

Application of The Educational Information Systems in Professional Training of Agricultural Engineers Studying Physics

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Abstract — The article deals with application of educational information systems in professional training of agricultural engineers studying physics with an emphasis on practice-oriented teaching methods. Physics is a key discipline that ensures the formation of engineering competencies that are necessary for solving problems of an agro-industrial complex. The modern digital technologies make it possible to significantly improve the quality of education, making the learning process more interactive, visual and closer to real professional activity. Particular attention is paid to application of practice-oriented methods, such as professional tests, case methods and digital simulators. Professional tests allow the students to simulate real engineering activities by solving practical problems, related to physical processes in agricultural engineering. The case method promotes the development of analytical and critical thinking, offering the students an opportunity to analyse real situations and engineering problems, followed by a search for optimal solutions. Application of digital simulators makes it possible to model complex physical phenomena and technological processes, conduct virtual experiments and analyse the results, which is especially important in conditions of a limited access to the laboratory equipment. There is an analysis made of the integration efficiency of the educational information systems into the educational process. The obtained results show that the use

of these technologies helps to increase the level of mastering the educational material by 20–30%; it increases the degree of the students' involvement in the educational process and improves the indicators of independent work. In addition, the students develop practical skills, related to the analysis of the engineering problems and the use of digital tools. A conclusion is made that application of practice-oriented methods in combination with the possibilities of the educational information systems allows not only to improve the quality of studying physics but also to create conditions for the development of the students' engineering thinking, the skills to work with digital tools and competencies, necessary for efficient operation in a modern agro-industrial complex.

Keywords — *agricultural engineers, agricultural machinery, agro-industrial complex, engineering competencies, innovative technologies, interdisciplinary approach, physics, professional training.*

I. INTRODUCTION

The modern agricultural and technical industry places high demands on professional training of engineers, who must master not only deep theoretical knowledge but also practical skills, and be ready to use innovative technologies. Traditional approaches to training often fail

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to fully ensure the development of the competencies that are necessary for the work in the context of digital transformation of the agricultural sector.

The main problems that need to be solved:

1. Insufficient digitalization of the educational process: the lack of a holistic information environment, capable of combining learning, practical training and data analysis, which creates a gap between theoretical knowledge and its practical application.

2. Limited personalization of learning: the diversity of the students' levels of learning, interests and individual characteristics remains without due attention due to the lack of adaptive tools, which negatively affects the efficiency of the educational process.

3. The lack of resources for practical training: Limited access to modern equipment, specialized software and simulators makes it difficult to develop practical skills, necessary for the future professional activities.

4. Insufficient integration of interdisciplinary approach: Traditional educational programs do not take into account the need to integrate knowledge from different fields, such as engineering, agronomy, information technology and management.

5. Difficulties in communication between the students and the teachers: outdated methods of interaction and insufficient feedback reduce the quality of communication and hinder the development of independence and the responsibility skills in the students.

6. The lack of tools for the analysis of the educational process: the lack of systems for monitoring and analysing the students' performance limits the ability to timely adjust the curricula and an individual approach to learning.

To solve these problems, it is necessary to create and implement an educational information environment that will combine modern technologies, methods and organizational approaches. Such an environment should be focused on developing the professional competencies of engineers in the agricultural and technical sector, adapting to the changing market requirements and ensuring high-quality training of specialists.

The issues, related to the educational information environment in the higher education system, have remained the key topic of scientific discussions already over the past decades. A significant number of investigations have been devoted to the analysis of both positive and negative effects of using digital technologies in the educational process.

