

Methodology for Developing STEM Competencies in Future Science Teachers in the Context of Educational Digitalization: Effectiveness and Outcomes

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Abstract

This paper presents a methodology for preparing future teachers of natural science disciplines to implement the STEM approach in the context of educational digitalization, as well as the results of its effectiveness evaluation. The methodology is grounded in competency-based, integrative, activity-oriented, and digital approaches and is implemented through a modular Minor program, “STEM Approach in Secondary Education,” a teaching and learning manual, and a digital learning environment. A pilot implementation was conducted with 36 pre-service teachers majoring in Biology, Physics, Chemistry, and Informatics at Zhanibekov University. The evaluation combined testing, surveys, classroom observations, analysis of student projects, and reflective reports. The findings demonstrate positive dynamics across all components of STEM competence formation. Increased motivation toward innovative pedagogy, enhanced soft skills, and strengthened interdisciplinary interaction were observed. The results confirm the effectiveness of the methodology and its potential for broader integration into teacher education programs and professional development pathways within the context of digital transformation in education.

Keywords

Digitalization, interdisciplinary integration, project-based learning, STEM education, teacher preparation.