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INCREASING MOTIVATION TO STUDY MATHEMATICS AMONG FUTURE AGRICULTURAL ENGINEERS

AUMENTO DA MOTIVAÇÃO PARA ESTUDAR MATEMÁTICA ENTRE FUTUROS ENGENHEIROS AGRÍCOLAS

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ABSTRACT

Objective: The objective of this study is to explore pedagogical strategies aimed at increasing motivation to study mathematics among future agricultural engineers. The research focuses on enhancing the quality of mathematical education and preparing students for the technical disciplines integral to their engineering training.

Methods: The study was conducted at the State Agrarian University of the Northern Trans-Urals between 2018 and 2020. A contextual learning approach was used, involving 143 students across different engineering disciplines. The research was carried out in three stages, each designed to progressively build students' mathematical competence and integrate practical, applied learning experiences.

Results: The study demonstrated that the implementation of contextual learning significantly increased students' motivation to study mathematics. By the end of the third stage, students showed improved analytical, logical, and critical thinking skills, essential for their future professional activities. Additionally, the study revealed that students became more engaged and less anxious about learning mathematics when they understood its practical applications.

Conclusions: The findings suggest that contextual learning methods are effective in enhancing mathematical motivation and competence among future engineers. This approach not only bridges the gap between theoretical knowledge and practical application but also prepares students for the challenges of their future professions.

Keywords: Mathematics. Contextual learning. Technical disciplines. Research activities. Pedagogical conditions. Student.

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RESUMO

Objetivo: O objetivo deste estudo é explorar estratégias pedagógicas voltadas para o aumento da motivação para estudar matemática entre futuros engenheiros agrícolas. A pesquisa foca na melhoria da qualidade da educação matemática e na preparação dos estudantes para as disciplinas técnicas essenciais ao seu treinamento em engenharia.

Métodos: O estudo foi realizado na Universidade Estadual Agrária do Norte Trans-Uraliano entre 2018 e 2020. Foi utilizada uma abordagem de aprendizagem contextual, envolvendo 143 estudantes de diferentes disciplinas de engenharia. A pesquisa foi conduzida em três etapas, cada uma projetada para construir progressivamente a competência matemática dos alunos e integrar experiências de aprendizagem prática e aplicada.

Resultados: O estudo demonstrou que a implementação da aprendizagem contextual aumentou significativamente a motivação dos estudantes para estudar matemática. Ao final da terceira etapa, os alunos apresentaram melhorias nas habilidades de pensamento analítico, lógico e crítico, essenciais para suas futuras atividades profissionais. Além disso, o estudo revelou que os alunos se tornaram mais engajados e menos ansiosos em relação ao aprendizado da matemática quando entenderam suas aplicações práticas.

Conclusões: Os resultados sugerem que os métodos de aprendizagem contextual são eficazes para aumentar a motivação e a competência matemática entre futuros engenheiros. Essa abordagem não só preenche a lacuna entre o conhecimento teórico e a aplicação prática, mas também prepara os alunos para os desafios de suas futuras profissões.

Palavras-chave: Matemática. Aprendizagem contextual. Disciplinas técnicas. Atividades de pesquisa. Condições pedagógicas. Estudante.

1 INTRODUCTION

The year 2020 profoundly adjusted life in Russia and the rest of the world (Degtev et al., 2022). Many industries that had been successfully operating until 2020 (e.g., tourism sector, air travel, restaurant business), with the onset of the COVID-19 pandemic, has suffered significant damage but still showed the stability of development (Akhmetshin et al., 2024; Rybak et al., 2023). This fact indicates large reserves and prospects for agriculture (Nurgaliyeva et al., 2022). The course taken by the government of Russia towards the digitalization of the economy directly concerns the agro-industrial complex of Russia (Borodina et al., 2023). Therefore, agriculture needs competent specialists who have fresh knowledge to introduce science-intensive technologies into agricultural production (Vinogradova & Iakobiuk, 2020).

