The Digital Competence of Future Teachers: Self-Assessment in the Context of their Development

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Abstract—In the context of a transforming school of the 21st century and in the context of the digital transformation of the economy and education globally, the digital competence of pedagogical specialists is crucial for the implementation of the new professional roles of the teacher in response to the ever-increasing requirements for it. This article examines the framework of teachers' digital competency by specifying the main competencies that guarantee their full practical experience. The empirical study presents a self-assessment of the digital competence of future pedagogical specialists trained in the professional field of pedagogy, as well as highlights from their real possibilities of solving specific practical tasks based on the application of information and communication technologies. Some recommendations have been made to rethink the education of future pedagogical specialists and the professional qualification of current teachers in the context of the formation and development of their digital competence.

Keywords—Digital competence, framework, self-assessment, university education, development of the digital competence, pedagogical specialists

1 Introduction

The learning paradigm is increasingly changing under the influence of Information and Communication Technologies (ICT). The question of how to properly use ICT in teaching practice remains challenging – a challenge for existing teachers, but also a challenge for future professionals whose professional development starts at the university. Adequate digital education is at the core of vocational training and lifelong learning. Digital competences are an essential element of the European Competence Reference Framework and one of the eight competences needed to improve personal development, active citizenship, social inclusion and employability.

Key competencies are a reflection of the development of society and technology, but they also predetermine the need for more complete realization. Digitization changes people's lives, changes the industry. Each organization must adopt technology and continue the race with competitors or end up lagging behind and dropping out of the race. This necessity leads to the introduction of new tools in the production process, which in turn leads to a requirement for building new skills in the employees.

Enhancing digital skills as part of the learning process as well as their promotion through retraining programs is becoming a top priority today.

Technological development of the industry outpaces the conservative education system considerably. Although there is a significant penetration of digitization in the education system, it is still partial, and most often the barriers to the spread of new technologies in education are: lack of school equipment, lack of student interest, and distrust of new and untested practices [1].

Technological trends clearly outline a number of key areas that will play an important role in the future:

- Cloud Computing and Big Data
- Virtual Reality and Augmented Reality
- Artificial Intelligence and Machine Learning
- Mobile Devices and the Internet of Things
- Cyber Security and Safety
- Social Networks, Social Activation and Crowdsourcing.

These technological trends must be reflected in the development of digital competence on the one hand by the teacher and the learner on the other. The definition of a competence framework and the setting of measurement and evaluation levels make it possible to manage it.

Digital competence research, presented as a key competency at the beginning of the 21st century, is aimed primarily at creating theoretical models, competence frameworks and competence assessment tools [2-5]. The research, conceptualization and operationalization of computer literacy, digital literacy, media competence, etc., lead to the definition of digital competence as a "set of knowledge, skills, attitudes (thus including abilities, strategies, values and awareness) that are required when using ICT and digital media to perform tasks; solve problems; communicate; manage information; collaborate; create and share content; and build knowledge effectively, efficiently, appropriately, critically, creatively, autonomously, flexibly, ethically, reflectively for work, leisure, participation, learning, socializing, consuming, and empowerment" [5].

Digital competences are not just about knowing how to surf the web, but they can be reduced to certain knowledge and skills integrated into a specific context of operation. The European Digital Competence Framework (DIGCOMP) outlines five areas that define the notion of "digital literacy": information processing, communication, content creation, safety and problem solving. Efforts in recent years in the European Union are geared towards creating different online tools for assessing and defining the level of digital competence [6].

