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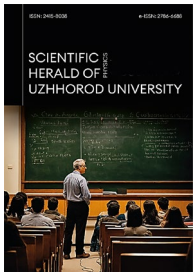

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Methodological characteristics of professional-oriented teaching of mathematics and physics to higher education students

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Abstract

Relevance. The modern stage of socio-economic changes in the society of the Republic of Kazakhstan and the need for transition of higher education to a new level, the issue of updating the system of methodological training of future specialists capable of developing new and optimising existing solutions in the field of mathematics and physics determine the research relevance.

Purpose. The study aims to develop pedagogical conditions for the implementation of the methodological system of teaching mathematics and physics students based on professional orientation in higher education as a guarantee of competitive specialists in the labour market.

Methodology. The following methods were used in the process of experimentation: analysis, synthesis, comparison, systematisation, classification, generalisation, and experimentation: establishing, forming, and controlling, as well as methods of mathematical statistics.

Results. Development and introduction, based on Narxoz University and Asfendiyarov Kazakh National Medical University, of the methodology of organisation of professionally directed teaching of mathematics and physics in the context of professional training of future specialists of the technical direction of higher educational institutions of the Republic of Kazakhstan is carried out. The results of the obtained data in the process of experimental research conclude that the proposed methodology is effective because it allowed to increase in the level of learning physics and mathematics

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in the process of professionally directed training of students of higher educational institutions. The study presents pedagogical conditions for the implementation of the proposed methodology: the development of motivation to study mathematics and physics, the development and implementation of the methodology of professionally oriented teaching of mathematics and physics, and the use of effective computer technologies.

Conclusions. The practical value of the study consists of the developed methodical system and computer programs, which are recommended to be used in the organisation of independent work of students, preparation of educational programs, syllabuses, and educational-methodical complexes for various technical specialities.

Keywords: technical education; computer programs; motivation; non-standard lectures; seminars; independent study.

Introduction

Physics and mathematics education has the most important role in the training of future specialists of the technical sphere, as the increase of the potential of the Republic of Kazakhstan in the technical direction requires improvement of the efficiency and development of professional training of specialists in higher educational institutions. The place of physics and mathematics in the system of specialist training is an important component in the development of intelligence, social and moral development of personality, introduction of scientific and technical ideas, and expansion of world outlook positions [1].

The State Programme for the Development of Education and Science of the Republic of Kazakhstan for 2020-2025 [2] notes that the priority directions of development of physics and mathematics education should be the personal orientation of education, holistic representation of physics and mathematics components in the context of higher education, implementation of an updated methodological system of teaching mathematics and physics in higher education institutions. Updating the methodological system of professionally oriented teaching of mathematics and physics allows students of higher education institutions of Kazakhstan to form professional competencies necessary for the implementation of future activities following the updated requirements to the system of training of future specialists in higher education institutions [3-5]. The principle of cross-disciplinarity applies on the way to realising the potential of such disciplines as mathematics and physics. For this reason, the proposed methodological system of teaching mathematics and physics is aimed at creating opportunities for the development of visual and intuitive foundations and practical orientation in a particular subject area. Insufficient development of the problem in terms of systematic study of methodological features of implementation of professionally oriented teaching of mathematics and physics, the existing contradictions between the need to teach these disciplines in the context of professional orientation and the lack of a clear methodology for the implementation of such a process necessitated the study.

According to Zh.A. Kalybekova [6], the strategic direction of the development of physics and mathematics education is to ensure its high quality in the context of using professionally oriented learning. That is why an important task in the system of training specialists of higher educational institutions of technical profile is the creation of a system of teaching physics and mathematics, based on the professional orientation in training. Professional orientation in training, according to the definition of J. Bergmann [7], requires the development of a system of motivations to carry out professional tasks and tasks aimed at professional development. According to scientists, such motivational components should include a set of needs, interests, attitudes, beliefs, ideals, and other psychological formations of a person. Concerning the results obtained in these studies, in the context of the development of professional orientation one should see interest in the profession and inclination to engage in it.

The modern methodological system of professionally oriented teaching of mathematics and physics to university students in the Republic of Kazakhstan requires teachers the active use of technical and research approaches. According to A.E. Abylkassymova et al. [8], it is necessary to ensure a high level of motivation to study mathematics and physics by solving professionally oriented tasks aimed at increasing interest in the study of these disciplines. Since researchers do not provide examples of the use of professionally directed tasks, there is a need to develop them. The use of professionally directed learning in mathematics and physics occupies an important place in the educational process of higher education institutions. According to researchers, the use of such training is aimed at activating the educational process, ensuring the improvement of the level of learning of mathematics and physics by future specialists, and establishing close links with future professional activities. However, the outlined works do not consider the specific methodology of implementation of professionally oriented teaching of mathematics and physics in higher education institutions of Kazakhstan.

J. König et al. [9] in their numerous scientific achievements investigated the issues of methodology of teaching mathematics and physics in higher education institutions. The researchers proved that in the process of teaching mathematics and physics in higher education institutions, it is necessary to consider the specific features that characterise physical and mathematical disciplines, namely: the logic of teaching and the practical direction of the teaching material. It is proved that the methodology of teaching physics and mathematics in higher education should solve the following problems, namely: clarification of the goals and objectives of physics and mathematics training depending on the profile; development of special courses in physics and mathematics to study them in the framework of electives, development, and implementation of methodological tools for teaching physics and mathematics. However, the presented scientific works lack a clear methodological component with the help of which it is possible to carry out professionally oriented training.

