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FORMATION OF PROFESSIONAL SKILLS OF AGRICULTURAL ENGINEERS DURING LABORATORY PRACTICE WHEN STUDYING FUNDAMENTAL SCIENCE

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Abstract. The article deals with the problems of organizing and conducting professionally oriented laboratory classes in fundamental sciences, in particular physics in agricultural and technical universities. The research aim is to theoretically substantiate and develop the methodology for the formation of professionally oriented experimental skills of future agricultural engineers in the process of performing laboratory work in physics in the conditions of the integration of fundamental and professional training. To achieve the research aim, we used the following research methods: theoretical (comparative analysis of scientific, methodological and pedagogical literature) and empirical (observation, analysis, survey of respondents, generalization and modeling of research results, generalization of pedagogical learning experience). In order to select and understand the experiment results, we conducted a survey of teachers and students in order to reveal their understanding of the importance of studying physics for future professional activities. The analysis of the content of physics curricula and other subjects of the natural-mathematical and professional cycles of training made it possible to determine the topics that can be supplemented at laboratory classes in physics (these additions are aimed at the formation of practical skills, which are a necessary component of the professional competence of future specialists in the agricultural sector). The professional orientation in teaching natural sciences involves studying the science basics in an organic connection with the specifics of the future profession. The research experimentally proved that the practical focus of teaching physics changes the student's attitude to theoretical training, helps him discover the deep internal interdependence of theory with future professional activity, his training as a specialist.

Keywords: professionally oriented training; competence; interdisciplinary connections; physics

Problem statement

The modernization of the higher education system of Ukraine requires the development of effective means of forming a comprehensively developed personality, capable not only of applying the acquired knowledge in professional activities, but also of constantly replenishing it.

The requirements that scientific and technical progress puts forward for the development of modern production consist in providing it with qualified personnel who would be mobile, knowledgeable, proactive, and creative. The economic development of the state depends on the quality professional training of future specialists. Future specialists' in-depth knowledge and practical skills is one of the main requirements of society for graduates of higher educational institutions, which are necessary for their implementation in professional activities.

Entering the 21st century, the world community found itself in a situation where the professional component of training specialists in any field, in particular agrarian and technical, occupies first place. Agrarian education as an integral part of the national education system should ensure reproduction of the intellectual potential of the agrarian and technical industry and contribute to strengthening the state economy in accordance with the Constitution and laws of Ukraine. And that is why of great importance are the problems of forming a future specialist's clear understanding of the integration of fundamental and professional knowledge, skills and abilities; professional direction of aspects and components of fundamental disciplines in the process of training in higher educational institutions, their role in the social sphere of work, prospects for the development of one's profession, as well as – confidence in the correct choice of the future profession.

Recent research and publications

Such scientists as V. Andrushchenko, I. Bekh, and I. Ziaziun dealt with issues of education development and implementation of new approaches in education while O. Liashenko, M. Shut et al. studied didactics of the higher school in the process of teaching physics. V. Kopetchuk, S.O. Sysoieva examined the problems of the implementation of modern professional education; A. Verbytskyi, Yu. Griaznov and O. Serhieiev, V. Monakhov and E. Bakhusov, V. Neizhmak, O. Ovcharuk, S. Nikolaienko, J. Raven, V. Shadrykov et al. conducted research on the competence of future specialists. I. Bardus, T. Volkova, T. Hordiienko, A. Kasperskyi, L. Konoshevskyi, I. Lagunov, O. Serhieiev, O. Martyniuk et al paid due attention to the introduction of innovative technologies into the educational process. T. Hordiienko, V. Dushchenko, V. Sergiienko, N. Sosnytska et al investigated the issue of improving the laboratory practice.

We fully support the author (Ramirez-Vazquez et al. 2022, pp. 5725 – 5734) in saying: "The knowledge gained in the laboratory is more than operating a combination of measuring instruments, it is asking questions and answering them through practical demonstrations". Educational research in practical training often deals with problems, and research is based on identifying these difficulties for further professional activities (Nygren 2021). The author of the study (Hogstrom 2009) divided the objectives of laboratory work into five different categories: to connect theory with practice, to develop experimental skills, to develop scientific thinking for motivation, personal development and social skills. McLean Phillips et al. 2021, emphasized that students practically do not perform non-traditional laboratory work. And one of the conclusions of this study is that the absence of laboratory work, which is related to their future activities, significantly reduces the experience and effectiveness of training.

