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DEVELOPMENT OF STUDENTS' METHODOLOGICAL COMPETENCE IN TEACHING THE ELECTROMAGNETISM SECTION THROUGH MODERN PEDAGOGICAL APPROACHES AND INNOVATIVE TECHNOLOGIES

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Abstract
Modern pedagogical approaches and innovative educational technologies were applied to develop students' methodical competence in teaching the Electromagnetism section of physics. An instructional model integrating interactive methods (laboratory work, PhET simulations, problem-based learning, etc.) and individualized learning trajectories was implemented for physics education students. A pedagogical experiment (with experimental and control groups) demonstrated that this approach significantly improves the future teachers' methodological competence and understanding of electromagnetism. The results confirmed the effectiveness and practical significance of the proposed method in higher education.

Keywords: Physics education; methodological competence; electromagnetism; innovative teaching technology; PhET simulations; individualized learning trajectory.

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Introduction

РАЗВИТИЕ МЕТОДИЧЕСКОЙ КОМПЕТЕНТНОСТИ СТУДЕНТОВ В ПРЕПОДАВАНИИ РАЗДЕЛА ЭЛЕКТРОМАГНЕТИЗМА С ИСПОЛЬЗОВАНИЕМ СОВРЕМЕННЫХ ПЕДАГОГИЧЕСКИХ ПОДХОДОВ И ИННОВАЦИОННЫХ ТЕХНОЛОГИЙ

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Аннотация

В данной статье рассматриваются современные педагогические подходы и инновационные образовательные технологии, направленные на развитие методической компетентности студентов в процессе изучения раздела «Электромагнетизм». Предложенная методика включает использование интерактивных методов обучения (лабораторные работы, симуляции PhET, проблемное обучение и др.) и построение индивидуальной образовательной траектории для каждого студента. Педагогический эксперимент с участием экспериментальной и контрольной групп подтвердил, что применение данного подхода значительно повышает методическую компетентность будущих учителей физики и качество усвоения ими материала по электромагнетизму. Результаты эксперимента доказали эффективность предложенного метода и его значимость для педагогической практики.

Ключевые слова: Физическое образование; методическая компетентность; электромагнетизм; инновационные образовательные технологии; симуляции PhET; индивидуальная образовательная траектория

INTRODUCTION

At present, one of the most pressing tasks in pedagogical higher education is to enhance students' readiness for professional activity by developing their independent creative thinking skills and creating opportunities to define

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individualized learning trajectories in accordance with each student's personal abilities and aspirations. This process contributes to the development of future physics teachers' capacity to apply modern technologies and innovative methods, as well as their ability to make independent decisions in their pedagogical practice. Therefore, integrating the educational process with contemporary achievements in industry and advanced technologies, along with the implementation of innovative educational technologies, is of particular importance. In this context, the development and practical implementation of advanced didactic support for teaching the Electromagnetism section of the physics curriculum has become a pressing necessity.

An analysis of the scientific literature shows that numerous studies have been conducted to improve the educational process from methodological and didactic perspectives. For example, O.I. Achilov emphasized the need to apply clarifying, standardizing, and adaptive principles in a balanced manner when improving pedagogical educational resources. However, his model mainly focuses on the structure of resources and does not sufficiently address interactive methods and student engagement. M.X. Abdurakhmanov identified the principles of universality, integrativity, fundamentality, and multilevel structure as the basis of didactic support in an electronic learning environment and demonstrated that the use of interactive methods such as the "T-chart" and "Cluster" in teaching the subject "Information Security" facilitates deeper knowledge acquisition and the development of students' creative and reflective competencies. Nevertheless, his approach places greater emphasis on general principles and does not fully address issues related to the individualization of learning. N.A. Ishbayeva, in turn, focused on the integration of reflective and cognitive components in the development of didactic competence and theoretically substantiated that the integration of innovative technologies enables learners to develop independent learning, analytical, and evaluative skills. Her model proposes organizing the teaching process through motivational, cognitive, and creative stages; however, this approach is mainly applied within the framework of retraining pedagogical staff and does not sufficiently reveal the methodology for mastering the content of a specific subject. B.M. Mirzakhmedov highlighted the necessity of creating a new generation of methodological and didactic support in modern education, noting that a well-designed textbook helps overcome challenges in the learning

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process, increases educational effectiveness, systematizes students' knowledge, develops creative abilities, and enhances professional motivation.

Based on the above studies, didactic support can be defined as a systematized set of educational and methodological materials that ensures the effective implementation of the learning process and promotes students' success in activities such as knowledge acquisition, creative thinking, and communication. In order to improve didactic support in teaching the Electromagnetism section, first, it is necessary to clearly define the fundamental concepts and laws of the subject and present the content in a standardized and systematic manner. Second, the educational process should be designed according to adaptive principles, taking into account each student's individual level of preparedness and abilities. Third, adherence to the principles of universality and integrativity requires linking electromagnetism topics with real-life examples and related disciplines. Fourth, the extensive use of interactive and innovative methods such as laboratory activities, PhET interactive simulations, and problem-based learning not only deepens the assimilation of theoretical knowledge but also fosters students' creative thinking and reflective analysis skills.

