

Modern Approaches and Factors, Contributing to the Formation of Professional Competence of an Agricultural Engineer in the Sphere of Life Safety

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Abstract — The article highlights modern approaches and key factors influencing the formation of professional competence of agricultural engineers in the field of life safety. In the context of rapid technological development, digitalization of agricultural production and increased requirements for safe operation of agricultural machinery, the training of specialists requires a comprehensive and multi-level approach. It includes a combination of theoretical training, practical training, digital technologies and active learning methods, aimed at the development of the competencies, required to work in the field of safety. It has been shown that the use of interactive and problem-oriented teaching methods, such as the case-stage method, the discussion method, heuristic questions and paraphrases, semantic echo, mirror and others, integrated into lectures and practical classes in discipline "Life Safety", contributes to a deeper assimilation of the theoretical material. These methods ensure not only the transfer of knowledge but also the development of analytical thinking, the ability to predict risks, make decisions in non-standard situations and work in a team, which is an important component of the professional training of agricultural engineers. There have been identified the key factors, influencing the training efficiency of specialists in this field, including: motivation of the students, based on the awareness of the importance of safety in professional activities; availability of modern

educational resources; the level of qualification of the teaching staff, including the knowledge of innovative educational technologies and practical experience in the field of safety; interaction with employers and specialized organizations, facilitating the implementation of students' project activities and industrial practices in real conditions. Within the framework of the study there is assessed the efficiency of modern approaches to the development of professional competence in the field of life safety. The results showed that the introduction of active learning methods and digital tools increases the assimilation level of the material by 35-40%, increases the students' motivation by 50%, and helps improve the practical skills to predict and prevent risks by 30-45%, compared to the traditional teaching methods. A conclusion is made about the need to create an adaptive educational system that will ensure the formation of sustainable professional competencies of agricultural engineers in the field of life safety. This system should take into account the contemporary challenges, the labour market requirements and ensure the training of specialists capable of risk analysis, making informed decisions and implementing innovative solutions in the field of agricultural engineering.

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I. INTRODUCTION

The modern agricultural sector faces numerous challenges, in particular the need to ensure a high level of life safety in the production processes. The growing demands for efficiency, environmental friendliness and safety of agricultural technologies require specialists not only to have deep technical knowledge but also the ability to integrate it into complex safety management systems.

The development of professional competence of an engineer in the field of life safety is becoming the key task in the training of highly qualified specialists, capable of working in conditions of global changes and increased risks. The importance of integrating modern technologies, an interdisciplinary approach, active learning and development of systems thinking to solve these problems determines the need to improve the teaching methods.

However, in contemporary conditions when, with the development of technology and the growing number of dangers, the people do not have time to counteract them, with the growth of the cost of the error, with the adaptation of man to danger and violations of the safety requirements, it becomes necessary to form in the graduates of higher educational institutions the requirements for human safety and security. It is the implementation of these requirements that guarantees the preservation of working capacity and health as a high value. Therefore, these requirements must be taken into account when training the graduates for safe actions in the production conditions. For the graduates from the agricultural sector the safety issues are especially relevant due to the high rate of industrial injuries in this sector of economy. The graduates from the higher education institutions with training in engineering are not prepared for professional activities from the safety standpoint. In addition, the lack of a developed need for safety and a propensity to take risks become the conductors of industry-related injuries for them.

The importance of these skills in the modern society has become obvious, which is why it is necessary in the system of higher agricultural education to develop in the students readiness to adequately assess the production situations and timely design safe actions, determined through professional competence in ensuring life safety. This is what determined the topicality of our research.

In the field of professional education there is a tendency towards a transition to the formation of professional competence. Investigations by Woods, D., Carrillo, H., Pingali M., Roberts P., Jovanović, J., Leveson, N., Skjold, T., Tamascelli, N. and others show that in the context of education modernization, professional competence has become the main goal of the educational process in the vocational education institutions.

Several researchers are working to improve the process of teaching safety in universities by studying the development of curricula and teaching methods [1; 2], evaluating the existing process of safety training [3; 7; 8; 12], and discussing the future challenges for safety process training since the agro-industrial complex changes with the introduction of new technologies [4; 5; 9].

In particular, J. Raven interprets competence as an ability, necessary for the successful completion of specific tasks in a particular area, which includes specialized knowledge, professional skills, a certain way of thinking and awareness of the responsibility for one's own actions [10]. Patriarca, R., et al. study the concept and practice of an integrated approach to the analysis and prevention of emergency situations in various industries [11]. It is assumed that the development of professional orientation depends on the development of basic cognitive and effective-motivational inclinations, such as professional knowledge and beliefs [6, 13]. Tamascelli, N. et al. consider the meta-learning approach as a learning tool, based on the analysis of major accidents [14]. The authors examine how organizations can systematically collect and integrate data from the past accident events to gain valuable insights into the improvement of the safety management.

