STATISTICAL ANALYSIS OF THE RESULTS OF PEDAGOGICAL EXPERIMENTS ON THE DEVELOPMENT OF PROFESSIONAL COMPETENCIES OF STUDENTS ON THE BASIS OF AN INTEGRATIVE APPROACH

Ismoilov Elmurod Olloberdi o'g'li
Teacher of Tashkent State Pedagogical University named after Nizami
Tashkent city, Republic of Uzbekistan
E-mail: elmurodismoilov170191@mail.ru

Abstract. The article provides a statistical analysis of the results of pedagogical experiments conducted on the development of professional competencies of students on the basis of an integrative approach. Based on the statistical analysis of the results of pedagogical experiments, teachers were recommended to teach mathematics and specialty subjects on the basis of an integrative approach in the formation of professional competencies in students.

Keywords: competence, professional competence, integration, integrative approach, pedagogical experimentation, McNamara criterion, career-oriented tasks.

Competence in terms of the requirements for the level of professional training of graduates of higher education institutions means the ability of the future specialist to apply a set of knowledge, skills and abilities, methods of activity in certain situations. From the point of view of pedagogical activity, competence is the ability to establish a link between knowledge and situation, or in a broad sense, to show the process (action and knowledge) needed to solve a problem. Integration is the process by which different parts of a system, a whole organism, are interconnected and produce the same condition. Integrated science teaching allows for the simultaneous and interconnected study of related topics. Integration in the educational process is a specific and interdisciplinary approach, and its implementation in the classroom is an integrative approach. An integrative approach is used to integrate content that is relevant, relevant, logically interdependent, and deepens and expands. In the implementation of the integration of mathematics and specialty sciences, pedagogical experiments were conducted to quantitatively and qualitatively assess the methodology we have developed. The purpose of pedagogical experiments is to improve the theoretical methodology of developing students' professional competencies on the basis of career-oriented tasks. 293 students of Samarkand State University, Bukhara State University and Tashkent State Pedagogical University (12 groups in total: 6 experiments and 6 control groups) took part in pedagogical experiments (see Table 1):

Table 1.

Number of students in the experimental and control groups of higher education institutions where pedagogical experiments were conducted

№	Educational institutions	Number of students in the experimental group	Number of students in the control group	Total number of students
1.	Samarkand State University	48	45	93
2.	Bukhara State University	50	51	101
3.	Tashkent State Pedagogical University	48	51	99
General		146	147	293

Model of development of professional competence of students on the basis of integration of mathematics with general and specialized disciplines in higher education institutions

