MODERNIZATION OF CONTENT OF LECTURE COURSE IN PHYSICS TO TRAIN FUTURE AGRICULTURAL ENGINEERS

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Abstract. The main goal of the higher education system of the agrarian and technical educational institutions is training qualified specialists in accordance with the public demand. The article contains analysis of the theoretical provisions that form the basis of the concept of teaching physics to the students of agrarian and technical educational institutions during the lectures. There are established integrative connections between the fundamental essence and professional orientation of teaching physics to the students of an agrarian-technical educational institution during the lectures, and a proven methodology described for their implementation. There are disclosed the main techniques for realization of professional orientation of teaching physics in the form of lectures to the students of agrarian and technical educational institutions. There are defined the main ways of increasing the professional knowledge of the students while studying the course of physics. Since the educational process in physics in an agrarian and technical educational institution is a complex system that includes many components, in order to investigate it, as a whole, and to study each of its components separately, it is necessary to determine the basic principles of the fundamental and professional orientation of education. It is proved that the use of a professionally directed material contributes to the formation of a system of physical knowledge by the students, as well as the acquisition of various practical skills and abilities. Introduction of professional competence into the educational process stimulates cognitive interest in the study of physics as a science, allows to better assimilate the material of other disciplines of the natural science cycle, develops cognitive and creative abilities, and influences the formation of sustainable motives for obtaining knowledge in special disciplines.

Keywords: physics, lecture, fundamentality, professional purposefulness.

Introduction

The content and organization of higher education has always been a subject of lively discussions. In recent years interest in this has increased even more due to the crisis in society, which entails a clear weakening of interest of the young people in higher education. In order to correct the current situation, it is necessary to radically restructure the entire education system in the country: to shift to more democratic forms of management, to form a continuous education system, to strengthen significantly vocational training, and develop new forms of organization of education. The contemporary scientific and information space is developing at fairly rapid pace, which, in turn, requires such knowledge, skills and abilities from the modern agro specialist, which are the result from a combination of many components – basic disciplines with exclusively professional ones, as well as their application in non-standard situations when working in one's specialty.

At the higher educational institutions, lectures are one of the leading forms of organizing the educational process. The lecture significantly determines the general directions and ways of forming the knowledge of the future specialists. At different stages of development of higher education there has been various attitude to the lecture form of the training sessions. Some teachers, considering the low cognitive activity of the students during the lectures, believe that they have lost their relevance and significance. A logically structured course of lectures provides the basis for scientific thinking, indicates the historical development of scientific truth, introduces new scientific methods of research. All this is a prerequisite that the future specialist will become a creative personality. The lecture describes to a significant degree the ways of conducting all types and forms of education, and, therefore, it can be attributed to the original highway of the learning process [1].

Although lectures may have changed slightly due to technologies, it was a process of replacement, not redefinition: from the blackboards to projectors and *Power Point*; and now, accelerated by the Covid-19 pandemic and the war, – to online. The traditional lecture requires a one-way delivery of information, which gives the students little opportunity to do something immediate or active with that information. For learning to be deeply acquired, the students must apply information in the context for themselves, when acquiring other disciplines, and in their professional lives. Other ways of teaching provide a much better structure to achieve this goal. So, why has the traditional lecture survived? Perhaps, because it was the most efficient way to transmitting information to large groups of students. Till now. Now smart use of technologies gives us an ability to reach hundreds of students with more interactive, engaging and flexible learning styles. If we want to rethink the lecture properly, we must determine the most appropriate format, complemented by interactive and collaborative learning.

