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Transversal nucleus of the digital competence of pre-service teachers

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Abstract

This study examines the integration of key and transversal competencies within the evolving professional competencies of teachers, emphasizing the development of a "transversal nucleus" that facilitates cognitive, experiential, and personal growth. The research aimed to explore how these competencies enhance self-cognition, self-regulation, and self-perfection, particularly in fostering digital competence among pre-service teachers. Using an experimental approach, the study tested technological models designed to develop digital competence through structural and functional experiences and the synchronization of skills and relationships. A sample of 101 first-year pedagogy students enrolled in "Information and Communication Technologies and Work in the Digital Environment" participated. Findings revealed the emergence of a transgressive segment within the transversal nucleus of digital competence, extending from cognitive to practical levels. This segment enhances self-awareness, reconstructs behavior, and synergizes motivational and integrative effects. The study concludes that this transgressive formation is essential for the holistic development of digital competence, driving both personal and professional growth. It recommends further refinement and broader application of these models to foster digital competence in teacher training programs, ensuring alignment with evolving educational demands.

Keywords: Digital competence; pre-service teachers; students; transversal nucleus .

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1. INTRODUCTION

The development of information and communication technologies and the digitalization of education in all its manifestations and forms of existence (formal, informal, non-formal), in all stages of the system of preschool and school education, as well as in the system of higher and continuing education and lifelong learning determines the research interest in exploring and forming the frameworks of digital competence of the citizen, the teacher, the pre-service teacher (Norhagen et al., 2024; Bertram et al., 2023; Kulaksız & Toran 2022; Yang et al., 2023; Chu et al., 2023).

The present research, therefore, focuses on the digital competence of the teacher in search of opportunities to overcome its framing (taxonomic, hierarchical, operationalized, and evaluative) in the course of university education through a transgressive projection (self-generating, self-perfecting, self-reflexive, and self-evaluating) within a multi-approach growth development in the education of pre-service teachers to the effect of providing for a meta-actualization of all professional competences of the teacher in the transformative complex.

1.1. Theoretical and conceptual framework

Despite the numerous studies focused on digital literacy, digital skills, information literacy, computer literacy, ICT literacy, media literacy, e-literacy, ICT competence, and digital competence, a systematic study of the scientific literature on the subject was conducted in 2020 (in Scopus databases). Web of Science and ERIC) shows that there is no unanimous interpretation of the concepts and there is still a long way to go to reach a consensus on their content and structure, which entails a necessity for ways to clarify the problem at the conceptual level. The review of the research leads to the conclusion that most of the documents focus preeminently on the assessment of digital competence rather than its development and design in an educational context (Sánchez-Caballé et al., 2020).

Retrospectively, early research on the definition of digital competence seems to have been significantly influenced by the definition of digital literacy as a basic level of information use, outside the traditional context, through the gradual convergence of information and communication technologies and digital resources with traditional ones. Continuous refocusing of scientific attention leads to the upgrading of digital competence within a wider and more complex set of knowledge, skills, attitudes, and attitudes, defining it as a specific way of critical thinking, and encoding. Decoding, and recoding of information (Ala-Mutka, 2011) are related to the continuous adaptation to growing technological possibilities and their projections and the reaching of expert digital competence or at least the vision for it (Janssen et al., 2013).

There are different concepts regarding the definition of digital competence, characterized by dimensions of "cognitive, relational and social nature", and given its integral nature, it is often seen as including technological, cognitive, and ethical elements integrated according to the context of its existence (Calvani et al., 2008; Merjovaara et al., 2024). There are also some contradictions regarding the content and structure of the digital competence of the teacher which hinder its full formation and development during university training. In educational theory and practice, these contradictions are most commonly subsumed as (1) misunderstanding and inability to distinguish between systematic training of specialists (mainly from technical majors) in the field of information technology, training of teachers of information technology, and pre-service teachers of other subjects as users of these technologies; (2) failure to take into account the competence approach in the design of the educational goals and expected results, as well as the lack of identification of the basic elements of each competence; (3) the ambiguity regarding the conceptual framework of teachers' digital competence and the possibilities for its full inclusion in their professional profile; (4) the lack of a conceptual model for designing technological solutions for the formation and development of the digital competence of teachers within their educational training.

Research has seen a steady expansion of the concept of digital competence with a gradual process of specifying it in a professional context based on its situational manifestation (Krumsvik, 2008). Within the teaching of different subjects, the dimensions of the digital competence of the teacher are further expanded, enriched, and acquired specificity, manifested variably, but preserving the invariant nature of the derived

conceptual framework. All this makes the digital competence of the teacher dynamic and constantly evolving, which necessitates its constant revision and upgrading, in the context of continuing education.

