FORMATION OF SELF-EDUCATIONAL COMPETENCE OF FUTURE ENGINEERS AS CONTEMPORARY PEDAGOGICAL PROBLEM

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Abstract. A new type of agricultural and technical sphere puts forward new requirements for the graduates of higher educational institutions. The main requirements for the graduates, among which systematically organized, intellectual, communicative, reflective, self-organizing specialists, allowing successful organization in social and cultural contexts, receive increasing priority. The proposed study presents a theoretical generalization and practical solution to a pressing problem, which consists in substantiation and experimental testing of a model for the formation of self-educational competence of the future engineers, based on the implemented organizational and pedagogical conditions. Based on well-founded organizational and pedagogical conditions, a structural-functional model and a set of didactic tools were developed, which made it possible to improve the methodology for increasing the self-educational competence in terms of its professional orientation. The work uses theoretical research methods: a study and analysis of psychological, pedagogical, normative and special literature on the research problem; an analysis of the state educational standards, programs, teaching aids and teaching materials. It has been proved that the formation of self-educational competence consists in the ability and readiness of an individual to carry out efficient independent cognitive creative activity, based on mastering flexible knowledge, generalized skills.

Key words: physics, self-educational competence, professional orientation, methodological model, engineer.

Introduction

Education is the key element in the development of society, and crisis situations, such as a pandemic or war, seriously impact the educational system and learning opportunities. In recent years, in Ukraine, first, due to the COVID-19 pandemic, now due to the war with the Russian Federation, quality education requires common efforts and understanding of the importance of education as the basis for sustainable development of society. In education, which is based mainly on learning, in this situation, the emphasis shifts to education, which is based on self-education. And under such conditions the development of the students' abilities to learn and motivated self-education become of particular importance. It is also important to consider that self-education can be not only a response to the challenges of society but also a person's internal need to develop, to improve and satisfy the desire for knowledge and self-realization. Thus, self-education is an important component of the educational process, helping create an educated, adaptive and highly skilled society.

All that was said above makes it possible to conclude that the need for self-education is determined by the needs of society and the individual himself. Thus, under contemporary conditions that have developed in the higher education system of Ukraine, the problem of forming self-educational competence of the students is extremely topical. Its solution will help improve the quality of training of the future specialists and increase their competitiveness. The identified contradictions and problems determined the **topicality** of our research.

According to the statements of Yu. Prishupa [1], self-educational competence is the ability and readiness of the subject to perform efficient self-cognitive creative activity, based on the mastery of flexible knowledge, generalized skills and abilities. Self-efficiency is of great importance for successful academic performance [2]. Many studies have also demonstrated that students' professional training is positively influenced by application of active learning methods [3-6], and self-education is the key to promoting to take control of one's own learning [7; 8].

In the structure of self-educational competence R. Perkaty identifies 4 components: motivational (characterizes the attitude of future specialists to professional activities), cognitive (involves mastering knowledge of self-education, as well as readiness for continuous self-education), operational (characterizes mastering the skills of organizing and managing self-education, applying the results of self-education in situations close to professional activity), reflective (includes assessment and self-assessment of students' efficiency at all stages of the self-education process) [9]. The authors of [4; 10] argue that it is difficult for the students to regulate their learning, and that self-education cannot be

spontaneously acquired. However, there are works that suggest that self-education can be helped by various programs that provide opportunities to control one's own learning and teaching [11-13].

At the same time, it was revealed that the formation of the self-educational competence among the future engineers requires more research and attention in the scientific community. Equipping the engineers with self-directed learning skills is the key aspect of their success in today's fast changing agricultural environment. We share the position of the scientists who define self-education as a purposeful process of independent mastery of a holistic system of knowledge and skills, views and beliefs, progressive experience in a certain field of activity under the influence of personal and public interests. But the insufficient development of the theoretical foundations for the formation of the self-education competence among the future engineers, which negatively affects the qualitative characteristics of their professional training, determined the purpose of our research. At the same time, the most efficient way to increase the competence of the future agricultural engineers during self-education is to use independent (with minimal consultation by the teacher) study of a scientific article, for example, V. Bulgakov [14], in which the theoretical foundations are set out methodically correctly and consistently with the completeness, required for understanding.