The study aims to develop the structure and content of methodological approaches to professionally oriented

teaching of mathematics and physics to students of higher education institutions. The study aim includes the following objectives:

1. Analysis of the current state of the methodology of professionally oriented teaching of mathematics and physics to students in higher education institutions of Kazakhstan.
2. Development of a methodology of professionally oriented teaching of mathematics and physics to students of higher educational institutions.
3. Development of pedagogical conditions for the implementation of the methodology of professionally oriented teaching of mathematics and physics to students of higher educational institutions.
4. Approbation of pedagogical conditions and author's methodology.

The resolution of the set objectives will allow to build of the educational process in higher educational institutions of the Republic of Kazakhstan at the highest level, using the methodology of professionally directed training in mathematics and physics, considering the requirements for specialists of technical profile in the labour market.

Materials and Methods

The analysis method was used in the process of experimental research to study the problems aimed at professionally oriented teaching of mathematics and physics. The synthesis method was used to combine similar thoughts of researchers concerning professionally oriented training described in philosophical, psychological, pedagogical, methodological, and physics-mathematical literature based on state-obligatory standards of higher education. The comparison method was used to study educational programs for training future specialists and to identify what is common and what is different in them. The systematisation method was used to consolidate different knowledge about the subjects (phenomena) presented in the working curricula and educational and methodical complexes in mathematics and physics for different specialities into a single scientific system, to establish their unity. The generalisation method was used to develop a methodological system for the implementation of professionally directed training based on the experience of teaching mathematics and physics in technical universities. The establishment, forming and control method of the experiment was used to verify the proposed methodological system of professionally oriented teaching of mathematics and physics to students of higher education institutions.

The experimental study was conducted at Narxoz University and Asfendiyarov Kazakh National Medical University during the 2022-2023 academic years. The experiment involved 162 respondents, whose ages ranged from 18 to 21 years old. The control group involved 81 respondents and the experimental group involved 81 participants. The participants in the control and experimental groups were in the same course and educational programme of study. The results of the experimental studies were evaluated on high, medium, and low levels.

The pedagogical conditions of effective implementation of the methodology of professionally oriented teaching of mathematics and physics to the students of higher educational institutions were identified at the stage of the establishing experiment. The effectiveness of the methodology of professionally directed teaching of mathematics and physics to students of higher educational institutions, studying on the educational programme 8D01501 "Mathematics", as well as the entrance control test to determine the level of student's knowledge in physics and mathematics for previous years was checked. During the test, difficulties in the perception of educational material and working in a group were determined. The forming stage of the experiment, aiming to determine the level of motivation of the respondents of the control and experimental groups before studying mathematics and physics, employed a diagnostic technique of personality on motivation to success, as per T. Ehlers [10].

To implement the second pedagogical condition – the development and implementation of the methodology of professionally oriented training in mathematics and physics, lectures with problem elements were used, the development of recommendations on the structure and blocks of lectures was carried out, namely: formulation of the base of applied problems, development of a general mathematical model, mastery of the methodology of solving different types of problems, non-traditional lectures on physics and mathematics, in the process of which the use of information schemes, independent work was proposed. The methods proposed for use in the implementation of independent work of students in the process of professionally oriented training were the following: independent discussion of educational material on the topic, work in pairs, tutor support, students' fulfilment of the role of the teacher, and computer-assisted questioning.

The third pedagogical condition is recommended to be realised through the use of computer technologies in the process of implementation of professionally oriented training. Those include GeoGebra, Mathcad, Wolfram, Photomath, 1C Maths Builder, and Living Maths. After the implementation of the developed methodology and pedagogical conditions, the initial control test was conducted to determine the changes in the level and quality of students' knowledge. The quality of the control test was assessed on a 100-point scale. At the control stage, the analysis of the obtained results was carried out, the calculation of qualitative and quantitative indicators of the pedagogical experiment using the Wilcoxon-Mann-Whitney criterion was worked out, their generalisation was carried out, conclusions were drawn and prospects for further research were outlined.

Results

The need to introduce a methodology for organising professionally oriented teaching of mathematics and physics to students of higher education institutions

Physics and mathematics in higher education institutions of the Republic of Kazakhstan are among the normative disciplines mandatory for study. Since during training students need to perform learning activities that should simulate their profession, it is necessary to implement the approach of professional orientation of disciplines of mathematics and physics. Providing professionally

oriented training in the process of selecting tasks for independent work is one of the most important aspects of studying physics and mathematics by students of higher educational institutions of the Republic of Kazakhstan. The implementation of such an approach will contribute to the improvement of the quality of learning in these disciplines by establishing cause-and-effect relationships aimed at improving the quality of training of future specialists at a productive level [11; 12].

Due to the differentiation of physics and mathematics content, changes in the sequence of material study, and introduction of the latest teaching methods and technologies into the educational process of higher education institutions in Kazakhstan, the system of physics and mathematics training of future specialists is subject to reorganisation. Higher education in Kazakhstan in the twentieth century requires renewal of approaches to the implementation of professionally oriented training [7]. Implementation of reorganisation of educational components in the curricula of the leading universities of Kazakhstan leads to a sharp decrease in the classroom load on the study of physics and mathematics, which requires updating the methodological system of obtaining professional competencies of students at the appropriate level, the formation of skills of independence.