However, despite numerous studies on the issue of integration of fundamental and professional components of future engineers' training, in all agricultural and technical higher educational institutions, the problems of forming a clear awareness of the possibilities of using the acquired fundamental knowledge for further training and practical professional activities are becoming important. The same is valid for the problems of professional direction of fundamental disciplines components in the process of training, their role in the social sphere of work, prospects for the development of one's profession, as well as confidence in the correct choice of the future profession. Graduates of National University of Life and Environmental Sciences of Ukraine and Podillia State University, bachelor's degree 208 Agricultural Engineering and bachelor's degree 201 Agronomy should be ready for work in primary positions in the relevant field. Future agricultural specialists get the specifics of this combination at the beginning of their studies – when learning the discipline of the fundamental cycle of training, especially physics.

This leads to the problem of increasing the efficiency and quality of teaching physics in a higher agricultural and technical educational institution. Therefore, there is a need, on the one hand, to organize the educational activities of students in physics in such a way as to activate the professional component of training, and on the other hand, not to disrupt the very process of studying the physics course, which will undoubtedly put the training of agricultural engineers at a higher quality level (Zbaravska et al. 2019, pp. 327 – 330). The current stage of higher education does not sufficiently cover the problem of formation and development of professional qualities of agricultural engineers in the context of combining knowledge of fundamental disciplines with disciplines of a special cycle. Although scientific and methodological works focus on the analysis of this issue, the ways of solving it are not indicated, that is why it is appropriate to develop such methodical materials that would specify the system of methods and means of teaching physics with the aim of forming and developing professional qualities and contribute to the elimination of the problem. Since educational materials do not focus the attention of agricultural engineers on issues related to the future profession, the issues of professional activity development already at the beginning of training require special research.

The above determines the relevance of the research "Formation of Professional Skills of Agricultural Engineers during the Laboratory Practice when Studying Fundamental Science."

Research aim

The research aim is to theoretically substantiate and develop the methodology for the formation of professionally oriented experimental skills of future agricultural engineers in the process of performing laboratory work in physics in the conditions of integration of fundamental and professional training.

Research methods

To achieve the research aims, we used the following research methods: theoretical (comparative analysis of scientific, methodological and pedagogical literature) and empirical (observation, analysis, survey of respondents, generalization and modeling of research results, generalization of pedagogical teaching experience). In order to select and understand the experiment results, we conducted a survey of teachers and students in order to reveal their understanding of the importance of studying physics for future professional activities.

Research material and its discussion

Indeed, in order to develop the student's ability for professional work, professional self-improvement and analysis, it is necessary to organize the educational process in such a way that when studying the disciplines of the fundamental cycle of training, in particular physics, students systematically perform various professionally oriented and research tasks during the years of studying at a higher agricultural and technical educational institution. Completion of such tasks will contribute to the formation and development of those professional knowledge and skills that are related to future professional activity and will become the basis for fruitful practical activity at the workplace of the future agricultural engineer (Beloev et al. 2023, pp. 73 – 84).

The educational experiment is a reflection of the scientific method of teaching physical phenomena. Professionally oriented laboratory work forms student's skills of independent performance of physical measurements, assembly of laboratory installations according to the proposed schemes, use of measuring devices, study of the characteristics of modern objects of technology. During the performance of laboratory projects, special attention should go to the interdisciplinary connections of physics with the disciplines of the professional cycle of training. Interdisciplinary connections contribute to a deeper understanding of nature laws, the formation of dialectical thinking, the ability to generalize knowledge from various academic disciplines. Without the development of intellectual abilities, it is impossible to train a specialist capable of solving professional problems that require the ability to synthesize knowledge from various subject areas. On the basis of interdisciplinary connections, it is necessary to form the structure and content of syllabuses and teaching books, to determine the sequence of studying the material (Bulgakova et al. 2023, pp. 661 – 666; Nikolaenko et al. 2022, pp. 638 – 644).

We realized the following possibilities of introducing a professional orientation of training during the performance of laboratory work by students:

– development of a system of applied questions for traditional laboratory works;

– carrying out professionally directed laboratory work on traditional physical installations;

– conducting laboratory works using agricultural objects and devices.

The research conducted during the pedagogical experiment showed the feasibility of a rational combination of these approaches. Properly organized and systematically conducted laboratory classes contributed to the formation of a system of physical knowledge among students, as well as the acquisition of various practical skills and abilities.

The list of traditional laboratory works from the section "Physical Foundations of Mechanics" that we proposed to perform in the laboratory workshop one can see in Table 1. The formation of professionally oriented physical knowledge during the performance of laboratory works largely depends on the list of control questions that students get for self-preparation for the defense of laboratory work. For these laboratory works, we suggested such a system of control questions that focus on the future profession of the students (Table 1).