Despite the extensive analysis of this problem in the scientific and methodological works, there are often no specific recommendations for its solution. This underlines the need to develop methodological materials that detail the system of the teaching methods and tools within a particular discipline. The machine and labour safety is formed at the design stage and in the study of their operational characteristics. Therefore, to form the educational materials of the discipline, it is advisable to use modern technical solutions and research in the industry where the future specialist will work [15-17]. Such materials should contribute to the development of professional qualities of the students and efficiently solve the existing problems. The development of such practical recommendations is the key stage in the process of improving the educational process. Therefore, the aim of the study is to develop and substantiate modern approaches, methods and conditions that contribute to the formation of professional competence of engineers in the field of life safety. Achieving this goal will allow one to create a comprehensive system for training engineers that meets modern challenges and ensures a high level of professional competence in the field of life safety.

The following research methods were applied in the work: digital analysis of literature, regulatory documents using specialized academic databases, empirical methods, including online surveys, virtual interviews and automated observation using educational analytics; experimental methods based on digital pedagogical experiments and testing; statistical methods based on data analysis and machine learning algorithms, as well as practice-oriented approaches using simulation and modelling educational platforms. This comprehensive approach ensured the

reliability and practical significance of the obtained results.

II. MATERIALS AND METHODS

In contemporary conditions, when technology is developing and the number of dangerous cases is growing, the people do not manage to counteract them. With the growing cost of the error, with the adaptation of the people to dangerous instances and violations of the safety requirements, it becomes necessary to develop in the graduates of higher education institutions an understanding of inseparable unity of efficient professional activity with the requirements for human safety and security. It is the implementation of these requirements that guarantees the preservation of the working capacity and health as the highest value. Therefore, these requirements should be taken into account when preparing the university graduates for safe actions under the production conditions. For the graduates of agricultural universities, the safety issues are especially relevant due to the high rate of industrial injuries in this sector of economics. The graduates of higher education institutions with a training in engineering are not prepared for professional activities from a safety standpoint. In addition, the lack of a developed need for safety and a propensity to take risks becomes a conductor of industrial injuries.

Taking into account the existing social prerequisites for the formation of professional competence in ensuring life safety, manifested in the state policy, an increase in the level of industrial injuries, an expansion of the range of hazards and determination of the society's social order, factors were identified that hinder the formation of professional competence in ensuring life safety. Among them are adaptability and disregard for dangers, which are manifested in a tendency to take risks and violation of the motivational foundations of activity. Low level of proficiency in the theoretical foundations of safety, which manifests itself in the implementation of industrial risks, insufficient development of the life safety skills, manifested in inability to apply the knowledge depending on the need of a situation and, as a consequence, violation of the orientation-activity foundations of safety. Accordingly, the essence of the concept of professional competence in ensuring life safety, its structure was determined in the form of a motivational component (motives, needs, values), a cognitive component (knowledge), an activity component (skills, possessions, abilities) and a personal component (professionally important qualities) [12]. The listed components of professional competence in ensuring life safety were characterized by indicators of formation by levels. A distinctive feature of the formation of professional competence in ensuring life safety is the mandatory presence of its component integrity, in the form of an integral indicator – “safe behaviour strategy” (Table 1).

TABLE 1 COMPONENTS, INDICATORS AND METHODS FOR THE DEVELOPMENT OF PROFESSIONAL COMPETENCE IN ENSURING LIFE SAFETY

Component	Indicators	Diagnostic tools
Motivational	Awareness of the priority of ensuring safety when performing various types of activities; propensity to take risks; formation of the educational and cognitive component	Methodology for assessing the “hierarchy of personal needs” according to A. Maslow; method for assessing the “degree of readiness for risk” by A.M. Schubert; method for assessing educational motivation (A.A. Rean, V.A. Yakunin).
Cognitive	Knowledge of the basics of safe existence in a dangerous world; professional safety orientation in the context of the profession; ability to analyze from a safety perspective	Test of Intelligence Structure (TSI) by T. Amthauer; testing (achievement tests); method of diagnostic situations.
Activity-based	Ability to identify the safety of working conditions; knowledge of safe action methods; ability to predict from a safety perspective	Assessment method "ability to predict" (L.A. Regush); testing (achievement tests); Method of diagnostic work (case assignments, essays, presentations)
Personal	Readiness to apply solutions in problematic situations in the presence of a threat to life and health, manifested in professionally important qualities: initiative, persistence, determination	Methodology for assessing volitional personality traits (M.V. Chumakov); method for assessing mental activation, interest, emotional tone, tension, comfort (L.A. Kurgansky)

The course of lectures of the discipline was carried out using the following organizational forms: the dialogue method (lecture-conversation); the discussion method (lecture-discussion); the visualization method (lecture-visualization); the problematic presentation method (problematic lecture); the case method (lecture on the analysis of specific situations) [1].

