PEDAGOGICAL CONDITIONS FOR DEVELOPING DIGITAL COMPETENCE IN PRE-SERVICE INFORMATICS TEACHERS

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Abstract. The rapid expansion of digital environments, mobile applications, interactive platforms, and AI-based educational tools in the 21st century has created new pedagogical conditions for the development of digital competence among future informatics teachers. Digital competence is not limited to the use of technological tools; it encompasses acquiring, processing, and applying knowledge for pedagogical purposes, as well as creating and presenting educational content. The integration of technological, pedagogical, and content knowledge (TPACK) provides a theoretical foundation for designing effective learning experiences, while frameworks such as **DigCompEdu** and the **SAMR model** offer systematic approaches for assessing and enhancing teachers' digital proficiency. This study emphasizes the role of mobile technology–based electronic resources, including LearningApps, Moodle Mobile, Google Classroom, Duolingo, and Khan Academy, in supporting TPACK integration, promoting personalized learning, and fostering analytical thinking and digital reflection. The findings highlight that professional development in digital competence is a multidimensional process involving technical, pedagogical, and reflective capacities, which are essential for achieving transformative learning outcomes in contemporary education.

Keywords: Digital competence, TPACK model, DigCompEdu framework, SAMR model, Mobile learning, Electronic educational resources, Teacher professional development, Digital pedagogy

Introduction. The rapid proliferation of digital technologies in the 21st century has fundamentally transformed the educational landscape, creating unprecedented opportunities and challenges for teachers and learners alike. Mobile applications, interactive platforms, and artificial intelligence (AI)–based educational tools have shifted the traditional paradigms of teaching and learning, necessitating the development of new pedagogical competencies among future informatics teachers. In this context, digital competence is no longer merely the ability to use technological tools; it encompasses the acquisition, processing, and application of knowledge for pedagogical purposes, as well as the creation and dissemination of educational content.

Integrating technological, pedagogical, and content knowledge, as conceptualized in the **TPACK model**, provides a theoretical foundation for effective instructional design. The TPACK framework emphasizes that technology should not function merely as an ancillary tool but should be harmonized with subject matter and pedagogical strategies to maximize educational outcomes. Complementary to this framework, models such as **DigCompEdu** and **SAMR model** provide structured approaches for assessing teachers' digital competence and the transformative potential of technology integration in classrooms.

Mobile technology–based electronic resources, including LearningApps, Moodle Mobile, Google Classroom, Duolingo, and Khan Academy, play a pivotal role in supporting TPACK integration. These resources enable interactive content delivery, personalized learning, digital assessment, and the cultivation of reflective and analytical thinking skills. Consequently, the professional development of future informatics teachers requires systematic training in both

technical skills and pedagogical design, ensuring that digital competence is embedded in teaching practices and contributes to transformative learning outcomes[2].

Literature Review. Digital Competence in Teacher Education. Digital competence is widely recognized as a multidimensional construct encompassing technical proficiency, pedagogical understanding, and reflective practices. According to the European Commission (2017), the **DigCompEdu framework** provides a comprehensive set of competencies for educators, organized across six proficiency levels from A1 (Beginning) to C2 (Pioneer). This framework emphasizes not only the ability to operate digital tools but also the capacity to generate educational value, enhance student learning, and support continuous professional development through digital means[1].

TPACK Framework. The **TPACK model**, introduced by Punya Mishra and Matthew J. Koehler, remains a foundational model in educational technology research. It conceptualizes teacher knowledge as the dynamic intersection of three domains: content knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK). Research indicates that the integration of these domains enables teachers to design and implement lessons that are both technologically enriched and pedagogically sound, leading to higher learner engagement and improved learning outcomes[2].

SAMR Model. The **SAMR model**, developed by Ruben Puentedura, provides a practical framework for evaluating the level of technology integration in education. SAMR classifies technology use into four stages: Substitution, Augmentation, Modification, and Redefinition. The model demonstrates the evolutionary progression from simple technological substitution to transformative learning experiences, highlighting how effective integration can fundamentally reshape teaching and learning processes[3].