Identifying one competence is always associated with a high degree of generality, especially given the diverse range of activities that characterize the teacher's professional profile. Of course, this pilot conceptualization is necessary in view of constructing the invariant features of one competence, allowing for its subsequent contextual and situational interpretation. There are different concepts regarding the definition of digital competence, characterized by dimensions of "cognitive, relational and

social nature" [7]. Given the multidimensional structure of the teacher's digital competency, its identification is often associated with difficulties such as:

1) Inadequate knowledge of the computer skills and skills required to work with various digital sources of information as the basis of digital competence
2) Inability to conduct a complete diagnosis, especially in the short term
3) Dependence on other skills, including metacognitive, complementing it, and giving it full personality
4) Contextual and subject dynamics, and to special determination

This set of problems makes it difficult to identify the core competencies integrated into the teacher's digital competence. Digital competence, given its integral nature, is often considered to include technological, cognitive and ethical elements integrated into the context of its existence [7].

These dimensions trace the basic features of the conceptual framework of the teacher's digital competence:

- Integrating skills to work with modern information and communication technologies and various digital media
- Opportunities to critically evaluate media content and to know the advantages and disadvantages of digital media
- Adequate use of digital means and opportunities for effective communication in different contexts
- Skillful use of information technologies and digital resources in various teaching activities with an impact at various levels: methodical, administrative, qualificational
- Organizing educational environment involving the integration of different digital and information technologies for multisensory learning
- Learning design based on the creative integration of digital media in the subject context, providing subjective expression to students and enhancing opportunities to develop skills for collaboration, sharing, openness, reflection, tackling challenges, trust, responsibility, privacy, and security
- Designing interdisciplinary learning paths to assist students in the use of information technologies and digital resources in teaching different subjects at different stages and levels of education in accordance with their personal, age and social needs

Within the framework of the training on the different subjects, the dimensions of the teacher's digital competence further expand, enrich and acquire a specificity that is manifested in a context that preserves the invariant essence of the derived conceptual framework. All this makes the teacher's digital competence dynamic and constantly evolving, which necessitates its frequent revision in the context of continuous education.

There are some controversies about the content and structure of the teacher's digital competency, which impedes its full formation and development. In educational theory and practice, these contradictions are most often confined to:

1) Misunderstanding and hence being unable to distinguish the systemic training of specialists (mostly technical specialties) in the field of information technology, the training of ICT teachers and IT of future teachers in other subjects as users of these technologies
2) Failure to take into account the opportunities of the competence approach in the design of the objectives and the expected results of education, as well as the inability to identify the basic elements of each competence
3) The ambiguity regarding the conceptual framework of the teacher's digital competence and the possibilities for its full inclusion in his/her professional profile
4) Lack of a conceptual model for designing technological solutions for forming and developing the digital competence of teachers in the framework of their educational preparation [8].

In recent years, a number of studies have analyzed and compared the European Framework of Digital Competence to different national frameworks [9-11]. Other studies determine the degree of correlation between digital competence and various concepts such as computational thinking [12] or safety awareness [13]. Others explore teaching practices related to digital competence [14-16] or develop tools for evaluating teachers' competences in the digital field [17].

Various studies have also been carried out in relation to assessment and self-assessment of the digital competences of students and teachers [18-19].

A number of studies have been conducted on the application of information and communication technologies in school education and the assessment and self-assessment of the digital competence of teachers in Bulgaria. In 2010 a summary of the competences and perceptions of Bulgarian teachers on the application of ICT in teaching and learning [20] was published. The results of the study show a lack of confidence in teachers, both about their computer skills and their ability to use them in the practice. However, there is a positive attitude of teachers towards integrating new technologies into their work, which is evident from the priorities they state. Teachers are motivated and strongly state their desire to improve their qualifications related to computer competence, as well as to change the educational environment through the opportunities offered by e-learning.

Another survey [21] from 2015 shows the opinion of teachers in one or more subject areas, regarding the opportunities and application of information and communication technologies in education in Bulgaria. The research was done by the method of interviewing in focus groups. A subsequent content analysis was made, showing that the teachers from the surveyed sample are well aware of the possibilities to apply ICT and possess sufficient technological knowledge and skills that combine with their subject knowledge to use technologies for presenting and visualizing educational content. However, according to the authors, the results of the analysis do not reveal a clear link between teachers' perceptions and attitudes and the opportunities to use computer technology in chemistry classes in relation to: structuring and solving learning problems; improving communication and cooperation; developing critical thinking and creativity. The findings of the study point to the need for additional qualification of teachers to discover the opportunities of information and communication tech-

nologies to improve learning and to develop key skills of students in the digital society.

