabilities but also prepares students to become creative, critical, and collaborative learners in a digitally connected world.

2. Literature Review

2.1. Concept of Digital Competence

Digital competence has become a central component of teacher professionalism in the 21st century, reflecting not only the ability to use technology but also the understanding of how digital tools can transform teaching and learning. The term refers to a set of knowledge, skills, and attitudes that enable individuals to use digital technologies effectively, creatively, and responsibly in different educational contexts. According to Falloon (2020), digital competence encompasses multiple dimensions, including technical proficiency, cognitive understanding, ethical awareness, and pedagogical application. These dimensions interact to create a holistic framework in which teachers are not only users of technology but also designers of digital learning environments.

The development of digital competence requires teachers to move beyond basic computer literacy toward pedagogical fluency. Teachers must be able to evaluate and select digital tools that align with learning goals, adapt them to specific classroom contexts, and assess their effectiveness. This competence involves critical thinking about when and how technology adds educational value, as well

as sensitivity to issues such as digital equity, data privacy, and online safety. As technology evolves rapidly, digital competence must also be understood as a dynamic process that develops through continuous practice, reflection, and professional learning rather than as a fixed skill set.

In recent years, various frameworks have been developed to define and assess teachers' digital competence, such as the European DigCompEdu framework, which identifies six key areas including digital resources, teaching and learning, assessment, and professional engagement. These models stress that digital competence is inseparable from pedagogical knowledge and is best cultivated through authentic teaching experiences. Teachers who integrate digital competence into their professional identity are more likely to innovate, collaborate, and support lifelong learning. In this sense, digital competence represents not only a professional requirement but also an essential foundation for fostering creativity, inclusiveness, and quality education in the digital era.

2.2. Interdisciplinary Teaching in Primary Education

Interdisciplinary teaching has long been recognized as an effective approach to creating meaningful and connected learning experiences for students. In its essence, interdisciplinary teaching involves combining knowledge, concepts, and methods from different subjects to explore complex questions and real world problems. It encourages teachers and students to see knowledge as integrated rather than fragmented, allowing them to make connections across disciplines and apply learning in authentic contexts. According to Johannesen and Øgrim (2020), interdisciplinarity acts as a catalyst for teacher learning by bridging theoretical understanding with practical application. It fosters collaboration among educators, promotes shared responsibility for student learning, and strengthens reflective thinking about pedagogy.

In primary education, interdisciplinary approaches are particularly relevant because learning at this level is naturally holistic and experiential. Young learners tend to think in concrete and interconnected ways, and they benefit from projects or themes that link mathematics, language, science, and the arts. Through such integration, teachers can design activities that stimulate curiosity and promote critical thinking while addressing multiple learning objectives simultaneously. For instance, a thematic project on environmental sustainability might involve mathematical data analysis, scientific observation, digital presentations, and creative writing, all supported by digital tools. This interconnected approach not only deepens student understanding but also challenges teachers to collaborate and innovate across subject boundaries.

Moreover, interdisciplinary teaching encourages teachers to rethink their roles as facilitators of inquiry rather than transmitters of isolated content. It nurtures pedagogical flexibility, as teachers learn to adapt knowledge from different disciplines to suit diverse learning styles and abilities. In modern classrooms, digital technologies amplify the potential of interdisciplinary teaching by enabling simulations, virtual experiments, and multimedia exploration that connect knowledge domains in engaging ways. Consequently, interdisciplinarity provides both a conceptual and practical foundation for developing teachers' digital

competence, as it pushes them to experiment with technology while designing cross disciplinary lessons that engage students in active learning.

2.3. The Relationship between Digital Competence and Interdisciplinary Practice

The relationship between digital competence and interdisciplinary practice is increasingly viewed as reciprocal and reinforcing. On one hand, digital competence enables teachers to implement interdisciplinary projects more effectively by providing tools for collaboration, creativity, and problem solving. On the other hand, interdisciplinary teaching creates authentic contexts for teachers to practice, refine, and expand their digital skills. Wang and Sang (2024) emphasize that interdisciplinary competence enhances teachers' capacity for collaboration and reflective thinking, both of which are essential components of digital competence development.