To increase the level of competence of a specialist, they must have internal motivation, which is the most significant factor determined by a number of external motivations (e.g., the degree of awareness and clarity of the object of motivation, the expected result,

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problematic nature, independence, attractiveness of the object, regularity, adequacy of performance appraisal) (Denisova et al., 2023; Togaibayeva et al., 2020; Vinogradova & Iakobiuk, 2020). The task of any university is to increase the competitiveness of its graduates in the labor market (Kenzhin et al., 2021). To achieve this goal, it is necessary to help graduates become competent in solving various problems of future professional activity. The competence of a modern specialist is formed due to many factors, including fundamental systemic knowledge (Bobkov et al., 2020). The basic fundamental sciences for future agricultural engineers include mathematical disciplines (Bodina & Telysheva, 2023).

The role of mathematics in the formation of the professional competencies of a future specialist is beyond doubt. Many researchers consider mathematics to be an essential way of developing human society. L. A. Yasyukova (2003) considers mathematics as a powerful tool for developing human thinking and is a school subject, thanks to which, in particular, abstract thinking develops. Mathematics had a significant impact on all spheres of the intellectual development of society, proving that it is a universal language of science and a perfect research method. These circumstances determine the central place of mathematics as an academic discipline in the education system.

The university community is concerned about the decline in the level of mathematical training of applicants, which complicates their education. V. I. Toktarova and S. N. Fedorova (2017) determined the following reasons that hinder the effective higher education: (1) lack of formation of the basic logical culture; (2) insufficient algebraic and geometric knowledge; (3) inability to analyze the conditions of the problem, search for ways to solve it, and apply standard algorithms in a changed situation; (4) inability to see and correct errors in one's reasoning and algebraic calculations and transformations.

A necessary component of mathematical training at a university is the formation of critical thinking. For the successful development of critical thinking, it is crucial to enrich the learning process with industrial and educational situations with a significant degree of uncertainty, forcing the student to think critically, and thereby, trigger the reflection and self-development since socio-economic and cultural transformations in Russia gave rise to new trends in the attitude of young people to their careers (Vinogradova, 2021b).

The pragmatism of the younger generation makes them not less pragmatic regarding science. Pure science is of interest only to gifted children, and the average student perceives only knowledge that can be applied in practice. Future engineers should be able to calculate changes related to the dynamics of the initial data, apply various knowledge of probabilistic and statistical dependencies, make a mathematical and statistical model of the expected situation (Vinogradova, 2021a); that is, they must have theoretical knowledge.

The main goal of studying at a university within the competence-based approach is to form and develop a set of necessary practice-oriented competencies, personal qualities, skills, and abilities in students that they will need in the future. In this regard, students must form such a level of fundamental training, which is required for solving professional problems and studying subsequent special disciplines (Biryukova, 2020). The development of any educational product should be based on the principle that it is critical not to fill the student with an extensive array of educational material but to organize an optimal individual set of knowledge and determine the discretization mode in which it is necessary to broadcast knowledge (Baehr, 2013).

Many textbooks and problem books in mathematics for higher education recommended for agricultural universities contain formulations of standard problems that do not contribute to the formation of the ability to apply knowledge of mathematics in professional activities (Vinogradova & Iakodiuk, 2021). Each teacher needs to determine the priorities of methods and means as elements of professional activity based on the semantic load of the academic discipline, the initial level of preparedness of students, and their pedagogical experience (Kulikova, 2020).

Every year it becomes increasingly difficult for university teachers to present lecture material on mathematics to first-year students. Numerous observations and personal experience allow us to conclude that the approach to teaching and formalizing the school mathematics course is quite stereotyped. The ability of students to abstractly understand the lecture material and perceive the given examples as a connection of logical reasoning and not a picture is decreasing. Former schoolchildren lack an understanding of mathematics as a unified science; they do not understand its practical significance. The level of anxiety and negative attitude towards this discipline are increasing among students due to misunderstanding and high requirements at the university. Therefore, one can often hear a question from first-year engineers: “Why do we have to study mathematics at university?” Hence the problem arises: how to motivate poorly prepared applicants to study mathematics and perceive its integrity as a science with a wide range of practical applications.

Certain pedagogical conditions were created to increase motivation to study mathematics and prepare students for training in engineering disciplines. The following tasks were set:

- Improve the quality of studying mathematics by the first-year students of engineering training areas.
- Develop analytical, logical, and critical thinking in future agricultural engineers.

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- Prepare future engineers to perceive theoretical and practical material of general technical and special disciplines.
- Contribute to forming general professional competencies prescribed in the Federal State Educational Standards of Higher Education.

