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# Improving the Level of Cognitive Component of Mathematical Competence in the Process of Mathematical Training of Students of Technical Specialties

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**Abstract**: The article reveals some approaches to the interpretation of the concept of the cognitive component of mathematical competence, reveals some ways of forming the cognitive component of mathematical competence of students of technical specialties. Based on the analysis of literature sources, the purpose and objectives of the study, the research hypothesis are substantiated. The purpose of the study is to check the effectiveness of the proposed method of improving the level of mathematical training of students of technical specialties (STS) in the form of checking the formation of the cognitive component of mathematical competence of STS. The method of improving the level of mathematical preparation consists in its fundamentalization. The paper also presents a statistical verification of the reliability of the obtained results. The methodological apparatus of the research covered modern principles and approaches of higher school pedagogy. The main approaches to improving the quality of mathematical training through its fundamentalization include: synergistic, systemic, activity, competence, knowledge-activity, personality-oriented; teaching and research approach. Also, the idea of forming professionally oriented mathematical competence is substantiated in the work. The work describes the structural scheme of the concepts of the proposed methodological system for improving the mathematical training of students of technical specialties through its fundamentalization. The obtained results of the study clearly confirm the effectiveness of the proposed concept of improving the quality of mathematical training of STS, and confirm the impact on improving the cognitive component of mathematical competence. The obtained results of the study indicate the need for further development in order to improve the quality and level of mathematical preparation of STS.

**Keywords:** *engineering; higher education; fundamentalization; mathematical training; future technical specialists; educational process; cognitive component; training of engineers.*

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## Introduction

The higher technical school has an important task - to provide society with technical specialists who would be fundamentally trained, would be able to put into practice knowledge and skills, would have creative thinking, having fundamental knowledge would be professionally mobile. The obtained results of the study indicate the need for further development in order to improve the quality and level of mathematical preparation of STS.

The methodological basis for improving the quality of mathematical training of STS is the fundamentalization of mathematical theory in the process of general professional training.

This is due to a number of economic, social and information changes in society and in education. The idea of fundamentalization of mathematical education is based on the principle of acquisition by future technical specialists of the basic knowledge and skills they need for productive professional activity. What kind of basic knowledge should be mastered by STS is determined by their specialty, it is this basic knowledge that will form the framework of mathematical training, with the help of which engineering operations will take place.

Based on the above considerations, the methodological basis for improving the quality of mathematical training of STS will be considered its fundamentalization, in the context of which improvement of the level of the cognitive component of mathematical competence of STS takes place. Under the cognitive component of mathematical competence of STS, we consider the ability to perceive and learn mathematical information (theories, laws, regularities). Improving the level of the cognitive component of mathematical competence involves students acquiring the ability to better assimilate mathematical information.

Systematic, activity, personality-oriented approaches are widely used in modern pedagogy of vocational education, acmeological and synergetic approaches that develop the ideas of continuing vocational education at a new level are gaining weight. Let's consider them in more detail regarding the training of future bachelors in electronics and telecommunications.

## Study design

Based on the formulated goal of the work, the following tasks were selected: to conduct an analysis of the scientific literature on the given problem field, to formulate the main conceptual principles of improving the quality of mathematical training of STS in the form of its fundamentalization, to conduct and describe an experiment to verify the formation of the cognitive component of mathematical competence as a result of the process of implementing improvement methods the quality of mathematical training, i.e. - the fundamentalization of mathematical education of STS, to conduct a statistical analysis of the obtained data.

**Research tasks**

Based on the stated purpose of the work, the following tasks were identified: to analyze the scientific literature on a given problem field, to formulate the basic conceptual principles of fundamentalization of mathematical training of future technicians, to conduct and describe an experiment to test the cognitive component of professionally oriented mathematical competence. technical specialists, to conduct statistical analysis of the obtained data.

Research hypothesis. We believe that the proposed theoretical and methodological principles of improving the quality of mathematical training - its fundamentalization, optimally influence the formation of the components of professional-oriented mathematical competence of future specialists of the technical profile, in particular, the cognitive component of the formation of which was studied in the work.

**Literature Review**

As noted by Maas, Geiger, Ariza and Goos (2020) development and improvement of mathematical competences and their components improve personal scientific literacy.

The problem of mathematical training of technical specialists was studied in his works by Alpers B. A. (2013), who identified the components of mathematical competence of future technical specialists. The cognitive component of mathematical competence includes the ability to think mathematically, knowledge of mathematical laws and concepts (Goldin, 2020). Mulligan, Woolcott, Mitchelmore, & Davis (2018) emphasize spatial thinking as a means of developing mathematical competencies.