Materials and methods

To achieve the raised goals of the research, the following methods were applied: theoretical (comparative analysis of the scientific, methodological and pedagogical literature) and empirical (observation, analysis, survey of respondents, generalization and simulation of the research results, generalization of pedagogical learning experience). To select and understand the results of the experiment, a survey of teachers and applicants for higher education was conducted in order to determine the level of formation of the self-educational competence of engineers during professional training.

A student who has a set of methods and techniques for working with the information sources and is able to implement them directly in self-educational activities can efficiently perform self-education and, accordingly, develop self-educational competence. The main indicator of a specialist's self-educational competence is his ability to set goals, find ways and means to achieve them by organizing productive self-educational activities: self-education and self-actualization.

The main ways, the implementation of which will contribute to efficient training of the future engineers, should be identified as follows:

- building an educational process, based on a competency-based approach;
- strengthening the professional orientation of training the applicants for higher education on the basis of professionally oriented simulation of the subject content of the future professional activity [15].

Teaching students to engage in self-education is important because it promotes their independent development and successful learning. Here are some strategies that we use to teach students to develop self-learning skills:

- focus on the development of critical thinking and analytical skills;
- application of interactive teaching methods to stimulate independent learning;
- providing access to modern information resources;
- use of open platforms and open software.

It is proposed to ensure a focus on the development of self-education of engineering students using a specific methodology. Here are some areas that have been used for this purpose.

Problematic physical problems of agroengineering may include various aspects of the interaction of physical processes in agriculture and the development of new technical solutions.

1. Determine the optimal technical parameters for the operation of agricultural machinery on different types of soil.

Assignment: Develop a model of the mechanical properties of different soils and study the effects of moisture and structure on resistance to movement.

Problem 1: Design a system for optimal distribution of thermal energy in the soil to support the plant growth in greenhouses.

Assignment: Study the laws of heat transfer in the soil and develop technologies to optimize the temperature conditions.

Problem 2: Optimize the location and design of the greenhouse lamps to maximize solar light.

Assignment: Study the physical laws of light distribution and use them to improve the efficiency of photosynthesis.

These tasks can help solve practical problems in the field of agricultural engineering and contribute to the introduction of new technologies in agriculture, as well as improve the self-educational competence of the future engineers.

2. Encourage the students to explore real and complex problems that require critical analysis.

Agriculture faces various physical and complex challenges that require respectful critical analysis and the development of innovative approaches. Some of these problems include:

Example: Overexploitation of land, climate change and poor agricultural practices often lead to soil erosion, which reduces soil fertility.

Critical analysis: Assessment of the land conservation methods, introduction of the land reduction technologies, introduction of vegetation to strengthen the land.

3. Group work and discussion.

In classes we organize group discussions for joint problem solving and problem analysis. At the same time, we do not forget to stimulate interaction and exchange of opinions among the students.

4. Using case methods.

The case method in physics teaching is a form of teaching in which the students are provided with real or fictitious scenarios that describe situations which require the use of physical principles to analyse and solve a problem. This method actively involves students in the learning process, helps develop critical thinking and the application of theoretical knowledge to real situations. Here are some examples of the case methods in physics:

Case: Irrigation optimization of agricultural crops.

Scenario: A farm has a field of crops, exposed to various climatic conditions. The farmer is faced with the problem of inefficient use of water during irrigation. He needs to optimize the irrigation system, taking into account factors, such as the soil type, climatic conditions and the needs of various crops.