The results of scientific research on the general issues of the methodology of teaching physics, as well as the readiness of a personality for the educational activities, are presented in the works by A.I. Arkhipova, G.F. Bushko, B.S. Kolupaeva, V.F. Zabolotny, V.M. Zimina, E.V. Luchika, O.M. Meleshina, I.K. Zotova, Yu.A. Pasechnik, P.I. Samoilenko, A.M. Sokhora, V.I. Sumy, M.I. Shuta and others. Scientific works, devoted to the specifics of introduction of professional training into the educational process, are created by such researchers as X. Cheng, L.-Y. Wu [2], S. Loucks-Horsley, K.E. Stiles, S. Mundry, N. Love, P. Hewson [3], H. Mizell [4], M. Mulder [5], S. Sandhu, T. Afifi, F. Amara [6], and others.

Most of the investigations, connected with the course of lectures studied, show that the lectures allow the student to develop a positive attitude and curiosity towards science only if they have a relation to and examples of their future professional activity [7-10].

S. Sandhu, T. Afifi, F. Amara [6] in their works consider traditional lectures or didactic lectures, as well as directions of the lecturers for efficient and deeper teaching of the students. According to these authors didactic lectures are still considered inefficient in terms of the impact upon the results of teaching, related to the knowledge retention, the students' satisfaction, synthesis and development of knowledge. Consequently, new strategies for transformation of the didactic lectures into efficient ones and facilitating deeper learning are emerging through the combination of science and technology. These achievements may be applied to teaching various students and in various educational settings.

Some authors find the lecture boring, useless and old-fashioned (Ben-Naim [11]; Biggs & Tang [12]; Clark [13]; DiPiro [14]; Dodd [15]; Lambert [16]; Palmer [17]); others emphasize its pedagogical value (Basturkmen & Shackleford [18]; Charlton, Marsh & Gurski [1; 19]; Cowling & Brack [20]; Furedi [21]; Gyspers, Johnston, Hancock & Denyer [22]; Penson [23]; Wolff [24]; Worthen [25]).

Those, who see the good sides in this, argue that whether a lecture is useful or not, depends on how it is applied in practice, how the students react to it, and what are their teachers and students' views on reading lectures [26].

Gunderman in his work [27] draws an analogy between a dance and reading a lecture, stating that reading a lecture is "a kind of dance in which lecturers and listeners observe, react and draw energy and inspiration from each other." In other words, to be efficient in a lecture, the students apply as much effort as the lecturer as dance partners. Otherwise, if only one partner paid effort, it would not work for both parties, and the lecture would not give the desired effect.

Although the scope of subjects of scientific research is quite wide, the problem of upgrading the methodology of conducting lecture classes in physics for the students of agricultural engineering specialties remains little studied. Based on the analysis of scientific research, we arrived at the following conclusions:

1. students do not see a close interrelation between natural-science, general technical disciplines and the disciplines of professional and practical training;
2. content of lectures and practical classes sometimes contains abstract material, and laboratory work differs little from the work performed, for example, at a pedagogical university.

The reasons for such condition are insufficiently formed professional orientation of the program in physics (taking into account the purpose of training). The traditional system of teaching physics in an agrarian-technical educational institution did not sufficiently contribute to the implementation of the professional orientation of education; it did not allow putting a significant impact onto the students' professional development. As a result, a significant part of students do not clearly understand the purpose of studying physics. When studying physics, they do not sufficiently acquire fundamental knowledge of physics and the ability to apply it to perform tasks related to future professional activities [9].

In this regard, the purpose of this article is to highlight the proposed modernization of the methodology for conducting lecture classes in physics for the students of agrarian and technical universities, which makes it possible to achieve most efficiently the task, set for the class.

For this purpose, the following methods of research were applied: theoretical analysis of the philosophical, psychological and pedagogical literature on the topic of the research with the purpose to select and understand the factual material; analysis of concepts, theories and methods, aimed at identifying the ways of solution of the research problem as close as possible to the students' future professional activity.