Table 1. List of traditional laboratory works and professionally oriented control questions to them

№	**List of traditional laboratory works from the section „Physical foundations of mechanics"**	**Professionally oriented control questions**
1.	Determination of Young's modulus of the rod by the deflection method.	– How is the modulus of elasticity of the rod taken into account in various parts of agricultural machines (springs, beams)? – What types of body (parts) deformations are used in agricultural processes? – Explain the principle of operation (action) of a spring in a vehicle.

2.	Determination of the coefficient of internal friction by Stokes' law.	– How to explain the phenomenon of viscosity based on the concept of "internal friction"? – Is there a relationship between the viscosity of the used lubricant and the pressure in the engine? – How does the viscosity of a liquid depend on a change in ambient temperature?
3.	Dry friction. Determination of the coefficient of sliding friction.	– What is the place and value of the frictional force in agricultural machines? – How does the frictional force affect the rotating parts of agricultural machines? – Explain the process of separating the grain mixture on the canvas slide.
4.	Determination of the moment of inertia using the Trifilar pendulum.	– How are the moments of inertia of rotating parts of machines and mechanisms (gearbox shaft, crankshaft, etc.) taken into account? – What is the purpose of balancing the crankshaft when manufacturing?
5.	Study of uniformly accelerated motion using the Atwood machine.	– In which agricultural machines and mechanisms one can observe a drop of cargo from different heights? – Give examples of mechanisms that carry out uniformly accelerated motion.
6.	Verification of the basic law of rotational motion of a rigid body using the Oberbeck pendulum.	– How to determine the rotational velocity of the pulley and the movement speed of the belt in flat belt and V-belt transmission? – How to determine the angular velocity of rotation of the cutting drum?

Along with traditional laboratory works in physics, students performed professionally oriented tasks. We offered the following laboratory works:

1. Determination of the friction coefficient of soil.
2. Determination of the friction coefficient of seeds of agricultural plants.
3. Studying the movement trajectory and the main physical characteristics of the reel.
4. Determination of the moment of inertia of the connecting rod (Fig. 1).

Figure 1. Determination of the moment of inertia of the connecting rod

5. Determination of kinematic and dynamic characteristics of the crank mechanism (Fig. 2).
6. Studying the height of water rising through soil capillaries.
7. Determination of the coefficient of surface tension of liquid (vegetable and fruit juices) by the drop method.

Figure 2. Determination of kinematic and dynamic characteristics crank mechanism

8. Determination of soil viscosity (Fig. 3).
9. Measuring the resistance of biotissues.
10. Determination of the coefficient of the soil thermal conductivity (Fig. 4).

Figure 3. Determination of soil viscosity

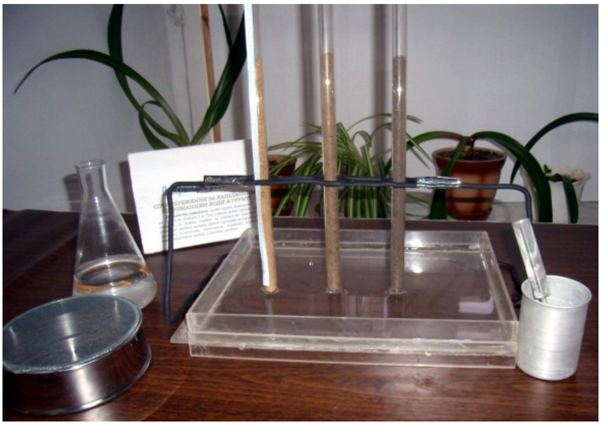

Figure 4. Determination of the coefficient of the soil thermal conductivity

Therefore, laboratory works in physics, performed by students of all specialties without taking into account the professional direction, no longer fully correspond to modern learning technologies, achievements of science and technology and innovative pedagogical experience, contribute little to solving the problem of overloading students and teachers, do not cause the formation of learning motives, and do not provide for the orientation of training on the professional component development. In the developed laboratory works on physics of professional content and modernized works, we can follow a clear direction of the educational process precisely on the future work according to the specialty. These laboratory works contain both informational material and a didactic part that will guide students to active activities in the physics laboratory, aimed at the formation and development of professional abilities and skills for further studying specialized courses in senior years and future work. Therefore, we may state that it increases the professional and creative potential of students.

In order to check the feasibility of implementing the developed methodology for the formation of professional knowledge and skills during laboratory works in physics, we conducted a pedagogical experiment, based on a competency-based approach to learning. The main indicators of the research were the level of formation of professionally oriented knowledge and skills in the study of fundamental disciplines during the performance of laboratory work in physics.

