PROFESSIONAL ORIENTATION OF MATHEMATICAL TRAINING FOR THE FUTURE TECHNICAL SPECIALISTS

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Abstract: Mathematical training is a fundamental part of the general professional training of future engineers. Fundamentalization of mathematical training is an important way to improve the quality of mathematical training of future engineers, aimed at the formation of future technical specialists of mathematical competencies in the context of their training. The purpose of the study is to experimentally test the effectiveness of the proposed method of fundamentalization of mathematical training of future engineers on the example of students in Electronics and Telecommunications area of study, to make statistical calculations, to correlate the quality of teaching mathematics and special disciplines.

Key words: Engineering, Educational Process, Fundamentalization, Future Technical Specialists, Higher Education, Mathematical Training, Operational Component, Training Of Engineers.

1 Introduction

Mathematical training of technical specialists is an integral and basic part of their general professional training. The modern engineer constantly uses mathematical knowledge. At the same time, there is a problem of the quality of mathematical training of future engineers and the search for ways to form students' mathematical professionally oriented competencies, as knowledge of mathematics must be fundamental, strong and professionally oriented.

This problem is solved by fundamentalizing the educational process, in particular by fundamentalizing the mathematical training of future technicians, which includes the fundamentalization of sections, topics and concepts. The conceptual foundations of the fundamental mathematical training of bachelors of technical specialties are subject to the general concept of fundamentalization of the educational process.

2 Literature review

Within the framework of the national symposium project, which is discussed in the work of Broadbridge & Henderson (2008), it is noted that mathematical knowledge is extremely important for engineering.Scientists present the fundamentalization of the educational process depending on their own author's approach to outlining the definitions of the problem field of fundamentalization. In particular, Kovtonyuk (2013) emphasizes that the result of the fundamental professional training of the student is the formed fundamental space of the student. The researcher notes that under the condition of fundamentalization of education, the future specialist will be able to receive not only professional training, but also the necessary basic basic knowledge for self-development.

Subetto (2010) defines the fundamentalization of education through the allocation of the core knowledge systems of the individual, which he describes as a fundamental-knowledge framework of the individual, which determines its potential for self-learning within the concept of continuing education.

Subetto (2010) emphasizes that the fundamentalization of education is a complex phenomenon that targets the individual and society as a whole, as well as social intelligence. According to Semerikov (2009), the fundamentalization of the educational process is distinguished by several features: the dynamics of universal fundamental basic knowledge, bringing them to priority positions and giving them the core value for the accumulation of other knowledge, integration of education and science, restructuring the learning process and technological mobility.

Vaskivska (2017) considers the fundamentalization of education as its methodology, which will form a variable and invariant components of the content of education.

According to researchers, in particular, Lypova (2014), the fundamentality of education means the focus of its content on methodological, invariant elements of knowledge, and it is such knowledge that contributes to the internal motivation for self-education.

Polishchuk (2018) notes that the essential importance of the fundamentalization of professional training should be seen in the transition from highly specialized to fundamental, holistic knowledge.

Researchers Rudyshyn, Kravets, Samilyk, Sereda, & Havrylin (2020) analyze the problem of fundamentalization of professional training in pedagogical higher education institutions. The authors emphasize that the fundamentalization of the educational process includes ensuring the integrity of knowledge by integrating them into the core of fundamental scientific concepts; Priority is given to a concentrated presentation of the basic laws and principles of science from a single methodological position, which allows to form interdisciplinary links. In their study, researchers Coupland, Gardner, & Carmody (2008) described an experiment conducted among students to identify topics in higher mathematics that are fundamental to students. Researchers Chalmers, Carter, & Cooper (2017) have formed a six-component model in the educational environment of future technicians.

The study by Henderson, Simi & Broadbridge (2009) discusses the problem of low levels of mathematical competence and ways to solve this problem in the educational process. Abdulwahed, Jaworski & Crawford (2012) analyzed the research of scientists on the methodology of methods and approaches that improve the quality of mathematical training. Scientists note that the first attempts to apply new methods in the learning process do not always seem convenient. Lagrange (2014) notes that innovations to improve the quality of mathematical training of future technicians cannot be implemented instantly, but require radical changes in the educational process.

