IMPLEMENTATION OF PROFESSIONAL ORIENTATION OF THEORETICAL TRAINING IN PHYSICS FOR STUDENTS OF ENGINEERING AND PEDAGOGICAL SPECIALTIES

Inna Savytska[1], Oksana Bulgakova[1], Lesya Zbaravska[2], Adolfs Rucins[3], Mykhailo Torchuk[2], Olena Podobied[4]
[1]National University of Life and Environmental Sciences of Ukraine, Ukraine;
[2]Podillia State University, Ukraine;
[3]Latvia University of Life Sciences and Technologies, Latvia;
[4]Dragomanov Ukrainian State University, Ukraine
adolfs.rucins@lbtu.lv

Abstract. The article is devoted to the peculiarities of teaching physics at a specialized educational institution. Fundamental training and specialization as directions for restructuring higher agrarian and technical education are due to the fact that most of the engineering education program is quite general in nature and does not provide a sufficiently deep basis for the acquisition of competence; therefore, a need arose to strengthen the fundamental and professional orientation of training, taking into account specialization. The purpose of the article is to describe methodological techniques in order to highlight the importance of studying specific issues of physics for further mastery of specialized and applied disciplines by the engineer-teachers, as well as in their future professional activities. To achieve the goals of the research, the following research methods were used: the theoretical (comparative analysis of scientific, methodological and pedagogical literature) and the empirical (observation, analysis, survey of respondents, generalization and modelling of the research results, generalization of the pedagogical learning experience). To select and understand the results of the experiment, a survey was conducted among applicants for higher education in order to clarify understanding of the importance of studying physics for the future professional activities. It has been demonstrated that the professional orientation of teaching physics is the leading factor in the fundamental and professional training of the future specialists in engineering and pedagogical specialties. There is described a proven methodology for the implementation of professional training in physics. It has been proved that the efficiency of studying physics in an educational institution is directly related to compliance with the principle of continuity in the study of physics with the future professional activity.

Key words: professional orientation, fundamentality, physics, lecture classes.

Introduction

The modern rapidly changing technological landscape of the agricultural technology industry requires a revision and improvement of the education system to train qualified specialists. Education in the 21st century must meet the challenges and requirements of industry and the global labour market. Contemporary employers expect from the graduates of higher agricultural and technical educational institutions an ability to work independently at a high professional level, to realize the maximum of their potential, and make unconventional creative decisions. Therefore, a need arises not just for highly qualified engineers but, above all, for specialists who can competently and responsibly implement professional tasks. Only by possessing these qualities an engineer can be what he should be - the central figure in scientific and technological progress. And this requires a high level of knowledge in the professional field, which determines the topicality of our research.

Analysis of the current research

The problems of professional orientation of training are the subject of research in the scientific works by: R. Nizamov, N. Kuzmina, V. Shvets, V. Shadrikov, V. Yakunin and others. The issues of professional direction of teaching physics to students of various specialties were studied by such local scientists as O.Bulgakova [1; 2], N. Burdeynaya [3], V. Shadrykov [4], M.Shut, V.Sergienko [5], T.Strogonova, N. Stuchinskaya [6], L. Zbaravska [7], and are also reflected in scientific research, using the basic physical laws, by V.Bulgakov and V. Adamchuk [8; 9].

The system of training specialists and, first of all, higher education should be an effective tool, a guide of a unified state and scientific and technical policy. The main quality of a qualified specialist is the ability to competently and responsibly perform professional tasks. Only by possessing these qualities, an engineer can be what he should be - the central figure of scientific and technological progress [1; 2; 7].

V. Shadrykov [4] believes that professional orientation is formed on the basis of a person's motivational sphere and is a system of motives that motivate a professional to perform professional tasks and tasks of professional development.

In the works of [3; 5; 6], professional orientation is understood as a set of motivational formations, such as interests, needs, inclinations, aspirations, etc., related to a person's professional activity, which influence, in particular, the choice of a profession, the desire to work, and obtaining satisfaction from the chosen professional activity.

Contemporary problems of teaching physics are reflected in the studies of foreign scientists: Blomeke S., Busse A., Kaiser G. [10], Erinosho S. [11], Kaiser G., Konig J. [12], Kuswanto K. [13], Seidel T., Stürmer K. [14], Sherin, M., Jacobs V., Philipp R. [15].