Mobile Learning and Electronic Resources. The proliferation of mobile learning resources has further expanded the possibilities for digital pedagogy. Platforms such as LearningApps, Moodle Mobile, Google Classroom, Duolingo, and Khan Academy facilitate interactive, personalized, and collaborative learning experiences. These tools support the practical application of TPACK by enabling content delivery (CK), tailored pedagogical strategies (PK), and technological facilitation (TK), while fostering digital reflection and critical thinking among learners[4][5][6][7][8].

Overall, the literature underscores the necessity of equipping future informatics teachers with digital competence that integrates technical skills, pedagogical expertise, and reflective practices. The combination of TPACK, DigCompEdu, and SAMR frameworks offers a coherent strategy for both developing and assessing these competencies, ensuring that teachers are prepared to leverage technology to achieve transformative learning outcomes.

Problems and solutions. The digital learning environment provides learners with opportunities for self-regulated learning, flexible and adaptive thinking, communication through virtual platforms, remote completion of assignments, and the creation of various forms of digital content such as video lectures, mobile-interface-based tasks, and electronic assessment tools. Consequently, higher education institutions are expected to establish not only an information-rich educational environment but also a comprehensive digital learning ecosystem that supports teaching, learning, and assessment processes.

Without mastering these competencies, it becomes difficult for future specialists to successfully carry out their professional pedagogical activities. From this perspective, competencies represent a combination of knowledge, skills, and abilities that ensure the continuous professional development of teachers.

According to European Union policy documents, digital literacy is manifested in the ability to effectively use digital information, apply media resources for educational purposes, critically

analyze information based on data, and develop digital products. Thus, the formation of digital competence is closely related to the development of digital culture, digital reflection, and digital responsibility among future teachers.

Thus, based on the results of our study, the development of digital competence among future informatics teachers can be ensured through the following pedagogical conditions:

- the creation of a digital learning environment;
- the individualization of learning tasks based on mobile technologies;
- the implementation of digital assessment mechanisms;
- the practice of developing e-portfolios, e-courses, and electronic learning materials;
- the encouragement of digital reflection and analytical thinking.

As a result, digital competence should not be interpreted merely as the consumption of information. Instead, it is formed as a complex quality that includes the following processes:

- acquiring knowledge through digital tools,
- processing and analyzing information,
- directing knowledge toward pedagogical purposes,
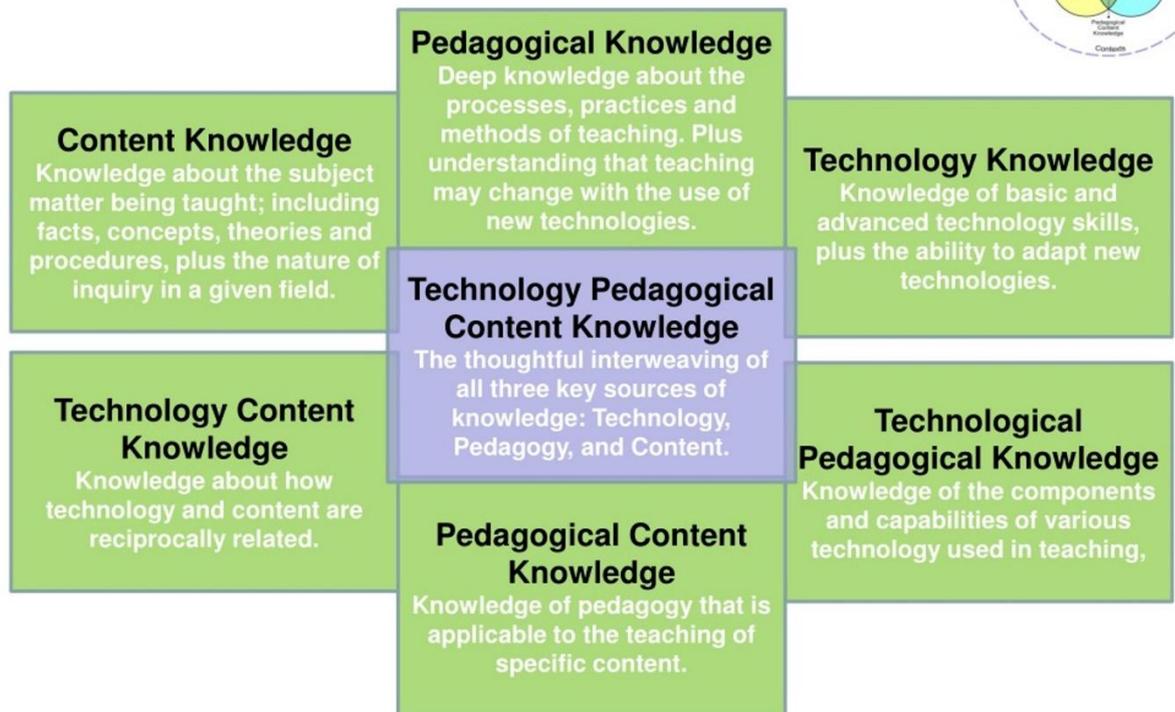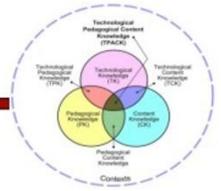- creating and presenting educational content.