Rakov (2005) defines mathematical competence as the ability to see and apply mathematics in real life, to understand the content and method of mathematical modeling, the ability to build a mathematical model, to explore it with methods of mathematics. Alpers (2013) lists the components of mathematical competence.

In his study, Sazhiienko (2021) forms the criteria, indicators and levels of operational and activity component of the professional competence of bachelors in computer technology, highlighting three levels of its formation. Researchers Blomhoj & Jensen (2003) describe the formation of students' competence in mathematical modeling.

King (2007) states that mathematical knowledge belongs to those who have a certain hierarchy. At the same time, Waldvogel (2006) proposes to focus on linear algebra when studying higher mathematics, to include elements of discrete mathematics in the educational process of engineers.

Authors Saiman, Puji Wahyuningsih, Hamdani (2017) conducted an expert study understanding the importance of the role of mathematics for engineers. The researchers stressed that most technical experts consider knowledge of mathematics to be basic for their work. In the work of Engelbrecht, Bergsten, and

Kagesten, (2012) it was proved that for specialists and technical specialists in particular, not only theoretical mathematical knowledge is important, but also practical mathematical knowledge is important for their professional activity.

The purpose of the article is to experimentally test the effectiveness of the method proposed by the authors of professionally oriented fundamentalization of mathematical training of future engineers on the example of students in Electronics and Telecommunications department, make statistical calculations, correlate the quality of teaching mathematics and special disciplines.

Research tasks are:

- give the stages of fundamentalization of mathematical training of future technicians;
- experimentally check the equivalence of selected control and experimental groups;
- experimentally test the effectiveness of the proposed method of fundamentalization of mathematical training of future technicians on the example of the formation of the operational component;
- to formulate criteria, indicators and levels of formation of the operational-activity component of professionally-oriented mathematical competence of future technical specialists;
- check the relationship between mathematical and professional training by determining a statistically significant correlation coefficient.

3 Materials and research methods

Theoretical analysis of literature sources was carried out, observations, questionnaires, sections were performed, correlation analysis of random variables was used.

Students of technical specialties in the field of Electronics and Telecommunications of Vinnytsia National Technical University took part in the experimental research. The experimental group had 129 students in 2013 admission and 98 students in 2015 admission. The control group included 134 students in 2012 and 105 students in 2014. The experiment was conducted twice: started in 2012, a control group of students was selected (which consisted of 6 study groups and 134 students), in 2013 an experimental group of students was selected (which consisted of 6 study groups of 129 students). The experimental method was implemented during three academic semesters (when students study higher mathematics), its effectiveness was tested at the end of each semester, as well as during the study of special disciplines during the next three semesters of study.

The experiment was conducted for the second time in a similar way, starting in 2014, when a control group of students consisting of 105 students and 5 study groups and an experimental group of 2015 admission students consisting of 98 students and 5 study groups were selected. The experimental group of students introduced the author's method of fundamentalization of mathematical training, which included the fundamentalization of sections, topics and concepts of the discipline Higher Mathematics.

To check the equivalence of the experimental and control groups of students, zero control work was performed. Assessment of group equivalence was performed using Fisher's test.

Zero control work was evaluated on a five-point scale (5, 4, 3, 2). Successful writing of the test is considered to be grades 5, 4. A table is compiled in which students are divided into groups: there is an effect, there is no effect. There is an effect, if students have successfully written a zero test, ie received grades 5, 4, have a sufficient and high level of school knowledge in mathematics; No effect if students have reached the intermediate or elementary level of school knowledge of mathematics.

According to the tables The value of the angle φ for different percentages we obtained the values of φ, which correspond to the percentages of the effect in each of the groups (φ_1 - experimental, φ_2 - control).

Indicators, criteria and levels of formation of operational-activity component of professionally-oriented mathematical competence are formulated.

Correlation analysis of the results of the exam in the discipline Higher Mathematics and special professional disciplines of students in the field of Electronics and Telecommunications was conducted using the Spearman correlation coefficient.

In addition to determining the levels of formation of operational components, the effectiveness of the proposed method of fundamentalization of mathematical training of future bachelors of technical specialties was tested by determining the correlation between the results of the exam by students of technical specialties (including Electronics and Telecommunications) in mathematics and special disciplines. systems , Fundamentals of circuit theory (or Theoretical foundations of electrical engineering) .