Han & Kim (2020), Ernest et al. (2019), Yang et al. (2021), Copur-Gencturk & Doleck (2021), Morze et al. (2022), Astafieva et al. (2019), Semenikhina et al. (2021) works on the problem of development of mathematical competencies. Borrell (2006), Niss & Højgaard (2019) outline the main aspects of mathematical competence. Niss & Jablonka (2020) describe the concept of mathematical literacy, which is closely related to the concept of mathematical competence. Victoria Wong (2019) deals with the development of mathematical skills of students of higher education in England.

Lagrange's study (2014) is devoted to the problem of mathematical training of future technical specialists, which notes the need for gradual introduction of new technologies that would improve the quality of the educational process. At work Nissim Sabag (2017) underlined that any engineering curriculum should include a large amount of mathematics study to enrich the engineer's tools (Avigad, 2021). The authors Kul & Çelik, S. (2020) prove the influence of solving mathematical problems on the development of students' thinking.

However, researchers of improving the quality of mathematical training Abdulwahed, Jaworski & Crawford (2012), Desoete & De Craene (2019) point to the inadequacy of the first attempts to improve the quality of mathematical training.

Li & Schoenfeld (2019) scientists claim that mathematics in a certain way repels students, because it is perceived as a hard science.

Studies by Broadbridge & Henderson (2009) highlight ways to improve the development of mathematical competence.

Pepin & Gueudet (2020), Geraniou & Jankvist (2019) improves the quality of mathematics education through the use of electronic resources. Chevallard & Bosch (2020) emphasize that high school math knowledge is shaped by university education.

Rakov (2005) in his research focuses on the formation of mathematical competence. The scientist describes this definition as "the ability to see and apply mathematics in real life, understand the content and method of mathematical modeling, the ability to build a mathematical model, to explore it with methods of mathematics." Emphasis is placed on the practical and profile application of mathematical apparatus, which leads to the expansion of the definitive boundaries of mathematical competence. Fried (2020) concludes that mathematical knowledge is universal and interplinar, so the formation of mathematical competence is a necessary component of a high level of professionalism.

Polishchuk (2018) sees the transition from highly specialized to fundamental, holistic knowledge in the fundamentalization of the educational process. The professional orientation of the fundamentalization of mathematical training of technical specialists is described in Kolomiiets et al. (2020).

At the same time, as noted by Rudyshyn, Kravets, Samilyk, Sereda, & Havrylin (2020), the fundamentalization of the educational process is not possible without the integrity of knowledge and their integration into the study of fundamental disciplines.

Researchers (Lai & Peng, 2020; Passey, 2019) propose to improve the quality of mathematical training through the selection of a mathematical core, that is, to fundamentalize mathematical education (Passey, 2019). Lai & Peng, (2020). However, according to scientists Karlusch, Sachsenhofer & Reinsberger (2018) basic education (core), which will be the basis for creating a common holistic system of knowledge, must contain the unity of natural sciences and humanities (Klochko et al., 2020a; 2020b). Kohut & Shishkina (2020) investigate the use of computer mathematics systems as a means of ensuring the process of identifying the mathematical core, that is, the fundamental component of education.

An important feature of ensuring the improvement of the quality of mathematical training of students of technical specialties (fundamentalization of their mathematical training (STS), according to Shabanova (2014) is the construction of the educational process based on a systematic approach, which allows to consider the fundamentalization of mathematical training FBETK as a holistic pedagogical system in which goals, forms, methods the content of mathematical training determines the choice of learning technology, ie the choice of methods and tools aimed at diagnosing student achievement.

Research of the problem of fundamentalization of mathematical training (improving the quality of mathematics education) in the works of scientists Kovtonyuk (2013), Semerikov & Teplytskyi (2009) lead to the conclusion that this process covers a wider range of knowledge and skills formed in the student, which are part of mathematical competence. Investigating the problem field of fundamentalization, scientists Yarkho & Emelyanova (2015) come to the conclusion about the formation of professionally-oriented mathematical competence as a result of the process of fundamentalization.

Sevastyanov (2011) investigates the formation of professional and mathematical competence in masters of technical specialties in solving professionally-oriented problems. In the work of Padalko, N., Padalko, H., & Padalko, A. (2020), Seidametova, Z. (2020), Astafieva, M., Bodnenko, D., Lytvyn, O., & Proshkin, V. (2020), Lvov, M., Shishko, L., Chernenko, I., & Kozlovsky, E. (2019). outlines the formation of professional competence of students of mathematical specialties through the use of ICT.

In his study, Sazhiienko (2021) explores the professional competence of future technicians.

Lyon & Magana (2020) substantiate the need for theoretical knowledge of future engineers, knowledge of the main sections of mathematics and skills of mathematical modeling, which leads to the need to develop the cognitive component of professionally-oriented mathematical competence. Fry, P.S. (1991), Rachel, C. F. Sun, Eadaoin K. P. Hui, (2012) describe cognitive competence as an integral formation of creative and critical thinking. Sun, Rachel C. F., and Eadaoin K. P. Hui (2006) emphasize that cognitive competence includes the ability to think creatively and critically, analyze multiple ideas, and draw conclusions based on this.