Results of implementation of the methodology of organising professionally oriented training in mathematics and physics

Pedagogical conditions of implementation of the methodology of organisation of professionally directed training of mathematics and physics are implemented at Narxoz University and Asfendiyarov Kazakh National Medical University.

The first teaching condition – the development of motivation to study mathematics and physics – consisted of the implementation of a system of motives and needs in the process of implementation of professionally directed training in mathematics and physics for university students. The level of formation of motivation to learning showed how students are inclined to autonomy in learning, independent performance of tasks, attitude to the learning process, the use of tools that contribute to the independent learning of knowledge, the degree of motivation to fulfil the tasks of professional direction, the desire for self-development and self-improvement.

The second pedagogical condition – improvement of the methodology of professionally oriented teaching of mathematics and physics to students of higher education institutions – includes the choice of forms, methods and means of teaching. The main method employing which the principle of professionally oriented learning is realised is the performance of professionally oriented tasks. The realisation of the outlined condition is planned to be carried out by solving professionally oriented tasks. The content of the tasks was formed based on the principle of complex differentiation for groups of students. Such tasks include professionally oriented tasks, tasks for independent work with the use of application programs and professionally oriented projects. To increase the effectiveness of such training, appropriate exercise materials are required, including lists of physics and mathematics tasks, as well as methodological instructions, brochures, and appropriate software.

In the context of the third pedagogical condition – the use of effective computer technologies – it is recommended to use packages of mathematical software for methodological purposes, which were used in laboratory works and should be classified as follows: training, simulators, controlling, information and reference, simulation, modelling. To solve professionally oriented tasks, the following innovative programs in mathematics and physics were used: GeoGebra, Mathcad, Wolfram, Photomath, 1C Maths Builder, and Living Maths. To determine the state of pedagogical conditions for the implementation of the method of organising professionally oriented training in mathematics and physics, an experiment was conducted. The sample size was 162 students from Narxoz University and Asfendiyarov Kazakh National Medical University. The control group consisted of 81 respondents, and the experimental group – 81 participants. The formation of groups within the experiment was carried out by the method of pair selection. The experiment was conducted during the 2022-2023 academic years.

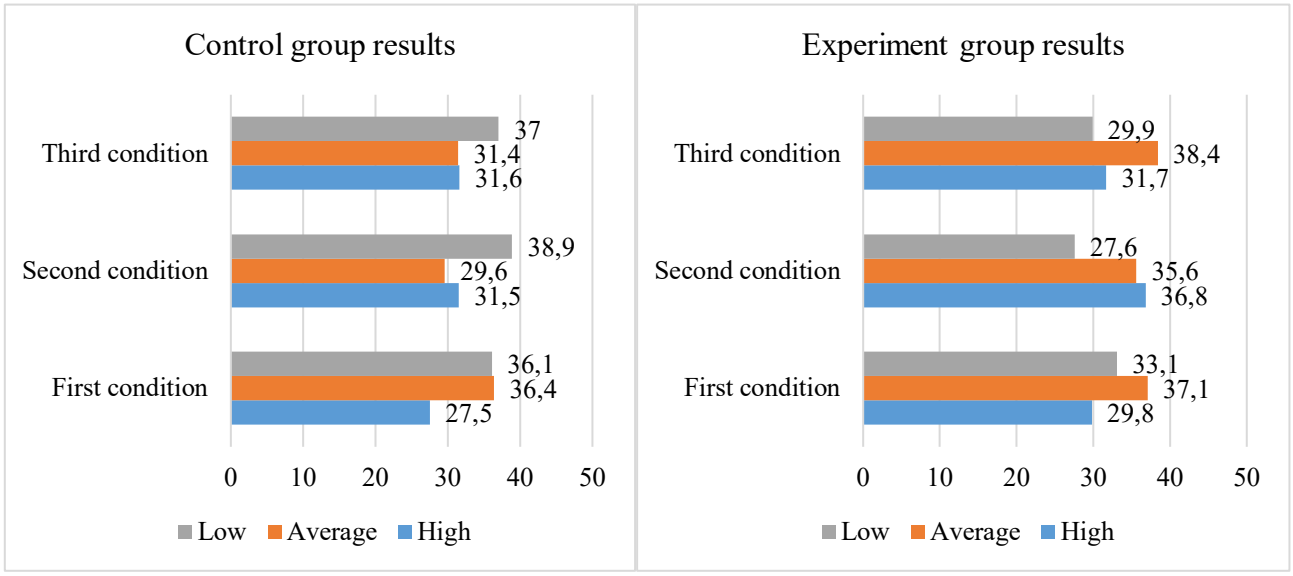
To determine the available levels of formation of pedagogical conditions of the implementation of the methodology of organising professionally oriented teaching of mathematics and physics in the outlined educational institutions, the ascertaining stage of the experiment was carried out. In the control group of students studying on the educational programme 8D01501 “Mathematics”, teaching was carried out according to the traditional method during the study of the subject’s “Mathematics” and “Physics”, the level of formation of pedagogical conditions of the implementation of the methodology of the organisation of professionally directed teaching of mathematics and physics was carried out. The purpose of conducting the ascending stage of the experiment is the following stages: determination of the level of formed competencies in physics and mathematics, skills of independent student learning, teamwork, determination of the quality of teaching physics and mathematics according to certain criteria and the presence of difficulties arising in the process of teaching physics and mathematics.

