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THEORETICAL AND METHODOLOGICAL FOUNDATIONS OF DEVELOPING PROFESSIONAL COMPETENCE IN FUTURE BIOLOGY TEACHERS

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Abstract
The modernization of the educational system and the growing demand for high-quality science education require the development of professional competence among future biology teachers. This study examines the theoretical and methodological foundations of professional competence development in pre-service biology teachers within higher pedagogical education. The research is based on competence-based, integrative, personality-oriented, and activity-based approaches. The article analyzes the structure of professional competence, including cognitive, methodological, communicative, digital, and research competencies necessary for biology teachers in contemporary education. Qualitative and theoretical methods such as comparative analysis, synthesis, pedagogical observation, and interpretation of scientific literature were employed. The findings reveal that the effective formation of professional competence depends on interdisciplinary integration, innovative teaching technologies, reflective practice, and continuous pedagogical training. The study highlights the importance of methodological preparedness and practical orientation in teacher education programs. The results contribute to improving pedagogical strategies for preparing competitive and professionally competent biology teachers capable of meeting international educational standards.

Keywords: Professional competence, biology teacher education, pedagogical competence, methodological foundations, competence-based approach, future biology teachers, higher education.

Introduction

In the context of globalization and rapid scientific development, the education system faces new challenges associated with improving the quality of teacher training (2). Special attention is given to the preparation of future biology teachers because biology as a science plays a significant role in forming students' scientific worldview, ecological culture, and research skills (8). Therefore, the issue of developing professional competence among future biology teachers has become one of the priority directions of modern pedagogical research. Professional competence is considered an integrated quality that combines theoretical knowledge, practical skills, pedagogical experience, creativity, and professional values necessary for effective

teaching activities (1). Contemporary educational reforms emphasize the transition from knowledge-oriented teaching to competence-based education, which requires future teachers to possess not only subject knowledge but also methodological, communicative, informational, and innovative competencies (4,5). Despite numerous studies devoted to teacher competence, the theoretical and methodological foundations of developing professional competence in future biology teachers remain insufficiently explored. In particular, there is a need to clarify the pedagogical conditions, methodological approaches, and effective mechanisms that ensure the successful formation of professional competence in higher educational institutions (3). The purpose of this study is to investigate the theoretical and methodological foundations for developing the professional competence of future biology teachers and to determine effective pedagogical approaches for its formation in the process of higher pedagogical education.

Methods

This study investigates the theoretical and methodological foundations of developing professional competence in future biology teachers through a comprehensive analysis of contemporary pedagogical concepts, educational approaches, and scientific literature related to teacher education. The research is grounded in the understanding that professional competence is a multidimensional phenomenon requiring systematic and interdisciplinary investigation (1). The research primarily employed qualitative and theoretical methods, which made it possible to analyze the existing scientific approaches and identify the most effective pedagogical conditions for preparing competent biology teachers. One of the central methods used in the study was the analysis of scientific and pedagogical literature. A wide range of international and national scholarly sources, including monographs, scientific articles, dissertations, conference materials, and educational policy documents, were examined in order to identify current trends in competence-based teacher education (6,7). In addition, comparative analysis was applied to examine diverse pedagogical approaches used in teacher education systems across different countries. This method enabled the study to determine common tendencies and effective educational practices aimed at developing professional competence in future teachers (7). The study also employed the method of theoretical synthesis and generalization. This approach made it possible to combine different scientific ideas and pedagogical concepts into a coherent theoretical framework. As a result, the essential characteristics of professional competence and its structural components were systematized (4). A systematic approach played a significant role in the research process. Professional competence was examined as an integrated pedagogical system consisting of interconnected elements such as subject knowledge, methodological preparedness, communication skills, research abilities, digital literacy, and professional values (1).

Furthermore, elements of pedagogical observation were incorporated into the research. Observation of educational activities in higher pedagogical institutions provided an opportunity to analyze the practical organization of teacher training, the implementation of innovative teaching methods, and the participation of students in laboratory work, pedagogical practice, and independent learning activities. The methodological foundation of the research is based on several modern pedagogical approaches that are widely recognized in contemporary

educational theory. First, the competence-based approach served as the primary methodological orientation of the study (4). Second, the personality-oriented approach was used to emphasize the importance of individual development in the process of professional training (10). Third, the activity-based approach was applied to examine the practical aspects of competence formation. Another important methodological principle of the study was the integrative approach. Since biology is closely connected with other scientific disciplines such as ecology, chemistry, medicine, psychology, and information technology, interdisciplinary integration was viewed as a necessary condition for improving teacher education (8). The reflective approach also occupied an important place in the methodological structure of the research because reflection is considered one of the key factors in professional growth (10).