4 Results

According to our proposed concept of fundamentalization is subject to professional (professional) training of future technicians, mathematical training of future technicians, within which the fundamentalization of sections, topics and concepts.

Fundamentalization of concepts can be classified as follows: fundamentalization of personality concepts and fundamentalization of concepts in the structure of the discipline.

The fundamentalization of the concepts of personality can be described as follows:

- The first stage is theoretical. At this stage, students of technical specialties learn basic theoretical information about the concept, learn to classify and systematize the theoretical knowledge about the concept.
- The second stage is practical. With the help of the proposed system of actions, students of technical specialties develop skills for the practical application of the concept, the ability to solve problems where a particular concept occurs.
- The third stage is activity-applicable. This stage, in contrast to the previous two, is more stretched in time, involves the systematic repetition of this concept in the form of its application in applied professional tasks.
- The fourth stage is verification and evaluation. At this stage, the assimilation of concepts is tested. Usually such a test takes place at the end of the academic semester, year or course of study of the discipline.

Fundamentalization of mathematical training of future engineers is part of the fundamentalization of the educational process and is integrated into the holistic process of fundamentalization of training of future engineers, covers a system of actions aimed at acquiring mathematical, professionally-oriented mathematical competencies. The criterion of mathematical training is the ability of a specialist to independently find, reproduce, operate with mathematical knowledge, use the mathematical core in engineering calculations. An engineer must apply mathematical knowledge in his professional activity in the same way that a user uses certain computer programs to achieve his goal.

To test the proposed method of fundamentalization of mathematical training of future technicians, a control and experimental group of students was selected. Let’s form a table for calculating φ* Fisher's test based on the results of zero control work in mathematics for EG-1 and CG-1 (Table 1).

Tab. 1: Table for calculating φ* Fisher's test according to the results of zero control work in mathematics

Group	There is an effect	No effect	Total
EG-1	38 (29,5%)	91(70,5%)	129
CG-1	43 (32%)	95(68%)	134
Total	81	186	263

Let’s formulate statistical hypotheses: H0: - the level of school knowledge in mathematics in the experimental group (EG-1) is not higher than in the control group (CG-1); H1: - the level of school knowledge in mathematics in the experimental group (EG-1) is higher than in the control group (CG-1).

According to the tables The value of the angle φ for different percentages Sydorenko (2002) we find the value of φ. Which correspond to the percentages of the effect in each of the groups (φ1 - experimental, φ2 - control):

φ1 (29,5%) =1,148 ; φ2 (32%) = 1,203.

The empirical value of φ* is calculated by formula (1):

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

where φ1 – is the angle corresponding to the higher percentage;

φ2 - is the angle corresponding to the smaller percentage;

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

n_k - number of surveyed students in the control sample.

$$\phi^*_{емп.} = (1,203 - 1,148)\cdot\sqrt{\frac{129\cdot 134}{129+134}} \approx 0,055\cdot\sqrt{\frac{17286}{263}} \approx 0,055\cdot 8,1071 \approx 0,4458$$

For the obtained value φ* = 0,4458, the level of statistical significance does not exceed 0.001 (the significance level is determined from the table Levels of statistical significance of different values of the φ* Fisher test given in Sydorenko (2002). For psychological and pedagogical research levels sufficient are levels $P \le 0{,}05$ i $P \le 0{,}01$

The critical values of the criterion φ*, which corresponds to them, are found in the same tables: φ кр* = $\begin{cases} 1{,}64\ (\rho \le 0{,}05) \\ 2{,}31\ (\rho \le 0{,}01) \end{cases}$.

We obtained, that φ*емп.>φ*кр., and therefore the obtained value φ*емп =0,4458 is in the zone of insignificance (fig.1).