A purposeful and systematic study [22] of the Digital National Coalition and Gallup International, on the level of digital competence of pre-primary and primary school teachers in the Northwestern region of Bulgaria, clearly demonstrates the need to reconsider the training and further qualification of pedagogical specialists their university education through the system of qualification and retraining to non-formal education. Conducted in 2018 among teachers from 215 institutions, the study draws attention to the following main findings:

1) More than half of the teachers surveyed in the Northwest region need additional information on opportunities for introduction of digital technologies in the learning process, this subjective feeling is true to a greater degree for teachers in pre-school education
2) Teachers with more experience in the field of education feel more unprepared than their younger counterparts, and the same applies to teachers in rural institutions
3) Teachers who confidently and purposefully use digital technologies say they need more information on the topic
4) Every second teacher shares that she/he does not feel confident enough and rarely uses digital technology in her/his teaching activities

All studies, despite conflicting results at certain times, draw attention to the search for opportunities to improve the quality of educational training of pedagogical professionals in the context of the application of information and communication technologies in training and work in the digital environment.

In addition to these results, we perform a study on self-assessment of future pedagogical specialists in terms of their digital competence.

2 Material and Methods

In the European context, a framework for teachers' digital competence is developed, targeting educators at all levels of education, from early childhood to higher education and adult education, including vocational training, special education and non-formal learning. It aims to encompass these digital competences specifically for teachers and draws attention to the specific dimensions of digital competency, enabling it to develop its models in European Union countries at national and regional level.

The proposed framework addresses six different levels of competence with a total of 22 specific competencies. These basic levels are:

- Professional engagement
- Digital resources
- Teaching and learning
- Evaluation
- Learning support
- Improving digital competency [23]

In order to facilitate the adoption of the framework, the expert levels are presented through a well-defined description of specific roles that can also be projected on the professional levels proposed in the Common European Framework for Foreign Language Skills from A1 to C2 (see Table 1). The training of pedagogical specialists at university level only reaches level B1, which tends to hinder subsequent qualification. This framework requires the development of a comprehensive strategy for the development of the digital competence of teachers guaranteeing quality both within their university education and in the context of continuing qualification of pedagogical specialists through different forms and activities.

Level 1 focuses on the professional environment and is directly related to professional engagement, which is concretized through:

1) Organizational communication
2) Professional cooperation
3) Professional reflection
4) Continuing professional development in the context of the digital environment

Level 2 focuses on creating and sharing digital resources through the possibilities of:

1) Selecting
2) Creating and modifying
3) Managing, protecting and sharing

Level 3 focuses on managing and regulating the use of digital tools in learning and teaching. Level 4 builds on digital tools and strategies to improve evaluation, as well as the analysis of evidence and the realization of complete feedback on evaluation. Level 5 focuses on the use of digital tools to support learning, focusing on their full involvement, engagement, differentiation and personalization. Level 6 is concerned with the improvement of students' digital competence with a focus on their information and media literacy, meaningful communication, content creation, responsible use of information and communication technologies and digital resources, and problem solving through targeted use. Levels 2 through 5 represent the core of the pedagogical framework and they detail teacher competences to create and strengthen effective, publicly accessible and innovative learning strategies through digital tools [23].

Table 1. European Framework of Digital Competence of Teachers. Adapted from [23].

