PHYSICAL TASKS AND THEIR FUNCTIONS IN TRAINING FUTURE SPECIALISTS IN AGRICULTURAL AND TECHNICAL INDUSTRY

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Abstract. Today in Ukraine there is an unfavorable situation with the staffing of the agricultural sector with qualified specialists, capable of doing successful professional activities. This article is devoted to the problem how to implement a model for teaching physics to the students, based on the use of a system of professionally oriented tasks. The purpose of the article is to study the formation of professionally oriented tasks as a mechanism for the implementation of a systematic approach to learning that does not involve passive acquisition of knowledge in physics but the development of the students' abilities to master rational techniques and methods of mental activity. This work uses theoretical research methods: study and analysis of psychological, pedagogical, normative and special literature on the research problem; analysis of the state educational standards, programs, teaching aids and teaching materials. It has been empirically proved that the efficiency of using professionally oriented tasks in order to improve the quality of the students' knowledge in teaching physics is ensured by a set of didactic conditions. Statistical study and interpretation of the results of the pedagogical experiment allows us to draw the following conclusions: after using the developed methodology, there is a significant difference between the levels of quality of knowledge of the experimental groups and the reference (control) groups. If in the reference (control) groups the sufficient and high level of educational achievements of higher education applicants increased by 12 and 3%, respectively, then in the experimental groups the growth of this indicator is much higher - 17 and 6%, which confirms the efficiency of the proposed methodological model of teaching physics, based on the use of a system of professionally oriented tasks.

Key words: physics, professional orientation, methodological model, professionally oriented tasks.

Introduction

Formulation of the problem. The main goal of higher agricultural and technical education is to train qualified specialists. Therefore it is the professional activity of specialists that sets and determines the purpose of teaching all academic disciplines, including the physics course as the basis for fundamental scientific training of engineers. Elimination of contradictions between the fundamental and professional education requires a systematic synthesis of natural science and general professional competence of higher agricultural education. But in the theory and practice of teaching physics in agricultural and technical institutions of higher education contradictions have accumulated between:

- the requirements of a society that is interested in a high level of professional maturity of graduates in a competitive environment and the educational process in educational institutions, where there is almost no scientifically based methodology for the formation of professional knowledge, skills and abilities of the applicants, necessary for the future specialists to carry out competent professional activities that are adequate to the needs and requirements of the modern labour market;
- the rapid changes in technology in the agricultural and technical industry and the content of the educational process under conditions of limited time for teaching physics.

Therefore there was a need to develop theoretical foundations to improve the study of physics, based on the creation and use of a system of physical problems in the professional training of the applicants for agricultural and technical specialties. As well as the formation of organizational and pedagogical conditions for their effective use in the preparation of applicants, the formation of strong professional knowledge, skills and abilities will contribute to the development of the creative abilities of future specialists.

The identified contradictions and problems determined the relevance of our research.

Analysis of the current research. Considerable attention to the problem of physical tasks and methods for solving them is given in the research works by psychologists, didactics, and methodologists V.S. Avanesova, P.S. Atamanchuk, I.T. Gorbachuk, V.V. Davydova, S.A. Sysoeva, Yu.A. Zhuka, E.V. Korshak, A.I. Pavlenko. Their research explores the organization of work in the process of solving problems. As noted by S.A. Sysoeva: “A young man can only fully receive a professional education when he knows that the acquired knowledge will become the basis of his professional development, success in life, a means of social protection, the basis that will allow him to find his place in society, to truly create his life, to assert oneself and realize self-realization in it” [1].

The current stage of development of society requires implementation of specific tasks, which include increasing the quality indicators in the educational process, improving the educational process, further improving educational programs, and introducing modern pedagogical teaching technologies [2; 3]. At present the attention of many teachers is attracted by the organization of optimal conditions, the formation of professional competencies of the future engineer in the learning process, the creation of conditions for personal growth and the development of their cognitive interests [4]. The main goal of the educational process is to determine the object of the practical professional activity of the future specialist. This allows the students to combine their educational activities with their future professional activities by defining professional tasks according to the specialist’s model [5].

The use of real-life tasks for the professional development of specialists has been widely researched but mainly in the descriptive studies [6]. In recent years the once wide-spread assumption in pedagogical education that real-world tasks are the key to overall success has been replaced by a more differentiated view [7]. However, the use of professionally oriented tasks plays an important role in solving one of the most important problems of pedagogical education (and not only in science), considering the gap between theory and practice [6; 7]. The work by Alonzo A., Berry A., Nilsson P. considers the question: “How can abstract academic learning be transformed into applied teaching practice?” The answer lies at the heart of the concept of the specialists’ professional knowledge [8].