The goal of this study is to enhance motivation for studying mathematics among students in engineering training areas at the State Agrarian University of the Northern Trans-Urals.

2 MATERIALS AND METHODS

The research in the form of practical pedagogical experience was conducted in the State Agrarian University of the Northern Trans-Urals in 2018–2020. The study involved 143 students in the following training areas: agro-engineering (3 groups), land cadastre (1 group), and nature management and water use (1 group). All three areas are related to the engineering profile. The following research methods were used: analysis of psychological, pedagogical, and methodological literature on the research topic, modern teaching methods in the context of contextual learning, and practical experience.

After analyzing the topics studied for the entire course of study in mathematics, we chose those most constructively embedded in the technology of contextual learning. The research focuses on topics of practical relevance to future engineers. The tasks were solved in three stages.

First stage. In the first semester, students were asked to study two topics: “Different equations of a straight line” (section “Analytical geometry”) and “Complex numbers” to understand the essence of studying mathematics, reduce anxiety, develop the vision of interdisciplinary connections, bridge the gap between the low level of school knowledge and the requirements for training in mathematics in higher education. In terms of complexity, these topics corresponded to first-year students’ level of perception of mathematical texts. The study of the topics was carried out using methods similar to the methods like the flip class and binary lesson.

For the proposed topics, a list of questions was compiled in a logical sequence of presentation of the material and distributed among all students in each group. For high-quality training, it was proposed to work with the university’s electronic library system, the internet, and educational literature. Each student in the practical lesson made a report on their question, and the teacher consulted the speakers before the presentation. The students of the group asked the speaker questions to clarify the information received. After the reports, tasks were proposed for the practical assimilation of the analyzed questions. The tasks were of different difficulty levels: basic – to consolidate the theoretical information received, intermediate – to see the interdisciplinary connections of mathematics with the general technical sciences, and advanced – tasks with elements of creativity.

Second stage. In the second semester, to prepare students' thinking for the study of special disciplines of an engineering profile, training was conducted within the contextual training with an emphasis on solving applied problems of a professional orientation on the topic "Application of a definite integral" with a pronounced applied nature. Moreover, the focus was on solving a specific problem using a definite integral in practice rather than theory. The section "Integral calculus" is one of the most difficult in mathematics; therefore, students are not always able to qualitatively master the theoretical part of the section on their own, given the weak logical and analytical thinking and low scientific culture of first-year students. Thus, the students were focused on a definite integral as a tool for solving engineering problems.

Each student was given an individual task and allotted a certain time. For the successful completion of the task, methodological developments and links to sources in the electronic library system of the university were proposed. The teacher consulted all students who applied. It was required to complete the task correctly and draw a practical conclusion, which contributes to the development of critical thinking. Since the task was more difficult than in the first semester, the results were lower than the first stage results. A little more than half of the students successfully coped with the task. About a third of the students needed several consultations with the teacher to correct mistakes. A small part of the students could not complete the task; those were first-year students with the lowest level of school mathematical training and poor analytical and logical thinking.

Third stage. In the third semester, the main teaching method was the project method, which helps integrate mathematical knowledge and apply it to solving interdisciplinary problems. For the project method, the section "Mathematical Statistics" was chosen, which offers methods of processing empirical data and has a wide practical application.

The students were given the task of collecting statistical data from technical literature or experimentally and performing the project work "Primary processing of observation results using the methods of mathematical statistics." This project was aimed at showing that a qualitative interpretation of the results obtained will help objectively analyze statistical data in semester works and final qualifying work in the future. During the work on the project, students consolidated their skills in applying the methods of mathematical statistics and learned to systematize their knowledge while studying special engineering literature. The teacher acted as a consultant, correcting the work of students.

3 RESULTS

The first stage showed that involvement in the learning process and responsibility for the assigned task significantly influenced the learners' assimilation of the proposed topics. Skill control showed that most of the respondents (85%) mastered the topics at high and above average levels, and 15% of respondents did not learn the topics due to frequent skipping classes and unwillingness to prepare a presentation (Figure 1).