## Research methods

Research methods: theoretical and empirical, they include analysis and synthesis of theoretical research on the selected topic, analysis and synthesis of scientific information, literature sources, pedagogical experiment selection and creation of tasks for testing students of experimental and control groups of students. the obtained results with the use of mathematical apparatus.

We used Fisher's angular test to verify the reliability of the obtained results ($\varphi^*$ Fisher's criterion), $\chi^2$ - Pearson's criterion.

The research methodology covers the approaches and principles of higher education, in particular systemic, synergetic (general scientific approaches), activity, competence, integrative, personality-oriented, teaching and research approach.

The experiment involved 466 students of the experimental and control groups, majoring in 17 "Electronics and Telecommunications" Vinnytsia National Technical University. Groups of students were selected at random and with the consent of students a pedagogical experiment.

The experimental group consisted of 279 students. The control group included 134 students Thus, the experiment was performed twice.

## Results of the research

We chose students of technical specialties to conduct the experiment. The control and experimental groups include students of the field of electronics and telecommunications - future bachelors in electronics and telecommunications (FBETK).

We describe the approach to improving the quality of mathematical training of FBETK through the fundamentalization of mathematical training.

This concept is based on) is based on the leading ideas of the Law of Ukraine on Higher Vocational Education and includes theoretical, methodological, technological concepts (Figure 1).

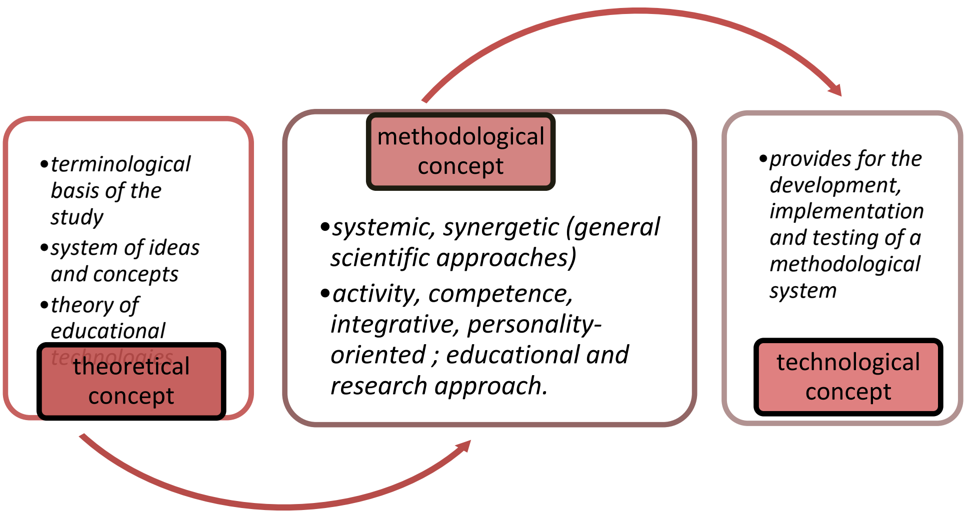


**Figure 1**. Structural and semantic scheme of the concept of fundamental mathematical training of students of technical specialties - FBETK

Theoretical concept of fundamentalization of mathematical training Methodological concept of fundamentalization of mathematical training FBETK covers the definition of leading research concepts: concepts of the problem field of fundamentalization of mathematical training FBETK, substantiation of the model of didactic system of fundamentalization of mathematical training, definition of content and components of mathematical training (theoretical and practical components). which are the result of the fundamentalization of mathematical training FBETK. The theoretical concept is based on scientific, philosophical theories of knowledge.

The theoretical concept of fundamentalization of mathematical training FBETK covers a system of ideas and theories based on personality-oriented pedagogy, based on the conceptual provisions of personality pedagogy, educational technologies of teaching and education, implementation of self-organization of students and teachers, non-traditional approaches to education and the use of methods, tools and forms of learning and personality-oriented and activity approaches, constant updating of content, the leading idea of the educational process is the transfer of information and communication technologies to a higher level of improvement, productive motivation, focus on personal interests that meet modern requirements.

The methodological concept combines the fundamental tenets of philosophy, sociology, psychology, theory of scientific knowledge, systems theory, pedagogy; takes into account social, economic, cultural, educational, historical patterns of society; based on modern principles of human adaptation to changing conditions of existence, learning, development, upbringing; fundamental scientific approaches that were used in the research process: creative, paradigmatic, complex, systemic, synergetic, integrative. The choice of methodological bases of professional training of future technical specialists (FBETK) is in the process of distinguishing general scientific (systemic, synergetic) and specific scientific approaches - activity, knowledge-activity, personality-oriented; professionally-oriented, educational and research approach.