Analysis of publications on the methods of teaching physics showed that the problem of improved methods of teaching physics, based on a system of professionally oriented tasks in higher education institutions, has not received enough attention. Most of the available publications are devoted directly to the methods of solving problems in physics, a much smaller part of them are devoted to the methods of solving professionally oriented problems and, as for the tasks of agricultural topics, the figure for such studies is only about 2%.

Materials and methods

Research methodology. In this regard, the problem of training specialists in agricultural and technical specialties in higher education institutions is especially relevant since its solution should direct the subjects of training to the formation of a competent personality of a future specialist. Therefore, the purpose of this study is to theoretically substantiate and develop a methodology for the application of professionally oriented physical tasks, which is intended to increase the level of competence of applicants.

To achieve the set goals, the following theoretical and empirical research methods were used: analysis of psychological, pedagogical and specialized literature on the research topic; synthesis – to determine the appropriate content of professionally oriented tasks in the context of developing competence and ensuring professional orientation of training; testing - for the purpose of monitoring the levels of educational achievements of applicants and establishing the levels of their competence in physics; pedagogical experiment – to evaluate the educational effect of the proposed model of teaching physics to the applicants of the agricultural and technical universities, based on the application of professionally oriented tasks.

During the study, the main methodological requirements were identified, on the basis of which the physical tasks with professional content were developed.

1. The content of the problems must correspond to the program of the physics course, and orient the student to the problems that he will solve in his professional activity.
2. The content of the tasks should not be highly specialized; it should be supplemented by related areas of knowledge that must be mastered when performing tasks of agricultural and technical content. For example, physical tasks, involving the use of agricultural machinery, their design and calculations, must be closely related to the production processes in which they are used.

3. When formulating the tasks, it is obligatory to reflect the parameters that will allow the students to identify the main indicators that determine the content and nature of actions when making decisions in order to solve them, and in their future professional activities.
4. The tasks must be drawn up in such a way that they reflect the relevant type of professional activity.

Based on an analysis of the literature [9-11] and the work experience, we have identified the following methods for composing tasks for agricultural and technical educational institutions.

1. Reformulation of educational tasks, taken from the collections of problems for the higher technical educational institutions, into tasks with agricultural content.
2. Compilation of tasks, based on the study of scientific and popular science literature. When drawing up professionally oriented tasks, one should take into account modern scientific achievements in the introduction of the new methods of producing and using parts of agricultural machines, instruments and mechanisms, the use of new materials, means of mechanization and automation of agro-industrial production The application of these problems is widely represented in scientific research, the foundations of which are laid in the study of the laws of physics: Adamchuk V. [12], Bulgakov V. [13; 14]. The combination of the classical fundamentals of physics and modern research works, which also need to be used in the training of engineering personnel at agricultural universities, will give the maximum effect in acquiring knowledge of the fundamental disciplines by the students and especially by the masters.
3. Compilation of tasks, based on the use of the material from professional disciplines [15].

Results and discussion

Analysis of the content of a professionally oriented task is an integral part of both the search for a way to solve it and its technical implementation. For agricultural-technical specialties they are intertwined, so that the general provisions of physics and the specific technical conditions of the problem are continuously correlated with each other. The task of our further research was to compile a bank of tasks and develop a methodology for training applicants for agricultural and technical universities and an ability to formulate and solve these problems.

As evidenced by the result of the pedagogical experiment, the task solution is one of the ways how to develop the professional qualities of the future agricultural engineers. Solving professionally oriented problems contributes to deep understanding of the physical essence of the processes occurring in the agricultural machines, mechanisms, and devices. Their use creates prerequisites for successful application of theoretical knowledge in the practice of agricultural production, high-quality implementation of educational tasks in related subjects, the course projects, etc.

The tasks were selected in such a way that it was possible to ensure transition from simple tasks to more complex ones not only from the point of view of physics but also based on the engineering problem that it contains [15].

The terms of the tasks, related to agricultural production, can sometimes be brief. Such tasks are usually more difficult than the tasks with complete data since the student first had to find out what the necessary quantities are to determine the desired value, find these quantities in a reference book, a textbook in one of the disciplines of the professional and practical training cycle, and only after that to begin the solution of the problem itself. However, these tasks make the student think logically, systematize knowledge in physics, linking patterns across different topics and sections; use knowledge of other sciences and, especially disciplines of the cycle of professional and practical training; finally, they learn how to use reference books correctly and efficiently.

Here are some examples of such tasks.

