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Ilona V. Batsurovska*, Nataliia A. Dotsenko

Mykolayiv National Agrarian University
54008, 9 Georgiy Gongadze Str., Mykolaiv, Ukraine

Formation of Professional Competencies in the Study of Biophysics in Bachelor Students of Technological Specialities in the Context of Distance Learning

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Abstract. Mastering the "Biophysics" discipline, Bachelor students of technological specialities need a deeper understanding of the physical processes that occur in biological systems. According to the educational programme, as a result of studying biophysics, Bachelor students of technological specialities develop programme competencies. Considering the orientation of the education system to the competence approach and the needs of the present in the development of distance education, the relevant issue is the development of a structural-methodological plan for the development of professional competencies in Bachelor students of technological specialities in the context of studying biophysics during distance learning. The purpose of the paper is to form professional competencies in the study of biophysics in Bachelor students of technological specialities in the context of distance learning. The research work uses the following methods: survey, analysis of the quality of educational results, and statistical processing of results using a nonparametric statistical Mann-Whitney *U*-test. Programme competencies in the study of biophysics in Bachelor students of technological specialities in the context of distance learning are outlined. It is proved that the distance course should contain information for conducting distance lectures, laboratory work, and practical classes. It is noted that the distance course should provide for the control of acquired knowledge during distance learning for Bachelor students of technological specialities based on test tasks, practical tests, and virtual-practical simulators. It is proved that test tasks, control sections and virtual-practical simulators provide monitoring of the results of educational activities of applicants for the higher education of technological specialities in the context of studying the "Biophysics" discipline in terms of qualitative and quantitative indicators: acquisition of competencies and obtaining points on the ECTS scale. The practical significance of the study is that as a result of such consistent work, the plan of which is covered, professional competencies are formed in Bachelor students of technical specialities in the context of studying biophysics during distance learning.

Keywords: study of physical processes, biological systems, competence approach, distance education, online course, knowledge control

*Corresponding author

INTRODUCTION

The "Biophysics" discipline is devoted to the investigation of physical processes that take place in biological systems and examines the influence of external physical factors on living organisms. The modern development of medical and biological sciences is closely correlated with the field of biological physics. Biophysics is a related science, it stands at the intersection of chemistry, biology, and physics. By

correlating physical data with biological data, Bachelor students of technological specialities gain a deeper understanding of processes in biological systems, acquiring professional competencies. In today's conditions, considering the relevance of distance learning during the pandemic, there is a need to form professional competencies among Bachelor students of technological specialities in the study of biophysics.

Within the framework of integration into the global educational space, it is relevant to focus the curricula of applicants on a competence-based approach. Well-known international organisations deal with the problems of competence Education: UNESCO [1], the European Commission [2], the Council of Europe [3], etc. In the modern conditions of the development of the information society, there is a need to develop a technology for training applicants for higher education, which would provide opportunities for obtaining professional competencies in the digital environment. While the widespread adoption of digital technologies in higher education has caused the need to test various technological tools for high-quality teaching and active individual and collaborative learning [4]. The advantages of mass open online courses and learning management systems facilitate the learning process by offering materials and providing information exchange [5].

Chinese researchers Y. Yu and J. Li investigated the reforms of the mixed training regime for specialists [6]. In the writings, T. Wu investigated the theoretical aspects and practice of training specialists against the background of engineering education [7]. Researcher S. Titovskii identifies the leading areas and features of virtualisation and problems of student training [8]. Features of mixed learning are presented in the papers of W. Locke [9], I.K. Faroun [10], C.N. Kresnanto, W.H. Putri [11], blended learning – in the papers of M. Amelia [12], N. Vaughan [13]. Researchers examine the similarities and differences that occurred in blended learning from multiple angles. Technologies for the use of information and communication and distance learning for electrotechnical education are described in the papers of A. Mushi, J. Justo [14]. The introduction of innovations, in particular, in the education of engineers, was conducted by S. Milshtein, S. Tello [15].

It is important that students' education corresponds to their professional context [16]. The need for a deep understanding and unambiguous interpretation of the intended general and specific competencies of teachers should not be underestimated when it comes to qualitative assessment of results [17]. Postgraduate programmes should organise activities that confirm achievements in acquiring such skills and competencies [18]. Psychological and pedagogical analysis of the formation of professional competence in the process of distance learning is presented in the papers of S.V. Mikhailova [19]. The development of students' professional competence in the context of distance learning is highlighted in the papers of O.F. Yatsyna [20]. O. Gavryliuk, T. Vakaliuk, V. Kontsedailo investigated the criteria for selecting cloud-based training technologies for the development of professional competencies of bachelors majoring in statistics. [21]. Methodological approaches to the formation of professional competence of future technical and technological specialists of agricultural colleges are highlighted in the papers of I. Stadniichuk [22].