Based on methodological principles, we have developed a conceptual model of fundamental mathematical training in the educational environment of technical free economic science.

Systematic and synergetic approaches are considered to be general scientific approaches to building a model of fundamentalization (improving the quality of mathematics education) of FBETK (Figure 2).

According to Shabanova, Yu.O. (2014) "understanding education as a system and using a systematic approach in educational activities allows teachers to carry out their professional activities in inseparable connection with external and internal systems, clearly define priority areas of teaching, structure learning objectives, etc."

The methodology for improving the quality of mathematical training of future technical specialists includes a systematic approach, which is implemented in the context of fundamentalization through the construction of an integral system of pedagogical approaches to improving mathematical training.

The synergetic approach is manifested as a state of imbalance in the fundamentalization of mathematical FBETK training as a pedagogical system. In a state of imbalance, the development of science "chooses" the vector of movement, and the fundamentalization of the educational process is realized in the context of the continuous dynamics of this process. As a result of such dynamics, the educational process moves to a qualitatively new state, with better organizational processes. In such a dynamic process of the student in solving problems of higher mathematics, requires not only knowledge of mathematics, but also a set of interrelated components of professionally oriented mathematical competence - knowledge, skills, abilities, professional orientation, reflectivity and others that have sufficient basis for their use in future professional activities.

The technological concept involves the development, implementation and testing of a methodical system for improving the quality of mathematical training of future technical specialists (i.e. fundamentalization of mathematical training).

The technological concept includes the development and evaluation of scientific and methodological support for fundamentalization. Scientific and methodological support includes methodical materials, training manuals, educational programs for students of technical specialties.

conceptual model that contributes to the creation of conditions for effective continuous mathematical training of bachelors in electronics and telecommunications.