1. It is necessary to plough virgin soil by the tractor T-150, with the soil resistivity being $p = 6 \cdot 10^4$ N·m^{-2}. Is it possible to plough by a PLN-5-35 plough without removing a single body if the ploughing depth should be 27 cm (Fig. 1)?

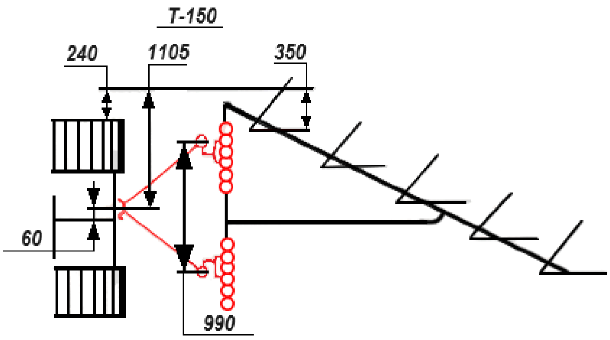

Fig. 1. **Towards Task No. 1**

2. Which engine has greater efficiency of the T-150 diesel tractor or the GAZ-51A lorry (Fig. 2)?

a)  b) 

Fig. 2. **Engines of:** a) T-150 tractor; b) GAZ-51A lorry

Using the reference book, we find: the fuel consumption (for a tractor per hour of operation, and for a car per 100 km at a given speed), the calorific value of the fuel, the engine power. Then we determine and compare the efficiency of the engines.

While solving such tasks, the applicants for higher education became convinced of the complexity of agricultural processes and a need for thorough knowledge of physics to master the basics of this production. Most of the tasks were selected in such a way that their solution would help overcome the difficulties that the higher education applicants face during practical training while studying the basics of agro-industrial production. They increase very well understanding of the physical essence of the task processes that would create a “conflict situation.” The attempt of the applicants to find an answer activates their thinking, attracts attention to the task at hand, and causes increased enthusiasm.

For example, when considering the question “Addition of forces acting upon a body at an angle,” the following task was proposed: The textbook on agricultural engineering indicates that the hitch height of the PLN-5-35 plough during ploughing is 49 cm, and on the virgin soil it decreases to 34 cm. Why does the height of the plough attachment depend on the type of the soil and its physical and mechanical properties? How can we explain that the plough trailer forms an angle with the horizon and is not mounted horizontally? [15].

In the process of studying the discipline “Machine Parts”, the applicants for higher education became familiar with the plough; they also knew that the plough trailer forms an angle with the horizon, the magnitude of this angle depends on the soil resistance. However, they did not find out why the soil resistance affects the angle, or how to determine in advance the angle of inclination of the trailer to the horizon. Having considered the rule of addition of the forces directed at an angle, and having found out what forces act upon the plough (such forces are the soil resistance force and the weight of the plow), the applicants for higher education found the resultant force (Fig. 3). Then they saw that, as the resistance force increases, the angle of inclination of the trailer to the horizon decreases. This circumstance is the answer to the question, asked in the task: the height of the plough attachment on the virgin soil should be less than on cultivated soils.

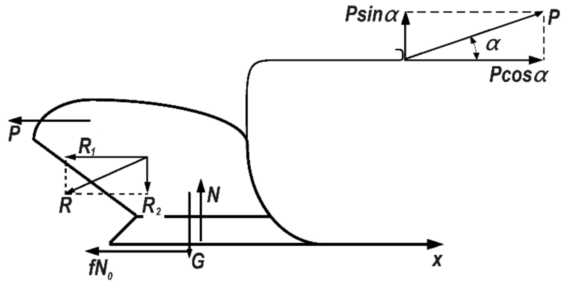

Fig. 3. **Decomposition of forces in the plough**

The success of using physical tasks during the classes often depends on how clearly the students understand the relationship between the individual elements of the task, whether they can find an auxiliary element or pose an auxiliary task. Therefore, when solving tasks, techniques, based on heuristic considerations, will be useful [16].

As an example would be the following task:

Sometimes in the process of operation the reducer, installed on the oxygen cylinder, becomes so cool that it becomes covered with ice (freezes) and stops working normally, although the ambient air temperature is about 20˚C. How to explain this phenomenon. What are the measures to combat the "freezing" of oxygen reducers? [17]. We carefully read the task (we find out the unknown terms: oxygen cylinder reducer and its purpose) (Fig. 4). We analyse the content of the problem: why is the reducer cooled? What does this lead to? We draw up a plan of solution. When oxygen passes through the pressure reducing valve, its pressure decreases sharply (the adiabatic process), as a result of which the temperature decreases. In addition, the water vapour, contained in the oxygen cylinder and in the air around the reducer, is so cooled upon contact with the reducer that it not only condenses on its surface, but also freezes. To prevent the reducer from "freezing", it is first dried before connecting to the cylinder. Besides this, it is recommended to fill the cylinder with dry oxygen.