In the papers of the authors [23; 24; 25], general aspects of methods for studying technical disciplines and introducing distance technologies in engineering education

are outlined. Notably, some aspects were initiated that partially cover the problems of training specialists in electrical engineering specialties and methods of teaching video lectures in distance courses. However, the issue of studying biophysics in the context of distance learning by future specialists of technological specialties in the context of a competence-based approach has not been sufficiently investigated.

The purpose of the study is to determine the effectiveness of the development of professional competencies in bachelors of technological specialties through the introduction of a structural-methodological plan for studying biophysics during distance learning.

The following tasks had to be completed to achieve this goal:

- to investigate the effectiveness of the development of professional competencies in Bachelor students of technological specialties;
- develop a structural-methodological plan for studying biophysics during distance learning;
- perform statistical verification of implementation performance of structural-methodological plan for studying biophysics by bachelors of technological specialties in the conditions of distance learning.

The scientific originality of the study is the development of a structural-methodological plan for studying biophysics by Bachelor students of technological specialties in the context of distance learning, indicating educational tools for its implementation. This plan provides an opportunity to consider not only the receipt of points according to the quality of tasks performed in the conditions of distance learning but also the acquisition of programme competencies by applicants for the higher education of technological specialties when studying the “Biophysics” discipline.

MATERIALS AND METHODS

The study was conducted at the Mykolayiv State Agrarian University in the 2021-2022 academic year. In the first stage of the study, the method of evaluating educational activities was used, considering quantitative and qualitative indicators of the results of acquiring professional competencies in Bachelor students of technological specialties while studying biophysics. A nonparametric statistical Mann-Whitney *U*-test was used to compare the results obtained in the experimental and control groups on two scales [26], which is used to estimate the difference between two samples in terms of the level of any feature measured in quality. As a result of the experiment, such methods as analysing the quality of educational results and statistical calculation of the effectiveness of applying the proposed technology were used. The analysis of the quality of educational results was conducted in the context of a distance course in biophysics. The first scale considers the comparison of self-assessment, and the second scale – the results of the analysis of the quality of knowledge. 31 applicants for the higher education of the 1st year of speciality 204 “Technology of production and processing of livestock products” took part in the experiment. 15 people were in the control group and 16 – in the experimental group.

RESULTS AND DISCUSSION

The development of professional competencies among Bachelor students of technical specialties leads to the formation of biophysics tasks based on general principles of physics, considering the atomic and molecular structure of substances.

The authors share the methodological approaches of researcher N.V. Serdyukova [27] regarding the teaching of a physics course for higher education applicants with non-core training in this discipline, in particular, the introduction of innovative technologies and educational tools. Information technologies have a positive impact on the quality of training in the context of studying physical phenomena

since in real conditions experimental modelling of some processes is difficult for technical reasons [28]. The implementation of digital online technologies in the process of teaching physics and technical disciplines in higher education institutions requires the development of a modern model of the educational process, the key difference of which should be competence orientation [29].

Figure 1 presents the structural-methodological plan developed by the authors of this study for the development of professional competencies in bachelors of technological specialties in the context of studying biophysics during distance learning (Fig. 1).

