JOURNAL OF MULTIDISCIPLINARY SCIENCES AND INNOVATIONS
VOLUME 5, ISSUE 02
MOPNTHLY JOURNALS
ISSN NUMBER: 2751-4390
IMPACT FACTOR: 9,08

DEVELOPMENT OF META-PROFESSIONAL COMPETENCE BASED ON DIGITAL TECHNOLOGIES IN TEACHING PHYSICS

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Abstract: This article comprehensively analyzes the development of students' metaprofessional competencies using digital technologies in physics education. It explores the potential for developing students' critical and systems thinking, analytical and problem-solving skills, independent information processing, communication, and creative skills through the integration of virtual laboratories, computer modeling, digital simulations, interactive educational platforms, and electronic learning resources into the educational process.

Key words: digital technologies, meta-professional competence, digital transformation, competency-based approach, virtual laboratories, critical thinking, independent learning.

Introduction. In today's context of globalization and digital transformation, one of the primary goals of the education system is to develop not only the professional knowledge and skills of future specialists, but also their metaprofessional competencies. Modern specialists must possess not only deep professional knowledge but also universal, or metaprofessional, competencies that enable them to work effectively in various fields. Therefore, the targeted and systematic use of digital educational technologies in physics teaching is of paramount importance. Physics is a complex subject, rich in abstract concepts and laws, and traditional approaches to teaching it are often ineffective in ensuring active student engagement. Therefore, the use of digital technologies—virtual labs, simulations, interactive platforms, digital modeling, and distance learning tools—creates new pedagogical opportunities in physics teaching.

These tools enable students to develop a deep understanding of knowledge, independently complete experimental tasks, and engage in reflective thinking skills. In this process, the combination of pedagogical mechanisms—that is, methods, tools, educational forms, and didactic conditions—is particularly important. A problem-based, project-oriented, and collaborative learning environment based on digital technologies facilitates the development of students' metaprofessional competence [9,11]. Therefore, the scientific substantiation of the potential of digital technologies and their pedagogical mechanisms in physics teaching is a pressing issue.

Main part. Teaching physics using technology is currently evolving and expanding its horizons. Over the years, new tools, methods, and materials are integrated into the educational process. Physics is taught based on theory and practice. The use of technology in this process improves the quality of the lesson and allows the teacher to use a variety of methods to explain the subject more effectively in a short period of time. Furthermore, organizing physics lessons using digital media and computers helps develop students' technological competencies. This gives teachers the opportunity to demonstrate new creative approaches and methods. The availability of computer technology in lessons can help teachers plan lessons and demonstrate laboratory work using new methods that are typically impossible to demonstrate to students in the classroom.[8]

The teaching of physics in the education system has undergone radical changes, with the widespread adoption of digital technologies becoming increasingly important. Physics education aims to develop students' scientific understanding of natural phenomena and laws, the ability to

connect theoretical knowledge with practice, and the ability to make independent decisions in problematic situations. Today, this process is organized based on a competency-based approach to education [7] and is not limited to the provision of knowledge, but is aimed at ensuring students' personal and professional development. The use of digital technologies in physics education improves the effectiveness of the educational process and clearly explains complex physical processes and phenomena. The digital educational environment utilizes electronic learning platforms, multimedia resources, online communication tools, and interactive programs, expanding students' opportunities for independent learning [10]. This environment facilitates the organization of the educational process in a flexible, open, and innovative manner.

Virtual laboratories and simulations are particularly important in physics teaching because they allow students to conduct real experiments by simulating them in a digital environment. This allows for the safe study of expensive or dangerous experiments, the analysis of experimental results, and a deeper understanding of theoretical knowledge [2, 3]. Simulations help students develop critical thinking skills by identifying cause-and-effect relationships and formulating and testing hypotheses. The interactive learning process, based on digital technologies, increases student engagement, transforming them from passive recipients of knowledge into active participants.

Through discussions, projects, problem-solving, and collaborative assignments, students acquire skills in communication, teamwork, and effective information management. This process directly influences the development of metaprofessional competence. Metaprofessional competence encompasses universal qualities essential to modern professionals, including critical and systems thinking, digital literacy, creativity, flexibility, and problem-solving skills. The targeted and effective use of digital technologies in physics education creates favorable pedagogical conditions for the development of relevant competencies. Organizing physics education using digital technologies, creating a digital learning environment, and utilizing virtual laboratories and simulations are important factors in the implementation of competency-based education. This contributes to the development of meta-professional competence in students, preparing them as competitive specialists who meet the demands of modern society and the labor market.