Fig. 4. **Oxygen cylinder reducer**

Physical tasks of a professional direction reflect real processes and situations that arise in the activities of a specialist in the agricultural and technical industry. Their solution allows the students of engineering specialities to understand the essence of the phenomena and agrotechnical processes used in agriculture, showing specific application of the physical laws in practice, makes it possible to better understand the physical laws, and contributes to the formation of the ability to apply the acquired knowledge in a specific production situation.

As the results of the pedagogical experiment showed, the described methodology for conducting practical classes contributed to rapid progress in mastering the skills of solving physical problems of applied content.

During the pedagogical experiment, first of all, we determined the actual state of teaching physics to the engineering applicants and established the initial parameters. Approbation of the model that we had developed for teaching physics to the applicants, based on the use of a system of professionally oriented tasks, was carried out on the basis of the higher education institution "Podolsk State University". A total of 365 applicants took part in the experiment. In the control (reference) groups (CG), training took place according to the traditional method, in the experimental groups (EG), training was made according to the method that we had developed.

To determine the level of development of the applicants' skills in solving professionally oriented tasks in physics, a control section was performed. The assignments contained learning tasks of different types and levels of complexity. During the experiment, we established a connection between the applicants' readiness to solve professionally oriented problems in the physics classes and the level of their activity in the educational process. Quantitative analysis of the tasks to be solved in the control and diagnostic section, qualitative characteristics of the proposed solutions and the results of observations of the educational and cognitive activities of the applicants made it possible to determine the applicant levels of activity (Table 1).

Table 1

Levels of the applicant activity in the process of solving professionally oriented tasks in physics

Levels	Number of stud.	%
Initial	80	21.9
Medium	179	49
Sufficient	92	25.1
High	14	4

The low level of activity (21.9%) is characterized by the fact that the higher education applicants are superficially aware of the role of professionally oriented tasks in physics in their professional development. Rational methods of mental activity are poorly developed, there is no non-standard and original thinking; the cognitive motives are external in nature; the applicants for higher education are unsure of their own abilities and seek help at the slightest difficulty.

The medium level of activity (49%) is characterized by the fact that the higher education applicants have a medium level of knowledge in physics; they use formal logical operations of analysis and synthesis to solve standard tasks. The applicants for higher education try to conscientiously fulfil their educational duties, yet show insufficient persistence in educational activities; independent search for information is a problem.

The sufficient level of activity (25.1%) is characterized by an adequate level of training in physics. The applicants for higher education are distinguished by their cognitive interest in solving professionally oriented problems in physics; they have developed abstract logical thinking; their activities are productive, practical and rational; an ability for non-standard actions, originality of thinking; however, the heuristic thinking is underdeveloped.

The high level of activity (4%) is characterized by a high level of professional training. The applicants for higher education have a stable cognitive interest and a positive emotional attitude towards solving non-standard professionally oriented tasks; they master heuristic techniques and methods; the heuristic type of thinking prevails; the applicants for higher education demonstrate complete independence of actions and self-confidence; the ability for critical analysis, their activities are creatively productive.

To identify the efficiency of the used system of professionally oriented tasks for teaching physics after completing experimental training, diagnostic control sections were created in the control (reference) and experimental groups, which made it possible to identify quantitative changes in the indicators of the quality of the applicants' knowledge. Comparative results of the diagnostic cross-section of applicants from the control (reference) and experimental groups after completion of the experiment are presented in Table 2.

Table 2

Comparative results of the diagnostic cross-section of applicants in the control (reference) and the experimental groups after completion of the experiment (the data in%)

Level	**Activity levels of the applicants**		**Levels of development of the skills to solve educational tasks**	
	C(R)G	**EG**	**C(R)G**	**EG**
Low	15.0	5.68	9.78	3.59
Medium	44.5	28.14	40.22	21.27
Sufficient	33.0	48.86	43.48	52.73
High	7.5	17.32	6.52	22.41

Analysis of the data, presented in Table 2, showed that among the applicants in the control (reference) groups, low and medium levels of activity predominate in the process of traditional physics teaching. In the experimental groups, where training was carried out using a system of professionally oriented tasks, the cognitive activity of the applicants increased significantly, and a sufficient and high level of activity began to prevail. This means that the activities of the applicants in the experimental group are productive in nature, characterized by a stable cognitive interest in the solution of professionally oriented tasks, practicality and rationality of mental actions, independence and originality of thinking. At the same time the higher education applicants in the control (reference) group demonstrated an insufficient level of activity in the process of solving professionally oriented tasks in physics. The main reasons, in our opinion, are formal mastering of the knowledge of natural science, predominance of the reproductive activity, and lack of cognitive interest in solving mental problems. The positive dynamics of the formation of skills to solve professionally oriented tasks may be traced among the applicants in the experimental group, which is explained by the use of a system of tasks in teaching and compliance with a set of didactic conditions for the organization of educational activities in the process of teaching physics.