Tasks for the students:

- Using the principles of fluid dynamics and thermodynamics, determine the optimal parameters of an irrigation system to minimize the water loss and maximize efficiency.
- Consider the influence of the soil type and climatic conditions upon the distribution of moisture in the soil.
- Explore the technologies of precision agriculture and automated irrigation systems that can be used to optimize the process.

When using the case method, we also select discussion questions on the topic:

- What physical principles can be used to optimize an irrigation system?
- What technologies and tools can help collect data on the soil moisture and adapt irrigation to the specific needs of crops?
- How can the climate changes be taken into account and water requirements for the crops predicted?

This case allows the students to apply physics concepts to a specific agricultural problem, work out solutions, based on theory, and evaluate the efficiency and sustainability of the proposed options. This approach not only deepens understanding of the physical principles but also develops the students' practical skills in the context of their future professional activities.

5. Projects and research.

Involve the students in the projects that require development and implementation of new ideas. Promote research where the students can apply their analytical skills.

Example: Create a lighting system that is as efficient as possible for photosynthesis.

Research: Using the physical principles of the light transmission and light absorption by plants, analysis of the effects of different light spectra.

These projects present examples of how the physical principles may be applied to agriculture in order to improve the efficiency, sustainability and environmental safety of the process.

6. Critical analysis of literature.

The task of critical analysis of scientific articles and publications develops an ability to critically perceive information. Encourage the students to express their points of view, based on evidence.

7. The use of technology.

Usage of a technology to analyze data and solve engineering problems and specialized software for simulation and problem solving.

Contemporary trends in the development of software allow the teachers to independently implement their ideas and plans for educational purposes, to create sufficiently high-quality products. This applies not only to the simplest types of static symbolic information when some content is created from electronic texts, drawings or photographs, using the editor programs that have already become part of everyday life but also to rapidly developing means for non-professionals to create almost professional products, from the simplest types of the multimedia content to complex analysis of the physical processes. As an example, such programs that allow to do complex physical analysis include: COMSOL Multiphysics, MATLAB, Ansys Fluent, SolidWorks Simulation and others (Fig. 1).

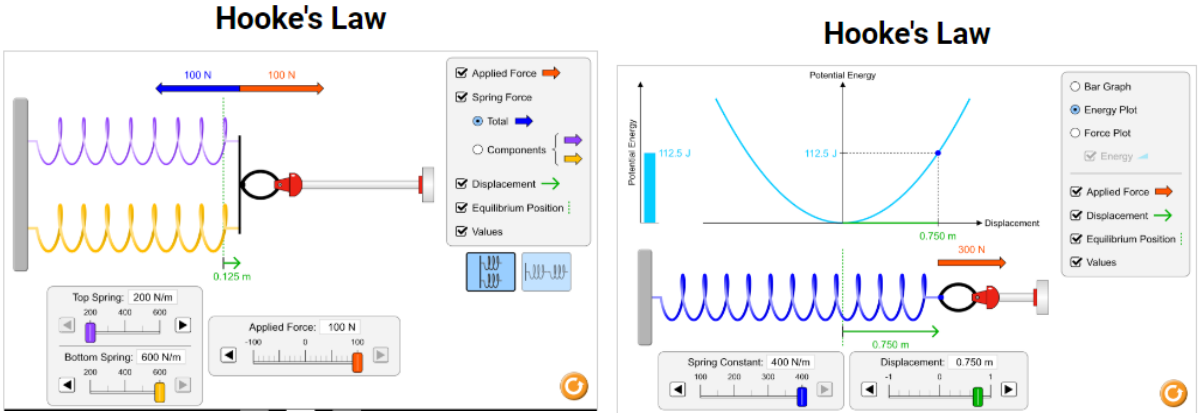

Fig. 1. **Use of specialized programs for simulation and solution of physical tasks**

8. Testing and simulation.

Use tests and simulations to test the students' analytical and decision skills.

Encourage them to draw conclusions and change strategies when testing.

Encourage them to develop a desire to improve their skills throughout their career.