Integration of modern technologies into education has been a strategic priority for many universities in the recent years [1]. Since the learning practices and technological tools are changing, such a training has to evolve [2]. The online technologies, engineering programs, and the internet access facilitate the transition to learning in an information-educational environment; yet immersion in the learning environment goes beyond the learning tools [3]. Wang, J., Tigelaar, D., Admiraal, W. consider the use of digital educational resources, as well as the integration

of theoretical and practical aspects of learning [4]. In the article by Zalewski, J., Novak, G., Carlson, R. E., attention is paid to the identification of the main challenges, faced by teachers, and finding optimal solutions to improve the quality of the students' training [5]. The efficiency of the content of general technical disciplines and the methodology of the teaching technology is determined by the performance of professional activities [6]. The main features of the development and implementation of practice-oriented classes, activation and stimulation students' cognitive interest in mastering the necessary profession are considered by Ivanov, M., Parnikova, T., Gulyaev, V., & Petrov, N. [7].

However, Lyu et al. [8] noted that the engineering students often find it difficult to identify the relevance of their disciplines to their future careers, suggesting a need for further research in this area. In training of agricultural engineers, new approaches are needed that are associated with interdisciplinary training and the use of modern technologies [9], [10].

At the same time the pragmatic approach of many modern applicants leads to the fact that they focus on studying the disciplines, directly related to their future specialty, reducing attention to other subjects that they consider less important. In particular, this concerns such a scientific and natural discipline as physics [11], [12].

Despite the fact that scientific and methodological works provide a comprehensive analysis of this issue, they often do not offer specific solutions. In this regard it is important to develop methodological materials that define in detail the system of the teaching methods and tools for a particular discipline. Such materials should be aimed at the formation and development of professional qualities of the students, as well as at the elimination of the existing problems. The creation of methodological materials that not only analyse the problem but also offer solutions is a significant step in improving the quality of education.

The aim of this research is to develop and implement the key areas of development of the digital educational technologies and author's content for the physics course, providing the teachers with theoretical and practical support in training the engineers in a modern information and educational environment to improve the quality of their professional training. The following methods were used to evaluate the developed methodology: digital questionnaires to analyse the students' motivation, adaptive online testing to assess their knowledge, simulation case methods to test practical skills, machine learning methods to identify the importance of disciplines, and educational analytics for a comparative analysis of assignment completion by the students in the experimental group (EG) and in the control group (CG).

II. MATERIALS AND METHODS

The information and educational environment is a set of information resources, technologies, tools and methods that ensure the organization, support and improvement of

the educational process. It is based on the integration of the traditional and digital teaching aids, using modern information and communication technologies. The information environment provides opportunities for the integration of modern technologies into the educational process, especially in physics, which requires a high level of visualization, modelling and practical work. Modern approaches to teaching physics to the engineers include the use of practice-oriented methods, such as professional tests, case methods and digital simulators. These methods allow integrating theoretical knowledge with the real-life tasks, developing engineering thinking and forming professional competencies, necessary for successful work in an agro-industrial complex.

A. Professional tests

Training engineers in an agricultural and technical sector while studying a course in physics has a number of features that are determined by the specifics of their future professional activities. A practical orientation of the physics course for engineers is the key aspect, as it allows the students to understand better how the physical laws and principles are applied in their professional activities. A practical orientation of the physics course for engineers ensures being informed about the knowledge and skills that are necessary to solve real problems in agriculture and technical engineering. Therefore, an important factor for the formation of professional competencies is the use of educational tasks that are close to further professional or research activities [13] – [17]. In addition, it allows the students not only to learn the theoretical laws of physics but also to apply them in practical situations that meet the specifics of the agricultural sector. Examples of how to use information and the educational system in studying physics for the engineers:

1.1. Section “Mechanics”: virtual modelling of the operation of agricultural equipment (tractors, ploughs, combines); studying the stability of machines on slopes or calculating the friction forces between the wheels and the ground (Fig. 1).