At the same time, defining the framework of the teacher's digital competence and defining levels for measurement and assessment set the parameters for managing its formation and development in an educational context, but in a linear setting. Yet, in the context of continuously expanding the application of information and communication technologies and work in the digital environment in the teacher's activity, it is necessary to rethink the approach applied so far, namely the framing of digital competence as key (through its ultimate definition, through areas of competence and/or sets of knowledge, skills, and attitudes), and to search for opportunities for its development as transversal and therefore transgressive competence.

These grounds also lead Merdzhanova (2002), who argue that “modern education is focused on “key” competencies, but they change over time and concerning socio-economic conditions they function as a pragmatic manifestation and concretization of transversal basic human competencies – the natural long-term ‘lifelong’ potential of humans. Transversality is connected, not so much with the ability in a specific, albeit typical situation, but with the type of attitude to any situation that is portable, that is, transversality is based on typifying a person's attitude to situations, not the situations themselves”. Speaking of a “kind of market of key competences” as the most sought after or most needed in current social conditions, Merdzhanova (2002) positions “transversal competencies as permanent, attributive to man, as transferable and valid throughout one's life as a rational social being, as related to an individual's cognition and metacognition (cognitive competencies), with the ethics of interpersonal and intergroup relations (social competences), with the intention orientation for perspective activity (methodological competence), with the self-knowledge (self-reflection and competences for self-regulation). According to Merdzhanova (2002), these 4 transversal competencies grow to be 3 internal aspects (a synthesized variant) of each competence: cognitive - understanding the situation; methodological - for designing the activity/ies; relational - for attitude towards others (partnership) and towards oneself as self-reflection and adequate self-assessment and self-regulation. This is the inner transferable core of any competence, which is not only transferred from situation to situation but also transformed according to its uniqueness – a matter of sustainability incompetence, which is sustainable in personality. From the nucleus derive the pragmatic skills of the behavioral realization of competence. They can and must change, adapt, and transform with the transition from situation to situation. This is inevitable. But when there is a stable portable core, adaptation, and variation do not cause stress and disruption in personality behavior. It is open, synergic, efficient, and effective. It is autonomous. The transversal core is the essence of competence, the pragmatic skills are its behavioral projections (Merdzhanova, 2002; Merdzhanova, 2010; Merdzhanova, 2021).

1.2. Related research

Research on digital competence, presented as a key competence at the beginning of the 21st century, is mainly aimed at creating theoretical models, competence frameworks, and research tools for competence assessment. In a European context, a framework of the digital competence of teachers has been developed (Redecker, 2017) to facilitate the perception of its overall framework, the expert levels are presented through a description of specific roles projectable onto the professional levels proposed in the Common European Framework of Reference for Languages A1 to C2.

In recent years, several studies have analyzed and compared the European Digital Competence Framework with different national frameworks. This finding is in full accord with the present research and its conceptual idea for substantiating the need for transgressive methodological approaches for the formation and development of basic, transversal competencies (in this case digital competence) and their transformation into transgressive ones. However, this is possible only through the continuous “transformation of the educational consciousness” (Tsankov, 2022). Merdzhanova (2010) interprets this transformation as: “(1) an opportunity to embrace the immediate participants in the pedagogical process, regardless of their roles in it; (2) the transformation of the educational consciousness as a complete and unified entity, including those parts of the individual consciousness that are engaged in the event of education, needing movement, development in all participants and stakeholders, but with a certain degree of specific pedagogical culture, because the cultural preservation and reproduction of humanity rest on the mechanism of pedagogical

connection, and each human consciousness has a "pedagogical part" which must be cultivated and developed because it participates in the overall "educational consciousness"; (3) in the direction of synchronization, coordination for transformation and real evolution" (Merdzhanova, 2010).

1.3. Purpose of the study

The purpose of the present study is to specify the conceptual foundation for the development of a model for the initial growth of digital competence, as a focus of productive learning organization, gradually including the modular cybernetic approach in an instructional environment, the constructivist approach, and the situational approach in a constructivist environment, where it is possible to apply and reconstruction of the cognitive and practical experience of students, depending on the structure of the new cognitive and practical tasks/problems/situations, tested in stages within the training in the discipline "Information and communication technologies in education and work in the digital environment".

The study of the effectiveness of the applied technological option for the development of digital competence is presented according to its application within the school year. The present study also aimed to reveal the mechanisms of the transfer of competence, as well as the determinants of this transfer. Of interest is the possibility of transferring the developed digital competence (more precisely the nucleus of the digital competence) through various activities, school years, and academic disciplines. The transversality test is aimed at assessing the transferability of the skills that underlie its nucleus, namely cognitive skills; practical and applied skills; problem-solving skills, as well as the self-assessment/assessment ratio (real achievements).