Level	Professional Engagement	Digital Resources	Teaching and Learning
C2 Pioneer Level	Innovating professional practice	Promoting the use of digital resources	Innovating teaching
C1 Leader Level	Discussing and renewing professional practice	Comprehensively using advanced strategies & resources	Strategically & purposefully renewing teaching practice
B2 Expert Level	Enhancing professional practice	Strategically using interactive resources	Enhancing teaching & learning activities
B1 Integrator Level	Expanding professional	Fitting digital resources to	Meaningfully integrating

	practice	the learning context	digital technologies
A2 Practical-applied, Research Level	Exploring digital options	Exploring digital options	Study of strategies for teaching and learning in a digital environment
A1 Newcomer Level	Awareness; uncertainty; basic use	Awareness; uncertainty; basic use	Awareness; uncertainty; basic use

Level	**Assessment**	**Empowering Learners**	**Facilitating, Learners' Digital, Competence**
C2 Pioneer Level	Innovating assessment	Innovating learner involvement	Using innovative formats to foster learners' digital competence
C1 Leader Level	Critically reflecting on digital assessment strategies	Holistically empowering learners	Comprehensively & critically fostering learners' digital competence
B2 Expert Level	Strategic and effective use of digital assessment	Strategically using a range of tools to empower	Strategically fostering learners' digital competence
B1 Integrator Level	Enhancing traditional assessment approaches	Addressing learner empowerment	Implementing activities to foster the digital competence of learners
A2 Practical-applied, Research Level	Research evaluation strategies in a digital environment	Exploring learner-centered strategies	Motivating and helping learners to use digital technologies
A1 Newcomer Level	Awareness; uncertainty; basic use	Awareness; uncertainty; basic use	Awareness; uncertainty; basic use

The empirical study was carried out with a contingent of 338 students admitted to Bachelor's and Master's degree programs in professional field of Pedagogy at South-West University, Blagoevgrad, Bulgaria. The aim of the study is to establish the level of digital competence of the future pedagogical specialists based on their self-assessment and to identify opportunities for its purposeful development in the context of their professional future. The Online Self-Assessment Map is based on the Digital Competence Self-Assessment Matrix and the Digital Skills Assessment Tool which is part of Europass: Curriculum vitae and is developed in accordance with the European Digital Competence Framework for Citizens, also known as DIGCOMP (see Table 2) areas: information processing, communication, content creation, safety/security and problem solving. The five basic digital competences are assessed in three levels of manifestation: basic, self-contained and free, including basic knowledge, skills and relationships in the five areas.

Table 2. European Framework for Digital Competence of Citizens (DIGCOMP).

Competence area	**Competence**
Information and data literacy	1.1 Browsing, searching and filtering data, information and digital content 1.2 Evaluating data, information and digital content 1.3 Managing data, information and digital content
Communication and collaboration	2.1 Interacting through digital technologies 2.2 Sharing through digital technologies 2.3 Engaging in citizenship through digital technologies 2.4 Collaborating through digital technologies 2.5 Netiquette

	2.6 Managing digital identity
Digital content creation	3.1 Developing digital content 3.2 Integrating and re-elaborating digital content 3.3 Copyright and licenses 3.4 Programming
Safety	4.1 Protecting devices 4.2 Protecting personal data and privacy 4.3 Protecting health and well-being 4.4 Protecting the environment
Problem solving	5.1 Solving technical problems 5.2 Identifying needs and technological responses 5.3 Creatively using digital technologies 5.4 Identifying digital competence gaps

3 Findings

The development of digital competences in the professional direction for future pedagogical specialists focuses on the application of digital resources and tools in the educational process, in communication and collaboration with colleagues and students, in selecting and creating learning content, working with different platforms to track student activity, achievements and commit feedback to learners, create opportunities for their active participation and increase their digital competence.

From the analysis of the results summarized in Figure 1, it is clear that 42.43% of the respondents in the first competence area (processing of information) self-assess their knowledge and skills at an independent level of knowledge and 33.75% as at basic level.