A lecture – a discussion on the topics of “Legal bases of production” and “Organizational bases of safety at work”; a lecture – visualization on the topics of “Harmful substances in the air of the working area”, “Technical means of ensuring labour safety at work”, “Ensuring safety when exposed to noise, vibration, radiation in the production conditions”, “Fundamentals of ensuring electrical and fire safety”; a lecture in a problematic presentation on the topics of “Ensuring a comfortable microclimate of industrial premises”, “Industrial lighting”, “Sanitary and hygienic requirements for general plans,

industrial utility rooms of enterprises”; a lecture – for two on the topic of “Safety in the field of the agro-industrial complex”.

A program for the development of the professional competence in safety, in the form of a theoretical block of the discipline “Life Safety”, made it possible to form an indicator, determined by the totality of knowledge of the basics of safe existence in a world of dangers, and professionally safe orientation of the future professional activity. The ability to analyze was developed throughout the entire training period. In all forms of the theoretical training a case method was used with an analysis of particular security situations. Application of this method made it possible to develop the students’ analytical capabilities, the presence of which was confirmed as the formation of risks of targeted thinking. It is no coincidence that the cases are called a “snapshot of reality” (live situation). In research, the cases are used in a wide range from the printed versions – (situation – problem, situation-assessment), to multimedia – (situation – illustration).

This method took into account the levels of development of the security problems. At the same time, it is impossible to form a level of consciousness for training those who are capable to assess global problems from the position of the existing risk.

It is for this reason that the range of case assignments was gradually expanded. However, the transition was done from the level of security problems at the enterprise level – the micro level, due to the security problems of a regional nature – the meso level, to the level of global problems – macro level, if necessary, and mega level.

To develop risk-oriented thinking a discussion method was used as a method. Discussion as a method of an event is multifaceted. In the experiment it was purposefully used in the lecture classes or as a technique in other methods (in the second block in practical classes during the facilitation support of the educational process, as well as during brainstorming or in the game modeling). A characteristic feature of this method in the experiment was the comparison (dialogue – communication) or opposition (dialogue – dispute) of the positions of those discussing the security issues. That is why this method allowed one to obtain a whole range of results: as a visible result – this is the receipt and generation of new information. And also the taking particular decisions by the students, that is, diagnostics and correction of the problem from the position of safety – this is an increase in the motivation for one's own strengths, getting rid of egoistic thinking, stimulating creativity, the desire to get to the bottom of the truth.

However, a discussion is impossible without asking questions. For this reason, a correctly asked question allowed the audience, whether it was a lecture or practice, to come to some of their own conclusions, based on one’s conviction. during the course of study of “Life Safety”. In this case the term “correctness” implied timeliness since the moment of asking the question (namely, “giving”)

made it possible to guarantee successful activation of the audience. However, we did not forget that the untimeliness of the question could also cause an opposite reaction – misunderstanding and passivity. In order the questions asked had successful application, they were applied during the experiment in accordance with their classification possibilities. For example, in the experimental group, open-ended questions were used: “What might happen if at the production facility where you are the director...”? Next, in accordance with the topic being studied, a mini (micro) incident was described, and the student was asked to provide an explanation. If the goal was to consolidate some material, then it made sense to ask questions, to call for a deeper and more detailed answer, an analysis, including: “Explain to us how and why you will act if in your production...”. “How” implies the knowledge of the algorithm of action, and “why” – analysis of the situation. As a result, by reflecting, the student actively participates in the process of cognition.

The redirected questions allowed in the study of the dialogical form of communication to move to the polylogical one. To be or not to be in this discussion – this was solved in the experiment situationally, that is, the teacher decided how much of it was needed in the particular moment of learning. If a discussion was required, then it made sense to develop it; if there was no time or sense, then it was necessary to restrain the audience, that is, to control it. The redirection was effected through the form of a statement: “What do your classmates think about this”? If the goal was to direct the question not to the audience but to the student, then it had a slightly different form of address: “What is the opinion on this issue of...” the surname, name and patronymic of the participant in the audience is called.

The questions to establish the feedback allowed in this period of the experiment to track this link: “If I understand you correctly, you meant...”. Then essence of the substantive conversation was briefly outlined. In addition, the student is forced to go to the next method, that is, a question with a closed limb but also with the right to choose, since he must choose between “yes” or “no”.