In the development of digital competence, the **TPACK model (Technological Pedagogical Content Knowledge)** has significant scientific and practical importance. This model emphasizes the integration of three key components of teacher knowledge:

- **Content Knowledge (CK)** — knowledge of subject matter;
- **Pedagogical Knowledge (PK)** — knowledge of teaching methods and pedagogical principles;
- **Technological Knowledge (TK)** — knowledge of digital technologies and tools.

The **TPACK model**, proposed by Punya Mishra and Matthew J. Koehler, is based on the scientific principle that technology in education should not be viewed merely as an additional tool[2]. Rather, the highest level of effectiveness is achieved when technology is integrated harmoniously with pedagogical approaches and subject content within the teaching and learning process(figure 1).

TPACK Model

Content Knowledge
Knowledge about the subject matter being taught; including facts, concepts, theories and procedures, plus the nature of inquiry in a given field.

Pedagogical Knowledge
Deep knowledge about the processes, practices and methods of teaching. Plus understanding that teaching may change with the use of new technologies.

Technology Knowledge
Knowledge of basic and advanced technology skills, plus the ability to adapt new technologies.

Technology Pedagogical Content Knowledge
The thoughtful interweaving of all three key sources of knowledge: Technology, Pedagogy, and Content.

Technology Content Knowledge
Knowledge about how technology and content are reciprocally related.

Pedagogical Content Knowledge
Knowledge of pedagogy that is applicable to the teaching of specific content.

Technological Pedagogical Knowledge
Knowledge of the components and capabilities of various technology used in teaching.

Interactions of TPACK as described by Mishra & Koehler (2006), in Robin (2008).

Figure 1. TPACK Model (Integration of Technological, Pedagogical, and Content Knowledge).

Mobile Technology–Based Electronic Resources as a Key Tool for TPACK Integration. Mobile applications, interactive platforms, AR/VR tools, and educational resources such as LearningApps, Moodle Mobile, Google Classroom, Duolingo, and Khan Academy enable the integration of all components of the **TPACK model** (Technological Pedagogical Content Knowledge). These resources allow the following:

- **CK (Content Knowledge):** subject matter is delivered interactively;
- **PK (Pedagogical Knowledge):** teaching strategies are adapted to students' age, level, and individual needs;
- **TK (Technological Knowledge):** teachers utilize the didactic capabilities of mobile applications.

In the context of digitalizing education, one of the most comprehensive frameworks for systematically assessing teachers' digital competence is the **DigCompEdu (Digital Competence Framework for Educators)**, developed by the European Commission. This framework, refined in multiple stages between 2017 and 2020, is now recognized globally as one of the most universal professional competence standards. The emergence of such frameworks is driven not merely by the quantity of technology usage but by the need to define quality standards for its pedagogical application.

