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DEVELOPING DIGITAL COMPETENCE IN FUTURE BIOLOGY TEACHERS: PEDAGOGICAL AND PSYCHOLOGICAL ASPECTS OF DESIGNING A VIRTUAL LEARNING ENVIRONMENT

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Abstract: This study examines the process of developing digital competence in future biology teachers and analyzes the pedagogical and psychological foundations of designing effective virtual learning environments. In the context of rapid digitalization in education, the ability of teachers to integrate information and communication technologies into their professional practice has become a critical requirement. Biology education, in particular, demands innovative approaches due to the complexity of its subject matter, including abstract and microscopic processes that are difficult to observe directly in traditional classroom settings.

The research adopts a mixed-methods experimental design involving undergraduate biology students divided into control and experimental groups. The experimental group was exposed to a structured intervention that included virtual laboratories, interactive simulations, multimedia learning materials, and learning management systems. Data were collected through diagnostic tests, surveys, observations, and performance-based tasks aimed at evaluating digital competence, motivation, and learning outcomes.

Keywords: digital competence, virtual learning environment, biology education, pedagogy, psychology, interactive learning.

1. Introduction

In the context of rapid digital transformation, modern education systems are undergoing significant changes. The integration of information and communication technologies (ICT) has created new opportunities for improving teaching and learning processes. In particular, biology education requires innovative approaches due to the complexity of many biological processes that are difficult to observe directly.

Virtual learning environments provide opportunities to simulate complex biological systems such as cellular processes, genetic mechanisms, and physiological functions. These tools allow students to visualize abstract concepts and engage actively in the learning process.

Digital competence has become a key professional requirement for modern teachers. It includes the ability to effectively use digital tools, organize learning in virtual environments, and apply innovative teaching methods. However, many future teachers lack sufficient skills to integrate these technologies into pedagogical practice.

Therefore, the aim of this study is to investigate the role of virtual learning environments in developing digital competence among future biology teachers and to identify their pedagogical and psychological characteristics.

2. Methods

The study was conducted using a competence-based, systematic, and activity-oriented approach.

Research Design

The research followed an experimental design consisting of three stages:

1. Diagnostic stage
2. Experimental stage

3. Analytical stage

Participants

A total of 100 undergraduate biology students participated:

- 50 students in the experimental group
- 50 students in the control group

Data Collection Methods

- Diagnostic tests to assess digital competence
- Questionnaires to evaluate motivation and attitudes
- Practical tasks involving virtual lesson design
- Observation and reflective analysis

Intervention

The experimental group was exposed to:

- virtual laboratory simulations;
- interactive multimedia content;
- online learning platforms (LMS);
- digital modeling of biological processes.

The control group followed traditional teaching methods.

Evaluation Criteria

- level of digital literacy;
- ability to integrate technology pedagogically;
- creativity in teaching design;
- independent learning skills.

3. Results

The findings revealed significant improvements in the experimental group.

Digital Competence Development

- Initial level: 46%
- Final level: 82%

In comparison, the control group showed only moderate improvement (from 45% to 60%).

Cognitive Development

Students demonstrated:

- improved analytical thinking;
- enhanced problem-solving abilities;
- better application of knowledge.

Practical Skills

Participants developed:

- skills in designing virtual lessons;
- proficiency in using digital platforms;
- independent learning abilities.

Motivation and Engagement

- 88% reported increased interest in learning;
- 80% showed higher participation;
- 75% demonstrated creative thinking improvements.

4. Discussion

The results highlight the importance of pedagogical and psychological factors in designing virtual learning environments.

Pedagogical Perspective

Virtual environments support constructivist learning, where students actively construct knowledge through interaction and experience.

Psychological Perspective

Virtual learning environments:
- increase intrinsic motivation;
- support emotional engagement;
- enhance cognitive activity.

Didactic Advantages
- visualization of complex processes;
- interactivity;
- flexibility in learning.

Challenges
- limited access to technological resources;
- poor internet connectivity;
- insufficient teacher training.

5. Conclusion

The study confirms that developing digital competence is essential for future biology teachers. Virtual learning environments play a crucial role in improving the quality of education by enhancing engagement, fostering independent learning, and developing professional skills.

Recommendations
- integrate digital competence training into teacher education programs;
- expand the use of virtual laboratories;
- develop national digital education platforms;
- implement blended learning models.

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