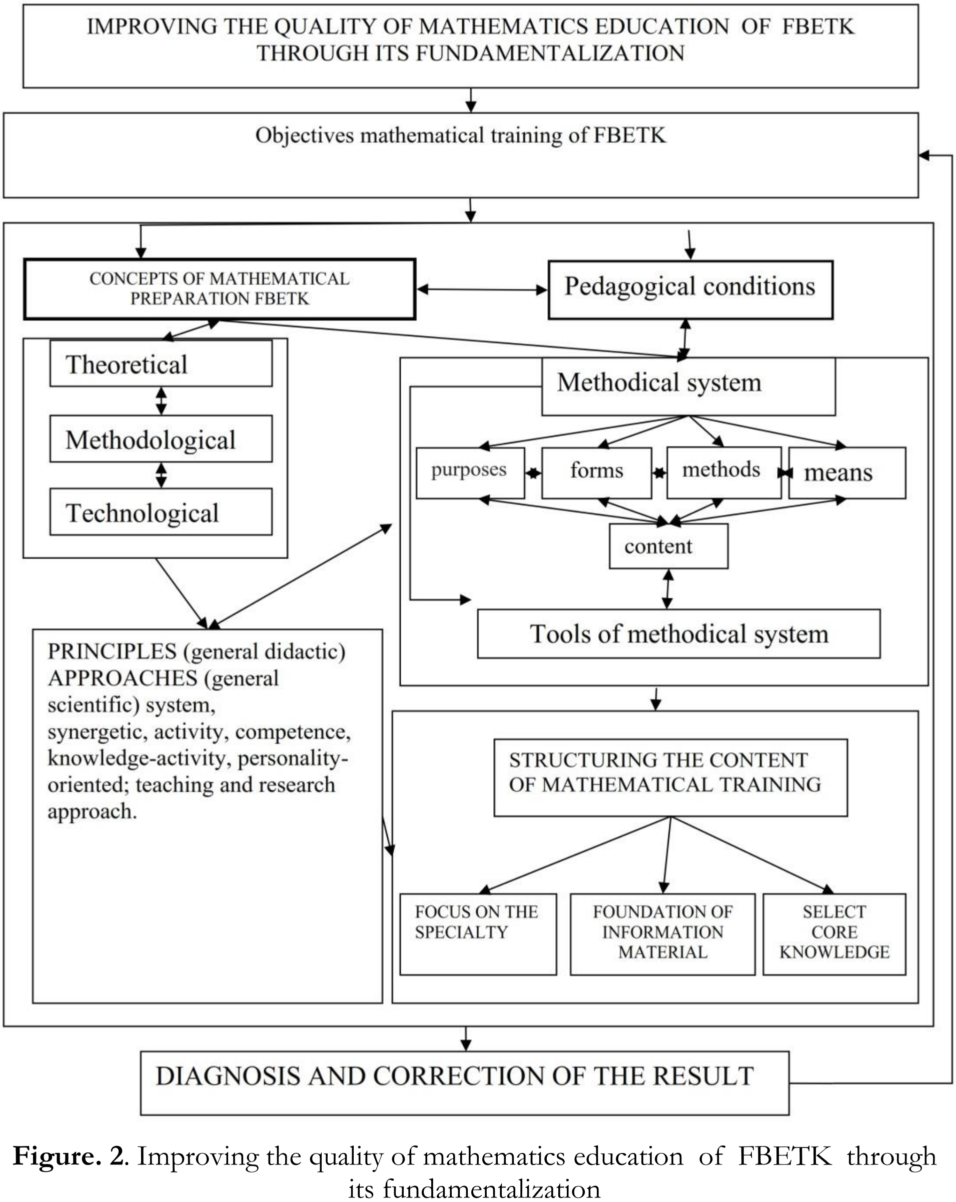


**Figure. 2**. Improving the quality of mathematics education of FBETK through its fundamentalization

The conceptual model reflects the main elements of the whole structure of the fundamentalization of mathematical training FBETK.

The structuring of the content of the mathematical preparation of the FBETK takes into account the following factors: the selection of basic information blocks, the professional orientation of the mathematical material.

In their research, M. Kovtonyuk, S. Semerikov, S. Rakov note that the implementation of the principle of funding in the educational process leads to a spiral study of concepts, reminiscent of the "boomerang movement". From this point of view, the principle of funding involves the allocation of invariant knowledge, fundamental concepts, the study of which will take place "in a spiral".

Mathematical competence is formed in the process of a holistic process of improving the quality of mathematical training due to its fundamentalization and provision of a set of pedagogical conditions. At the same time, fundamentalization involves directing the mathematical knowledge of future technical specialists to future professional activity. Therefore, in the process of fundamentalization of mathematical education, there is a process of forming not only the components of mathematical competence, but also the components of professionally oriented mathematical competence of FBETK .

The set of students' acquired abilities to use mathematical apparatus, skills and abilities of practical application of mathematical knowledge to solve applied problems of professional direction, together with mastered basic and axiomatic concepts of higher mathematics, deep understanding and knowledge of basic methods and algorithms of mathematical operations, analysis skills, to systematize and generalize the information that is formed as a result of the fundamentalization of mathematical training FBETK outline as a professionally-oriented mathematical competence.

Professionally oriented competence is an extension of mathematical competence due to the inclusion of components of professional competence. That is, the core of professionally-oriented competence is mathematical competence, into which elements of professional competence are integrated. The formation of components of professionally oriented competence contributes to a high level of general professional training of future technical specialists. Schematically, the formation of professionally oriented mathematical competence is shown in the figure 3.

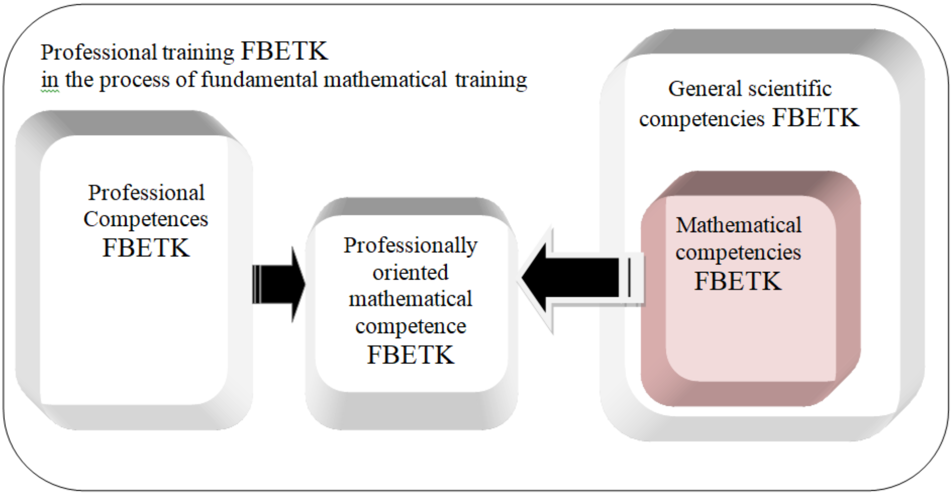


**Figure 3**. Scheme of professional training FBETK in the process of fundamental mathematical training

Thus, according to the results of the study, analysis of educational and methodological literature offered to students, analysis of curricula for future engineers of higher technical education, it can be argued that students of different specialties need "different professional mathematics". The analysis of researches of scientists of the competence approach, the analysis of educational and professional programs of preparation of future bachelors in the field of Electronics and telecommunications allowed to form components of POMC. POMC includes motivational, *cognitive*, operational-activity, design-algorithmic components.