Results

The results of the study demonstrate that the development of professional competence in future biology teachers represents a multifaceted and dynamic pedagogical process influenced by theoretical preparation, practical experience, methodological readiness, and personal-professional development (3). The findings indicate that modern higher pedagogical education increasingly prioritizes competence-oriented training, where the primary focus is placed not only on mastering biological knowledge but also on developing the ability to apply this knowledge effectively in educational practice (5). One of the major findings of the study is that cognitive competence remains the foundational component of professional preparedness. Future biology teachers must possess profound theoretical knowledge in biological sciences, including genetics, botany, zoology, ecology, microbiology, anatomy, physiology, and molecular biology (8). The study further demonstrated that methodological competence occupies a central place in the structure of professional competence. Effective biology teaching requires not only scientific knowledge but also the ability to organize educational activities creatively and productively (1). The findings show that future teachers who actively engage in methodological training become more capable of selecting appropriate teaching strategies, organizing laboratory work, conducting practical lessons, and implementing student-centered educational approaches. In particular, the use of interactive teaching technologies, problem-based learning, project methods, and inquiry-based instruction positively influences the methodological preparedness of future biology teachers (4). The study also identified digital competence as one of the most essential components of modern teacher professionalism. Rapid technological development and the digital transformation of education require future biology teachers to integrate information and communication technologies into the learning process effectively (9).

Furthermore, the research revealed that research competence plays a decisive role in preparing future biology teachers for innovative pedagogical activity. Participation in scientific projects, laboratory experiments, independent investigations, and academic conferences contributes substantially to the development of analytical thinking, problem-solving abilities, and intellectual independence among future teachers (3). The findings additionally emphasize the importance of innovative educational technologies in modern teacher preparation. The use of interactive methods, digital platforms, case studies, project-based assignments, and reflective

learning strategies creates favorable conditions for active student participation and independent professional development (9,10).

Discussion

The results confirm that professional competence is not limited to subject knowledge alone but represents a complex integration of pedagogical, methodological, technological, and personal qualities. This corresponds with contemporary international educational trends emphasizing competence-oriented teacher preparation (6). The competence-based approach serves as the central methodological foundation for preparing future biology teachers. It shifts educational priorities from passive acquisition of knowledge to active application of skills and professional problem-solving abilities (4). The activity-based approach contributes to the development of practical teaching skills through pedagogical practice, laboratory work, project-based learning, and research activities (1). Such educational strategies increase professional motivation and improve methodological readiness. The personality-oriented approach ensures the consideration of individual abilities, interests, and professional needs of students in teacher education programs (10). This approach promotes creativity, self-development, and professional reflection among future biology teachers. Furthermore, digital transformation in education significantly influences teacher competence formation. Modern biology teachers are expected to integrate information technologies effectively into the learning process. Therefore, digital competence becomes an essential component of professional preparedness (9). The study also emphasizes the importance of interdisciplinary integration. The combination of biological sciences with pedagogy, psychology, ecology, and information technologies enhances the quality of teacher training and broadens professional opportunities for future specialists (8).

Conclusion

The development of professional competence among future biology teachers is a complex and continuous pedagogical process requiring scientifically grounded theoretical and methodological approaches (1,4). The study revealed that professional competence includes cognitive, methodological, communicative, digital, and research components that collectively ensure effective pedagogical activity. The competence-based, activity-based, personality-oriented, and integrative approaches serve as the primary methodological foundations for competence development in higher pedagogical education (4,6). The effectiveness of this process largely depends on the integration of theory and practice, implementation of innovative teaching technologies, and organization of reflective educational activities (9,10). The findings of the study may contribute to improving teacher education curricula, enhancing pedagogical training systems, and developing modern strategies for preparing professionally competent biology teachers capable of meeting international educational standards and contemporary educational challenges (5).

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