According to S. Y. Erinosho: "Physical education comes from two words. This is education and physics. Education is a process of self-development that requires a process of awareness to form a habit. Physics is the basis for understanding the complexity of modern technologies and knowledge to form a technically savvy society" [11]. Therefore, the scope of physics education should be broad not only around concepts and content but also how the students can understand the essence of all learning activities [13]. The works [15; 16] have analysed the concept of professional direction describing the teacher's ability to notice and interpret important features of the production situations. This is considered a key component of the teacher's experience [14] that should be developed [12; 17].

It is assumed that the development of professional orientation depends on the development of the basic cognitive and effective-motivational dispositions, such as professional knowledge and belief. The analysis of psychological and pedagogical research, presented in the methodological literature on the problem of using professional orientation for the students of higher educational institutions, indicates that, despite the significant research results, no attention has been paid by the researchers to important issues of the theoretical and methodological foundations of the introduction and use of the elements of professional orientation when studying the theoretical course of physics for the engineering students [10; 14; 18].

The analysis of psychological and pedagogical investigations, presented in the methodological literature on the problem of using professional orientation for the students of higher educational institutions indicates that, despite the significant research results, there are important issues of the theoretical and methodological foundations for the introduction and use of elements of professional orientation in studying a theoretical course in physics for engineering students. Therefore, the purpose of the article is to describe methodological techniques for the implementation of the professional orientation of studying theoretical issues of physics for further acquisition by the engineers of specialized and applied disciplines, as well as in their future professional activities.

The methods of the used pedagogical research are isolated into groups: organizational, theoretical, empirical and data processing.

The organizational methods are oriented on identification of the task that requires research. The theoretical methods are focused on a reasoned and logically substantiated solution of a problem based on a deep and comprehensive theoretical analysis. The interdisciplinary research methods are aimed at a set of integrative methods, aimed primarily at the intersections of scientific disciplines. With the help of the empirical methods there was ensured accumulation, fixation and generalization of the source material for the further development of the pedagogical theory. The data processing methods made it possible to evaluate qualitatively the objects and processes of the research, to accurately analyse and predict their manifestations, and confirm the efficiency of the proposed methodology. Data processing methods made it possible to qualitatively evaluate the objects and processes of the study, accurately analyse and predict their manifestations, and confirm the effectiveness of the proposed methodology.

Materials and methods

In higher agricultural and technical educational institutions physics, mathematics and chemistry are the main fundamental disciplines in the professional training of the future specialists. Therefore, professional orientation of teaching physics is a pressing issue in the professional training of engineers. The efficiency of studying physics in an educational institution is directly related to compliance with the principle of professional orientation in the study of physics with the future activities. In turn, we [1;

2; 19] understand the professional orientation of teaching physics as such an organization of its study in which the students purposefully acquire theoretical knowledge in physics, professional skills to apply this knowledge to solve problems when studying the disciplines of the professional training cycle in the future professional activity.

In the institution of higher education “Podilskyi State University” a survey was conducted among students of the first and fourth years, the purpose of which was to find out what needs to be changed in the work of a physics teacher so that classes in this subject become more interesting? This study revealed how students can be motivated to increase their interest in studying physics.

As a result of the survey, it was found that students want to increase the number of experiments in classes – 25%, to focus physics material on future professional activity, its practical significance – 38%, to teach the material more interestingly - 19%, to reduce the number of homework – 11%, 7% of students believe that it is necessary to teach them to improve their knowledge independently.

Based on the analysis of the questionnaire survey of students, in order to increase interest in studying physics, it is necessary to:

1. include in the content of the lecture material examples of the application of physical laws and phenomena in the agricultural and technical field;
2. to use together with “classical” tasks such tasks that include professionally oriented material;
3. conduct professionally oriented laboratory and practical work.

The process of forming professional orientation during the study of physics among students will be carried out effectively if a holistic system of activities is functioning that takes into account the modern requirements for the future specialist in the agrarian and technical field.

The main organizational form for theoretical training in any academic discipline in a higher educational institution is usually a lecture. Its main didactic goal is “the formation of an indicative basis for the students’ further acquisition of educational material” [5].