The *cognitive component* includes knowledge of basic meanings and theorems, the ability to apply this knowledge in solving problems, the formation of creative thinking Rachel, C. F. Sun, Eadaoin K. P. Hui, (2012).

Ehe cognitive component of PSMK includes the formation of abilities to perceive and reproduce mathematical information, symbols, and mathematical laws.

One of the objectives of the study is to investigate the formation of the cognitive component of professionally-oriented mathematical competence FBETK.

The formation of the cognitive component took place through the systematic systematization and repetition of the educational material. In the process of this, students identified the main basic mathematical objects (we will call them elements of knowledge) and wrote them down in an additional notebook - a notebook. Students of the experimental group regularly participated in conferences, prepared reports, participated in the preparation of projects, thus increasing their level of mathematical training. The regular systematization and classification of educational material, the selection of the main educational material with a focus on the profession contributed to the formation of the cognitive component. Also, during classes, students worked out examples to establish correspondences when solving professionally oriented tasks. All these factors contributed to the formation of the cognitive component, which is also confirmed by statistical calculations and results.

In the work of Kolomiiets et al. (2021) was tested selected for the experimental and control groups for equivalence. It is proved that the experimental and control groups are equivalent.

We will briefly describe the essence of testing the selected experimental and control groups for equivalence.

At the beginning of the experiment, an experimental and control group of students was randomly selected.

In both groups of students, zero control work was conducted to determine the level of school mathematical training in order to determine the equivalence of experimental and control groups.

At the beginning of the experiment, it was checked whether the experimental and control groups were equal. For this, the students of the control and experimental groups were offered a test to determine the level of residual mathematical knowledge.

We will demonstrate the general result of the verification work in mathematics to determine the remaining mathematical knowledge in the form of a table.

The experimental group of students consisted of two subgroups: 129 and 98 students, the control group of students also consisted of two subgroups: 134 and 105 students.

**Table 1 -** Table for calculating the $\varphi$ * Fisher test by the results of the zero test in mathematics to check the remaining school mathematical knowledge

| Group | “Effect exists” | “No effect” | Total |
|---|---|---|---|
| EG | 76 (33%) | 151(67%) | 227 |
| KG | 94 (39%) | 145(61%) | 239 |
| Total | 81 | 186 | 466 |

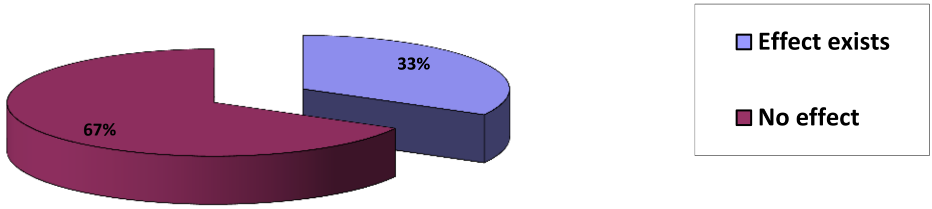


**Figure 3**. The results of the test, classified according to the criteria "there is an effect" and "there is no effect" in the experimental group

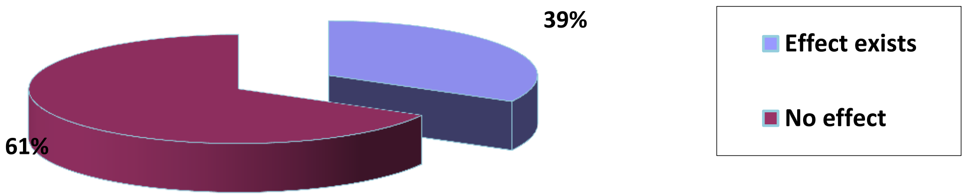


**Figure 4.** The results of the test, classified according to the criteria "there is an effect" and "there is no effect" in the control group

Let's build hypotheses

$H_0$ - the hypothesis that the level of school mathematical knowledge in the experimental group is not higher than the same level in the control group,

$H_1$ - the level of school mathematical knowledge in the experimental group is higher than the same level in the control group.

According to the tables "The value of the angle j for different percentages we find the value φ, which correspond to the percentages of the "effect" in each of the groups ($\varphi_1$ – experimental, $\varphi_2$ – control). We will find the value for each percentage according to the table of values

$\varphi_1$ (33%) =1,232 ; $\varphi_2$ (38,8%) = 1,355.

To calculate the angular value of the Fisher criterion, we apply the formula (1):

$$\varphi^* = (\varphi_1 - \varphi_2) \cdot \sqrt{\frac{n_e \cdot n_k}{n_e + n_k}} \quad (1)$$

where $\varphi_1$ – an angle corresponding to a higher percentage;

$\varphi_2$ - an angle corresponding to a smaller percentage;

$n_e$ - the number of students studied in the experimental sample;

$n_k$ - the number of students studied in the control sample.

$$\varphi_{\text{empirical value}} = (1,355 - 1,232) \cdot \sqrt{\frac{227 \cdot 239}{227 + 239}} \approx 0,123 \cdot \sqrt{\frac{54253}{466}} \approx 0,123 \cdot 10,8 \approx 1,32$$

.