Materials and methods

The course of lectures on physics for the engineering direction of the agrarian-technical industry is the basis of physics – a science that includes facts, concepts, quantities, laws, theories, the physical picture of the world, methods and practical application of physics. Facts, concepts and laws, theories of the physics course must be presented to the students in a systematized form in accordance with the didactic principles of systematicity and sequence of the knowledge presentation. The need to structure the physical knowledge is determined not only by the principle of systematic learning. The increase in the volume of knowledge and the absence of opportunities for increasing the time to study the lecture material, which reflects the professional orientation of the physics course, requires careful selection and systematization of the teaching material.

This problem may be solved in various ways. When selecting the content of the lecture material and structuring it, we widely use the principle of generalization [10], which assumes the selection of one or several main ideas and grouping the material around this idea. The material of the physics course is grouped around the physical theories. Such an approach to the selection of the content of the lecture material and its structuring is, in our opinion, very fruitful. Therefore, combining the lecture material around the physical theories allows the students formulation of a certain image of thinking, the so-called theoretical thinking, which corresponds to the modern level of public knowledge. Such structuring of the lecture material allows distinguishing the variable and the invariant parts in it and determining the place of professionally oriented material. The variative part must include "devices, technologies, which are related to the theoretical content of the physics course and systematized in accordance with the most important directions of the scientific and technical progress..." [28].

Applying the principle of integration of fundamental and professional orientation of teaching physics at higher agrarian and technical educational institutions, we will carry out distribution of the educational material in the following way.

We will attribute to the invariant part the material that all students of the agrarian and technical educational institutions who study physics should know: fundamental experiments, included into the empirical basis; models, concepts and quantities that form the basis of the theory; completely the core of the theory; some of the most important conclusions, and practical applications. To the variative part we will refer the material, related to the professional training of students. It is according to the content of this material that the principle of professional orientation of training is carried out. To the variative part of the content of the physics course are referred some elements of the empirical basis, and the implementation of the theory. As for the basis of the theory and, especially its empirical basis, in addition to fundamental experiments that serve as the basis for putting forward hypotheses and turning them into a theory, it includes various experimental facts that play an important role at the stage of the knowledge accumulation. At this stage there is a real opportunity to attract professional material, related to the future activities of a specialist, which will awaken a certain motivation and interest in studying the material and intensify the work of the students. To a greater extent the professionally directed material can be studied when considering the consequences of theories, their practical application.

Thus, the content of the physics course includes an invariant component, containing mainly the core of the theory; a partially empirical basis for applying the laws studied; as well as a variable component. This component may change; it is specific for various educational institutions, for various groups of professions (Fig. 1).

As an example, we will give a fragment of the physics course, compiled in accordance with the structure of the physical theory for the section "Mechanics". There are singled out particular theoretical schemes, elements of their structure, invariant and variant (professionally oriented) material. From Table 1 it is evident that, when introducing the basic concepts of kinematics and dynamics, along with the historical experience, there were considered examples, related to the professional activities of the future engineers in the agricultural sphere.