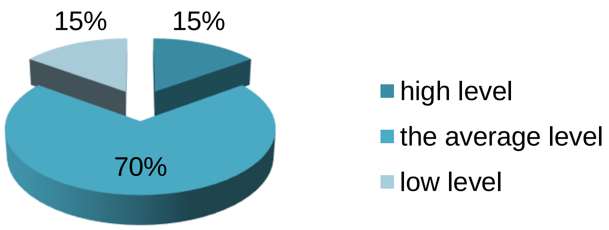

Figure 1. Control of the development of educational material

The final interview revealed that the students liked such a form of teaching; the anxiety threshold decreased. Furthermore, there was an interest in continuing to study mathematics; personal responsibility for the result when studying the discipline program increased, while self-discipline and interest in mental activity increased. The involvement of students in the independent study of educational material, in terms of complexity comparable to their level of school mathematical training, made it possible to increase the motivation to study mathematics. At the end of the first stage, we did not hear the traditional question from the students: "Why do we have to study mathematics at the university?" because they knew the answer.

Based on the results of the control interview, the second stage demonstrated that the students began to understand the practical meaning of integral calculus, saw the connection between mathematics and technical disciplines, and showed interest in these topics. Understanding the practical meaning of the chosen topic allowed us to prepare students for the perception of the theoretical material of professional engineering disciplines, psychologically motivating them to cognition.

Drawing conclusions on the third stage, we should note that the students, having mastered the basic theoretical knowledge in the "Mathematical statistics" section, consolidated them in practical activities, thereby acquiring research skills for future

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professional activities. At the same time, about a quarter of the students could not start working with the assigned task without consulting the teacher since they could not draw up a plan of their actions and predict the research results.

The positive side of the third stage is that students restored gaps in knowledge and learned how to extract the necessary information from special literature and collect empirical data, thereby increasing their readiness to perceive and process new information. When working on a practical task, students learned to comprehend empirical results critically, compare them with reality, and draw qualitative conclusions. The acquired skills and abilities will help future engineers consciously perceive technical sciences and form specific competencies.

4 DISCUSSION

The study showed that the students in the first semester did not understand the connection between their future profession and mathematics. From the first year, the applicants were set up to receive professional knowledge without thinking about the basics of engineering knowledge. Disruption of the school-university connection was visible. We found that secondary education programs poorly orient schoolchildren towards understanding their future professional activity and individual school subjects. Therefore, first-year students experience a high level of anxiety concerning mathematics in the first semester.

Another problem of the school is the underdevelopment of the thinking apparatus. A stereotyped and formal approach to teaching mathematics does not allow future students to develop analytical, logical, conceptual, and, most importantly, critical thinking. Subject to the formation of students' critical thinking at a high level, their further professional activity grows, which requires the university graduate to be independent, possess the skills of business interaction and cooperation, and solve complex production problems (Iakobiuk & Vinogradova, 2023).

Students' immersion in cognitive and research activities within contextual learning allows them to see the simplicity and beauty of mathematics, understand this science as a necessary and universal tool for understanding the world and the foundations of a future profession. The perception of mathematics as a strictly algorithmic science, which does not allow creative thinking, has become a thing of the past.

The limitation of the study was that at each stage, one or two topics of the program were chosen, no more. This situation is due to the low readiness of first-year students to perceive the program of university mathematics and the weak development of scientific thinking and culture.

Expanding the capabilities of the cognitive process and paying particular attention to the practical component of mathematics allowed students to increase their interest in mathematics and technical sciences, which are the basis for the future professional activities of agricultural engineers. Therefore, the students saw the path of self-improvement, realized the importance of self-education, and, ultimately, by the end of the training process, became competent specialists capable of making independent and responsible decisions.

5 CONCLUSION

Based on the results of practical research on contextual learning, the following conclusions were obtained:

- Due to the pedagogical conditions created, students' anxiety threshold regarding mathematics and self-doubt decreased. At the same time, an interest in continuing the study of mathematics appeared, personal responsibility for their learning outcomes increased, the level of self-discipline increased, and motivation for mental activity developed.
- Given the applicants' low level of basic school knowledge in mathematics, the teaching of mathematical disciplines at the university must be adjusted in terms of teaching methods and the psychological readiness of students to perceive mathematics as the basis of other sciences and engineering in particular. It is necessary to focus on the applied side of mathematics. Therefore, more and more teachers use contextual learning technologies in their work.
- It is necessary to correct the programs and methods of teaching mathematics at school, encouraging the thinking process and activating the cognitive activity of students, making mathematics more understandable, shifting from formalism and stereotyped teaching.

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