It should be noted that the integration of technological and creative approaches plays a significant role in pedagogical education. According to some contemporary researchers, the combination of creative and technological approaches leads to the emergence of innovative solutions that yield effective outcomes in the educational process. Therefore, in developing students' methodological competence, it is essential not only to technologize research and educational activities by introducing modern technical tools and information technologies into the learning process but also to apply a creative approach as a necessary condition.

In this regard, within the framework of the present study, we developed a methodological solution based on modern pedagogical approaches and technologies for training physics teachers, using the Electromagnetism section as an example. The main objective of this solution is to develop students' methodological competence through individualized learning trajectories. The following sections present the stages of implementing this methodological approach and an evaluation of its effectiveness.

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METHODS

The research implementation was experimentally tested with the participation of students enrolled in the Physics and Astronomy programs at Chirchiq State Pedagogical University, Kokand State University, and Navoi State University. The pedagogical experiment was conducted over the period 2022–2025 and involved a total of 490 students. The participants were randomly assigned to an experimental group (248 students) and a control group (242 students). The experiment was carried out in two main stages: the **diagnostic (ascertaining) stage** during the 2022–2023 academic year and the **formative (developmental) stage** during 2023–2025, followed by a final stage in which comprehensive analysis and evaluation were conducted. During the diagnostic stage, the initial level of students' methodological competence in the Electromagnetism section was examined, and their baseline knowledge and skills were identified. At the formative stage, the proposed methodology was implemented in the experimental group, and its impact was systematically observed.

The methodology developed for the experimental group was implemented as follows: the content of the educational process was structured around the Electromagnetism section, instructional activities were systematically organized through collaboration between students and instructors, and individualized teaching was provided by designing personal learning trajectories for each student. In particular, innovative lesson plans were developed for both lectures and practical classes. Unlike traditional information-based lectures, the lecture sessions were enriched with interactive methods such as **problem-based learning** and **brainstorming.** For example, in the lecture on the application of the Biot–Savart–Laplace law to calculating various magnetic fields, problem-oriented questions were used to stimulate student engagement, and **PhET interactive simulations** were employed to organize visual modeling activities of magnetic fields. In addition, SWOT analysis, discussions, and group-based practical tasks were applied to ensure a deeper understanding of the topic. Practical sessions were designed in small groups and included laboratory experiments and problem-solving activities, allowing for individual assessment of each student's participation and performance. Within this approach, a system of individualized learning tasks was offered to each student according to their level of knowledge and learning pace. This represents the **individual learning**

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trajectory approach, which emphasizes independent work, task selection, and timely completion by students [1].

Throughout the experiment, various methods were used for data collection and analysis. **Diagnostic tests** were applied to assess the initial and final levels of students' methodological knowledge and skills. In addition, **observation** and **interviews** were conducted to record qualitative changes in students' learning activities. **Questionnaire surveys** were administered to examine students' attitudes toward the use of innovative technologies, including simulations and electronic platforms. The collected data were analyzed using **mathematical and statistical methods** (percentage distribution and t-tests), and the performance indicators of the experimental and control groups were systematically compared.

RESULTS

The results obtained at the end of the experiment clearly demonstrated the practical effectiveness of the newly proposed methodology. At the initial diagnostic stage, the students in the experimental and control groups showed nearly identical levels of methodological preparedness, with the majority in both groups demonstrating a moderate level and a smaller proportion exhibiting a low level. However, by the end of the formative stage, significant positive changes were observed in the experimental group, where a substantial number of students achieved a high level of methodological competence. According to the specially developed assessment criteria, performance in the range of 90–100% was classified as the highest level, defined as readiness for creative professional activity. The proportion of students in the experimental group who achieved such results in the final tests was considerably higher than that in the control group. In particular, a notable share of experimental group students completed all tasks accurately and comprehensively, demonstrating the ability to apply methodological knowledge and skills creatively, corresponding to the highest (five-point) performance level. In contrast, the number of students achieving similarly high results in the control group was relatively small; most remained at a moderate level or experienced difficulties with more complex tasks. Moreover, students in the experimental group demonstrated the ability to independently select and apply teaching methods, whereas students in the control group tended to rely more heavily on instructor support.

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The implemented innovative approaches also enhanced the quality of learning outcomes in the Electromagnetism section. Students in the experimental group showed a high level of engagement in applying theoretical knowledge to practice, such as independently planning laboratory activities and modeling physical processes. They demonstrated improved abilities to visualize magnetic field concepts and to analyze physical phenomena. In contrast, students in the control group, who were taught using traditional methods, exhibited a comparatively lower level of development in these skills.

Statistical analyses confirmed the presence of a statistically significant difference in favor of the experimental group ($p < 0.05$). This finding provides scientific evidence that the proposed methodology is significantly more effective than traditional approaches in developing students' methodological competence. Consequently, the pedagogical experiment validated the effectiveness of the proposed methodological and didactic solution, confirming its importance as a meaningful scientific contribution to pedagogical practice [2, 3].