Teachers who are digitally competent are better equipped to integrate technology into interdisciplinary lessons that promote active learning and engagement. For example, digital storytelling tools can merge language arts with social studies, while coding or robotics projects can link mathematics, science, and design. Huang and Pan (2023) found that teachers with advanced digital literacy were more capable of designing such activities, using technology not merely as a support tool but as a means to foster higher order thinking skills. In this way, digital competence empowers teachers to transform interdisciplinary teaching into an interactive and learner centered process.

Conversely, the interdisciplinary approach strengthens the motivation and context for developing digital competence. Teachers working across subject boundaries encounter new challenges that require technological solutions, prompting them to explore unfamiliar tools and platforms. This continuous experimentation promotes adaptive learning and innovation. Collaborative interdisciplinary teams also provide social support for digital learning, allowing teachers to share resources, co design lessons, and engage in reflective discussions about technology integration. Therefore, digital competence and interdisciplinarity are intertwined in a cycle of mutual reinforcement: digital technologies enrich interdisciplinary learning, while interdisciplinary practice deepens and contextualizes digital competence.

Furthermore, this relationship has important implications for teacher education and professional development. Pre service and in service training programs that integrate interdisciplinary digital projects help teachers acquire not only technical knowledge but also pedagogical agility and collaborative mindset. Such integration ensures that digital competence is not developed in isolation but embedded within meaningful teaching practices that reflect real classroom challenges.

2.4. Empirical Evidence and Models of Integration

A growing body of empirical research provides convincing evidence of the relationship between digital competence and interdisciplinary pedagogy. Numerous studies indicate that interdisciplinary projects, digital learning communities, and collaborative teaching models are effective strategies for

enhancing teachers' digital skills. Vorontsova and colleagues (2022) examined how interdisciplinary projects can serve as a pathway for developing digital competence through teamwork and project based learning. Their findings revealed that when teachers engage in cross disciplinary projects requiring the use of digital tools, they not only strengthen their technical abilities but also improve communication, problem solving, and creative thinking. These results are consistent with constructivist theories that emphasize learning through experience and collaboration.

Kusumawati and Pratama (2025) introduced an interdisciplinary model of digital learning innovation that highlights the value of shared teaching environments and co designed curricula. Their study demonstrated that teachers who work collaboratively across disciplines are more inclined to explore new digital platforms, align them with specific learning objectives, and sustain innovation over extended periods. Similarly, Dele Ajayi, Dunsin, and Okoli (2021) observed that teachers' concerns regarding technology integration—such as lack of confidence, fear of technical difficulties, and doubts about pedagogical relevance—can be effectively addressed through collective reflection and peer mentoring within interdisciplinary teams. Such environments encourage open discussion of challenges, exchange of practical experiences, and gradual development of both competence and confidence in using technology.

Beyond individual studies, meta analyses and international reports suggest that embedding digital competence within interdisciplinary frameworks enhances teacher effectiveness and student learning outcomes. Schools that adopt cross curricular digital projects often report higher levels of engagement, more profound conceptual understanding, and stronger collaboration among both teachers and students. Furthermore, interdisciplinary digital initiatives can promote educational equity by ensuring that all learners have access to diverse, inclusive, and meaningful digital learning opportunities.

3. Methodology

This study is based entirely on documentary research using secondary data from books, peer reviewed journals, and conference proceedings indexed in Scopus and Web of Science.
The research process included the following stages:

1. **Identification:** Relevant studies were located using search terms such as "digital competence," "interdisciplinary teaching," "teacher education," and "primary school."
2. **Selection:** Studies published between 2020 and 2025 were reviewed, focusing on those that addressed the development of digital competence through interdisciplinary approaches.
3. **Analysis:** Qualitative content analysis was used to identify recurring concepts, theoretical frameworks, and practical strategies discussed in the literature.
4. **Synthesis:** The results were grouped into key themes including conceptual understanding, interdisciplinary applications, challenges, and policy implications.