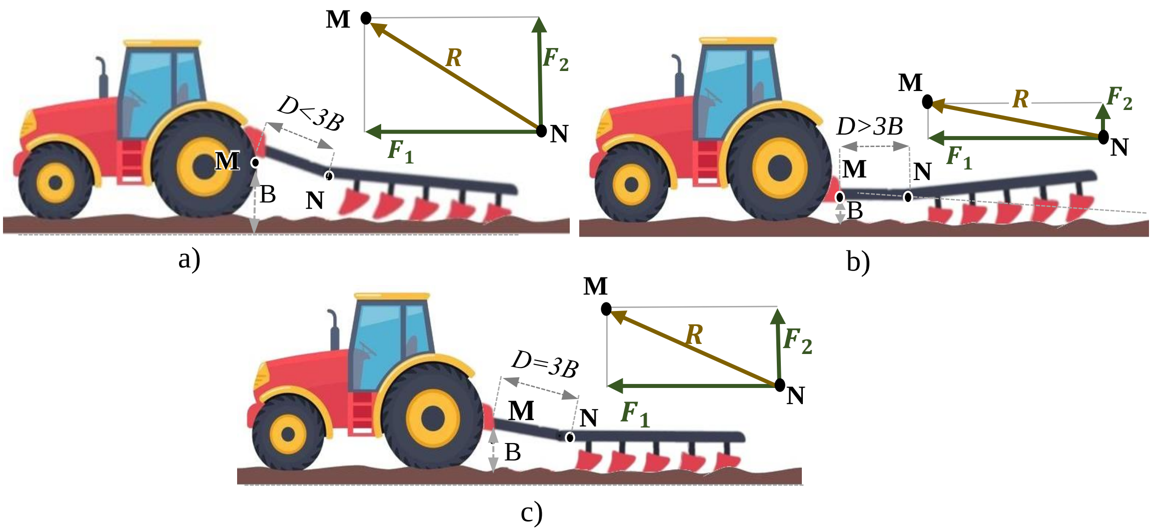

Fig. 1. **Plow position and force decomposition diagram:** a – the plough goes deeper; b – the front teeth of the plough deepen; c – greater than the height B

The methodological approach to the lecture classes is to develop students’ interest in physics, creating in them a holistic understanding of it as a discipline, which contributes to the creative assimilation of educational material. A significant means of increasing the students’ interest in studying physics is the use of multimedia visualization of a presentational nature in combination with visualization of calculations and modelling the physical phenomena and laws under consideration, using COMSOL Multiphysics, MATLAB, Ansys Fluent, SolidWorks Simulation and other web resources. When conducting theoretical classes in physics, in order to increase motivation and awaken the interest of the students, it is advisable to demonstrate by illustration the manifestation of the laws and phenomena of physics in agricultural machinery [20; 21].

When teaching fundamental laws, concepts and phenomena, we consider it advisable to provide examples and tasks that illustrate their application in professional activities. For example, in the process of explaining the topic “Newton’s Third Law”, its manifestation in agriculture can be shown using the following examples:

The performance of all tillage devices is an example of the interaction of two bodies. Thus, the field board of the plough body, acting on the ground, itself, in turn, experiences a reaction force from the soil. This is taken into account when designing ploughs and their operation. Having reminded students that the components of a force act in the direction of the connections and movements, it should be emphasized that the components of the force depend not only on the resultant, but also on the direction of the connections. This rule should be used when clutching. Not only the efficiency of the tractor but also the quality of tillage depends on the direction for which the hitch is made. Incorrect selection of the length of the hitch for ploughing leads to uneven depth of loosening the soil, and unstable movement of the plough – to a decrease in the quality of ploughing.

If the hitch is short and raised (Fig. 1, a), the plough goes deeper from the soil, so the front rows of its teeth go shallow in the soil, and sometimes even come out of the soil completely. The rear teeth with this clutch become too deep. In this case the large lumps do not pass under the rear frame of the plough, and the plough becomes completely clogged. If the hitch is long and low (Fig. 1, b), the front teeth of the plough deepen but the rear ones come out of the soil.

Consequently, the front part of the plough becomes clogged. In both cases the quality of ploughing deteriorates. As experience has shown, the most appropriate length D is the plough coupling, the second being greater than the height B (Fig. 1, c).

In this topic it is important to show the distribution of force on the plough teeth (Fig. 2), on the plough blade (Fig. 3), on the ploughshare, on various mechanical regulators, brackets, etc.