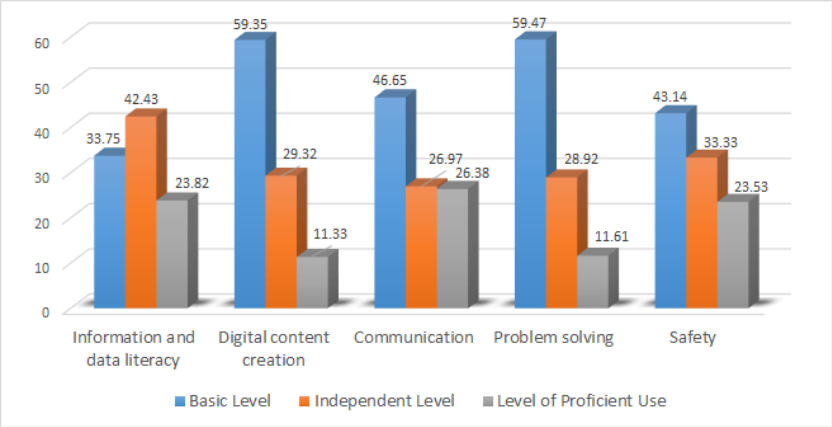

Fig. 1. Self-assessment of digital competence

A deeper analysis shows that 92.90% of students can search for information online using a search engine, and 71.01% can use various search engines to find information. 68.05% of self-assessors use search filters, 83.43% know that not every online information is reliable and 67.16% of students compare different sources to assess the

reliability of the information they find, such as only 29.88% can assess the validity and reliability of information using a set of criteria. 64.50% of respondents classify and properly sort the information they are looking for to facilitate their subsequent use. All of this from underlying training is in favor of building up the search and processing skills of future pedagogical specialists, given that the use of online resources available for learning purposes should go through additional expertise from the teacher, superimposed misconceptions of learning content. Only 23.82% of students admitted to education in the Pedagogical field self-assess their knowledge and skills in the field of "information processing" to level of proficient use. Serious are students' difficulties in using web feeds (like RSS - Really Simple Syndication) to get the information they are interested in. Only 10.06% of them can use the capabilities to subscribe to information aggregated from different sites through a set of formats to feed information from the global Internet network. The share of respondents - 19.53% - who can use advanced search methods (for example, using search operators) to find reliable information on the Internet, even with regard to the use of the simplest opportunities through this, is unsatisfactory quotes, underscores, and so on. Only 31.07% can use cloud storage for information, which requires the search for opportunities to improve skills in the application of cloud technologies in the context of the activities of pedagogical specialists. Despite the comparatively high self-assessment of students in terms of information processing, subsequent testing and solving of a specific practical task by the respondents, observations show that, when performing a practical task by searching for information, most of them are uncertain as to how to use various formats, and it emerges that only 10.50% of students are able to complete the task successfully.

Cloud computing appears as a vital practice for online delivery of computing resources such as services. Cloud computing customers do not need to install any software and can access their data from any computer connected to the Internet through a browser. It is precisely this characteristic that allows with minimal investments to be applied in the educational process, which in turn would allow the accumulation of experience and knowledge of the future pedagogical specialists for their implementation. Again, through the wider overlap of cloud technologies, the ability to consolidate different information and service providers can be improved. Last but not least, it is important to overlap in the training of pedagogical specialists with systems of criteria and indicators for expert evaluation of the electronic educational resources, each of which is subsequently enriched and expanded in a technological and methodological context [24].

The second area of competence is content creation competence. Apart from being a basic one for modern man, is also in direct connection with the context of activities of pedagogical specialists. In their self-assessment, 75.74% of students indicate that they can create just digital content (such as text, tables, images, audio files) in at least one format using digital tools, and 60.36% can edit content created from others. Although 59.35% of respondents considered their level of command as the basic, only 19% of them in the course of solving a specific practical task related to content creation can complete successfully it in the foreseen time. There is a significant discrepancy between self-assessment and practical implementation in solving specific tasks. Only