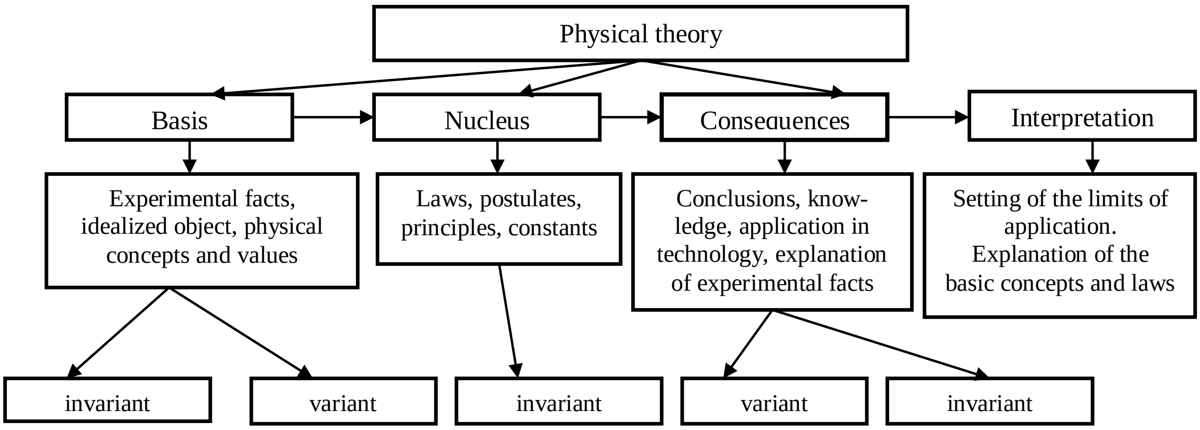


Fig. 1. **Scheme of introducing the invariant and variable components into the course content**

Table 1

Fragment of the physics course

Section "Mechanics"						
Basis		**Nucleus**		**Consequences**		
Partial theoretical scheme	Invariant part	Variant part	Invariant part	Invariant part	Variant part	
Kinematics	Idealized objects, material point, absolutely rigid body	Movement of parts in the mechanisms, devices: a harrow, a seeder, movement of running wheels, movement of the piston, knives in the mowers	Equation of movement, homogeneity and isotropy of space, homogeneity of time	Solving direct and inverse problems for a material point and a rigid body, using the laws of kinematics	Movement of a body on an inclined plane	
Dynamics of a material point and forward movement of a rigid body	Experimental facts (observations by Galileo, Newton, Huygens). Monitoring of the body movement	Forces acting upon the mechanisms of agricultural machines and parts. Movement of the thresher drum, the fan of the fanner, movement of the soil layer along the plough board	Newton's laws. Principle of independence of action of forces	Determination of the position of a material point in space at an arbitrary moment for a particular force and initial conditions	Application of Newton's law (movement of a detail along an inclined plane). Forces acting when grain is moving in a harvester with harrow tines	

Table 1 (continued)

Basis		**Nucleus**		**Consequences**	
Partial theoretical scheme	Invariant part	Variant part	Invariant part	Invariant part	Variant part
Conservation laws. Dynamics of rotational movement	Mechanical system, closed system. External, internal, conservative forces	Movement of mechanisms. Relative movement of details in the nodes of machines and mechanisms. Rotational movement of details and instruments: rotation of the drum in combines, straw cutters	Law of conservation of energy, angular momentum. Dynamics of rotational movement of a rigid body. Steiner's theorem	Using the laws of conservation of momentum, dynamics of rotational motion.	Determination of the moment of inertia of details during the processing and operation of the units and devices
Statics	Hooke's law, Young's modulus, friction forces	Deformation of details when used in agricultural mechanisms. Wear and destruction of the machine parts (stretching, bending of plough elements, cultivators, harrows)	Deformation	Application of Hooke's laws, theoretical provisions on the force of friction	Determination of deformation of details and instruments, and their impact upon the feed accuracy. Determination of friction forces and their influence on the operation of devices

Theoretical presentation of the material was illustrated not only by means of abstract schemes but also by technical ones; for example, the movement of not simply an abstract material point but a point placed on a part of the rotating drum of a combine harvester reel (Fig. 2).

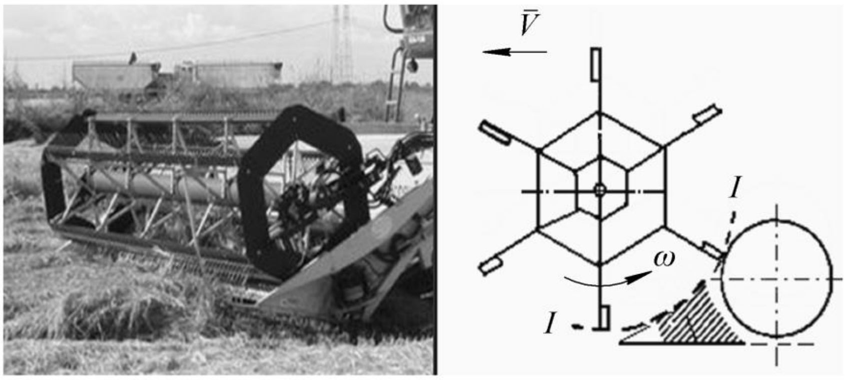
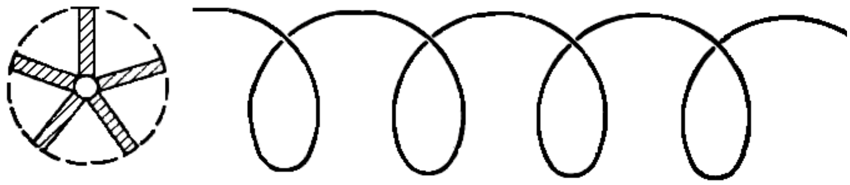