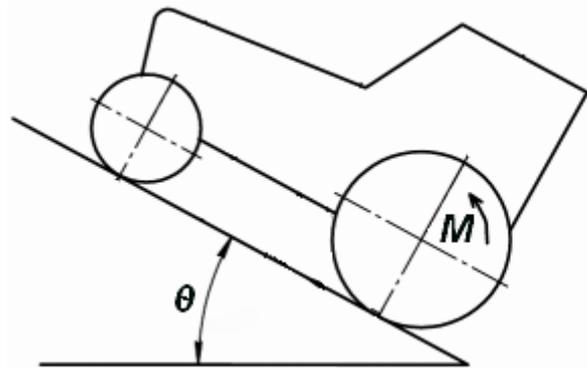
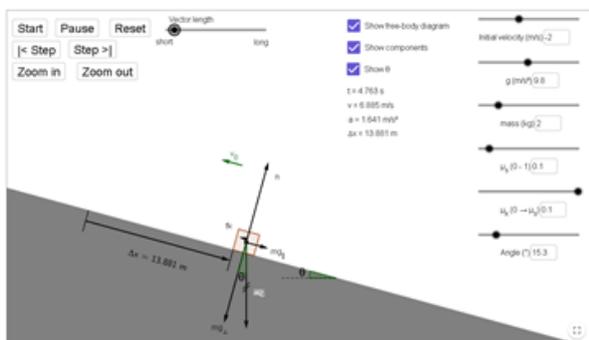


Fig. 1. Virtual modelling of the tractor movement on slopes, or calculation of the friction forces between the wheels and the soil.

1.2. Section “Hydrodynamics”: modelling of the irrigation systems (calculation of the water pressure in the pipelines and the pump efficiency) (Fig. 2).

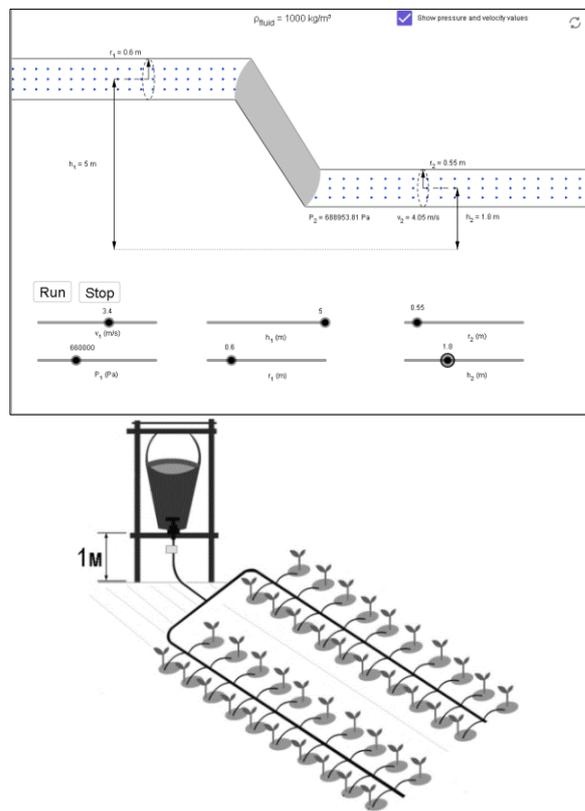


Fig. 2. Virtual modelling of the irrigation systems.

1.3. Section “Thermodynamics”: virtual experiments on calculating the heat transfer in the grain drying systems or the greenhouse operation; study of the operating principles of internal combustion engines.

1.4. Section “Electromagnetism”: simulation of the operation of electric motors, generators and sensors; calculation of the parameters of electrical circuits for the automation systems.

Such an approach to studying physics allows the engineers not only to master the theoretical foundations

but also to apply them in practice, which increases their professional readiness to work in the agricultural sector.

B. The Case method

The case method involves students who are working with real or simulated situations that require analysis and decision-making, based on the knowledge of physics. For example:

2.1. Selecting an irrigation system for a specific crop: calculating the parameters of a drip irrigation system, based on the data about the soil and climate.

2.2. Optimization of the tractor engine operation: analysis of the thermodynamic processes in the engine to increase its coefficient of efficiency.