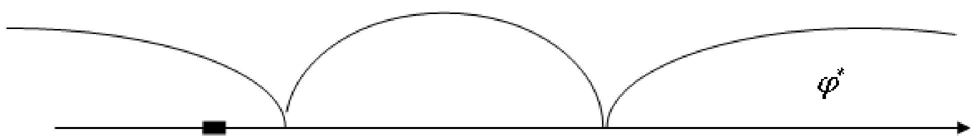

Figure1 – Geometric interpretation of the values of the criterion φ^*

The obtained results give grounds to reject the H_1 hypothesis that the level of school knowledge in mathematics in the experimental group (EG-1) is higher than in the control group (CG-1). Accordingly, we accept the H_0 -hypothesis that the level of school knowledge in mathematics in the experimental group (EG-1) is not higher than in the control group (CG-1). And the selected EG-1 and CG-1 are homogeneous in the level of school mathematical training. Similarly, the homogeneities of EG-2 and CG-2 were checked according to the level of school mathematical training. Let’s evaluate the equivalence of groups using Fisher's test. Let’s form a table for calculating φ^* Fisher's test based on the results of zero control work in mathematics for EG-2 and CG-2 (Table 2)

Tab. 2: Table for calculating φ^* Fisher's test according to the results of zero control work in mathematics

Group	There is an effect	No effect	Total
EG-2	38 (38,78%)	60(61,22%)	98
CG-2	51(48,57%)	54(51,43%)	105
Total	89	114	203

Let’s formulate statistical hypotheses: H_0 : - the level of school knowledge in mathematics in the experimental group (EG-2) is not higher than in the control group (CG-2); H_1: - the level of school knowledge in mathematics in the experimental group (EG-2) is higher than in the control group (CG-2).

According to the tables The value of the angle φ for different percentages (Sydorenko, 2002) we find the value of φ. Which correspond to the percentages of the effect in each of the groups (φ_1 - experimental, φ_2 - control):

φ_1 (38,78%) =1,345 ; φ_2 (48,57%)= 1,543.

The empirical value of φ^* is calculated by the formula:

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

where φ_1 – an angle corresponding to a higher percentage;

φ_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 in the control sample.

$$\phi^*_{емп.} = (1,543 - 1,345)\cdot\sqrt{\frac{98\cdot 105}{98+105}} \approx 0,198\cdot\sqrt{\frac{10290}{203}} \approx 0,198\cdot 7,12 \approx 1,409$$

For the obtained value φ^* = 0,014, the level of statistical significance does not exceed 0,001. (The analysis of the significance level is determined from the table Levels of statistical significance of different values of the criterion φ^* by Fisher (Sydorenko, 2002).

Got that $\varphi^*_{емп.} < \varphi^*_{кр.}$, and therefore the value obtained $\varphi^*_{емп}$ =1,409 is in the zone of insignificance (see fig.2).

The obtained results give grounds to reject the H_1 hypothesis that the level of school knowledge in mathematics in the experimental group (EG-2) is higher than in the control group (CG-2). Accordingly, we accept the H_0 hypothesis that the level of school knowledge in mathematics in the experimental group (EG-2) is not higher than in the control group (CG-2). And the selected EG-2 and CG-2 are homogeneous in the level of school mathematical training. Similarly, the homogeneity of EG-2 and CG-2 was checked for the level of school mathematical training. Thus, the selected control and experimental groups are homogeneous in terms of mathematical training.

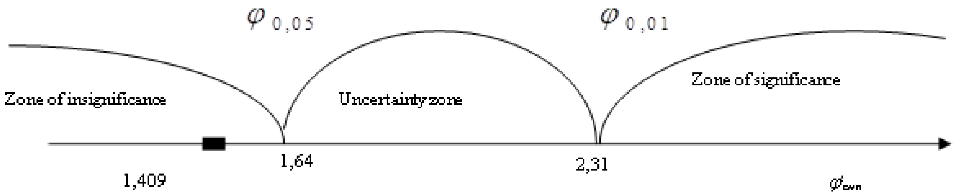

*Figure 2 – Geometric interpretation of criterion values φ**

Let's check the level of formation of the operational-activity component of the mathematical training of experimental students in the control groups. To do this, in both groups: experimental and control, testing was performed to determine the level of formation of this component.

The following tasks were included in the section on higher mathematics, with the help of which the level of the operational-activity component was determined.