These strategies can be integrated into educational programs and the methodological framework for active development of critical thinking and analytical skills of the engineering students, which will not only increase self-educational competence, but also contribute to the development of professional competence.

To test the efficiency of the methodology for the implementation of pedagogical conditions and the main components for the formation of the self-educational competence of the future engineers, a pedagogical experiment was conducted with the participation of higher education applicants (126 students) for the educational degree "Bachelor" at the higher educational institution "Podillia state university", studying in specialty 208 "Agroengineering".

Based on the results of initial diagnostic testing, it turned out that the problem of organizing systematic self-educational training of the future engineers exists and has not been solved up to the present day. The main reason for this is that there is a contradiction between the requirements of the time and the actual practice of self-educational training of the higher education applicants in higher

educational institutions, mainly aimed at reproductive activity and forms a "specialist performer" within the framework of a general information and explanatory approach to training. As a result, the graduates have formal and fragmented knowledge of professional training.

As part of the study, the state of self-educational competence in the qualifications of engineers was analysed. During the experiment the knowledge and skills of the self-educational competence were tested as components of the professional activity environment, in particular: the focus; the need for self-education and creative self-expression; professional value orientations, professional attitude and self-attitude; consideration of values as a means of realization of self-motivation; the ability to plan one's activities; the ability to create conditions for successful performance of activities; the ability to navigate information flows; the ability to self-control one's own self-educational activities. A survey of higher education applicants led to the conclusion that a significant part of the contingent of applicants has self-educational competence on the verge of average and low levels, which has an extremely negative impact on their professional training.

The efficiency and quality of implementation of the methodology for the formation of the self-educational competence depend on the awareness of all participants in the educational process in higher educational institutions, including the applicants, of the importance and need to improve personal and professional qualities, on the targeted content of the educational process, and the activities of the scientific and pedagogical staff in implementing these events. We wanted to determine this in the process of conducting a pedagogical experiment. For this purpose, the experimental (E) and control (reference) (CR) groups were formed, in which the process of formation of the self-educational competence of the future engineers in the process of professional training was studied. In each group 63 participants in the educational process took part.

Thus, in the experimental group four organizational and pedagogical conditions were implemented in the process of professional training, namely:

1. development of motivational and value orientations of the applicants for self-education and self-improvement: introduction of a set of problematic tasks, projects and research, using professional orientation of training;
2. use of group work, case methods and their discussion for joint problem solving and problem analysis for the future engineers;
3. activation of the educational and cognitive activity of the applicants, using problem-based learning technologies and ICT tools: creating problem situations, conversations, surveys, brainstorming, dramatization, the round table;
4. use of various forms of self-education, and self-education of the future engineers in the process of classroom and extracurricular work: self-observation, auto-training, discourses, project method, presentations.

The pedagogical process in the control (reference) group proceeded without implementation of the identified organizational and pedagogical conditions.

The purpose of the experiment was to test (refute or confirm) the hypothesis that the formation of the self-educational competence of the future engineers will increase if mastery of the general education disciplines (using the example of physics) is carried out using organizational and pedagogical conditions, and purposefully and consistently develops students' abilities for self-educational activities in the process of professional training.

Results and discussion

At the beginning and the end of the experiment, we carried out level differentiation of the studied groups according to the levels of formation of the self-educational competence.

It is noteworthy that by the end of the experiment the number of students in the experimental group with a sufficient and high level of self-educational competence had increased: the increase was 5.4% (at a sufficient level) and 10.83% (at a high level), respectively (Fig. 2).