In addition, the percentage-based assessment system developed to evaluate methodological competence proved to be effective. This system classified students' acquired knowledge and skills into four levels (high, good, moderate, and low), enabling the monitoring of each student's individual developmental dynamics. Through this approach, each student's methodological preparedness was expressed using objective numerical indicators, providing data essential for designing individualized learning trajectories. For example, specific weaknesses identified in some students such as deficiencies in lesson planning were recorded as priority areas for targeted improvement in subsequent stages. Overall, the experimental results indicate that the proposed approach is not only theoretically well-grounded but also practically beneficial.

DISCUSSION

The results of this study confirm that high effectiveness can be achieved in training physics teachers through the integration of modern educational technologies and pedagogical approaches. First of all, the use of interactive computer simulations was observed to significantly enhance students' learning activities in the subject area. According to the scientific literature, interactive simulations such as PhET are widely applied in physics and chemistry education and serve as a powerful tool for improving students' learning outcomes [4].

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Simulations enable the visualization of abstract concepts, the investigation of relationships between different physical quantities, and the performance of virtual experiments. Research findings indicate that well-organized virtual laboratory activities can produce learning outcomes comparable to, and in some cases even more effective than, those of traditional laboratories [5]. In particular, the visualization of invisible processes in a virtual environment such as animating magnetic field lines helps students develop strong conceptual understanding [4]. However, it is emphasized that to achieve maximum effectiveness, simulations should be implemented within a well-structured methodological framework and supported by appropriate pedagogical guidance from instructors [6].

One of the key aspects of the approach implemented in this study is the adaptation of instruction by taking into account students' individual learning trajectories. In the literature, an individual learning trajectory is understood as the process of selecting and implementing a personalized learning pathway that corresponds to each learner's needs, interests, and abilities [1]. In our model, each student was provided with additional independent tasks aligned with their areas of interest, and problems of varying levels of complexity were offered to enrich their knowledge. As a result, high-achieving students were given opportunities to expand their potential through creative tasks, while students experiencing difficulties received additional guidance and support to prevent learning gaps. This approach contributes to reducing educational disparities among students and creates conditions for maximizing each learner's development.

The assessment criteria system proposed for identifying and developing methodological competence also deserves special attention. This system was developed based on the core components of the competency-based approach proposed by E.F. Zeer, namely the cognitive, operational, and reflective components. As emphasized by Zeer, competence is not merely a collection of knowledge but also encompasses an individual's ability to evaluate their own activity, think independently, and demonstrate readiness for creative problem-solving. Accordingly, our assessment criteria were designed to evaluate these aspects in practice. In particular, students' abilities to conduct independent analysis and generate creative solutions were assessed through specially designed tasks and expressed in quantitative scores. In line with the model for

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developing creative thinking in physics education proposed by Y. Azimov, readiness for creative professional activity was identified as the highest level of methodological competence in our approach. This made it possible to assess students' potential to apply non-standard solutions in teaching practice and to implement innovative pedagogical technologies in the future.

Furthermore, the developed assessment system was implemented in integration with modern information technologies. Specifically, the results of test assessments were automatically processed using the MyTestX electronic platform, which generated detailed reports for each student. This approach enabled real-time monitoring of students' levels of methodological preparedness, identification of strengths and weaknesses, and the introduction of targeted pedagogical interventions. Scientific studies also emphasize that such technology-based approaches enhance flexibility in education and contribute to better preparation of students for future innovative activities [7]. Indeed, the findings of our experiment demonstrate that the integration of digital technologies into the educational process increased students' motivation and engagement. Students actively expressed their views through online tests and reflective feedback, which fostered a sense of ownership and responsibility for their learning process.

Overall, the results indicate that the combined application of modern pedagogical approachesm such as the competency-based approach and learner-centered education and innovative technologies facilitates the effective development of not only students' theoretical knowledge in physics but also their methodological skills and professional competencies. This approach not only meets the current demands of education but also ensures that future teachers are creative, adaptable, and capable of responding effectively to the challenges of scientific and technological advancement.

CONCLUSION

In conclusion, the application of modern pedagogical approaches and innovative educational technologies in teaching the Electromagnetism section significantly contributes to the development of methodological competence among students of physics education programs (future teachers). The approach proposed in this study enriching traditional educational content with new didactic solutions, designing individualized learning trajectories for each student, and employing

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interactive and information technologies in an integrated manner has demonstrated its effectiveness in practice. The experimental results confirmed the advantages of this methodology, showing enhanced integration of theoretical knowledge with practical application and an increased level of readiness for independent pedagogical activity among students.

The methodology and assessment criteria developed within the framework of this research represent a meaningful scientific contribution to pedagogical practice and are recommended as an effective means of developing methodological competence in the training of physics teachers. In future research, this approach may be extended to other areas of natural science education, and longitudinal monitoring may be conducted to examine its long-term impact. Overall, the findings once again demonstrate that the synergy of innovative technologies and individualized approaches in modern education yields high pedagogical effectiveness, serving as an important step toward addressing the pressing task of preparing competent and highly qualified teaching professionals.

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