1. Find an algebraic complement A $_{23}$ to the element a$_{23}$

$$A=\begin{pmatrix} 0 & -1 & -2 \\ -8 & 1 & -6 \\ -3 & 0 & -3 \end{pmatrix};$$ (2 marks)

2. Solve a system of equations based on Kirghhoff's laws using the Cramer method (*i1, i2, i3* – values of constant currents in different branches of the circuit)

$$\begin{cases} 11i_1+6i_2-5i_3=10; \\ 6i_1+26i_2+10i_3=15; \\ -2i_1+4i_2+11i_3=2. \end{cases}$$ (2 marks)

3. Two bodies began to move at the same time in a straight line from the same point in the same direction. One body moves with speed $v=5t^2+2t$, the second - with speed $v=2t$. In how many seconds the distance between them will be equal 135 м. (2 marks).

4. Dynamic self-induction of the antenna at constant wave elongation per unit length is expressed by the formula $L=L_0\dfrac{tg(\pi l/\lambda)}{2\pi l/\lambda}$ - where, L – dynamic self-induction; L_0 - static self-induction; l - current antenna length; λ - antenna wavelength. Find $\lim\limits_{\lambda\to\infty} L$ (3 marks).

5. The material point oscillates in a circle near its middle position according to the law $x=A\cdot e^{-k\cdot t}\cdot\sin\omega\cdot t$, where $(A,k,\omega>0)$. Find $\lim\limits_{t\to\infty} x$ (3 marks).

Levels and criteria of formation of operational-activity component of mathematical competence are formed: high, sufficient, average, low. The scores that the student scored for the correct solution of the relevant tasks are selected as indicators (see Tab. 3).

Table 3: Criteria, indicators and levels of formation of the operational component of professionally-oriented mathematical competence

Levels	Criteria of formation	Indexes
High	Student performs all tasks without errors, orients in the material, distinguishes methods of solving specific tasks, knows what methods to use for specific tasks, solves problems of professional content.	12-10
Sufficient	Student is well versed in ways of solving problems, but makes minor mistakes in calculations.	9-7
Average	Student performs tasks, is guided in theoretical material, ways of solving problems.	6-4
Low	Student is practically unfamiliar with the ways of solving problems, solves problems with errors.	1-4

According to the results of writing the test, table 4 is compiled

Table 4: The results of the success of students of the experimental and control groups

	Number of students	High	Sufficient	Average	Low
EG -1	129	29(22,5%)	33(25,6%)	47(36,4%)	20(15,5%)
CG -1	134	11(8,2%)	23(17,1%)	84(62,7%)	16(12%)
EG -2	98	21(21,42%)	26(26,5%)	38(38,78%)	13(13,3%)
CG -2	105	11(10,5%)	19(18%)	53(50,5%)	22(21%)

Let's form a table for EG-1 and EG-2. We will assume that There is an effect if students have reached a high and sufficient level, respectively No effect if students have reached a medium and low level (Table 5).

Table 5: Calculation table for φ^* Fisher's criterion according to the test results

Group	There is an effect		There is no effect		Total
	High level	Sufficient level	Average level	Low level	
EG-1	29(22,5%)	33(25,6%)	47(24,8%)	20(15,5%)	129
	48,1%		51,9%		100%
CG-1	11(8,2%)	23(17,1%)	84(62,7%)	16(12%)	134
Total	25,3%		74,7%		100%

Let's formulate statistical hypotheses: H_0- the level of measurement results of the operational component of professionally oriented mathematical competence in the experimental group (EG-1) is not higher than in the control group (CG-1); H_1: - the level of measurement results of the operational component of professionally oriented mathematical competence in the experimental group (EG-1) is higher than in the control group (CG-1).

According to the tables, the value of the angle φ for different percentages Sydorenko (2002) we find the values of φ, which correspond to the percentages of the effect in each of the groups (φ_1 - experimental, φ_2 - control): φ_1 (48,1%) =1,531 ; φ_2 (25%) = 1,047. The empirical value of φ^* is calculated by formula (1):

$$\phi^{*}_{емп.} = \left(1,531 - 1,047\right)\cdot\sqrt{\frac{129\cdot 134}{129+134}} \approx 0,484\cdot\sqrt{\frac{17286}{263}} \approx 0,484\cdot 8,1071 \approx 3,9238\cdot$$

Got that $\varphi^{*}_{емп.} > \varphi^{*}_{кр.}$, and therefore the value obtained $\varphi^{*}_{емп}$ =3,9238 is in the area of significance. We reject H_0 hypothesis and accept H_1 the hypothesis that the level of measurement results of the operational component of professionally oriented mathematical competence in the experimental group (EG-1) is higher than in the control group (CG-1). Similarly, make a table for the values of EG-2 and CG-2 (see Tab.6).