Fig. 2. **Computer model of the movement of the reel of a combine harvester**

So, to describe the trajectory of the movement of a material point, one can consider the rectilinear and forward movements of ploughs, harrows, cultivators, and seeders across the field (Fig. 3).



a *b*

Fig. 3. **Trajectory of points of the blades of the reel during the movement of the combine:**
a – in the reference system, connected with the body of the combine;
b – relative to the observer, standing on the ground

When considering the laws of dynamics, one should pay attention to the forces, acting upon the mechanisms and devices of the agricultural machines (Fig. 4).

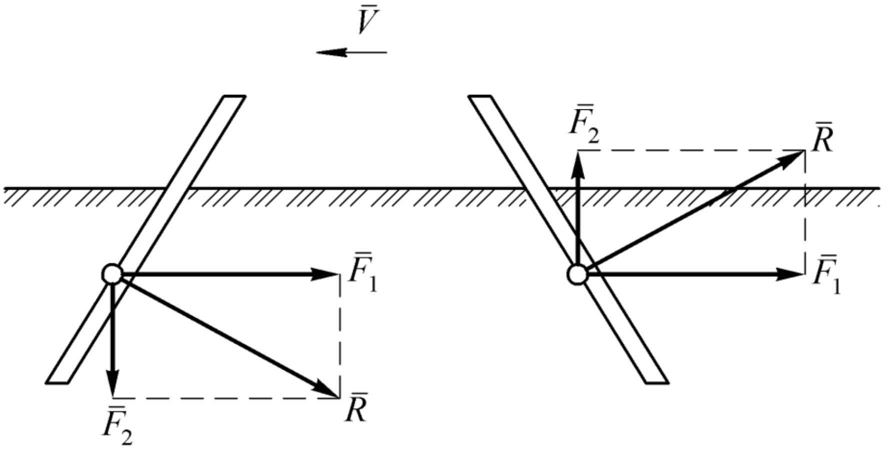


Fig. 4. **Decomposition of the force acting upon the harrow tine**

Thus, as the experiment shows, the study of the basic concepts and provisions of the physical foundations, illustrated by examples of objects, related to the student's future professional activity, contributed to an increase in the level of professional training of agricultural engineers.

At such a presentation of the lecture material, the students were aware that the study of physical laws and principles, describing mechanical movement, would allow them to subsequently calculate the physical parameters of units, and devices. Such an approach created motivation to use these movements in the design and technological development of devices and technological agricultural processes, which, of course, stimulated the students to creative knowledge of the laws and principles of mechanics. Further expansion of the acquired knowledge and their more complex engineering and practical application took place in the study of the courses "Machine parts", "Hydraulics and water supply", "Machines and equipment in the agro-industrial complex" and other professional disciplines.