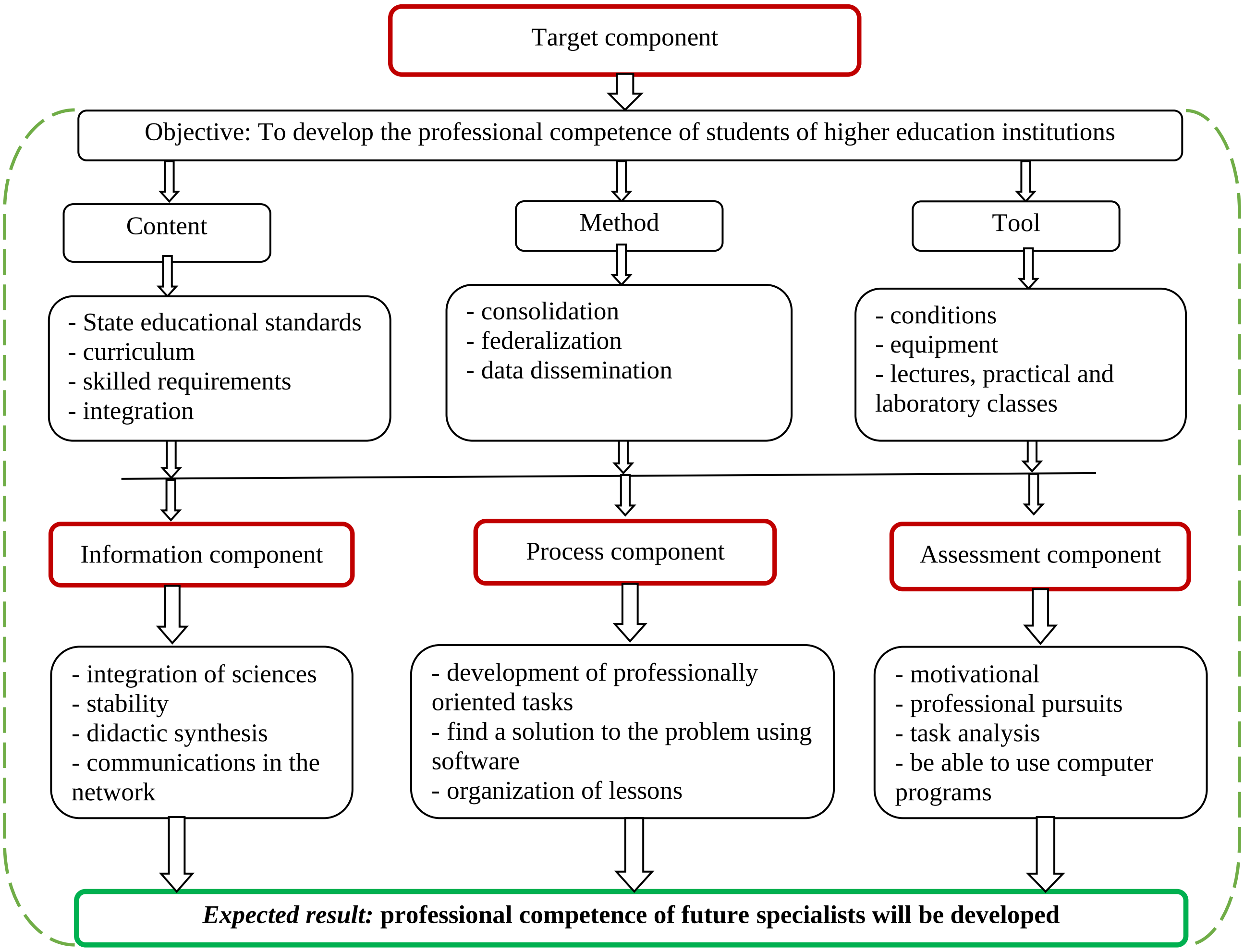

Figure 1. Structural-functional model of developing students' professional competence.

The nature of the effect of the developed methodology on the study of mathematics, which increases the activity and independence of students, was studied using the McNamar criterion. To apply the criterion, 75 students were randomly selected from 146 students in the experimental group. The results of the answer to the question twice (before applying the test method and at the end of the experiment) were evaluated according to the names that had 2 categories. It was necessary to ensure that the members of the experimental group did not interfere with each other in the process of answering the questions, and that the samples were self-contained in the first and second surveys (same students answered twice). During the experiment, while answering the question of whether mathematical knowledge can help to acquire professional skills, students were introduced to the motivations manifested in acknowledging the need to learn more about mathematics and use mathematics for professional activities. Student responses were rated in two categories - “0” (no) or “1” (yes). Before the start of the pedagogical experiment, 30 people (40% of respondents) answered the proposed question in the affirmative, and at the end of the experiment, 58 people (77.3% of respondents) answered in the affirmative. The initial responses of the students in this survey were defined as the x (first query) values of the variables $x_1, x_2, x_3, \dots, x_{22}$, and the results of the experiment were marked as the y (second query) values of the variables $y_1, y_2, y_3, \dots, y_{22}$. If we define the answers of each student to the question as pairs, respectively, then the answers of one student can be of the following four types: (0;0), (0;1), (1;0) and (1;1). The number of these pairs is denoted by (0; 0) -a, (0; 1) -b, (1; 0) -c, (1; 1) -d (see Table 2):

Table 2.

The results of the experiment conducted twice

(x_i,y_i)	“0” (no)	“1” (yes)