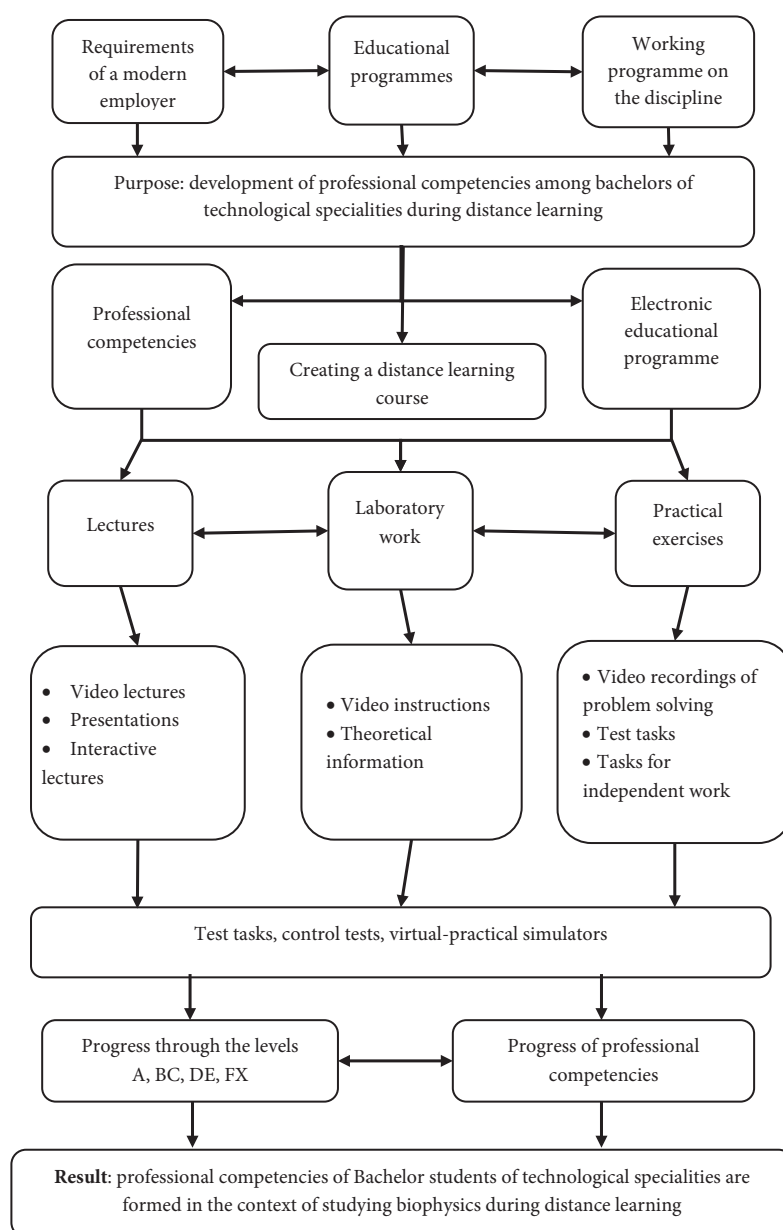


Figure 1. Structural and methodological plan of development of professional competencies in Bachelor students of technological specialties in the context of studying biophysics during distance learning

Source: developed by the author of this study

The requirements of a modern employer, educational and work programmes in the discipline lead to the goal: the development of professional competencies among Bachelor students of technological specialities during distance learning. According to the goal, a distance course is created, which is closely related to the electronic educational programme and professional competencies.

According to the educational programme, as a result of studying biophysics, Bachelor students of technological specialities of the discipline develop programme competencies. Those include the ability to use knowledge of biophysics to the extent necessary to achieve other results of the educational programme; being able to apply modern mathematical methods to solve practical problems related to the research and design of biotechnological processes, using knowledge of physics for the analysis of biotechnological processes; using microbiological, chemical, physical, physico-chemical, and biochemical methods, being able to conduct chemical, technological, and microbiological control of microbiological purity and sterility of biotechnological products for various purposes; based on knowledge about the laws of mechanical hydromechanical heat and mass transfer processes and basic structure design features, being able to choose the appropriate equipment in the process of designing biotechnological products for various purposes to ensure their maximum efficiency.

The formation of a distance course for Bachelor students of technical specialities is based on the development of content for conducting distance lectures, laboratory work, and practical classes. The distance course also provides for monitoring the acquired knowledge during distance learning with bachelors of technological specialities based on test tasks, practical tests, and virtual-practical simulators.

It is necessary to develop educational content in such a way that students understand the physical and physicochemical processes that occur in living organisms, the results of the influence of physical factors on living systems, have an idea of methods for measuring physical parameters and the physics of processes in biological systems to form these professional competencies in bachelors of technical specialities during distance learning.

Lectures. The formation of lecture content involved the development of video lectures, presentations, and interactive lectures. Notably, attending a video lecture, viewing, and taking notes on a presentation, and working through an interactive lecture should not exceed one academic hour in the context of working hours. The subjects of lectures precede the laboratory and practical classes.

Video lecture should not exceed 15-20 minutes. If the video lecture provides an explanation of the presentation, then the presentation should not exceed 7-12 slides. When recording a video lecture, it is advisable to consider some aspects of its perception. The teacher should speak clearly and understandably. The choice of the colour plan should be according to the harmonious perception by the eye. It is advisable to use pastel colours, excluding red, orange, and other bright colours. The teacher's clothing should be in

business style and consider the background colour. If the video lecture involves explaining the presentation, then it is better to consider that eye perception works better if there are dynamic processes every 30 seconds. It is advisable to use animations of certain biophysical processes and systems.

Presentations should not be too long. They should not to exceed 15 slides. It is advisable to combine presentations both with watching a video lecture and working in the context of an interactive lecture. The presentation should contain more visualisations: logical diagrams, tables, and technological processes, cover the analysis of the structure of biological systems.