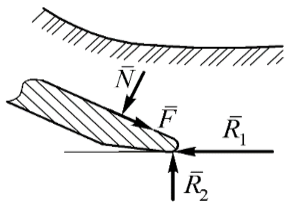

Fig. 2. **Decomposition of the soil resistance force on the plough tine**

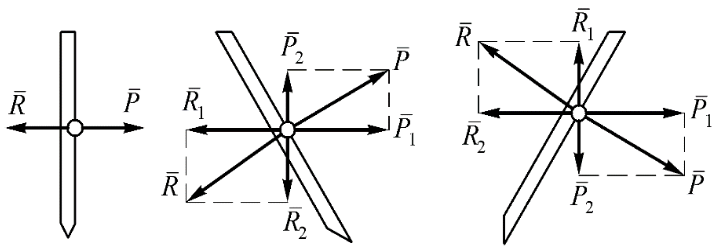

Fig. 3. **Decomposition of the resistance force on the plough blade**

Theoretical training must be accompanied by the need of students for the practical implementation of acquired knowledge, which is associated with the development of new dynamic stereotypes. By encouraging interest in knowledge, the teacher thereby gives a psychological impetus to strengthen professional interest. It is imperative that after conducting a theoretical analysis of the problem under study (for example, the decomposition of force on the teeth of a harrow, on a plow blade, on a ploughshare, on various mechanical regulators, brackets, etc.), we use computer modeling of the physical phenomena and laws under consideration using available web resources (https://ophysics.com/k1.html; https://www.radian.com.hk/simulations/index.html#/details/15).

Computer models can perform calculations and simulations much faster than it can be done with traditional methods (Fig. 4).

This increases the efficiency of research and allows to conduct more experiments in a short period of time. Simulations allow the students to make mistakes and learn from them without having to face real-life consequences. This promotes better understanding and improvement of skills.

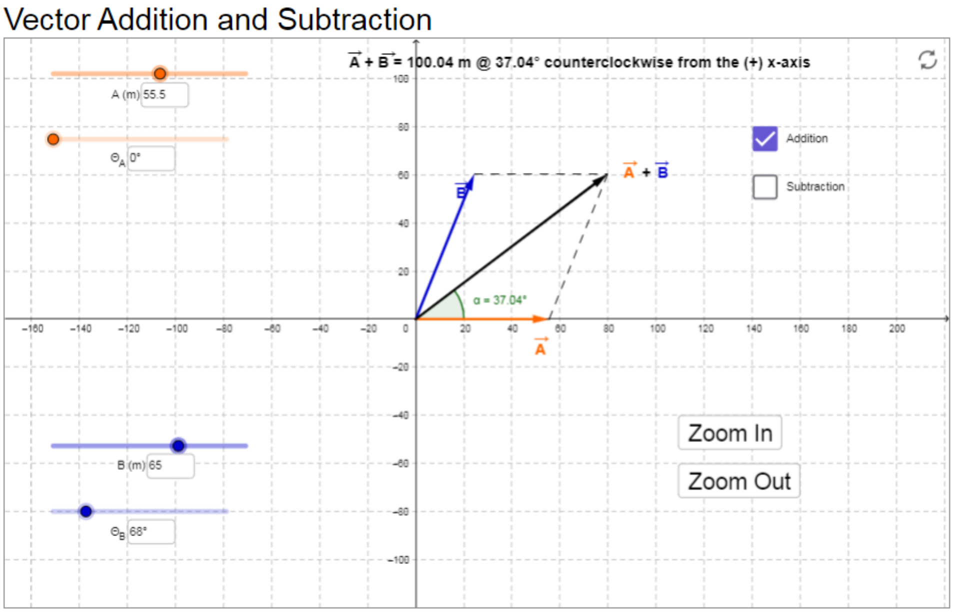

Fig. 4. **Computer simulation of physical phenomena and laws**

Results and discussion

In order to make a thorough and comprehensive research of the students' achievements, it is necessary to test their knowledge at all possible stages of learning. For this purpose, a pedagogical experiment was conducted in which 239 applicants from the higher education institution "Podolsk State University", specialty 208 "Agroengineering", took part. To identify the level of fundamental knowledge, formed interest in learning, in general, and to identify interest in the discipline "Physics", the acquired knowledge, the level of the formed intellectual skills, changes in the level of established professional competence at the beginning and end of the experiment, we carried out sections of professional knowledge and identified the level of success of the discipline "Physics" (Table 1).

Table 1

Levels of performance in the discipline "Physics" before and after the experiment

Groups	Success% before the experiment				Success% after the experiment			
	Initial	Medium	Sufficient	High	Initial	Medium	Sufficient	High
Experimental	22.4	69.4	7.1	1.1	17.24	61.52	13.79	7.45
Control (Reference)	55.17	37.93	6.9	0	53.17	37.3	8.33	1.2

As the analysis of success showed, the success rate of the students in the experimental group increased to a sufficient level of 6.8%, and a high level of 6.35%.