For the obtained value $\varphi^*$ = 1,32 the level of statistical significance does not exceed 0.001 Levels of significance are sufficient for psychological and pedagogical research $p \leq$ 0,05 i $p \leq$ 0,01 Critical values of the criterion $\varphi^*$, that correspond to them, we find the same tables:

$$\varphi_{\text{critical value}} = \begin{cases} 1,64\ (\rho \leq 0,05) \\ 2,31\ (\rho \leq 0,01) \end{cases}.$$

The obtained empirical value is less than the table value for a given significance level.Got that $\varphi^*_{\text{empirical value}} > \varphi^*_{\text{critical value}\ кр.}$, and therefore the value obtained $\varphi^*_{\text{empirical value}}$ =1,32 is in the zone of insignificance (Fig. 4).

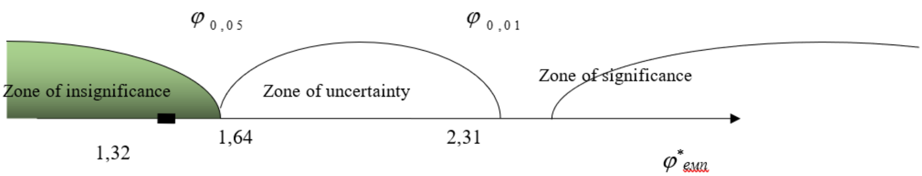


**Figure 5.** Geometric interpretation of criterion values $\varphi^*$

The study examined the effectiveness of the developed methodical system for increasing the level of the cognitive component of mathematical competence (professionally oriented)

We created indicators, criteria and levels of formation of the cognitive component of mathematical competence of students of technical specialties. The students performed the developed tests and tasks, according to the results of the testing, their answers were assigned to a certain level of the formation of mathematical competence.

**Table 2 -** Criteria, indicators and levels of formation of the cognitive component of professionally-oriented mathematical competence FBETK.

| Levels | Formation criteria | Indexes |
|---|---|---|
| High | The student has a deep understanding of mathematical symbols, definitions of concepts, and is able to apply them, answering questions of theoretical material, the student does not make mistakes or in rare cases inaccuracies. | 12-10 |
| Sufficient | The student knows the definitions, understands mathematical language, but there are gaps in knowledge of the theory of mathematical material. There are skills to distinguish and use mathematical symbols | 9-7 |
| Average | The student performs tasks, sometimes with errors, understands the theoretical material, knows how to choose a way to solve the problem. Distinguishes symbols, knows some definitions of mathematical concepts from theoretical material, confused in terminology, teacher's tips help to navigate in theoretical material | 6-4 |
| Low | The student is practically not oriented in theoretical material, answers theoretical questions with errors. | 1-4 |

**Table 3** - The table of results of formation of a cognitive component of professionally-directed mathematical competence on results of a cut

| Group | Levels of formation and percentage of students | | | | Total |
|---|---|---|---|---|---|
| | High | Sufficient | Average | Low | |
| **EG-1** | 24(18,6%) | 61(47,3%) | 32(24,8%) | 12(9,3%) | 129 |
| **KG-1** | 20(14,9%) | 47(35,1%) | 52(38,8%) | 15(11,2%) | 134 |
| **EG-2** | 18(18,4%) | 49(50%) | 24(24,5%) | 7(7,1%) | 98 |
| **KG-2** | 8(7,6%) | 41(39%) | 45(42,9%) | 11(10,5%) | 105 |

Experimental and control groups consisted of subgroups EG-1 the experimental group included 129 students, EG-2 the experimental group included 98 students, the control group KG-1 included 134 students, the control group KG-2 included 105 students.

We verified the effectiveness of the methodical system for raising the level of mathematical training through its foundationalization statistically.

We built the following hypotheses

$H_0$ - The hypothesis is that the proportion of students who showed a certain level of formation of the *cognitive component* of mathematical competence (professionally-oriented) in the experimental group EG-1 is not greater than in the control KG-1.

$H_1$ - The hypothesis is that the proportion of students who showed a certain level of formation of the *cognitive component* of mathematical competence (professionally-oriented) in the experimental group EG-1 is greater than in the control KG-1.