The methods used at this stage include analysis, synthesis, comparison, systematisation, classification, generalisation of theoretical analysis of scientific and theoretical problems of physics and mathematics teaching, visits to lecture and practical classes in physics and mathematics, discussions with students and teachers on existing problems in the process of mathematics teaching, checking of control works, analysis of curricula for specialities. To determine the levels of formation of the first condition in students the method of diagnostics of personality on motivation to success per T. Ehlers [10] was used. To determine the students’ knowledge levels in physics and mathematics for the previous years, an entrance control test was conducted, the results of which were evaluated using a 100-point scale. In the course of the test, difficulties in the perception of educational material and group work were determined.

The methodological system of organising professionally oriented teaching of mathematics and

physics to university students proposed in the framework of the experiment is set up for the integration of physics and mathematics knowledge. The central element of the methodology is the use of professionally oriented tasks, which are proposed to be performed at all stages of training in the implementation of the outlined pedagogical conditions. The solution of professionally directed tasks is the main method of practical implementation of interdisciplinary links in teaching physics and mathematics. The specified methodological system of teaching mathematics and physics is a complex approach based on a combination of individual and organisational aspects using the following elements: control of tasks for independent study; use of traditional and non-traditional forms and methods of teaching; creation of a system of different forms of organisation of student's independent learning; a clear and understandable system of score control, providing feedback using non-traditional methods of control.

The ascertaining stage of the experiment revealed that, as a rule, the solution of professionally directed handovers from mathematics and physics follows a pattern that blocks the development of students' motivation in the learning process. As a result of the fact that students have no experience of independent work with new material, its search and processing, they experience difficulties in outlining, which requires simultaneous listening and writing. The results obtained at the formative stage of the experiment are presented in Figure 1.



Source: compiled by the authors.

To form updated approaches to the study of physics and mathematics, as well as pedagogical conditions for the implementation of the methodological system based on professionally oriented learning, the forming stage of the experiment was conducted. The methodology of professionally directed learning was proposed, which included the use of various methods of cognitive and formal learning, provided for the active activity of students, quality control at lectures and seminars, as well as the use of professionally directed tasks and computer programs in the process of learning the material. In the process of conducting the formative stage of the experiment in Narxoz University and Asfendiyarov Kazakh National Medical University the method of organisation of teaching mathematics and physics under the outlined pedagogical conditions was improved and experimentally tested. The formation of positive motivation to study mathematics and physics students was carried out through conversations and analysis of achievements in the field of mathematics and physics of famous personalities.

The implementation of the second condition consists of increasing the level of knowledge in physics and mathematics, including types, ways, methods and techniques affecting the organisation of independent learning activity, its implementation and management, the implementation of ways to optimise and intensify it, to instil skills in the use of techniques and methods of implementation of professionally directed learning, the introduction of its components in the educational process of higher education institutions. The condition reflects the level of formation of students' skills to carry out independent learning activities in the study of physics and mathematics. To implement the second condition in the process of studying physics and mathematics, lectures with problem elements were used. To ensure a comprehensive understanding of mathematical concepts and methods and to establish relationships with the practical features of certain specialities, recommendations on the structure and blocks of lectures have been developed, namely: formulation of the base of applied problems, development of a general mathematical model, mastery of methods for solving different types of problems.

The content components of physics and mathematics have been proven to include information on professional direction for students of certain specialities, which can be presented at different stages of their training. It is proposed to include such questions in lecture materials, internships and independent work of students, which will ensure the increase of interest in physics and mathematics and renewal of professional motives. As a result, students learn to apply knowledge and skills in the context of real professional situations, which contributes to avoiding

formal presentation of material and enhancing opportunities for interdisciplinary communication. In lecture and seminar classes, within the framework of the presented methodology, methods of active interaction of students were used, and lectures with current control were held for instant verification of acquired competencies and correction of made mistakes. Computer programs for interpreting algebraic concepts were used in seminars; in the framework of independent work – laboratory practice on computer programs, practical examples of using physical and mathematical methods in real life were considered, which allows students to establish links with their future professional activity.

The research proposes the development of non-traditional physics and mathematics lectures offered to students at Narxoz University and Asfendiyarov Kazakh National Medical University. Lectures on pre-planned errors, lectures with current control, and lecture visualisation are offered. In the process of using such lectures, it is possible to use information schemes, which allow not only to qualitatively organise the lecture material on a certain topic but also to simplify its perception, while such schemes can also be used to solve professionally directed tasks. During laboratory activities and seminars, computer technologies were used in the process of professionally oriented training. This approach was used to optimise the work of the teacher and adapt the learning process to the needs of students. Packages of mathematical software for methodological purposes, which were used in laboratory works, should be classified as follows: training, simulators, controlling, information and reference, simulation, and modelling. In the study, the following innovative programs in mathematics and physics were used to solve professionally oriented problems: GeoGebra, Mathcad, Wolfram, Photomath, 1C Maths Builder, and Living Maths.