As evidenced by the histogram of the comparative distribution of the levels of formation of skills to solve professionally oriented problems (Fig. 5), among the students of the experimental group, after completion of the formative experiment, a sufficient and high level of formation of skills to solve professionally oriented tasks prevails. Such a result is ensured by the use of an integral system of tasks, implementation of interdisciplinary connections in a system of professionally oriented tasks, and acquisition of rational techniques and methods for solving them. All this stimulated the interest of the applicants in studying the program material, the desire to solve heuristic and creative tasks, and display of originality, evidence, creativity and independent judgment. The attitude of the students from the experimental group to the nature of educational activities had also changed. Thus, if in the control (reference) groups they preferred reproductive and algorithmic tasks, then, after completing experimental training in the experimental groups, preference was given to logical-heuristic and creative-search tasks.

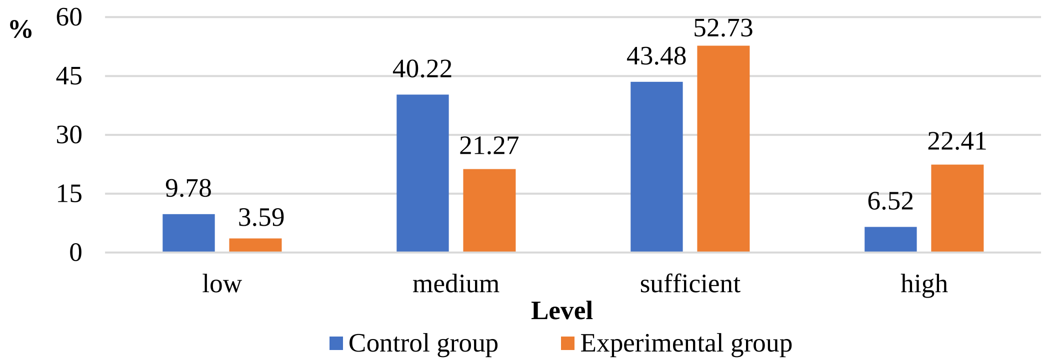

Fig. 5. **Comparative distribution of the levels of development of the skills to solve professionally oriented tasks in the process of teaching physics**

The positive dynamics in the levels of the quality of knowledge in physics of the students from the experimental groups, compared to the students in control (reference) groups after completion of experimental training, indicates the efficiency of the proposed methodology.

In the experimental groups, the sufficient and high level of quality of the students' knowledge increased by 24% and 13%, respectively, which confirms the efficiency of the proposed methodological model of teaching physics, based on the use of a system of professionally oriented tasks.

Conclusions

1. A study of publications on methods of teaching physics indicates a lack of attention to improve the teaching methods, based on professionally oriented tasks in institutions of higher agricultural and technical education.

2. Most existing publications focus on methods for solving general problems in physics, while much less attention is paid to the methods for using and solving tasks, associated with specific professional fields (e.g. agriculture).
3. The research, proposed by the authors of the article, is aimed not only to the study of theoretical concepts but also to apply them in practice.
4. The methodology that we have developed involves the use of physical tasks that are directly related to the aspects of agriculture.
5. This allows the students not only to understand abstract physical concepts but also to see their application in real-life agricultural situations. The tasks of agricultural themes allow the students to develop skills in data analysis, decision making, and real-world engineering problem solving, which is an important aspect of training for the future careers.
6. These peculiarities make our research more efficient and attractive since it not only helps the students master the material but also trains them for real challenges of professional work in the agro-technical industry.

Author contributions

Conceptualization, O.B.; methodology, O.B. and I.S.; software, L.Z.; validation, O.B. and I.S; formal analysis, O.B and L.Z.; data curation, O.B., I.S. an L.Z.; writing – original draft preparation, A.R.; writing – review and editing, A.R. and O.B.; visualization, O.B., A.R.; project administration, A.R.; funding acquisition, A.R. All authors have read and agreed to the published version of the manuscript.

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