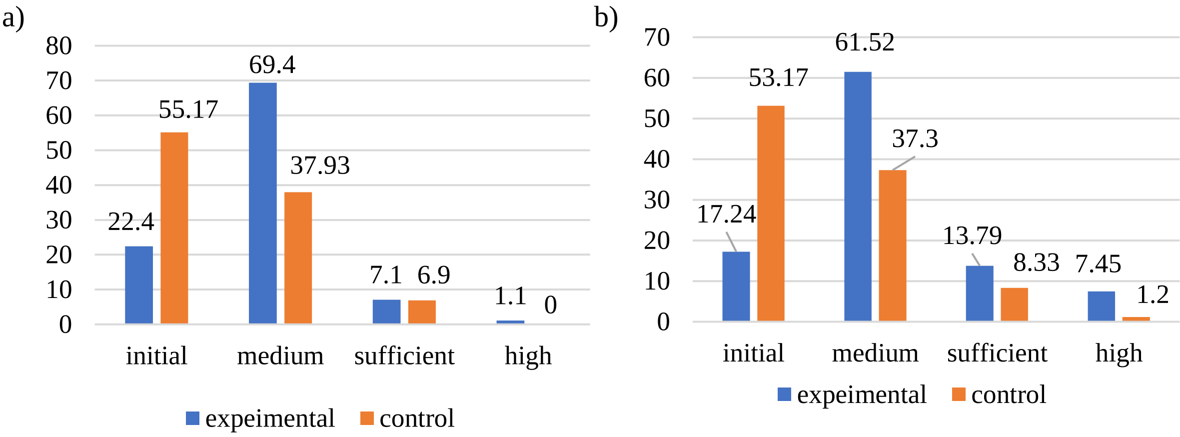

Fig. 6. **Analysis of student performance:** a – before the experiment, b – after the experiment

Thus, the results of the pedagogical experiment confirmed that theoretical learning should be accompanied by the need for the students to implement the acquired knowledge in practice, which is connected with the development of new dynamic stereotypes. By arousing interest in knowledge, the teacher thereby gives a psychological impulse to strengthen professional interest. The professionalization of education is associated with deep intellectual and emotional experiences of the students, which are caused by changes that arise and occur in the process of educational and production activities.

The methodology, proposed by the authors of the article, includes introduction of examples of a professional nature into the process of theoretical training of the physics course, and it differs from the existing approaches in the following peculiarities:

- this methodology is aimed at developing professional competencies of the students already at the stage of studying physics. This means that the students receive not only basic knowledge in the field of physics but also related skills and abilities that can be applied when studying special disciplines;
- introduction of examples of a professional nature makes learning more applied and allows the students to better understand what specific skills and knowledge will be useful to them in their future professional activities;
- examples of a professional nature, as well as the use of computer simulation of the considered physical phenomena and laws, help the students better understand the context in which theoretical knowledge of physics is applied in the field of agriculture. This helps them better acquire the material and see its practical significance;
- this technique not only promotes knowledge acquisition but also actively develops professionally significant qualities in the students, such as analytical thinking, problem thinking, communication skills and the ability to work in a team.

On the whole, this new methodology is an innovative approach to teaching physics, which not only improves the quality of learning the material, helps mastering special disciplines, but also trains the students for professional activities in the agricultural and technical industry.

Conclusions

1. The developed methodology for the introduction of professional orientation in teaching physics by introducing examples of a professional nature into teaching in the process of theoretical teaching of a physics course improves the quality of knowledge and efficiently contributes to the formation and development of professionally significant qualities.
2. Introduction of professional examples into the theoretical preparation process of a physics course is an innovative and practical approach that significantly enriches the student learning experience and prepares them for real-life professional applications.
3. Based on the experiment, it was established that the introduction of a methodology for implementing professional orientation in a theoretical physics course increases academic performance at a sufficient level by 6.8%, and at a high level by 6.35%. These changes affect the level of training specialists, their ability to solve complex tasks in their field.

Author contributions

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

References

[1] Bulgakova O., Zbaravska L., Dukulis I., Rucins A. Content of professionally oriented training in course of physics for students of agricultural engineering specialties. Engineering for Rural Development. Vol. 22, 2023, pp. 661-666.

[2] Bulgakova O., Zbaravska L., Slobodian S., Dukulis I. Formation of information-communication competence of future agricultural engineering specialists at agricultural institutions of higher education. Engineering for Rural Development. Vol. 22, 2023, pp. 691-699.