An example of a professionally orientated task used as part of the research. Recode verbal information (definitions, theorems, rules) into a diagram, picture, drawing, graph, chart, symbolic record, diagram, table or matrix, outline, visual aid. How much labour is required to fill a heap of sand of conical shape, the radius of the base of which is R (m) and the height H (m)? Make a drawing. While solving the laboratory works, the following tasks are suggested for the students on the topic presented in Table 1.

Table 1. Tasks on the topic: "An algorithm for using Kirchhoff's laws in the calculation of complex electrical circuits"

No.	Task	Score
1	Calculate the resistances in a complex circuit.	20
2	Calculate the alternating current in complex form.	20
3	Find the equivalent impedance (Angular frequency ω= 314 rad/s)	20
4	Calculate the currents in the branch circuit using the loop current method.	20
5	Build a vector diagram of currents in the complex plane.	20
Total		100

Source: compiled by the authors.

The diagram options for solving the assignment are shown in Figure 2.

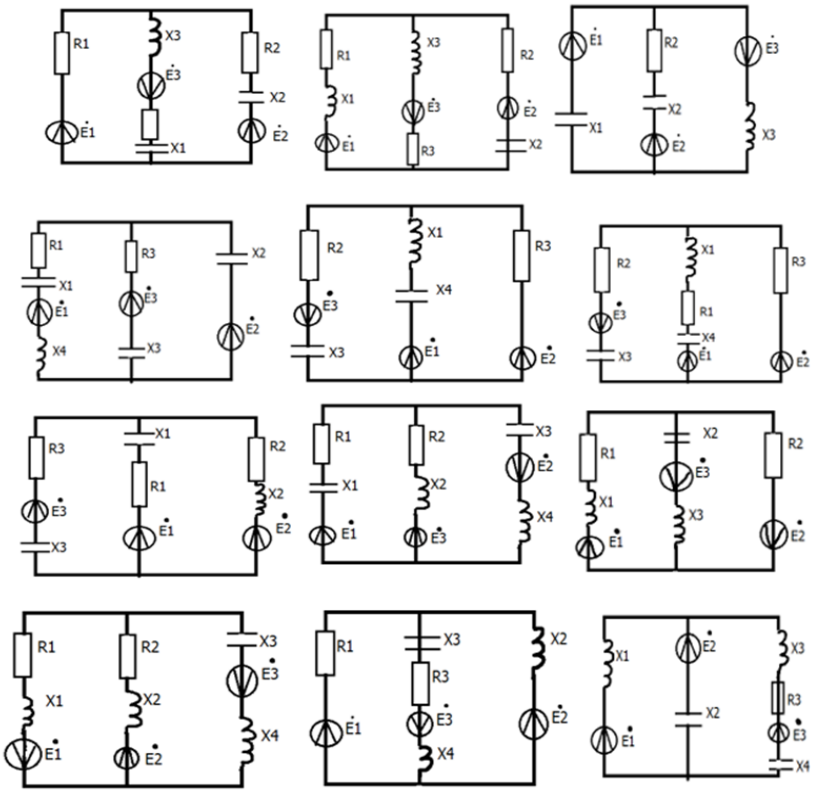


Figure 2. Diagram options
Source: compiled by the authors.

The circuit parameters for solving the problem are given in Table 2.

Table 2. Circuit parameters

Circuit N_n parameters	R_1	R_2	R_3	X_1	X_2	X_3	X_4	X_5
1	10	5	11	7	4	12	17	11
2	42	21	17	13	17	14	12	9
3	14	12	13	6	4	4	3	2
4	45	58	33	19	23	10	15	22
5	12	17	21	22	9	5	14	4
6	41	41	20	16	16	16	41	34
7	39	52	19	19	14	13	34	12
8	21	16	15	12	13	21	48	32
9	47	58	37	11	9	43	15	27
10	37	78	43	30	34	77	15	14
11	28	20	31	11	40	28	12	9
12	14	19	19	7	12	8	17	16

Source: compiled by the authors.

When studying the topic "Matrices and determinants", after familiarising students with the methods of calculating determinants, students are asked to perform the following tasks.

1. Calculate the matrix identifiers using Mathcad:

$$A = \begin{pmatrix} 1 & 2 & -1 \\ 4 & 6 & 8 \\ 0 & 2 & -3 \end{pmatrix}, B = \begin{pmatrix} 1 & 2 & -1 \\ 2 & 3 & 4 \\ 0 & 2 & -3 \end{pmatrix},$$

$$C = \begin{pmatrix} 1 & -1 & -1 \\ 4 & -3 & 8 \\ 0 & -1 & -3 \end{pmatrix},$$

$$D = \begin{pmatrix} 0 & 2 & -3 \\ 4 & 6 & 8 \\ 1 & 2 & -1 \end{pmatrix}, E = \begin{pmatrix} -1 & 2 & 1 \\ 8 & 6 & 4 \\ -3 & 2 & 0 \end{pmatrix},$$

$$F = \begin{pmatrix} 1 & 4 & 0 \\ 2 & 6 & 2 \\ -1 & 8 & -3 \end{pmatrix}.$$

2. Determine and conclude how the transformation of a matrix affects its determinant.

3. Compare the results obtained with other constructed examples.

4. Illustrate the following properties of the determinant by selecting suitable examples:

a) if in a determinant two rows (columns) are equal to each other, then such a determinant…;

b) if all elements of any row (column) of the determinant are equal to 0, then such determinant…;

c) if the elements of any row (column) of the determinant are multiplied by the corresponding elements of another row (column) of the same determinant, then the determinant….