Table 6: Calculation table φ* Fisher's criterion according to the test results

Group	There is an effect		There is no effect		Total
	High level	Sufficient level	Average level	Low level	High level
EG-2	21(21,42%)	26(26,5%)	38(38,78%)	13(13,3%)	98
	47,92%		52,08%		100%
CG-2	11(10,5%)	19(18%)	53(50,5%)	22(21%)	105
Total	28,5%		71,5%		100%

Let's formulate statistical hypotheses: H_0- the level of measurement results of the operational component of professionally oriented mathematical competencies in the experimental group (EG-2) is not higher than in the control group (CG-2); H_1: - the level of measurement results of the operational component of professionally oriented mathematical competence in the experimental group (EG-2) is higher than in the control group (CG-2). Similarly, the empirical value φ* calculated by the formula (1):

$$\phi^{*}_{емп.} = \left(1,529 - 1,126\right)\cdot\sqrt{\frac{98\cdot 105}{98+105}} \approx 0,484\cdot\sqrt{\frac{10290}{203}} \approx 0,403\cdot 7,11 \approx 2,82$$

.Got that $\varphi^{*}_{емп.} > \varphi^{*}_{кр.}$, and therefore the value obtained $\varphi^{*}_{емп}$ =2,82 is in the area of significance. Therefore, we reject H_0 hypothesis and accept H_1 the hypothesis that the level of measurement results of the operational component of professionally oriented mathematical competence in the experimental group (EG-2) is higher than in the control group (CG-2).

Fundamentalization of concepts, topics and sections involves the selection of invariant mathematical elements of knowledge (concepts) that are most applicable in special professional disciplines. We have shown this dependence for special disciplines studied by students majoring in Electronics and Telecommunications (Figure 3).

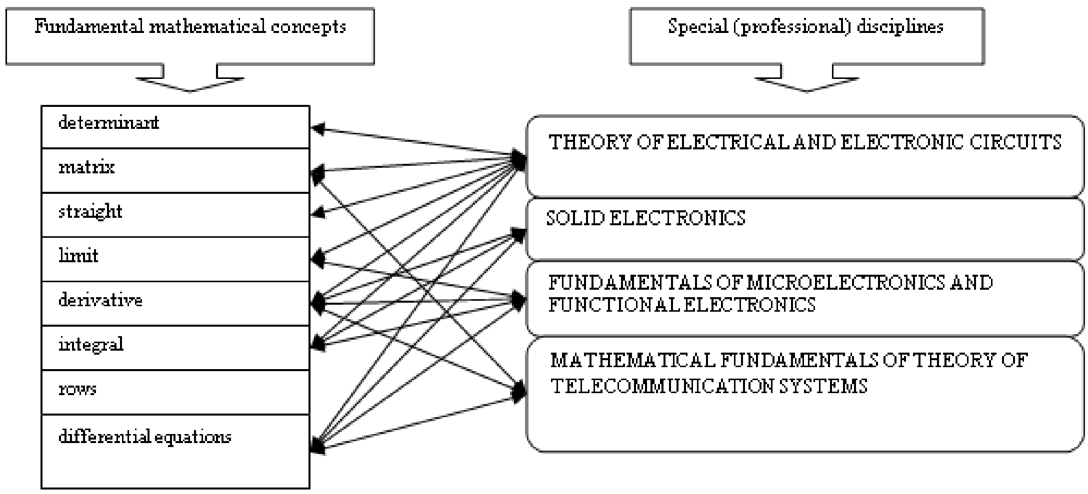

Figure 3 – The relationship of fundamental mathematical concepts and special (professional) disciplines, where these concepts are used

The effectiveness of the proposed method of fundamentalization of mathematical training of future bachelors of technical specialties was also tested by determining the correlation between the results of the exam by students of technical specialties (in particular, Electronics and Telecommunications) in mathematics and special disciplines. The following special disciplines were identified: Mathematical foundations of the theory of telecommunication systems, Fundamentals of the theory of circuits (or Theoretical foundations of electrical engineering).