2.3. Solution of problems in the grain storage: analysis of the heat and moisture exchange processes in the storage facilities to prevent spoilage of the products.

As a result of using the case method in studying physics for the engineers, the following is achieved:

1. Increased motivation and engagement: the students actively participate in solving practical

problems, seeing the real importance of physics for their profession. For example, a case study on choosing an irrigation system, based on hydrodynamic calculations, generates interest and stimulates the application of knowledge.

2. Developing analytical thinking: working with cases requires deep data analysis, application of physical laws and making informed decisions. For example, calculating the stability of a tractor on a slope helps to understand the practical application of mechanics.

3. Development of practical skills: the case solution involves modeling of processes, calculations and using the tools of analysis. For example, calculating the operating parameters of a grain dryer helps to master the laws of thermodynamics.

4. Strengthening of interdisciplinary links: the case method allows to integrate physics with other disciplines, such as mathematics, chemistry and biology. For example, calculating the heat losses in greenhouses involves knowledge from various fields.

5. Training for real professional situations: the students gain experience in solving problems, similar to those they will encounter in their work. For example, the analysis of the grain storage problems through the heat and moisture exchange processes.

6. Assessment of the students' competencies: the case method makes it possible to objectively assess the level of the students' training through the quality of solutions and proposed approaches. For example, completing a case study on optimizing the operation of the internal combustion engines allows one to measure the level of their knowledge and skills.

The case method promotes a deeper understanding of physics, it develops professional competencies and trains the engineers how to solve real problems, making training more practice-oriented and efficient.

C. Digital simulators

The use of virtual laboratories and software to simulate the physical processes, related to engineering. For example:

3.1. Modelling the performance of the agricultural equipment: The analysis of the tractor dynamics by using the simulators of mechanical systems.

3.2. A study of hydraulic processes: modelling the operation of the pumping systems, calculation of the pressure losses in pipelines.

3.3. Working with thermal systems: virtual study of thermal processes in the grain dryers and greenhouses.

The use of digital simulators in studying a physics course makes it possible to study complex processes without a risk to damage the equipment; it increases the students' interest through the use of modern technologies, and also develops their skills in the work with digital tools.

The use of a project-based learning, professional trials, case studies and digital simulators in teaching physics to the engineers significantly enriches the educational process. First, the students gain a deeper understanding of theory because the physical laws that they study are illustrated through their application to professional engineering-related problems. Second, the practical orientation of training contributes to the development of professional competencies: the students solve real problems, create models and complete projects, which trains them for the future work. In addition, such methods increase motivation and involvement in the learning process, as they make knowledge meaningful and useful for the future profession. As a result, education becomes not only more interesting but also focused on the practical implementation of knowledge.

III. RESULTS AND DISCUSSION

During the pedagogical experiment the main task was to evaluate the efficiency of developing the professional competence of the future engineers by using various approaches and methods, such as professional tests, the case methods and digital simulators.

A total of 456 students of specialty 208 "Agroengineering" participated in the experiment. The experimental group (EG) is trained, using a new method; classes in the control group (CG) were held according to the traditional method.

To study the actual state of the students' readiness for a professional activity, the following tools were developed:

- Questionnaires to determine students' interest in professional activities.
- Test assignments to assess knowledge of special disciplines.
- Cases for testing practical skills.
- Criteria for evaluation of the results of design and laboratory works.

To conduct an initial diagnosis of the level of competence, we conducted a survey to identify the level of interest and awareness of the importance of the professional disciplines (Table 1).

TABLE 1. SURVEY QUESTIONS TO IDENTIFY THE LEVEL OF INTEREST AND AWARENESS OF THE IMPORTANCE OF PROFESSIONAL DISCIPLINES

Closed questions:	Answers
How interesting is discipline "Physics" to you?	1 – not interesting at all, 5 – very interesting
How do you evaluate the importance of physics for your professional training?	1 – as insignificant, 5 – as very significant
What topics from the physics course do you find most useful?	Select from the list: mechanics, hydrodynamics, thermodynamics, electromagnetism
Open questions:	
What would you like to change in the methodology of teaching physics?	
How can knowledge, gained in the physics classes, be used in engineering?	
What practical problems, related to physics, do you find most interesting?	