Conclude the properties of the determinant. Let's consider the independent works aimed at the formation of professional competence of future engineers. The use of this approach creates conditions for increasing interest in learning, stimulates students' productive thinking, and promotes active solutions to the outlined problem. The next form of professionally oriented teaching of physics and mathematics is the organisation of students' independent learning [13]. This type of work is relevant in the process of preparation for lecture classes and their independent study; revision of materials in the process of preparation for internships; writing essays; taking exams; and doing homework. The study identifies the main forms of conducting independent work, namely self-organisation, group, and mass. Methods that are proposed to be used in the implementation of independent work of students in professionally oriented training were the following: independent discussion of the study material on the topic, work in pairs, tutor support, students' performance of the role of the teacher, computer-assisted questioning, complexes of problem-solving methods, project-based learning, methods of collective mental activity, methods of application of the latest digital technologies in learning.

To ensure the continuity between school and university programmes in physics and mathematics, within the framework of the experiment, a section "Elementary Mathematics" is included in the mathematics programme, where it is planned to consider the basic concepts and methods of elementary mathematics. The main task of studying physics and mathematics by students in the universities of the Republic of Kazakhstan is the process of qualitative assimilation of basic principles of mathematics and physics. This process is aimed at the development of intellectual abilities of the personality, namely the development of abstract and logical thinking, intuition, cognitive interest, independence and will, development of mathematical language, algorithmic and graphic culture. When designing curricula, it is essential to consider the intra-subject and interdisciplinary links between physics and mathematics. At the end of the forming stage of the experiment, the initial control test was conducted to determine changes in the level and quality of students' knowledge. The quality of the control test was assessed on a 100-point scale.

The respondents of the experimental group after training in the experimental methodology demonstrated high motivation for learning physics and mathematics, as well as a desire to work with the GeoGebra computer program. In general, students performed professionally oriented tasks independently, receiving counselling from the instructor. It should also be noted that students, using computer programs, had the opportunity to check the results of solving the problems and compare their answers with those obtained on the computer. The use of such an approach in conducting physics and mathematics classes

increased students' interest in learning new sections of physics and mathematics. The respondents constantly received tasks for independent study of both theoretical and practical content. The control stage of the experiment, where the analysis of the results of the experimental research and the evaluation of the effectiveness of the proposed method of organising professionally directed training in mathematics and physics for students of higher educational institutions was carried out.

The Wilcoxon-Mann-Whitney test was used to evaluate the effectiveness of the developed methodology of implementation of professionally oriented teaching of physics and mathematics of higher education students and to calculate qualitative and quantitative indicators of the pedagogical experiment. The results that were obtained at the formative stage of the experiment in the control and experimental groups are presented in Figure 3.

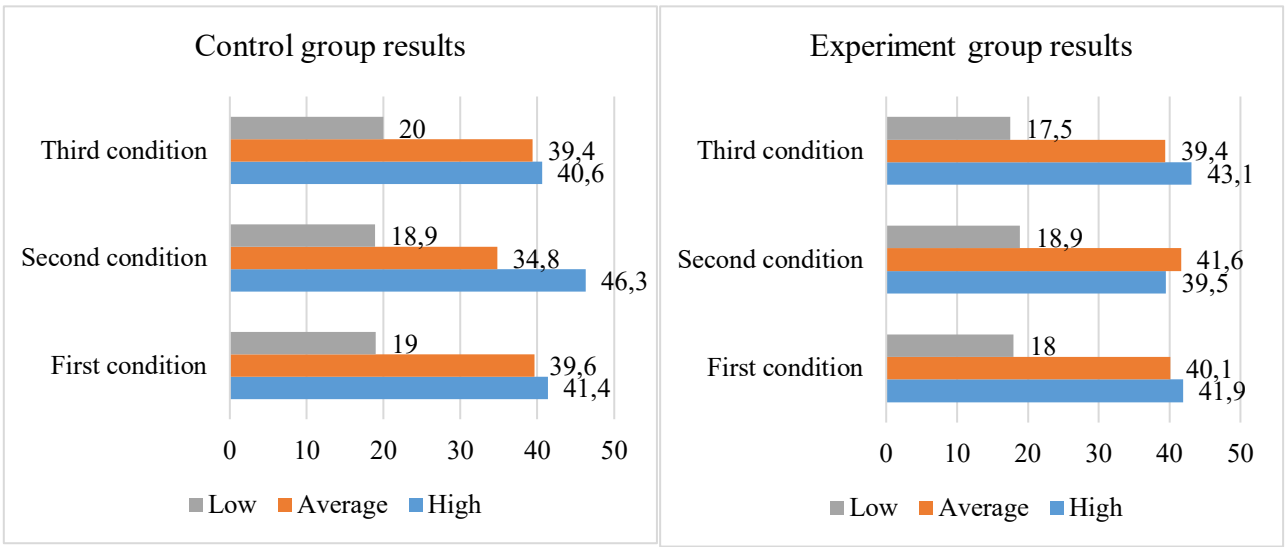


Figure 3. Results of the implementation of pedagogical conditions of the method of organising professionally oriented training in mathematics and physics in the control and experimental groups at the formative stage of the experiment
Source: compiled by the authors.