2. METHOD AND MATERIALS

2.1. Research method

The research includes a pilot experiment, a didactic experiment, and a final study. The determination of the variables, the criteria, and the indicators of the research is an important stage of the overall design of the experiment. Independent variables are those whose influence is explored - in this case, it is the didactic technology for developing the digital competence of pre-service teachers. The experimental research changes and diagnoses the dependent variables - in this case, it is the degree of development of digital competence in the course of training in "Information and communication technologies in learning and working in a digital environment."

2.2. Participants

The study of the transversal nature of the nucleus of digital competence was conducted with extramural students completing their Bachelor's degree as part of their studies in Education Science (Part II) – *Didactics and Methodology and Methods of Educational Research*. The empirical research was conducted with a sample of 101 students studying the discipline "Information and Communication Technologies and Work in the Digital Environment" in the professional field of Pedagogy, within the first semester of the first year of their education.

2.3. Data collection tools

In the present study, the criteria, indicators, and factors for reporting the development of competence are summarized in Table 1.

In developing the system of criteria and indicators, the leading factor is the search for opportunities to overcome the framing of the digital competence through its content-thematic assessment, and not by tracking the formation and development of the "transversal core" of the competence, which is by nature cross-curricular. Therefore, the selected criteria, indicators, and factors have a high level of generality, and although they are considered in the context of a specific curriculum, their supra-subject/supra-content /supra-thematic degree of manifestation is sought for, even their degree of independence from the content.

Table 1
A system of criteria and indicators for the empirical study

Criteria	Indicators	Factors
Cognitive achievements	Knowledge	<ul style="list-style-type: none"> - content (completeness) - consideration - durability - applicability
	Cognitive skills	<ul style="list-style-type: none"> - skills for critical analysis and synthesis; - skills for comprehension of relations (part-whole, singular-general, cause-result, goal-means, determinateness); - skills for classification and definition; - modeling skills; - skills for self-instilled variations of activities or actions; - assessment skills.
Practical achievements	Practical-and-application skills	<ul style="list-style-type: none"> - reproductive (standard) task solution following instructions; - explorative task solution by constructing recreation; - creative transfer of skills in problem situations by design of new constructs.
	Problem-solving skills	<ul style="list-style-type: none"> - identification of the basic elements of the problem; - selection of information and technological potential solutions, needed for the problem-solving process; - generation of solution ideas; - decision making; - (self)assessment of the solution.
Relations	Operational aspect	
	Interest	<ul style="list-style-type: none"> - in the activity; - in its result.
	Motivation	<ul style="list-style-type: none"> - procedural (internal) motives; - resultative (external) motives.
	Personality aspect	
	Relation self-assessment/assessment (actual achievements)	<ul style="list-style-type: none"> - identification of one's own cognitive and practical capacities; - reflexive skills; - skills for adequate self-assessment
	Orientation	<ul style="list-style-type: none"> - emotional; - will power; - cognitive; - transversal.

2.4. Data collection process

To ensure the objectivity of the comparisons of the results from the assessment of the segments of the digital competence of the students, the sample within this stage of the research (Bachelor's degree - extramural study) was conducted in different periods depending on the chosen subject field.

2.5. Data analysis

To verify portability, they are subjected to additional statistical processing to determine whether there are significant differences between the different groups about different aspects of digital competence. For this purpose, all groups were successively compared to each other (two by two), using the Mann-Whitney test to compare two independent groups.

3. RESULTS

When analyzing the results of the Test Statistics Mann-Whitney U using the p-value of the statistical test Asymp. Sig. (2-tailed) (Asymptotic Significance (Bilateral)), it was found that in all consecutive comparisons between groups through different segments of students' digital competence in the study of its portability, $p < 0.05$ was found, which is a statistically significant value. This makes it possible to reject the null hypothesis

H0 and to conclude that there is a difference between the two groups (consistently compared) in the ranking of the evaluation of the segments of the core of digital competence of students (table 2).

Table 2

Average coefficients of achievement K_x for the assessment of the transversality of the nucleus of the digital competence

Groups	K_x (Didactics – summer term 2018/2019 academic year)				K_x (Methodology and methods of educational research – summer terms 2019/2020 academic year)			
	Cognitive skills	Practical-and- application skills	Skills for problem	Attitude assessment/ self- assessment	Cognitive skills	Practical-and- application skills- apply skills	Problem-solving skills	Attitude assessment/ self- assessment
Control	0.33	0.28	0.31	0.13	0.29	0.25	0.26	0.10
Experimental	0.70	0.73	0.82	0.69	0.65	0.70	0.76	0.63
Difference	0.37	0.45	0.51	0.56	0.36	0.45	0.50	0.53

To study the relationship between the results of the experimental group in Pedagogy Part II - Didactics and Methodology and methods of educational research (- the relationship between the developed segments of the nucleus of the digital competence and their portability in solving problems in alternative disciplines), correlation analysis was used - a statistical method for studying the relationship between variables to reveal the strength of the dependence. The indicators that convey quantitative information about the strength of the dependence are the correlation coefficients. Pearson's coefficient for simple linear correlation was used in the study. In this case, the Pearson correlation coefficient is $r=0.714$, which shows a significant strength (degree) of the relationship between the degree of development of the segments of the nucleus of the digital competence and the degree of its portability. This gives grounds for the conclusion that with a certain level of development of the segments of the nucleus through the discipline "Information and communication technologies in teaching and working in the digital environment", they are transferable in other subject areas when applying the tested technological variants within the constructivist and situational approach.