Interactive lectures provide for working with text information. This type of presentation of educational material implies an inverse relationship with the applicant for higher education. Text information is divided into small parts, followed by a question for reflection. The volume of one part of such material should not exceed two thousand characters. It is advisable to combine text information with presentations, including illustrations and diagrams. Each interactive lecture should contain a list of recommended sources and useful links for independent work.

Laboratory work. Creating content in a remote course for laboratory work involves preparing video instructions and theoretical information.

The **video instructions** have to be 2-5 minutes long. The video instruction should present the technology and procedure for performing measurements in the laboratory work. The image should be clear, and the laboratory assistant's actions – understandable. If necessary, certain processes or actions can be explained to better understand the biophysical process.

Theoretical information should be presented in the form of text, which includes a brief description of the subject and purpose of the lesson, studying the main provisions and independently processing them. Such content should be prepared for the purpose of teaching students to determine and measure the physical parameters of biological systems, model the interaction of physical factors with biological systems, and use educational and reference literature.

Practical classes. In practical classes of the distance course, the teacher organises studies by higher education applicants of certain theoretical provisions from the biophysics course and contributes to the formation of skills for their practical application by performing practical tasks.

Video recordings of problem solving. Video recordings of solving problems in biophysics need to focus on a logical sequence of the solution. Thus, a video with explanations of the problem solution must necessarily include a presentation of the problem condition and a description of the content of new terms and expressions, a brief record of the problem condition, drawings and schematic explanation, analysis of the problem condition to clarify its physical essence, that is, biophysical phenomena, processes and states of the system are clarified, and physical laws and formulas that are necessary for solving the problem are restored in the memory of bachelors of technological specialities. It is advisable

to present a plan for solving the problem and express the relationships between values in the form of formulas. The analysis of the obtained results and the search and consideration of other ways to solve the problem expand the possibilities of logical thinking of students.

Test tasks. Biophysics testing is a method of checking the level of acquisition of competencies in an academic discipline. The use of computer testing methods in the context of a distance course depends on the level of proficiency of the student in educational material in biophysics. In a remote course, testing is usually used to solve simple problems and involves either entering a numerical result or choosing the correct numerical answer. The purpose of such tasks is the actualising of knowledge, preliminary preparation for control tests and modular colloquiums on biophysics.

Tasks for independent study. An Independent solution of biophysical problems is training for the mental activity of a bachelor of technological speciality. Solving a problem for the independent study can be divided into three stages: biophysical (a closed system of equations is created), mathematical (obtaining a solution to the problem), and analysis of the solution. Bachelor students of

technological specialities independently learn to solve problems during extracurricular hours and demonstrate their skills on test papers, the photo report of which is sent to the teacher of the distance course. The complexity of tasks should be decided based on the level of training of future bachelors-technologists. Solving even a simple problem in biophysics contributes to the development of a scientific worldview, and the use of distance courses improves the quality of practical classes in biophysics.

Test tasks, control tests, and virtual-practical simulators at the end of the semester contribute to the diagnosis of the acquisition of levels according to the ECTS scale and ensure the acquisition of professional competencies.

Developed professional competencies for Bachelor students of technical specialities in the context of studying biophysics during distance learning are the result.

The Mann-Whitney *U*-test [29] was used to compare the results of experimental and control groups on two scales. Table 1 displays the empirical values of the Mann-Whitney *U*-test on comparing the results of the experimental and control groups on two scales before the start of the experiment.

Table 1. Empirical values of Mann-Whitney *U*-test on comparing the results of the experimental and control groups on two scales before the start of the experiment

Scales	Mean value in the experimental group	Mean value in the control group	Empirical value	Value level
Scale 1	18.5	16.067	86.5	0.184
Scale 2	30.0	20.933	149.0	0.249

No substantial differences were identified between the experimental and control groups on the investigated scales. At the end of the experiment, a statistical comparison was

also made and the empirical value was calculated based on the Mann-Whitney *U*-test. The results of the analysis are presented in Table 2.

Table 2. Empirical values of the Mann-Whitney *U*-test on comparing the results of the experimental and control groups on two scales after the end of the experiment

Scales	Mean value in the experimental group	Mean value in the control group	Empirical value	Value level
Scale 1	19.125	16.067	88.5	0.211
Scale 2	208.625	20.933	230.0	0.988

There are substantial differences on a scale of 2 between the experimental and control groups ($U = 230$, $p < 0.001$). The indicator in the experimental group is higher than in the control group ($X_1 = 208.625$, $X_2 = 20.933$).