Let's test the formulated hypotheses with $\chi^2$ - Pearson's criterion

To check the formation of the cognitive component according to the results of the cut, we use the criterion $\chi^2$ Pearson's criterion

$$\chi^2_{емп} = N \cdot M \sum_{i=1}^{L} \frac{\left(\frac{n_i}{N} - \frac{m_i}{M}\right)}{n_i + m_i} \quad (2),$$

We get:

$$\chi^2_{емп} = N \cdot M \sum_{i=1}^{L} \frac{\left(\frac{n_i}{N} - \frac{m_i}{M}\right)}{n_i + m_i} =$$

$$= 129 \cdot 134 \left[ \frac{\left(\frac{24}{129} - \frac{47}{134}\right)^2}{24+20} + \frac{\left(\frac{61}{129} - \frac{47}{134}\right)^2}{61+47} + \frac{\left(\frac{32}{129} - \frac{52}{134}\right)^2}{32+52} + \frac{\left(\frac{12}{129} - \frac{15}{134}\right)^2}{12+15} \right] =$$

$$= 17286 \cdot 0,001067 = 18,4$$

Let's compare the obtained value $\chi^2_{емп} = 18,4$ with critical. For the level of significance 0,01 $\chi^2_{крит}$ =9,2 . We have $\chi^2_{емп} > \chi^2_{крит}$. This gives grounds to reject $H_0$ - hypothesis, and accept $H_1$ an alternative hypothesis that the share of students who showed a certain level of formation of the *cognitive component* of mathematical competence (professionally-oriented) in the experimental group EG-1 is greater than in the control KG-1 (according to the results of the cut).

Similarly, check the formation of the *cognitive component* of mathematical competence (professionally-oriented) in EG-2 and KG-2 according to the results of the cut.

Let's formulate the hypotheses.

$H_0$ - The hypothesis is that the proportion of students who showed a certain level of formation of the *cognitive component* of mathematical competence (professionally-oriented) in the experimental group EG-2 is not greater than in the control KG-2.

$H_1$ - The hypothesis is that the share of students who showed a certain level of formation of the *cognitive component* of mathematical competence (professionally-oriented) in the experimental group EG-2 is greater than in the control KG-2.

Let's test the formulated hypotheses with $\chi^2$ - Pearson's criterion

$$\chi^2_{емп} = N \cdot M \sum_{i=1}^{L} \frac{\left(\frac{n_i}{N} - \frac{m_i}{M}\right)}{n_i + m_i} \qquad (2)$$

$$\chi^2_{емп} = N \cdot M \sum_{i=1}^{L} \frac{\left(\frac{n_i}{N} - \frac{m_i}{M}\right)}{n_i + m_i} =$$

$$= 98 \cdot 105 \left[ \frac{\left(\frac{18}{98} - \frac{8}{105}\right)^2}{26} + \frac{\left(\frac{49}{98} - \frac{41}{105}\right)^2}{90} + \frac{\left(\frac{24}{98} - \frac{45}{105}\right)^2}{69} + \frac{\left(\frac{7}{98} - \frac{11}{105}\right)^2}{18} \right] =$$

$$= 10290 \cdot 0{,}00112 = 11{,}52$$

We have $\chi^2_{емп} > \chi^2_{крит}$. This gives grounds to reject $H_0$ - hypothesis, and accept $H_1$ an alternative hypothesis. According to the statistical results, we see that the level of formality of the cognitive component of mathematical competence is higher in the experimental group of students than in the control group. Accordingly, we are convinced of the effectiveness of the methodical system for improving the quality of mathematical training.

## Conclusions

1. The proposed methodology for increasing the level of mathematical training of students of technical specialties (STS) was tested, in the form of a test of the formation of the cognitive component of mathematical competence of STS. The method of raising the level of mathematical preparation consists in its fundamentalization.

2. The cognitive component is an important component of mathematical competence for a future technical specialist. The cognitive component of mathematical competence includes the ability to perceive mathematical material, understand mathematical symbols, the ability to establish correspondences, knowledge and understanding of basic mathematical laws, and awareness of mathematical concepts. Knowledge of basic mathematical concepts and their relationships is necessary for high-quality professional training of future technical specialists/

3. The concept of improving the quality of mathematical training, thanks to which the level of the cognitive component of mathematical competence increases, includes theoretical, methodological, technological concepts.

4. The experiment to check the formation of the cognitive component of mathematical competence consisted of two stages. The first stage of the experiment included testing the experimental and control groups for homogeneity. After establishing the homogeneity of the experimental and control groups, the second stage of the experiment was conducted.

The second stage of the experiment included testing the effectiveness of methods for increasing the level of the cognitive component of mathematical competence.

After the implementation of the developed methodology in the experimental group, testing was conducted in both groups (experimental and control). Based on the results of the testing, the levels of cognitive component sphoromorphism among the students of the experimental and control groups were determined.

5. With the help of statistical testing, it was established that the level of formation of the cognitive component of mathematical competence in the students of the experimental group is higher than in the students of the control group.

6. In this way, the developed method of improving the level of mathematical training of future technical specialists by fundamentalizing mathematical training was proven.

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