32.54% of students say they can create complex digital content in different formats (such as text, tables, images, audio files) and 48.22% of them claim they can do basic formatting (for example, footnotes, charts, tables) related to content created by them or another user as in a real situation, this share drops to 11.46%. The percentage of self-assessors is unsatisfactory in terms of their basic knowledge in the field of programming - 5.62%, which in the conditions of introduction of the subject Computer Modeling in the primary school curriculum, require programming skills and demand for compensatory opportunities for learning and obtaining basic knowledge and skills in this direction. Only 3.94% of students rate their level of content creation as proficient. Unsatisfactory share - 12.43% can create or modify complex multimedia content in different formats using different digital platforms, tools and environments, and only 13.02% know how to design, create and modify a database with computer tool. 6.51% of students have indicated that they know how licenses and copyrights apply, which requires special attention in the course of training in the licensing of e-learning resources.

Trends in technology development predetermine a growing share of rich multimedia content. There is a need to extend learning to create not only 2D but also 3D graphic content, building knowledge and skills for creation of graphics and infographics, and acquiring skills to use smart devices for creating authoring content.

The highest is the share of respondents self-assessing their level as proficient - 26.38% in communication. 95.56% of respondents indicate that they can communicate using a mobile phone, Voice Over IP (for example, Skype), e-mail or chat - using basic features (such as voice, SMS, sending and receiving e-mail, text messages), 84.91% of them can share files and content using simple tools, and 72.49% are aware of the availability of social networks and online collaboration tools. Despite the high self-confidence in the communications area, only 11.00% of respondents use it with educational purpose, while 77.51% of them can use some online services (e.g. public services, e-banking, online shopping). 58.88% of respondents are active online and use several online services. At the third level (proficient use) 82.84% of students are actively using a wide range of communication tools (email, chat, SMS, instant messaging, blogging, microblogs, social networks) for online communication, and 48.52% of them can use advanced messaging features (such as video conferencing, data sharing, app sharing). However, only 22.78% of respondents can create and manage content with collaborative tools (such as electronic calendars, project management systems, online surveys, online spreadsheets), which is currently part of pedagogical work. Digital communication skills are primarily shaped by informal communication. The accumulation of experience with systems for collaborative work and the implementation of platforms for crowdsourcing in different educational activities is one possible direction for the development of these competencies.

Results in the fiend of problem solving (Figure 2) are of particular interest, where the students' self-assessment also draws attention to the prospects and areas for their future training. 60.65% of them are aware that digital tools could help them solve problems and 68.93% are aware that they need to update their digital skills on a regular basis. However, only 18.64% regularly update their digital skills. Unsatisfactory is the relative share (of 18.64%) of respondents who can choose the most appropriate

tool, device, application, software or service to solve (non-technical) problems, and only 13.91% are aware of new technological developments and 6.51% of them can solve almost all problems that arise with the use of digital technology. All this is unambiguously confirmed by putting real practical tasks from the field of application of the information and communication technologies into the activity of the pedagogical specialists. Only 9.85% of students are orientated on what tools to use to solve problems, and over 92% of them have serious difficulties if the problem chosen is an integral one, i.e. requires various technological solutions. All this draws attention to the design of the educational environment in ICT training and work in a digital environment so as to provide an opportunity to solve integrated problems from the practice of pedagogical specialists with integrated technology application. It is necessary to develop didactic materials to help and give ideas to pedagogical specialists about how to integrate this aspect of digital competence into the learning process.