"0" (no)	$a = 17$	$b = 28$
"1" (yes)	$c = 0$	$d = 30$

$H_0: P(x_i = 0; y_i = 1) = P(x_i = 1; y_i = 0)$ is obtained for any value as the hypothesis of zero. The laws of X and Y distribution are the same and the teaching methodology used does not affect students 'interest in learning mathematics. If b> c, the alternative hypothesis has a value, for any value of which is
$H_1: P(x_i = 0; y_i = 1) \neq P(x_i = 1; y_i = 0)$.
The X and Y distribution laws are different, differing essentially the same before and after applying the new teaching method. Since $N = b + c = 28$ the criterion statistic will be $T2 = min(28,0) = 0$. If the hypothesis H_0 is true, the statistics of the criterion T2 are distributed by $p = 0.5$. Therefore, the probability of the appearance of the value of $P - \text{T2} < \text{T2}$ for $b = 28$ in the table is 0. $P(\text{T2} < 0) = 0.001$. The probability obtained was $0.001 < 0.025 = \frac{0.05}{2}$ so at the level of meaning $a = 0.05$ the hypothesis H_0 was rejected and the alternative hypothesis H_1 was accepted. That is, students' interest in learning mathematics is significantly different before and after the proposed methodology, and the dynamics of the changing motivational attitudes are positive. Given the positive dynamics of this motivational attitude, we present a statistical analysis of the results obtained in pedagogical experiments using the χ^2 criterion. In order to calculate the results of pedagogical experiments and compare the mastery of the experimental and control groups, we determine the average value of the mastering score in groups with $X = \frac{\sum_{i=1}^{k} x_i m_i}{N}$. In this case, x_i is an indicator of mastery achieved as a result of pedagogical experience, which can take values such as 2,3,4,5; m_i is the number of repetitions of the grades obtained in the process of mastering; N the number of students participating in the pedagogical experiment. The efficiency coefficient $\eta = \frac{X_E^*}{X_C^*}$ is determined based on the ratio of the arithmetic mean values of the assessments of the experimental and control groups that assess the effectiveness of the training. Where X_E^* is the experimental group and X_C^* is the arithmetic mean of the control group mastery values. The obtained results were analyzed on the basis of K. Pearson's χ^2 (xi square) criterion and appropriate conclusions were drawn. In applying this criterion, there is no significant difference between the two sampling taken as the H_0 hypothesis, i.e., the learning process in the control groups does not affect the learning process in the experimental groups. There is a significant difference between the samplings obtained as an alternative hypothesis H_1, i.e. there is a significant difference in the teaching process in the experimental groups from the teaching process in the control groups. According to the H_0 hypothesis, the expected probability in the control and experimental groups is equal ($p_{11} = p_{21}, p_{12} = p_{22}, \ldots, p_{1c} = p_{2c}$), and according to the H_1 hypothesis, the expected probability in the control and experimental groups is not equal ($p_{11} \neq p_{21}, p_{12} \neq p_{22}, \ldots, p_{1c} \neq p_{2c}$). Here we find the observed value of the Pearson criterion: $x_{obs.}^2 = \sum (n_i - n_i')^2 / n_i'$. Where $x_{obs.}^2$ is a static value. n_i and n_i' are the number of students in the control and experimental groups who participated in pedagogical experiments on the types of assessment, the value of $x_{obs.}^2$ is compared with the value of $x_{crit.}^2$. If $x_{obs.}^2 > x_{crit.}^2$, the H_0 hypothesis is rejected and the H_1 hypothesis is accepted. Here $x_{crit.}^2$ is determined on the basis of the probability of normalized confidence p. The degree of freedom is found by the formula $K = C - 1$. C indicates the types of assessments. The results of the χ^2 criterion are equal to $C = 4$, as they were conducted on the basis of 4 types of assessments in the selected control and experimental group students. In this case, if we assume that $p = 0.05$, then $K = C - 1 = 4 - 1 = 3$, and $x_{crit.}^2$ obtained from the table χ^2 is equal to 7.815. Table 3 shows the test results obtained from students at the beginning of the experiment. Based on the data in this table, we examine whether there are differences between the experimental and control groups and whether there is a difference in the knowledge levels of the selected groups.

Table 3.

Test results

№		Groups		Evaluation levels

	Educational		Number of	«2»	«3»	«4»	«5»
1.	Samarkand State University	**Experimental group**	48	**12**	**25**	**10**	**1**
		Control group	45	**12**	**23**	8	2
2.	Bukhara State University	**Experimental group**	50	**14**	**24**	**10**	**2**
		Control group	**51**	**13**	**25**	11	2
3.	Tashkent State Pedagogical University	**Experimental group**	48	**13**	**23**	**10**	**2**
		Control group	51	**14**	**24**	11	2
General		**Experimental group**	146	**39**	**72**	**30**	**5**
		Control group	**147**	**39**	**72**	30	6

To do this, we calculate the values corresponding to the results obtained by the groups selected at Samarkand State University.

1. In order to compare the mastery of the experimental and control groups, we find the average value of the mastering score in the groups:

For the experimental group: $X_E^* = \frac{\sum_{i=1}^{k} x_i m_i}{N} = \frac{12\cdot 2+25\cdot 3+10\cdot 4+1\cdot 5}{48} = \frac{144}{48} = 3.00.$

For the control group: $X_C^* = \frac{\sum_{i=1}^{k} x_i m_i}{N} = \frac{12\cdot 2+23\cdot 3+8\cdot 4+2\cdot 5}{45} = \frac{135}{45} = 3.00.$

2. Based on the ratio of the arithmetic mean values of the experimental and control group assessments, the coefficient of effectiveness that assessed the increase in teaching effectiveness was determined: $\eta = \frac{X_E^*}{X_C^*} = \frac{3.00}{3.00} = 1.00.$

3. To test the hypotheses, we find the observational value of the Pearson criterion (see Table 4):

Table 4.

