Asian Journal of Multidisciplinary Research
(AJMDR)
ISSN: 2395-1729

Crossref doi Google Scholar WorldCat Mendeley

ENHANCING THE METHODOLOGICAL COMPETENCE OF FUTURE PHYSICS TEACHERS IN A DIGITAL EDUCATIONAL ENVIRONMENT

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Abstract. This article examines the scientific and methodological foundations for improving the methodological training of physics specialists in a digital educational environment. In the modern educational process, the rapid development of digital technologies necessitates the organization of the content, methods, and tools of physics education based on innovative approaches. Particular importance is attached to the development of methodological competencies of future and practicing physics specialists, focusing on the purposeful use of digital pedagogical tools, organization of virtual experiments, creation of interactive educational resources, utilization of digital laboratory capabilities, and consideration of learners' individual educational needs.

Keywords: digital educational environment, physics education, methodological training, professional and methodological competence, digital pedagogical technologies, virtual laboratory, digital modeling, interactive learning, multimedia tools, digital educational resources, physics teaching methodology.

The development of modern science and technology, the rapid expansion of digital technologies, and the transformation of educational requirements have created new demands for the professional preparation of specialists in the field of physics. Contemporary physics education is increasingly moving beyond traditional approaches based exclusively on lectures, textbooks, and laboratory experiments conducted with physical equipment. Digital educational resources now provide opportunities to visualize complex physical phenomena, conduct virtual experiments, model processes that are difficult to observe in real conditions, organize individualized learning, and provide immediate feedback.

In this context, methodological training occupies a special place in the preparation of future physics specialists. Methodological training should not be understood simply as the acquisition of knowledge about teaching methods. It represents an integrated process through which future specialists learn to select appropriate educational content, formulate learning objectives, choose teaching methods, organize experiments and practical activities, use digital resources, assess learning outcomes, and reflect on the effectiveness of their own pedagogical decisions.

The digital transformation of education has significantly expanded the methodological possibilities available to physics teachers. Interactive simulations, virtual laboratories, digital measurement tools, learning management systems, multimedia resources, electronic textbooks, online assessment systems, and artificial intelligence applications can support both theoretical and practical components of physics education. UNESCO emphasizes that digital technologies can improve instruction by expanding opportunities for practice, personalizing instruction, stimulating interaction, and supporting collaboration. At the same time, the effective use of technology depends considerably on teachers' professional preparation and digital competence.

Improving the methodological training of physics specialists in a digital educational environment is an important direction of contemporary teacher education. The digital transformation of education requires future physics teachers to possess not only strong subject knowledge but also methodological, digital, research, creative, and reflective competencies.

The analysis shows that virtual laboratories, interactive simulations, digital platforms, project-based learning, problem-based learning, flipped learning, electronic portfolios, and artificial intelligence can significantly expand the methodological possibilities of physics education when they are applied purposefully.

The proposed methodological model includes motivational-target, content, technological, practical-activity, assessment-diagnostic, and reflective components. Its implementation can support the gradual development of future physics specialists' ability to design, implement, evaluate, and improve digitally supported physics lessons.

The key principle is that technology should serve pedagogy rather than replace it. The effectiveness of a digital educational environment depends not on the number of technological tools used but on their correspondence to educational objectives, students' needs, subject content, and assessment requirements.

Therefore, future research should focus on developing experimentally validated models for digital methodological training, establishing diagnostic criteria for digital-methodological competence, designing integrated electronic learning modules, and investigating the pedagogical effectiveness of AI-supported physics teacher education.

Physics is particularly suitable for the application of digital educational technologies because many physical processes are abstract, microscopic, extremely rapid, extremely slow, dangerous, expensive, or otherwise difficult to reproduce under ordinary classroom conditions. Digital simulations can make such phenomena observable and manipulable. For example, students can investigate motion, forces, electric circuits, electromagnetic phenomena, waves, optics, thermodynamics, and atomic processes by changing parameters and observing their effects.

Therefore, the methodological training of future physics specialists should be redesigned in accordance with the requirements of the digital educational environment. The future teacher should be able not only to use digital tools technically but also to determine when, why, and how a particular technology should be integrated into a physics lesson.

The problem of integrating digital technologies into education has been widely discussed in contemporary pedagogical research. One of the important directions is the development of teachers' technological and pedagogical knowledge. The TPACK framework developed by Mishra and Koehler emphasizes the interaction between technological knowledge, pedagogical knowledge, and content knowledge. This framework is particularly relevant to physics teacher education because effective digital teaching requires the integration of subject-specific knowledge with pedagogical and technological competencies.

Research in physics education demonstrates the pedagogical value of interactive simulations and digital experimentation. PhET Interactive Simulations, for example, provides interactive environments in which learners can manipulate physical parameters and observe corresponding changes in phenomena. Digital simulations can therefore support conceptual understanding and encourage inquiry-based learning.

Recent research also emphasizes the importance of virtual laboratories in the preparation of future physics teachers. Virtual laboratory environments allow students to conduct experiments, formulate hypotheses, analyze results, and repeat experimental procedures without the limitations associated with physical laboratory equipment. Studies of digital technologies in physics teacher education have specifically highlighted virtual laboratories as an important component of the professional preparation of future physics teachers.

Recent research has also focused on AI-supported digital-didactic technologies for developing the methodological competence of future physics and astronomy teachers. Such approaches combine diagnostic testing, electronic modules, methodological assignments, virtual laboratories, adaptive recommendations, teacher feedback, and portfolio-based assessment.

Similarly, integrated electronic learning modules have been proposed as a means of connecting general pedagogy, physics teaching methodology, digital resources, assessment, reflection, and adaptive learning support. Such modules can help future teachers transform theoretical knowledge into lesson plans, practical tasks, virtual laboratory activities, projects, assessment tools, and reflective products.

Recent research also indicates that technological innovations such as PhET simulations, virtual and augmented reality, artificial intelligence, and blended learning can contribute to physics learning when they are integrated through appropriate pedagogical design. However, evidence also shows substantial variation in effectiveness, emphasizing the importance of teacher preparation, infrastructure, accessibility, and methodological rigor.

Thus, the literature suggests that digitalization alone does not guarantee improved educational outcomes. The central issue is the pedagogically justified integration of digital technologies into the teaching process.

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