The results of the students are summarized by the average success rate in the transferability of skills in another subject area in Table № 2 and visualized in Figures 1 and 2.

Figure 1

Average success rate in the transferability of skills

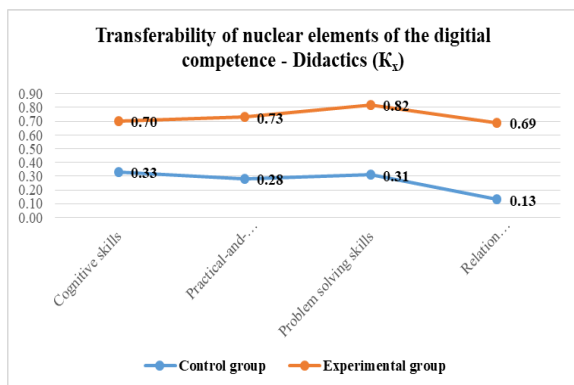
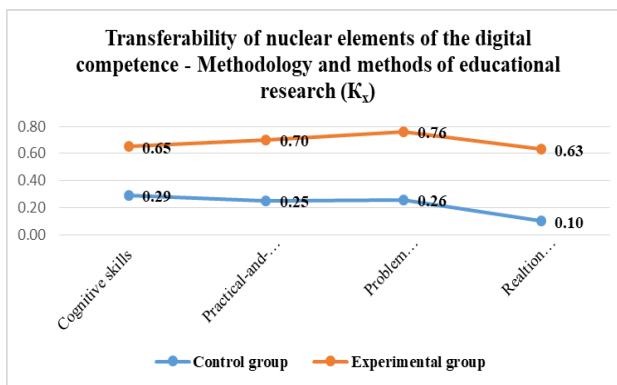


Figure 2

Average success rate in the transferability of skills



4. DISCUSSION

The results obtained to some extent prove the existence of the competence (its nucleus) - as an intention, as a point of view, as an approach, as a manner, as a style - which can be formed and developed as transferable (transversal) through ages and activities (Merdzhanova, 2002), and as independent of the subject content. Thus, the subject (student) "conveys his attitude, style, approach" and gives meaning to his competence as transversal. Analyzed in educational terms, the results of the study give grounds for the conclusion that the developed and applied technology for the development of digital competence based on the developed model has an impact on the possibility of portability (transversality). In the personal and activity-oriented aspect (directly related to the subjects in the activity) it has a positive effect on the motivation and overall cognitive behavior of students.

The application of the technological variant within the constructivist and then situational approaches in the education of students a statistically significant tendency was established to synchronization of the relation self-assessment – real assessment in the process of solving cognitive and practical tasks within the discipline Information and communication technologies and work in a digital environment. The same tendency emerges in the process of the transferability of digital competence in the training in the discipline of Education sciences (Part 2) - Didactics and in Methodology and methods of educational research in the following terms in the studies of extramural pre-service teachers pursuing their Bachelor's degree. This gives evidence of the degree of formation and development of a "transversal nucleus" in the digital competence of students in the professional field of Pedagogy.

In the final stages of the experimental research after the application of the technological variant based on the constructivist and situational approach in learning, a tendency emerges to synchronize the motives for cognitively active and behaviorally active learning in a constructivist educational environment.

5. CONCLUSION

In conclusion, the development of supra-subject, supra-content, and supra-thematic digital competence is essential for students in Pedagogy, particularly those pursuing qualifications as preschool and primary school teachers. This framework fosters an "internal nucleus of competence" that is both transferable and transformative, enabling educators to adapt their skills to diverse professional contexts while maintaining their unique pedagogical identity. Such a foundation promotes sustainable competence and personality, equipping future teachers with the resilience and adaptability necessary for effective practice in evolving educational environments.

Moreover, the transgressive segment of this competence facilitates continuous growth, allowing learners to push beyond cognitive and practical boundaries. By fostering self-awareness, self-regulation, and self-perfection, this model ensures the dynamic development of digital competence, empowering educators to innovate and excel. This conclusion underscores the imperative for teacher education programs to prioritize the holistic and adaptable development of digital competencies, preparing educators for the challenges and opportunities of the modern classroom.

Conflict of Interest: The authors declare no conflict of interest.

Ethical Approval: The study adheres to the ethical guidelines for conducting research.

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