Based on the study results at the formative stage of the experiment, it is possible to conclude the effectiveness of the proposed methodological system, because the quality of success in the experimental group increased. The presented results confirm the effectiveness of the experimental methodology in the respondents of the experimental group compared to the same indicators of the control group due to the study of physics and mathematics courses by the experimental methodology. Thus, the implementation of the experimental method of organising professionally oriented teaching of physics and mathematics to students of higher education institutions is effective and ensures the successful mastering of competencies in the disciplines outlined.

Discussion

Providing quality organisation of professionally oriented teaching of mathematics and physics to university students is a key task of pedagogical science. An important role in solving this problem is the use of professionally oriented tasks. Qualitatively planned professionally oriented training allows one to form the necessary professional competencies required in the future professional activity of a future specialist. The ability to qualitatively plan the educational process of teaching mathematics and physics to university students will ensure the rhythm and intensification of students' studies at the highest level [14-16]. Given the reorganisation processes associated with the transition of higher education institutions to distance learning, the improvement of the learning process by searching for modern methods of organising professionally oriented training, particularly in the disciplines of mathematics and physics, is of particular relevance. Therefore, it is an extremely important task for universities to provide quality training for specialists in the conditions of distance education [17-19].

In modern conditions, the issue of the organisation of students' independent study in mathematics and physics becomes relevant in the conditions of information and educational environment. Future specialists studying in such an environment should have both theoretical and practical knowledge at a high level. In higher education institutions of Kazakhstan, independent work is usually divided into studies involving preparation for classes, tests, credits, and examinations and is carried out under the guidance of a teacher [20-22]. The educational process should be built in such a way as to form in students the qualities aimed at the independent application of competencies in professional activity, the ability to self-assess their results, to ensure constructive study in the process of solving professionally directed tasks [23; 24]. The study identified the main forms of independent study in the context of the implementation of professionally oriented learning, namely self-organisation, group, and mass. The modern methods of students' independent study include problem-solving methods, project-based learning, methods of collective mental activity, and methods of applying the latest digital technologies in learning [6; 25].

The process of higher education students' readiness for professionally oriented training in mathematics and physics should correspond to systematicity content and methodological integrity. It is proposed to consider the course of physics and higher mathematics as a set of invariant and variable components. The variable part of the

physics and mathematics course consists of topics of professional importance by certain specialisations. The invariant component includes theoretical and practical elements necessary for students of all specialisations [26-28]. The concept of "professionally directed task" in the study is interpreted as such type of task, which is an abstract modelling of a professionally directed situation, which can be solved by mathematical methods, which take place in the professional activity of a future specialist and contribute to personal development.

M. Shirrell et al. [29], researching the implementation of professionally oriented tasks in the system of training future specialists, distinguish two main types of tasks, namely: tasks consisting of professional concepts and terms used as motivational; tasks that create a certain professional situation and require the use of mathematical methods and are designed to develop professional thinking necessary in future professional activity. The use of the outlined approach is considered to be correct and, within the framework of the experiment, the necessity of including professionally directed tasks in the educational process of training specialists in higher education institutions has been proved, considering the following stages, namely: selection of theoretical material from the subject area of mathematics and physics and establishment of interdisciplinary links between the subject and the subject area of its use.

H.A. Susanto et al. [30], studying the issues of methods of teaching university students to solve professionally oriented problems, concluded that it is necessary to understand the structure of the problem and the sequence of their solution. This opinion makes sense, but it is appropriate for every teacher of physics and mathematics courses to know the methodology of teaching students to solve typical problems. In this matter, it is important to understand the algorithm for solving systems of equations and calculating derivatives and integrals. Based on the analysis of the goals and results of students' training in higher education institutions in the technical direction, the research proposes the development of a methodological system of teaching mathematics and physics, focused on professionally oriented training. This methodological system classifies various forms and methods of physics and mathematics education according to the degree of assimilation.

Z.M. Ozhybayeva and N.N. Nurmuhanbetova [31], in the process of studying the methodology of solving professionally directed problems, highlight the following stages of solving professionally directed problems, namely: analysing the problem condition, building a mathematical model, in-model solution, interpretation of the problem solution. The proposed position is supported; however, the study proves that the implementation of the outlined stages of problem-solving should be carried out based on the requirements for such tasks. The requirements include the content of the task should relate to the situation related to the specific activity of a certain specialist, the task should have the characteristics of a professional object to be investigated, problem-solving should contribute to the sustainable learning of knowledge, establishing the relationship between physics and mathematics and special disciplines, problem-solving should ensure the professional development of the specialist's personality.

S. O'Hara and R.H. Pritchard [32] actively researched the process of introducing professionally oriented tasks in the educational process of training future specialists. In numerous scientific achievements, it is noted that the solution of such tasks of different types will contribute to the student's mastery of basic mathematical concepts in conjunction with professional terms. It is proved that the systematic use of mathematical concepts and terms will deepen the professional orientation in teaching physics and mathematics. The researchers' opinion is supported, as it is proved by the experiment that the study of physics and mathematics course, where students are offered to solve professionally oriented problems, promotes the establishment of a connection between theory and practice and acts as one of the most effective teaching methods, which improves the quality of professional training of future specialist. The possibilities of using digital technologies in the educational process when studying physics and mathematics were investigated by F.M. Cavite and D.E. Marcial [33]. The scientists proved that the use of digital technologies in the process of teaching physics and mathematics provides stimulation of motivation to learning, activation of learning and cognitive activity, and implementation of the principle of visibility at a higher level.