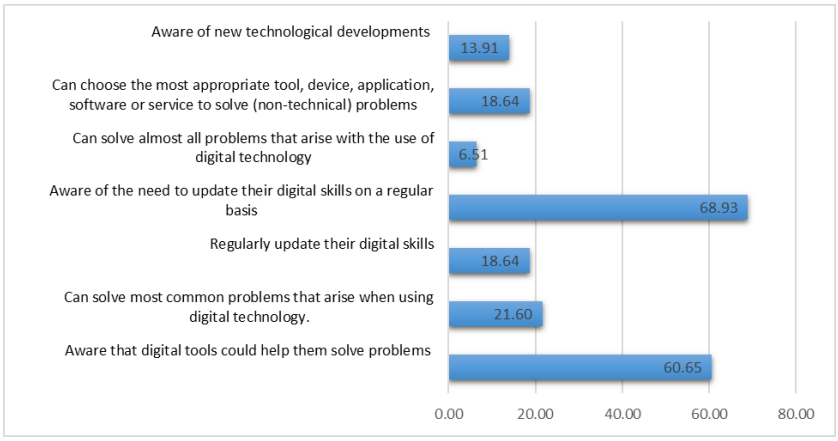

Fig. 2. Problem Solving

Although there are some discrepancies in students' understanding of personal data and their protection, especially in view of the 2016/679 Regulation of the European Parliament and of the Council of the European Union on the protection of natural persons with regard to the processing of personal data and on the free movement of such data (or GDPR) 96.15% of respondents know they should not disclose personal information online however, only 7.69% of them are aware of their online identity and watch for their digital footprint. That is, there is some contradiction between students' knowledge and the ways they apply it in practice in a real online environment. Only 19.23% of them can identify phishing mail (malicious attempts to acquire information) and 11.82% of them can encrypt emails or files. 64.20% of future pedagogical specialists to avoid health problems (both physically and mentally) use information and communication technologies wisely and 63.02% of them are informed about the impact of digital technology on everyday life, online consumption, and environment. However, a daily clash with various digital security issues does not always lead to awareness of digital security and safety. The authors see the potential

to improve this aspect of the teacher's digital competency by building simulators for training different security and safety scenarios in the digital environment.

4 Discussion and Conclusion

In the framework of the overall study, there are a number of contradictions between the self-assessment of the digital competences of the students at the beginning of their education in the pedagogical specialties and their actual knowledge and skills registered during the studying Information and Communication Technologies in Learning and Working in the Digital Environment. Obviously, there is a discrepancy of student self-assessment based on the digital competence self-assessment matrix and their actual knowledge and skills as basic level at the entrance to university education for Bachelor's degree program or its continuation for acquiring a professional qualification teacher at Master's degree, verified through a series of practical tasks in the course of training.

All this necessitates a thorough rethinking of the placement of the subjects in the curriculum of the students who study to become teachers, and its workload, as well as the possibilities for developing the digital competences in subsequent courses taking into account the requirements of the European Framework for the Digital Competence of Teachers, and the possibilities to cover at least the B1 level after graduation, ensuring opportunities for the integrated use of information and communication technologies in the teacher's activities, to be sensible in pedagogical and methodological terms, as well as to open up opportunities for a full vocational qualification subsequently to upgrade it to B2 level, which should be considered as mandatory in the activity of the existing teachers in the system of pre-school and school education.

In order to create an environment that allows us to shape and develop the information competence of the future pedagogical specialist, we need to know this system of competencies, apply it to relevant knowledge, skills and attitudes.

The methodological analysis of the competence approach in education directs us towards the search for a cognitive, active, creative, personal and axiological component in the digital competence of future pedagogical specialists. This is the reason to seek specific technological solutions and opportunities for the formation and development of digital competence.

These technological solutions can be successfully found on the basis of technological variants of the project-invariant for the formation and development of digital competence, which takes into account the following key determinants:

- Social needs for development of the digital competence of pedagogical specialists
- Goal formation, complex projection and educational design of the formation and development of digital competence
- A project for the development and improvement of digital competence, containing: concept, content and procedure
- Developing model-invariant and opportunistic options for forming and developing the digital competence of pedagogical specialists

Thus, with a comprehensive and methodologically reasonable conceptual vision, it is possible to form and fully develop the digital competence of future teachers.

It is equally important to follow the technological trends that need be reflected in the curriculum. Some trends that have been established over the long-term (such as cloud computing and social networking/social activation) have a partial presence in the curriculum, while others, which require significantly greater technology and financial resources (e.g. virtual and augmented reality or the Internet of things), are still at the initial and experimental stage.

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