The **DigCompEdu** model focuses not on the mere presence or frequency of technology use, but on how teachers generate educational value through digital tools. At the core of this approach are principles of professional transformation, student development through digital resources, and

enhanced educational outcomes. In essence, digital competence is not defined by technical skills alone but by the teacher's pedagogical initiatives, instructional design activities, and active reflection.

DigCompEdu Proficiency Levels: A1–C2 Transformational Stages

The framework outlines a six-level professional development continuum:

- **A1 Beginning:** can use existing tools;
- **A2 Discovering:** experiments with tool functionalities;
- **B1 Integrating:** applies tools methodologically in lessons;
- **B2 Advancing:** designs individualized learning activities;
- **C1 Expert:** manages the learning platform effectively;
- **C2 Pioneer:** develops new digital teaching methodologies.

Each level represents markers of qualitative professional transformation.

In contemporary digital education, the **SAMR model**, developed by Ruben Puentedura, is the most widely used conceptual framework for assessing the degree of technology integration in teaching. This model allows educators to classify the stages of pedagogical transformation by evaluating the effectiveness of digital tools in instructional practice. Essentially, the SAMR model illustrates the evolutionary progression of educational technology integration, from simple substitution to transformative learning experiences.

Results. The implementation of mobile technology–based electronic resources and TPACK-aligned instructional strategies in teacher training programs has demonstrated significant positive outcomes. Future informatics teachers who actively engaged with interactive platforms, mobile applications, and AR/VR tools showed enhanced abilities to integrate content knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK) in lesson planning and delivery.

Key findings include:

1. **Improved Digital Competence:** Teachers demonstrated proficiency in utilizing digital tools not only for content delivery but also for assessment, feedback, and interactive student engagement.

2. **Enhanced Pedagogical Strategies:** The application of DigCompEdu and SAMR frameworks enabled teachers to design personalized, adaptive, and transformative learning experiences.

3. **Development of Reflective Practice:** Teachers engaged in continuous digital reflection, evaluating the effectiveness of technology integration and making informed pedagogical decisions.

4. **Creation of Digital Learning Materials:** Teachers produced e-portfolios, e-courses, and multimedia learning resources, reinforcing both their subject knowledge and technological skills.

Overall, these results indicate that structured integration of TPACK principles, mobile learning tools, and digital competence frameworks leads to measurable improvements in teacher preparedness and professional development, fostering transformative educational practices.

Conclusion. The study highlights that the development of digital competence among future informatics teachers is a multidimensional process that extends beyond mere technical skills. Effective digital pedagogy requires the integration of content knowledge, pedagogical strategies, and technological tools, as emphasized in the TPACK framework. Complementary frameworks, such as DigCompEdu and SAMR, provide structured approaches for assessing and enhancing teachers' digital proficiency, ensuring quality and transformative outcomes in the learning process.

Mobile technology–based resources, including LearningApps, Moodle Mobile, Google Classroom, Duolingo, and Khan Academy, play a pivotal role in supporting interactive and personalized learning experiences, digital assessment, and reflective practices.

In conclusion, equipping future teachers with digital competence requires not only access to technological tools but also systematic training in pedagogical integration, content adaptation, and reflective evaluation. The combination of TPACK, DigCompEdu, and SAMR frameworks provides a comprehensive approach to fostering professional growth, enabling teachers to create meaningful, transformative, and technology-enhanced educational experiences.

References:

1. European Commission. (2017). *DigCompEdu: The digital competence framework for educators*. Publications Office of the European Union. https://ec.europa.eu/jrc/en/digcompedu

2. 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

3. Puentedura, R. R. (2014). *SAMR and TPCK: Introduction to advanced practice*. Hippasus. http://hippasus.com/rrpweblog/

4. LearningApps. (n.d.). *Interactive learning modules*. https://learningapps.org/

5. Moodle Mobile. (n.d.). *Mobile learning platform*. https://moodle.com/mobile/

6. Google for Education. (n.d.). *Google Classroom*. https://edu.google.com/products/classroom/

7. Duolingo. (n.d.). *Language learning app*. https://www.duolingo.com/

8. Khan Academy. (n.d.). *Free online courses, lessons & practice*. https://www.khanacademy.org/