Let's analyze for the experimental group the correlation between the results of exams in higher mathematics and special (professional) disciplines. To determine the statistically significant correlation between the values we use the Spearman correlation coefficient.

Let's form hypotheses. H_0 The hypothesis is that the correlation of control results in higher mathematics and control results in the discipline Theoretical Foundations of Electrical Engineering (TOE) of the experimental group of students does not differ from zero. H_1 The hypothesis is that the correlation of control results in higher mathematics and control results of an experimental group of students in the discipline Theoretical Foundations of Electrical Engineering (TOE) is different from zero.

From a general sample of the experimental group, we will randomly select a group of students. During the fundamental mathematical training in the experimental group of students, the author's method of professionally-oriented fundamentalization, which was mentioned above, was introduced. Since the students of the experimental group studied in different specialties, the special (professional) disciplines for them were somewhat different. A group of students of one specialty was randomly selected from the experimental group and the correlation of control results in higher mathematics and control results in the discipline Theoretical Foundations of Electrical Engineering (TOE) was checked for it.

Denote the scores obtained in the exam in the discipline of Higher Mathematics for the third semester by a random variable X, and the scores obtained in the exam in the discipline TOE denote by Y. Record the results in table 7.

Table 7: Table of values of the results of the exam in higher mathematics and theoretical foundations of electrical engineering students of control and experimental groups

№	Marks X	Marks Y	Ranks X	Ranks Y	Rank difference D_i	Rank difference D_i Elevated to the square
1	75	75	3,5	1,5	2	4
2	63	64	3,5	1,5	2	4
3	62	62	3,5	3	0,5	0,25
4	35	62	3,5	4	-0,5	0,25
5	62	35	3,5	5,5	-2	4
6	75	77	3,5	5,5	-2	4
7	35	62	8	8	0	0
8	62	60	8	8	0	0
9	35	50	8	8	0	0
10	91	90	10	10	0	0
11	35	62	11,5	12	-0,5	0,25
12	82	75	11,5	12	-0,5	0,25
13	35	62	13	12	1	1
14	91	90	14	14	0	0
15	35	35	16	15,5	-0,5	0,25
16	90	75	16	15,5	0,5	0,25
17	91	93	16	17	-1	1

Sum19,5

The correlation is calculated by the formula:

$$r_s = 1 - 6 \cdot \frac{\sum d^2}{N(\mathrm{N}^2 - 1)} \quad (2)$$

If the ranks match, use the formula (3)

$$r_s = 1 - 6 \cdot \frac{\sum d^2 + T_a + T_b}{N(\mathrm{N}^2 - 1)} \quad (3),$$

Where T_a , T_b - correction for the same ranks, which is calculated by the formula:

$$T_a = \sum (a^3 - a)/12 \quad (4.1)$$

$$T_a = \sum (\mathrm{b}^3 - b)/12 \quad (4.2)$$

Since the ranks coincided, it is necessary to calculate a correction for the ranks.

$$T_a = \left(6^3 - 6 + 3^3 - 3 + 2^3 - 2 + 3^3 - 3\right)/1 \quad = 22$$

$$T_b = \left(2^3 - 2 + 2^3 - 2 + 3^3 - 3 + 3^3 - 3 + 2^3 - 2\right)/1 \quad = 25,5$$

$$r_s = 1 - 6 \cdot \frac{\sum d^2 + T_a + T_b}{N(\mathrm{N}^2 - 1)} = 1 - 6 \cdot \frac{19,5 + 22 + 5,5}{17(17^2 - 1)} = 1 - \frac{282}{4896} = 0,942$$

According to the table we determine the critical values r_s at $n = 17$

For psychological and pedagogical research, as noted by Sydorenko (2002) levels of significance $p \le 0,05$ i $p \le 0,01$ are sufficient. Corresponding critical values of the criterion r_s find the same tables:

$$r_{кр}{}^* = \begin{cases} 0,48\ (\rho \le 0,05) \\ 0,62\ (\rho \le 0,01) \end{cases}.$$

Got, $r_{s_{емп}} > r_{s_{кр}}$ and therefore the value obtained $r_{s_{емп}} = 0,942$ is in the zone of significance (Fig. 4).