4. Findings

The analysis of the reviewed literature reveals several essential findings concerning the integration of digital competence into interdisciplinary teaching for primary school teachers. The results indicate that this integration not only strengthens teachers' professional skills but also transforms their pedagogical approaches and classroom practices. Four main themes emerge from the synthesis: authentic learning opportunities, pedagogical transformation, collaborative innovation, and inclusive digital learning.

First, interdisciplinary contexts create meaningful opportunities for teachers to apply and develop digital competence in real teaching situations. When teachers design and implement projects that combine different subject areas, they naturally engage in digital planning, data management, communication, and evaluation. These processes allow teachers to use technology as a creative and problem solving tool rather than a supplementary instrument. Through interdisciplinary projects, teachers become more confident in integrating digital resources into lessons and begin to recognize the connection between digital competence and professional growth.

Second, the integration of digital competence within interdisciplinary lessons encourages significant pedagogical transformation. Teachers tend to shift from traditional content delivery toward more inquiry based, student centered approaches. This transformation promotes creativity, collaboration, and critical thinking among students. Teachers who continuously design and experiment with digital interdisciplinary activities develop greater flexibility and adaptability in their instructional methods. As a result, the teaching process becomes more dynamic, and students experience learning as an interactive and technology enriched journey rather than a passive reception of knowledge.

Third, collaboration plays a crucial role in sustaining teachers' digital competence development. Working across disciplines enables teachers to exchange ideas, share resources, and reflect together on their teaching practices. Such collaboration provides an environment for mutual support, where teachers can discuss challenges related to technology use and learn collectively. Through regular interaction and teamwork, teachers gradually build confidence in applying digital tools and foster a professional culture of innovation. Collaborative environments also enhance teachers' motivation to explore new digital platforms and adapt them to diverse educational goals.

Fourth, interdisciplinary digital practices contribute to educational inclusivity and equity. Integrating digital competence across subjects allows teachers to design lessons that accommodate different learning styles and abilities. By using visual, auditory, and interactive technologies, educators can engage students with varied backgrounds and ensure equal participation in learning activities. This inclusive approach helps reduce disparities in digital access and promotes a sense of belonging among all learners. Moreover, interdisciplinary digital learning encourages students to connect knowledge from different domains, developing their ability to think critically and act creatively in real life contexts.

In general, the findings show that digital competence development is most effective when it takes place within authentic and collaborative interdisciplinary settings. Teachers who integrate technology across disciplines tend to demonstrate greater professional confidence, creativity, and reflective thinking. The integration of digital competence into interdisciplinary pedagogy therefore supports both personal and institutional innovation, fostering an educational culture that values exploration, collaboration, and continuous improvement.

Ultimately, these findings confirm that the future of teacher professional development lies in comprehensive and context based models that embed digital competence into interdisciplinary teaching. Such an approach not only equips teachers with the necessary skills for the digital era but also enhances students' ability to learn, create, and collaborate effectively in an increasingly interconnected world.

5. Conclusion

The synthesis of research findings confirms that the integration of digital competence into interdisciplinary teaching serves as an essential pathway for innovation in primary education. Digital competence empowers teachers to design creative and interactive learning environments, while interdisciplinary approaches provide authentic contexts for applying and refining these digital skills. When combined, these elements transform traditional pedagogy into a dynamic process that fosters collaboration, critical thinking, and lifelong learning.

Developing digital competence through interdisciplinary practice enables teachers to connect knowledge across subject areas and apply technology meaningfully in diverse classroom situations. This process strengthens teachers' confidence, enhances their professional identity, and promotes a culture of continuous improvement. Moreover, interdisciplinary digital learning contributes to educational equity by providing students with access to diverse, inclusive, and engaging forms of learning that reflect real world connections.

The study underscores that the future of teacher professional development lies in comprehensive and context based approaches that integrate digital competence with interdisciplinary teaching. Instead of treating technology as an isolated tool, educators should view it as an integral component of pedagogical design and collaboration. Institutions and policymakers are encouraged to create supportive frameworks that promote joint curriculum design, peer mentoring, and continuous reflection within digital learning communities.

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