Metaprofessional competence encompasses a person's ability to think critically and systematically, make independent decisions in problematic situations, process information, possess digital literacy, and communicate effectively in a team. These competencies are essential for developing a competitive professional in today's labor market. Metacompetence helps to understand a person's inner potential and limitations, identify their strengths, and improve their weaknesses [5]. Improving the organizational and methodological system for developing metacompetence in future teachers in the context of student-centered education, refining the pedagogical model of education, clarifying the specifics of an integrative approach to increasing students' interest in studying society and social phenomena, developing and effectively using interactive technologies to organize social interaction, and improving the quality and fundamentally improving the level of higher education are some of the most important factors needed today. This requires improving the didactic conditions for developing metacompetence in future teachers, developing a model of integration and integrative professional orientation through the creation of an integrative and facilitative learning environment. Developing metaprofessional competence using digital technologies in physics education is a process of developing future specialists not only in physics knowledge but also in general skills that ensure flexibility in various professional situations. Digital tools and their role. The following technologies are used to enhance metaprofessional competence in physics education:

Virtual Laboratories and Simulations: Platforms such as PhET and Gizmos enable visualization and experimentation with complex physical processes. Virtual laboratories and simulations are an important component of digital technologies in modern physics education. In particular, platforms such as PhET Interactive Simulations and ExploreLearning Gizmos enable visual, interactive, and simulated representation of complex physical processes and phenomena. Using these digital tools, students can conduct experiments in a virtual environment that would be difficult or dangerous to conduct in a real laboratory setting [4].

Modeling allows for the observation of dynamic changes in physical laws and relationships, independent modification of parameters, and analysis of results. PhET and Gizmos platforms foster deepening conceptual understanding in physics education by helping students comprehend abstract concepts through concrete models. Experiments conducted in virtual laboratories develop students' research skills, critical and systems thinking, and the ability to make independent decisions in problematic situations. These platforms also facilitate interactive learning between instructor and student, implement differentiated approaches, and effectively implement competency-based education. As a result, virtual laboratories and modeling play an important pedagogical role in improving the quality of physics education and developing metaprofessional competence.

PhET Interactive Simulations is a free digital educational platform developed by the University of Colorado that provides interactive simulations in physics, chemistry, mathematics, and biology. PhET simulations are based on scientific research and designed to explain complex physical concepts and processes using visual and dynamic models. This platform allows students to explore topics such as electricity, mechanics, waves, and thermal processes through virtual experiments. PhET simulations promote independent learning and develop critical thinking and problem-solving skills.

ExploreLearning Gizmos offers in-depth interactive simulations in physics and mathematics. Gizmos simulations are tailored to educational programs and integrated with ready-made assignments, instructions, and assessment elements for each subject. This platform allows you to organize laboratory work in a virtual environment, analyze experimental results, and systematically implement processes for drawing scientific conclusions. The PhET and Gizmos platforms are of great pedagogical importance for the implementation of a competency-based approach to teaching physics using digital technologies, the development of students' metaprofessional competence, and increased learning effectiveness.

Using tools such as NetLogo, Scratch, or Trinket/GlowScript, students learn to create their own physical models, which develops algorithmic thinking. In physics teaching, this is an effective tool for understanding complex processes and developing self-study skills. Using these platforms, students learn to create physical phenomena using mathematical and visual models during the learning process, as well as conduct virtual experiments, changing parameters, and analyzing the results. NetLogo provides agent-based modeling capabilities, allowing students to simulate multi-element systems, such as collective systems, the behavior of gas molecules, or ecological processes. Scratch, as a visual programming environment, develops students' algorithmic thinking skills, step-by-step creation of software solutions, and the ability to describe processes through programming

Conclusion. Developing metaprofessional competence using digital technologies in physics education is a priority for the modern education system. Digital tools—virtual laboratories, simulations, digital learning platforms, artificial intelligence-based learning systems, and interactive resources—enable a deeper understanding of physical phenomena and processes and the integration of theoretical knowledge with practical activities. This process fosters students'

metaprofessional competencies, such as critical and systems thinking, problem analysis, independent decision-making, creativity, and communication skills. Digital technologies also enable the personalization of the educational process, taking into account the individual needs and abilities of students. This strengthens students' competencies in self-development, planning, and evaluating independent learning activities. Effective use of the digital environment in physics teaching not only fosters a thorough understanding of the subject but also creates the foundation for developing the universal, flexible, and integrative competencies students need for their future professional careers. Thus, the systematic and methodologically sound implementation of digital technologies in physics education is an effective mechanism for developing meta-professional competence, contributing to improving the quality of education and the level of training of competitive personnel.

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