Conducting a survey allows us to identify the proportion of students with low, medium and high levels of interest, as well as to determine the extent to which the students understand the link between the professional disciplines and the real engineering tasks. This helped us also to identify elements of the course or teaching methods that stimulate the students' interest. The results of this stage of the experimental work are presented in Table 2.

TABLE 2. RESULTS OF A SURVEY TO IDENTIFY THE LEVEL OF INTEREST AND AWARENESS OF THE IMPORTANCE OF PHYSICS

Parameter	Low level (1-2)	Medium level (3)	High level (4-5)
Interest in discipline "Physics"	15	45	40
Awareness of the importance of the discipline	10	35	55
Preference to practical classes	5	25	70

As regards the students' interest in professional competence of the future engineers, we found that the majority of the students are aware of the importance of physics (55% high level), yet the interest in the discipline requires improvement (40% high level), and the students' motivation can be increased by the practice-oriented teaching methods (preferably, 70%).

During the pedagogical experiment of the experimental group, the following measures were carried out to organize the educational process:

1. Conducting professional tests: performing practical tasks in educational laboratories or at agricultural enterprises.
2. Using the case method: analysis and solution of real engineering problems.
3. The work with digital simulators and programs (AutoCAD, SolidWorks, modelling systems of hydraulic processes).

For the control group the training was conducted using standard methods (lectures, seminars, the traditional laboratory work).

As shown by the results (Table 3) of the pedagogical experiment (monitoring the students' progress in completing the assignments, conducting intermediate tests, surveys and questionnaires), the implementation of the created methodology for the development of the professional competence of the future engineers in the process of studying physics had a positive impact on the level of development of this competence.

TABLE 3. DYNAMICS OF FORMATION OF PROFESSIONAL COMPETENCE OF THE FUTURE ENGINEERS (%)

Level of professional competence	At the beginning of the experiment		At the end of the experiment	
	EG	CG	EG	CG
High level	30	28	48	32
Medium level	40	42	42	43
Low level	30	30	10	25

Thus, in the experimental group (EG) 48% of students achieved a high level (previously 30%), and 42% of students achieved an average level (previously 40%). In the control group (CG) 32% of students achieved a high level (previously 28%), and 43% achieved an average level (previously 42%).

CONCLUSION

The results, obtained during the experiment, indicate a significant influence of the proposed methodology on increasing the level of professional competence of the future engineers. An increase in the proportion of the students with a high level of readiness in the experimental group (48% versus 32% in the control group) and a significant decrease in the indicator of a low level of formation (by 20% versus 5% in the control group) indicate the efficiency of the application of the developed digital educational technologies and the corresponding methodology.

Comparison of the data with the results of research by other authors confirms the general trend according to which the integration of innovative approaches into the teaching of fundamental disciplines, in particular physics, has a positive effect on the professional training of the students. Our work is not limited to a general assessment of the impact of innovative methods; we have focused on the practical orientation of the tasks specifically in the field of engineering and demonstrated the results in particular professional contexts. Thus, along with the

introduction of virtual laboratories and simulators, we developed a series of tasks, related to real production and technological processes in agriculture, which allowed the students to see immediately the practical significance of the knowledge they are gaining. In addition, we created, as part of the experiment, a digital educational environment in which the training modules were supplemented with materials and cases from the partner employers, thereby strengthening the professional focus of training and motivating the students to study physics in depth in the context of their future specialty. It is this complex integration of fundamental knowledge and real professional tasks that allows us to say that the presented experience goes beyond general recommendations and provides a specific tool for the improvement of the level of training of the future engineers.

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