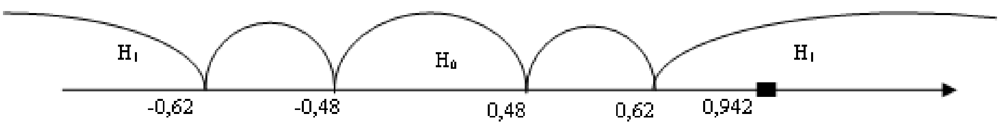

Figure 4 – Geometric interpretation of the obtained values

Thus, we reject the H_0 hypothesis and accept the H_1 hypothesis - the correlation of control results in higher mathematics and control results in the discipline Theoretical foundations of electrical engineering (TFE) is different from zero.

5 Discussion

The efficiency of fundamentalization of mathematical training of future technical specialists has been experimentally proved. Thus, in the experimental group EG-1 of the first wave of the experiment, students of high and sufficient level of formation of the operational component of professional-oriented mathematical competence by 22.8% more than in the control group CG-1, in the experimental group EG-2 of the second wave of the experiment students of high and sufficient levels of formation of the operational component of professionally-oriented mathematical competence by 19.42% more than in the control group CG-2. When checking the obtained values for statistical significance. The obtained values are statistically significant, which was proved by Fisher's test. In his work, Sazhiienko, O (2021) investigated the equivalence of the experimental and control group using the Wilcoxon - Mann - Whitney test, as well as the formation of operational and operational component of the professional competence of bachelors in computer technology. The researcher also tested the formation of the operational component of the professional competence of bachelors in the field of computer technology.

Given the research of scientists we have considered, we conclude that the fundamentalization of mathematical training of future technicians has a professional focus.

Based on the research of Semerikov (2009), Polishchuk (2018), Lypovoyi (2014), the main features of the fundamentalization of educational space include: selection of the core of fundamental knowledge - fundamental, basic elements of knowledge that are conservative and basic to study, generalization of knowledge (their unification) , selection and adherence to the basic principles and approaches in the educational process.

Scientists Saiman et al. (2017) emphasize that theoretical knowledge and operational (procedural) skills develop in parallel. According to this opinion, we can say about the effectiveness of the method of fundamentalization of mathematical training of future technicians in the process of forming also the cognitive component.

Coupland, Gardner & Carmody (2008) conducted an expert assessment among students on their understanding of the relationship between mathematics and the study of special (professional) disciplines in senior courses, in particular, 52.4% of surveyed students clearly understand this relationship Coupland, Gardner & Carmody (2008). At the same time, in our study, we experimentally tested and determined a statistically significant correlation between the study of higher mathematics and special (professional) disciplines.

6 Conclusion

Fundamentalization of the educational process plays an exceptional role in improving the quality of education and includes a hierarchical structure of fundamentalization of mathematical training, fundamentalization of sections and concepts.

Fundamentalization of the concepts of personality can be described in stages: the assimilation of basic theoretical information about the concept, the formation of skills for classification and systematization of theoretical knowledge; formation of skills for the practical application of concepts, the ability to solve problems where a particular concept occurs; formation of skills to solve professional tasks, testing the mastery of concepts.

The effectiveness of the method of fundamentalization of mathematical training of future engineers is experimentally tested in the work. In particular, it was statistically verified that the students of the experimental group of high and sufficient levels of formation of the operational component of professionally-oriented mathematical competence are 24.11% more than in the control group.

The correlation between the formed operational and activity component of professionally oriented mathematical competence of future engineers and the results of studying the discipline of TOE is checked. For the experimental group, the correlation was statistically significant. Therefore, we can say about the effectiveness of the proposed method of fundamentalization of mathematical training of future technicians.

We see further research in this direction in the experimental verification of the formation of the cognitive component of professionally oriented mathematical competence, which is formed in the process of fundamentalization of mathematical training of future technicians.

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