Thus, the structural-methodological plan for the development of professional competencies in Bachelor students of technological specialities in the context of studying biophysics during distance learning is effective.

CONCLUSIONS

The development of professional competencies among bachelors of technological specialities in the study of biophysics in the context of distance learning occurs through working with an online course. The distance course should contain information for conducting distance lectures, laboratory work, and practical classes. The study describes the

programme competencies that higher education applicants acquire when studying the "Biophysics" course. The development of a structural-methodological plan for the development of professional competencies in bachelors of technological specialities in the context of studying biophysics during distance learning was prompted by the needs of a modern employer, educational programmes for training applicants for higher education in technological specialities and the requirements of the work programme in the "Biophysics" discipline. The formation of a distance course is based on an electronic educational programme and professional competencies that must be acquired in the process of studying the "Biophysics" course. Lecture material in the context of distance learning is presented in the form of video lectures, presentations, and interactive lectures. Laboratory classes in the "Biophysics" discipline are based

on the presentation of theoretical information in the form of video instructions. When presenting practical classes in a distance course in biophysics, video recordings of problem solving, test tasks, and tasks for independent study are used. In addition, the distance course should provide for the control of the acquired knowledge during distance learning with students of technological specialties based on test tasks, practical tests, and virtual-practical simulators. Diagnostics of progress at levels A, BC, DE, FX and in professional competencies are provided by test tasks, control tests, and virtual-practical simulators at the end of the semester. As a result of such consistent work, professional competencies are formed in Bachelor students of technical specialties in the context of studying biophysics during distance learning. Statistical calculation using the

Mann-Whitney U-test for comparing the results of the experimental and control groups on two scales before and at the end of the experiment indicates that the use of a structural-methodological plan for the development of professional competencies in students of technological specialties in the context of studying biophysics during distance learning is effective because at the end of the experiment there are substantial differences in the indicators of the experimental and control groups.

Prospects for further research will be the development and implementation in the educational process of audiovisual support of a distance course for the development of professional competencies in bachelors of technological specialties during the study of the "Physics" discipline in the conditions of distance learning.

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Ілона Вікторівна Бацуровська, Наталія Андріївна Доценко

Миколаївський національний аграрний університет
54008, вул. Георгія Гонгадзе, 9, м. Миколаїв, Україна

Формування професійних компетентностей під час вивчення біофізики в бакалаврів технологічних спеціальностей в умовах дистанційного навчання

Анотація. Засвоюючи дисципліну «Біофізика», бакалаври технологічних спеціальностей потребують більш глибокого опанування фізичних процесів, які відбуваються в біологічних системах. Згідно з освітньою програмою, у результаті вивчення біофізики в бакалаврів технологічних спеціальностей формуються програмні компетентності. Зважаючи на орієнтацію системи освіти на компетентнісний підхід та потреби сьогодення в розвитку дистанційної освіти, актуальним питанням є розробка структурно-методичної схеми формування професійних компетентностей у бакалаврів технологічних спеціальностей у контексті вивчення біофізики під час дистанційного навчання. Мета авторської розробки – формування професійних компетентностей під час вивчення біофізики в бакалаврів технологічних спеціальностей в умовах дистанційного навчання. У дослідженні використано такі методи: опитування, аналіз якості освітніх результатів, статистична обробка результатів за допомогою непараметричного статистичного критерію УМанна-Вітні. Окреслено програмні компетентності під час вивчення біофізики в бакалаврів технологічних спеціальностей в умовах дистанційного навчання. Обґрунтовано, що дистанційний курс повинен містити інформацію для проведення дистанційних лекцій, лабораторних робіт та практичних занять. Наголошено, що дистанційний курс має передбачати контроль отриманих знань під час дистанційного навчання в бакалаврів технологічних спеціальностей на основі тестових завдань, практичних зрізів та віртуально-практичних тренажерів. Доведено, що тестові завдання, контрольні зрізи та віртуально-практичні тренажери забезпечують моніторинг результатів навчальної діяльності здобувачів вищої освіти технологічних спеціальностей в контексті вивчення дисципліни «Біофізика» з погляду якісних та кількісних показників: набуття компетентностей та отримання балів за шкалою ECTS. Практичне значення дослідження полягає в тому, що в результаті такої послідовної роботи, схему якої висвітлено у статті, формуються професійні компетентності в бакалаврів технічних спеціальностей в контексті вивчення біофізики під час дистанційного навчання

Ключові слова: вивчення фізичних процесів, біологічні системи, компетентнісний підхід, дистанційна освіта, онлайн-курс, контроль знань