To evaluate the effectiveness of the proposed methodology, we used the following methods: questionnaires (introduction and exit), interviews, and scientific observation. At various stages of the experiment, we monitored the acquired knowledge and skills by giving students tests and control papers. Questionnaires and interviews served to identify the level of awareness and the importance of fundamental knowledge for further studying and professional activities, the formation of interest in learning in general and the identification of interest in the discipline of physics, the quality of acquired knowledge (completeness, awareness), the level of formation of intellectual skills (selection of the main, comparison, analysis, generalization), changes in the level of formation of professional competence at the beginning and at the end of the experiment. In the experimental and control groups we conducted tests of professional knowledge and revealed the level of motivation to studying physics. Classes in the control group took place according to the traditional syllabus of physics. In the experimental group, students worked according to the developed teaching methodology.

It is worth noting that the students of the control and experimental groups show a high level of importance of fundamental knowledge for the full mastery of the disciplines of special courses as well as its applying in further life and practical activities, what is presented in table 2.

Table 2. Results of the test on the formation of students' professional knowledge

No.	Knowledge	Control group		Experimental group	
		Significance level	Formation level	Significance level	Formation level
1.	208 "Agricultural engineering"	0.72	0.47	0.83	0.68
2.	201 "Agronomy"	0.65	0.45	0.74	0.55

Similarly, we investigated the level of professionally oriented skills acquired by students of the first year of study during the performance of laboratory works in physics, what is shown in Table 3.

Table 3. Results of the test of the formation of students' professional skills

No.	Skills	Control group		Experimental group	
		Significance level	Formation level	Significance level	Formation level
1.	208 "Agricultural engineering"	0.61	0.42	0.72	0.61
2.	201 "Agronomy"	0.79	0.42	0.87	0.57

The results of the study presented in the table showed that the highest level of formation of professional skills is in the experimental group: experimental group – 0.59%, control group – 0.42%. This component of our study also confirmed the expected results of the experiment.

Performance of professionally oriented laboratory work in physics, constant emphasis on the use of acquired knowledge and skills in further education and practical activities in the specialty showed an increase in the level of knowledge and skills in the discipline Physics, an increase in students' interest and motivation to studying. The students directly in the physics laboratory have seen the practical importance of the discipline Physics for further education.

Therefore, the analysis of the results of the conducted research made it possible to reveal a higher level of formation of professional knowledge and skills of the students of the experimental groups and an increase in their motivation to study the disciplines of the fundamental cycle on the example of the discipline Physics. The obtained data testify to the effectiveness and expediency of the work carried out: there increased both the general level of knowledge, abilities and skills in the discipline of the fundamental cycle Physics, as well as the level of awareness of the need to study the disciplines of special training courses in order to use the gained knowledge in the future professional activity. We also noted significant increase in the level of cognitive activity and cognitive motivation of the students. Since our research is aimed at the importance of the integration of fundamental and professional components in the process of training students, we should note the importance of professional competence of students according to the following basic and most important criteria for our research: motivational, operational and reflective. The results regarding the level of professional competence of students are presented in Table 4.

Table 4. The level of students' professional competence

No.	Levels	Control group		Experimental group	
		Number of students	%	Number of students	%
1.	Low	30	25.3	9	7.5
2.	Average	47	39.5	50	42
3.	Sufficient	33	27.7	40	34
4.	High	9	7.5	21	17.5
In total		119	100	120	100

The obtained results prove that the level of professional competence of the students of the control group is lower compared to the level of professional competence of the experimental group. So, the results of the conducted experimental research make it possible to state: in the laboratory classes in physics, which were conducted according to the traditional methodology (for the control group), the goal was achieved in terms of general training in physics, while in the classes, which were conducted according to the developed methodology (for the experimental group) – not only in terms of fundamental training in physics, but also of the importance of the professional component in the process of integrating modern components of training in the aspect of formation and development of basic and special professional knowledge and skills. Thus, we achieved the goal set before the start of physics classes, taking into account their professional content, which is evidenced by the students' formed professional knowledge and skills in physics, the overall higher level of professional competence of students of the experimental group, noted by the conclusions of university teachers.

Conclusions

The conducted research shows that a clearly and correctly organized laboratory practice becomes a reliable tool during the study of physics; it helps to overcome the gap between theory and practice, to demonstrate the connection between physics and technology; it also promotes the development of logical thinking; it allows to consolidate, expand and deepen the system of variable knowledge and increase the effectiveness of the formation of physical knowledge and professional skills of the future specialist.

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