[3] Burdeina N.B. The use of professionally oriented qualitative problems and questions from physics in higher construction educational institutions Scientific notes. Ed. coll.: V.F. Cherkasov, V.V. Radul, N.S. Savchenko and others. Issue 169. Series: Pedagogical Sciences. Kropyvnytskyi: RVV Central State University named after V. Vinnichenko, 2018. 242 p. (In Ukrainian).

[4] Shadrykov V. D. Activities and abilities. M.: Logos, 2004. 315 p. (In Ukrainian).

[5] Shut M. I., Sergienko V. P. Research work on physics in secondary and higher educational institutions: teaching manual. K. School World, 2004. 128 p. (In Ukrainian).

[6] Strogonova T. V., Stuchynska N. B. Analysis of modern problems of biophysics teaching methods. Science notes of the BSPU. Ser. Pedagogical sciences. 2020. Issue 1. pp. 95-103. DOI: 10.31494/2412-9208-2020-1-1-95-103. (In Ukrainian).

[7] Zbaravska L. The study of physics in the field of agrarian-technical primary education is important as the main source of effective readiness for professional activity of future agricultural engineers. Science of the XXI century: blogs and perspectives: collective monograph. Ternopil: Osadtsa, 2021. T. 1. pp. 188-200. (In Ukrainian).

[8] Bulgakov V., Adamchuk V., Ivanovs S., Ihnatiev Y. Theoretical investigation of aggregation of top removal machine frontally mounted on wheeled tractor. Engineering for Rural Development, 16, 2017. pp. 273-280.

[9] Bulgakov V., Adamchuk V., Nozdrovický L., Ihnatiev Y. Theory of Vibrations of Sugar Beet Leaf Harvester Front-Mounted on Universal Tractor. Acta Technologica Agriculturae, 20(4), 2017. pp. 96-103.

[10] Blömeke S., Busse A., Kaiser G., König J. [et al]. The relation between content-specific and general teacher knowledge and skills. Teaching and Teacher Education, 56, 2016, pp. 35-46.

[11] Erinosho S. Y. How do students perceive the difficulty of physics in secondary school? An Exploratory Study in Nigeria, Int. J. Cross-Disciplinary Subj. Educ., Vol. 3, 2013, pp. 1510-1515.

[12] Kaiser G., Konig J. Competence measurement in (mathematics) teacher education and beyond: Implications for policy. Higher Education Policy, 32(4), 2019, pp. 597-615.

[13] Kuswanto K. Where is the direction of physics education? Jurnal Pijar Mipa, 15(1), 2020, pp. 59-64. https://doi.org/10.29303/jpm.v15i1.1226.

[14] Seidel T., Stürmer K. Modeling and measuring the structure of professional vision in preservice teachers. American Educational Research Journal, 51(4), 2014, pp. 739-771.

[15] Sherin M. G., Jacobs V. R., Philipp R. A. Mathematics teacher noticing: Seeing through teachers' eyes. New York: Routledge, 2011. 280 p.

[16] Sherin M. G. The development of teachers' professional vision in video clubs. In R. Goldman, R. Pea, B. Barron, S. J. Denny (Eds.), Video research in the learning sciences. Erlbaum. 2007, pp. 383-395.

[17] Stürmer K., Seidel T., Holzberge, D. Intra-individual differences in developing professional vision: Preservice teachers' changes in the course of an innovative teacher education program. Instructional Science, 44(3), 2016, pp. 293-309.

[18] Jenssen L., Dunekacke S., Eid M., Szczesny M. [et al]. From teacher education to practice: Development of early childhood teachers knowledge and beliefs in mathematics. Teaching and Teacher Education, 114, 2022. https://doi.org/10.1016/j.tate.2022.103699.

[19] Nikolaenko S., Ivanyshyn V., Bulgakova O., Zbaravska L. [et al]. Programming of pedagogical technology for formation of professional competence when studying natural and general technical disciplines. Engineering for Rural Development. Vol. 21, 2022, pp. 623-630.

[20] Bulgakov V., Nikolaenko S., Holovach I., Boris A., Kiurchev S., Ihnatiev Y., Olt J. Theory of motion of grain mixture particle in the process of aspiration separation. Agronomy Research, 18(Special Issue 2), 2020. pp. 1177-1188.

[21] Bulgakov V., Sevostianov I., Kaletnik G., Babyn I., Svanovs S., Holovach I., Ihnatiev, Y. Theoretical Studies of the Vibration Process of the Dryer for Waste of Food. Rural Sustainability Research, 44(339), 2020. pp. 32-45.