A.B. Aitbaeva and Zh.N. Shaigozova [34] believe that the effective implementation of professionally oriented teaching of physics and mathematics requires the use of computer programs. The study supports the opinion of scientists and considers the peculiarities of the implementation of the following computer programs: GeoGebra, Mathcad, Wolfram, Photomath, 1C Maths Builder, and Living Maths. The process of using this software proved that the calculation process is well automated and allows to save time and focus on the physical content of the result. Certain software will help to reveal more fully the possibilities of mathematical methods and prepare specialists for more professional use of mathematical methods. In the process of the research, the development of a physics and mathematics laboratory workshop for independent studies using GeoGebra software has been carried out. Attempts were made to review some topics, and on its example to show the possibilities of presenting theory on digital technologies as a means of visual and dynamic presentation of information.

Therefore, ensuring the systematic use of professionally oriented tasks at all stages of learning physics and mathematics allows to ensure the maintenance of students' learning motivation at a high level by developing interest in the study of the outlined disciplines. That is why the digitalisation of the educational process in higher education institutions of the Republic of Kazakhstan plays an important role in improving the level of education and provides opportunities for learning the basics of sciences and updating the educational process.

Conclusions

The study concludes that the quality professional training of students of technical universities of the Republic of Kazakhstan is based on the creation of pedagogical conditions for the implementation of the methodology of organising professionally oriented teaching of mathematics and physics.

The concept of "professionally oriented task" was defined. Perspective directions of improvement of methods of organisation of professionally directed training of mathematics and physics in higher educational institutions of Kazakhstan were formed. The level of formation of pedagogical conditions for the implementation of the methodology of organising professionally oriented teaching of mathematics and physics was found to be at an average and low position in the course of the experiment. This trend demands the creation of necessary methodological tools based on professionally oriented training, which will serve to improve the level of training of future specialists. The following pedagogical conditions influencing the improvement of the methodology of professionally oriented teaching of mathematics and physics to students of higher educational institutions have been identified: development of motivation to study mathematics and physics, development, and implementation of the methodology of professionally oriented teaching of mathematics and physics, application of effective computer technologies.

The experiment was conducted, in the course of which a set of non-traditional lectures on physics and mathematics was developed, the solution of professionally directed tasks was proposed, and computer technologies were used in the process of implementation of professionally directed training. The generalised data of the experimental results after the application of the proposed methodology can be used to conclude the effectiveness of the implemented methodological toolkit. In this regard, the policy of educational institutions of higher education in Kazakhstan should be aimed at updating the pedagogical conditions for the implementation of methods of organising professionally oriented training in mathematics and physics.

Thus, further research aims to consider modern programmes of international level for teachers with the possibility of professional development abroad and the results of our research. The scientific research, as well as the conclusions formed based on it, can be used in the future as an effective basis for improving the training of future specialists in technical direction, the introduction of digital resources for the organization of professionally oriented training, the implementation of professional activities at a high level, considering the requirements of the labour market.

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Conflict of Interest

None.

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Методологічні особливості професійно-орієнтованого навчання математики та фізики студентів вищих навчальних закладів

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Анотація

Актуальність. Сучасний етап соціально-економічних змін у суспільстві Республіки Казахстан і необхідність переходу вищої освіти на якісно новий рівень, питання оновлення системи методологічної підготовки майбутніх фахівців, здатних розробляти нові та оптимізувати існуючі рішення в галузі математики і фізики, визначають актуальність дослідження.

Мета. Метою дослідження є розробка педагогічних умов реалізації методичної системи навчання студентів математики і фізики на засадах професійної спрямованості у вищій школі як запоруки підготовки конкурентоспроможних фахівців на ринку праці.

Методика. У процесі дослідження використано такі методи: аналіз, синтез, порівняння, систематизація, класифікація, узагальнення; експеримент: констатувальний, формувальний, контрольний, а також методи математичної статистики.

Результати. Розроблено та впроваджено на базі Університету "Нарксоз" та Казахського національного медичного університету імені Асфендіярова методику організації професійно спрямованого навчання математики та фізики в контексті професійної підготовки майбутніх фахівців технічного спрямування вищих навчальних закладів Республіки Казахстан. За результатами отриманих даних у процесі експериментального дослідження зроблено висновок, що запропонована методика є ефективною, оскільки дозволила підвищити рівень засвоєння фізики і математики в процесі професійно спрямованої підготовки студентів вищих навчальних закладів. У дослідженні представлено педагогічні умови реалізації запропонованої методики: розвиток мотивації до вивчення математики та фізики, розробка та впровадження методики професійно орієнтованого навчання математики та фізики, використання ефективних комп'ютерних технологій.

Висновки. Практична цінність дослідження полягає в тому, що розроблена методична система та комп'ютерні програми рекомендуються для використання в організації самостійної роботи студентів, підготовці навчальних програм, навчальних планів та навчально-методичних комплексів для різних технічних спеціальностей.

Ключові слова: технічна освіта; комп'ютерні програми; мотивація; нестандартні лекції; семінарські заняття; самостійна робота.