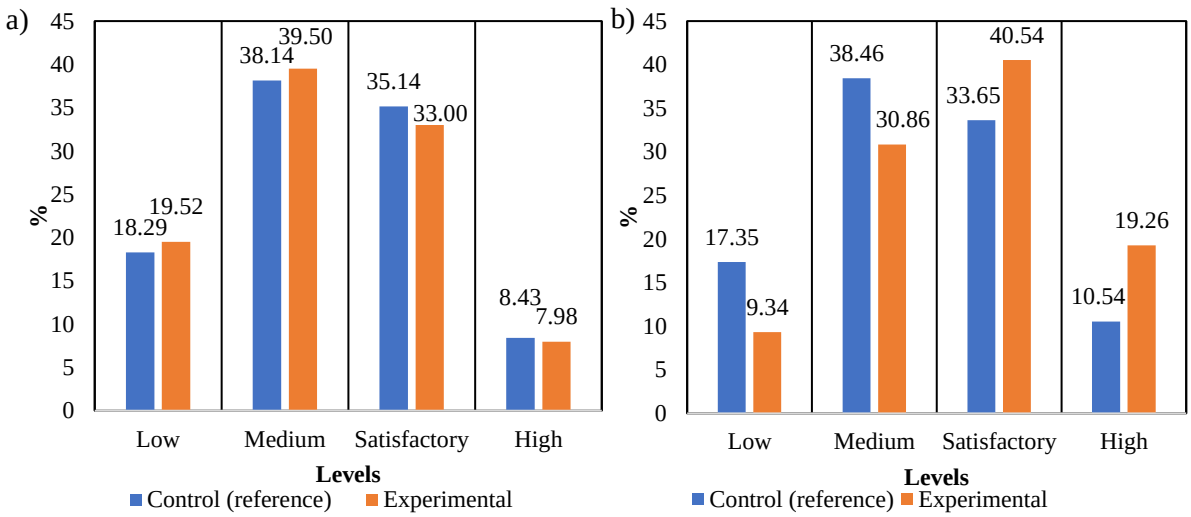

Fig. 2. **Diagram of the levels of the self-educational competence formation of students in the experimental and control (reference) groups**: a – beginning; b – end of the experiment

Based on the results of observations, the self-educational competence of the students under the organizational and pedagogical conditions in the classroom has significantly increased, and the organization of productive independent work of the participants in the educational process has also improved.

This investigation examined the relationship between the self-educational competence of the engineers and the achievement of the professional knowledge and skills. First, our main conclusion was that the use of the proposed methodology for increasing the self-educational competence is very important for the development of professional knowledge and skills. This finding is consistent with several previous studies [16-18].

Our proposed methodology of developing self-education for the engineering students differs from the existing approaches by the following peculiarities:

1. it focuses on the use of specific examples and cases from the engineering practice. This allows the students to directly connect the course material to real-life situations that they will encounter in their professional lives, which increases their motivation and understanding of the material;
2. it is focused on the development of practical skills and abilities of students. The use of this technique helps the students not only learn theory but also develop the ability to apply the acquired knowledge in practice;
3. it involves an individualized approach to learning taking into account the interests, needs and level of training of each student. Professional examples can be adapted to different levels of difficulty and aimed at meeting the individual needs of the students.

These approaches can be introduced into the curricula and methodological frameworks in order to stimulate the active development of critical thinking and analytical abilities of the future engineers. This not only helps improve students' self-educational readiness but also helps expand their professional skills and knowledge.

Conclusions

1. Consequently, the experiment confirmed the correctness of our conceptual provisions that, when using the developed methodology, certain and justified pedagogical conditions, the efficiency of the formation of self-educational competence of future engineers in the process of general training increases.
2. It has been proved that application of the proposed methodology significantly increased the number of students with sufficient and high levels of self-educational competence: the increase was 5.4% (at a sufficient level) and 10.83% (at a high level), respectively. These results also show the importance of self-education for the development of professional competencies for the students of agricultural and technical higher education institutions.

3. Thus, integration of justified pedagogical conditions of the proposed methodology into educational programs and methodological framework will help students not only develop greater independence in learning but also acquire a wide range of skills, including critical thinking, analytical thinking, communication skills and creative problem solving.

Author contributions

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

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