The implementation of the selected didactic methods during the period of formation of the professional competence in ensuring the safety of life activities made it possible to form the degree of readiness for professional activity from the standpoint of safety. The student’s readiness is assessed through the indicator of the professional competence in ensuring life safety through the involvement of each of the components of the professional competence being formed. With a total implementation of all the above methods, the subject develops an independent strategy of behavior in any situation from the position of safety.

III. RESULTS AND DISCUSSION

In the research the process of conducting the experimental work on the formation of a professional

competence in ensuring life safety was made in the direction 208 “Agroengineering” of the institution of higher education “Podolsk State University”. The number of participants in the groups was: CG – 53 people; EG – 54 people. The aim of the experimental work was to test the efficiency of implementation of the developed methodology for the formation of the professional competence in safety in the process of professional training at the university.

In the research the indicator of the formation of the professional competence in ensuring the safety of life of an engineer is presented in the form of component integrity at the levels: executive, managerial, strategic.

The analysis of the development of the professional competence at the start of the experiment by components allowed one to draw the following conclusions:

- the knowledge that the students have in the context of security is fragmented and not deep enough;
- the motivational foundations that could compensate for the lack of knowledge are not developed to a sufficient level;
- the skills, knowledge and abilities that could guarantee safety in activities are poorly or partially developed;
- professionally important qualities appear episodically or are in an “embryonic” state.

The purpose of the next stage of the pedagogical experiment was to test the efficiency of the model for the development of the professional competence in ensuring life safety, taking into account a set of identified pedagogical conditions, correlated with the methods, forms and means. During the experimental work, a 90-hour course was implemented, conditionally divided into parts: theoretical, practical and independent work. The goal of each lesson was a complex development of the professional competence in ensuring life safety. Within the framework of the research there were used individual, group and collective forms of lectures and practical classes. The results of collective activity were assessed, based on a diagnostic work, which influenced the activity component of the competence. Accordingly, the students gained experience in the context of their profession but without industrial risks they mastered the methods of improving life safety.

At the control stage of the experimental work the efficiency of the proposed model for the formation of the professional competence in order to ensure life safety was assessed by the components and by the integral indicator. The summary data of the ascertaining and control stages of the research by components are presented in Table 2.

The data, presented in Table 3, show positive changes in the components of the professional competence in order to ensure life safety at stages of the experiment. In the control group the following changes occurred in the components: the motivational component changed by 5.0% (from 0.61 to 0.66); the cognitive component – by 4.0% (from 0.73 to 0.77); the activity component – by 5.0% (from 0.81 to 0.86), and the personal component – by 2.0% (from 0.62 to 0.64). In the experimental group more significant changes occurred: the motivational component increased by 20.0%, the cognitive component by 24.0%; the activity component by 22.0%, and the personal component by 19.0%.

TABLE 2 SUMMARY DATA BY THE LEVELS OF FORMATION OF THE COMPONENTS OF THE INTEGRAL INDICATOR OF THE PROFESSIONAL COMPETENCE IN ENSURING LIFE SAFETY

Components (levels) of the professional competence in security	Before the experiment		After the experiment	
	CG	EG	CG	EG
Motivational (unconscious, conscious, justified)	0.61	0.64	0.66	0.84
Cognitive (reproductive, productive, creative)	0.73	0.71	0.77	0.95
Activity-based (elementary, algorithmic, independent)	0.81	0.78	0.86	1.00
Personal (episodic, fragmentary, optimal)	0.62	0.63	0.64	0.82

The data, presented in Table 3, indicate that positive changes occurred in the control and the experimental groups. However, before the start of the experimental work the control and the experimental groups did not have reliable differences, and after the experimental work on the formation of the professional competence in order to ensure life safety, reliable differences were observed in all the indicators characterizing the motivational, cognitive, activity, and personal components.

IV. CONCLUSIONS

Thus the results of the experimental work indicate both quantitative and qualitative changes in the indicators of the formation of the professional competence in order to ensure life safety. It follows from this that these changes are due to the introduction of the formation model, which confirms the purpose of the investigation.

Efficient training of the engineers in the field of life safety requires the creation of an adaptive educational system that combines theoretical and practical training, digital technologies and active methods, such as the case methods, discussions and heuristic questions. These approaches promote in-depth acquisition of the material, development of critical thinking, the risk forecasting skills, and making justified decisions. Important factors are the students’ high motivation, availability of modern educational resources, qualified teachers who use innovative methods and have practical experience, as well as close interaction with employers and specialized organizations.

Comparison of the obtained results with the investigations by other authors confirms the tendency to increase the efficiency of professional training using digital educational technologies and interactive methods. In contrast to other studies our research focuses on professionally oriented teaching, taking into account the specifics of the engineering industry, which allows not only to develop general competencies but also to train specialists, capable of risk analysis and implementation of innovative solutions in real production conditions.

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