Results and discussion

To identify the level of preparation of students of engineering specialties in physics, we conducted an experimental study. In total, 255 students of specialty 208 "Agroengineering" of the higher education institution "Podilsky State University" participated in the experiment. Analysis of the work programs, teaching methods showed that the course of physics in the higher agrarian and technical educational institution has turned from a fundamental into a general education subject. The students are not aware of the purpose of teaching physics as the foundation of their future professional activities, they cannot transform the knowledge, gained in the classes of physics, into disciplines of vocational training and general technical cycle, as well as when doing term papers and graduation design. The facts mentioned above allow us to conclude that it is necessary to interconnect the principles of fundamentality and professional orientation when teaching physics to the students of agrarian and technical educational institutions.

For deeper investigation of the professional approach at an agrarian technical university, we developed a questionnaire to determine the attitude of students to the study of a physics course (Table 2).

Table 2

Questioning and interviewing in relation to students' attitude to the study of physics

Are You interested in the physics course in terms of your future profession?	No
	Partially interested
	Yes, it is the theoretical basis of my specialty
Do you consider physical concepts in professional objects?	No
	Partially interested
	Yes, exactly where?
Do you distinguish laws and phenomena of physics in the professional objects (combine, plough, car, and conveyor)?	No
	Partially interested
	Yes, exactly where?

Answers to the questions about the students' attitude to the study of physics from the point of view of their future profession were generally diverse, as shown in Table. 3.

Table 3

Students' attitude to the study of physics from the point of view of their future profession

Question	**Variants of answers, %**			
	No	Partially	Yes, exactly where?	No answer
Are you interested in the physics course in terms of your future profession?	10	65	18	7
Do you see physical concepts in the professional objects?	15	61	13	11
Do you distinguish laws and phenomena of physics in the professional objects (combine, plough, car, and conveyor)?	17	58	11	14

Most of the answers testify intuitive understanding of the need for a physics course for the future profession, but from 10 to 18% of students have a definite idea of the place of physics in their future professional activity. Answers to the question: "Where exactly are the laws and phenomena of the course of physics used?" indicate that most students cannot apply knowledge of physics to professional situations and do not see physical phenomena in agricultural processes.

One of the reasons for such state of affairs is that the students and teachers of the higher education institution "Podilsky State University", who took part in the survey and interviews, see that the course of physics is rather abstract; the collections of problems and laboratory workshops do not adequately reflect the specifics of the professional activity of the future agricultural engineer.

The conducted experiment showed that, despite the fact that 87.2% of teachers have a positive attitude towards the very idea of synthesizing theoretical and professionally directed knowledge in teaching physics, the question of the application remains open. In addition, the teachers believe that for educational institutions of the agro-technical profile it is necessary to develop their own programs, collections and laboratory workshops, reflecting the principle of professional orientation of education.

Conclusions

One of the results at this stage was a conclusion about the need to provide a professionally oriented lecture course in physics, which would be based on widespread use of the principle of professional orientation, integration of new and classical teaching aids, and innovative teaching technologies. It is in compliance with these requirements that ensure successful activity of the future specialist in the agro-technical sphere. Therefore, in the process of teaching physics to the students of higher agrarian and technical educational institutions, it is necessary to focus on the principle of integration of fundamental and professional orientation. It is interrelation of fundamental and professionally directed knowledge in teaching physics that should contribute to the combination of these disciplines with the special disciplines. Therefore, the process of training specialists at a higher agrarian and technical educational institution should be built as a comprehensive target program, and not as the sum of autonomous disciplines independent on each other.

Consequently, the higher agrarian school has a wide range of work to reform all aspects of its activities. It will take time, great effort and extraordinary perseverance. Here it is appropriate to recall the words of the ancient Chinese philosopher Kuan-Tsu, who lived in 551-449 BC: "If you make plans for a year, sow a seed; if for ten years, plant a tree; if for a hundred years, teach children. If you ever sow a seed, you will reap one harvest; if you teach people, you will reap a hundred harvests," We need a hundred harvests throughout Ukraine and hundreds of years. This requires highly educated, competent personalities who understand the complex inner world of a young person. And such personalities should be trained.

Author contributions

All the authors have contributed equally to creation of this article. All authors have read and agreed to the published version of the manuscript.

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