Pearson criterion

I	n_i- control group	n_i'- experimental group	$n_i - n_i'$	$(n_i - n_i')^2$	$(n_i - n_i')^2/n_i'$
2	12	12	0	0	0.00
3	23	25	-2	4	0.16
4	8	10	-2	4	0.40
5	2	1	1	1	1.00
Σ	45	48			1.56

From this table we find the observed value of the Pearson criterion

$x_{obs.}^2 = 1.56$ and $x_{crit.}^2 = 7.815$.

Since $x_{obs.}^2 < x_{crit.}^2$ there is no reason to reject the H_0 hypothesis. Therefore, there is no significant difference between the two sampling obtained as the H_0 hypothesis, i.e., the results obtained in the control groups do not differ from those obtained in the experimental groups, and based on the results, it can be concluded that the students' knowledge levels are the same. Now we present the statistical calculation based on the results obtained in all educational institutions in the following table (see Table 5):

Table 5.

Statistical calculation based on the results obtained in all educational institutions

№	Educational institutions	Groups	Average value	Efficiency	$x_{crit.}^2$	$x_{obs.}^2$	Summary

1.	Samarkand State University	**Experimental group**	3.00	1.00	7.81	1.56	H_0
		Control group	3.00				
2.	Bukhara State University	**Experimental group**	3.00	0.99	7.81	0.21	H_0
		Control group	**3.04**				
3.	Tashkent State Pedagogical University	**Experimental group**	3.02	1.00	7.81	0.22	H_0
		Control group	3.02				
General		**Experimental group**	3.01	1.00	7.81	0.20	$\boldsymbol{H_0}$
		Control group	**3.02**				

According to the result of the statistical values in the table and the conclusion of the criterion $x^2_{obs.} = 0.20$ and $x^2_{crit.} = 7.81$. Therefore, the fact that $x^2_{obs.} < x^2_{crit.}$ leads to the conclusion that students in both groups have the same level of knowledge, the method is not effective, and the hypothesis H_0 is accepted.

During the pedagogical experiment, independent work was carried out for control and experimental groups on various topics (see Table 6):

Table 6.

The results of independent work carried out during the pedagogical experiment

№	Educational institutions	Groups	Number of students	Evaluation levels		
				«3»	«4»	«5»
1.	Samarkand State University	**Experimental group**	48	**5**	**30**	**13**
		Control group	45	**19**	19	7
2.	Bukhara State University	**Experimental group**	50	**9**	**26**	**15**
		Control group	**51**	**22**	21	8
3.	Tashkent State Pedagogical University	**Experimental group**	48	**9**	**24**	**15**
		Control group	51	**23**	19	9
General		**Experimental group**	146	**23**	**80**	**43**
		Control group	**147**	**64**	59	24

In Table 7, we present the calculations on the results of independent work performed during the pedagogical experiment on the Pearson criterion. In the evaluation of independent work, there are 3 types of assessment, that is, the results of the criterion χ^2 are made on the basis of 3 types of assessment in students of the selected control and experimental group, so $C = 3$. In this case, if we assume that $p = 0.05$, then $K = C - 1 = 3 - 1 = 2$, and $x^2_{crit.}$ obtained on the basis of the table χ^2 is equal to 5.99.

The calculations on the results of independent work performed during the pedagogical experiment are given in the following table (see Table 7):

Table 7.

The effectiveness of independent learning conducted during a pedagogical experiment

№	Educational institutions	Groups	Average value	Efficiency	$x^2_{crit.}$	$x^2_{obs.}$	Summary
1.	Samarkand State University	**Experimental group**	4.17	1.12	5.99	46.00	H_1
		Control group	3.73				
2.	Bukhara State University	**Experimental group**	4.12	1.11	5.99	23.01	H_1
		Control group	**3.73**				
3.	Tashkent State Pedagogical University	**Experimental group**	4.13	1.11	5.99	25.22	H_1
		Control group	3.73				
General		**Experimental group**	4.14	1.11	5.99	89.99	$\boldsymbol{H_1}$
		Control group	**3.73**				

Hence, according to the statistical calculation of the results obtained from the organization and conduct of independent work in groups participating in the pedagogical experiment, $x^2_{obs.} = 89.99$ and $x^2_{crit.} = 5.99$. Since $x^2_{obs.} > x^2_{crit.}$, it is efficient to organize and conduct independent work in experimental groups, which leads to the rejection of the H_0 hypothesis and the acceptance of the H_1 hypothesis.
The diagram of the average values in the experimental and control groups on these calculations takes the following view (see Figure 2):

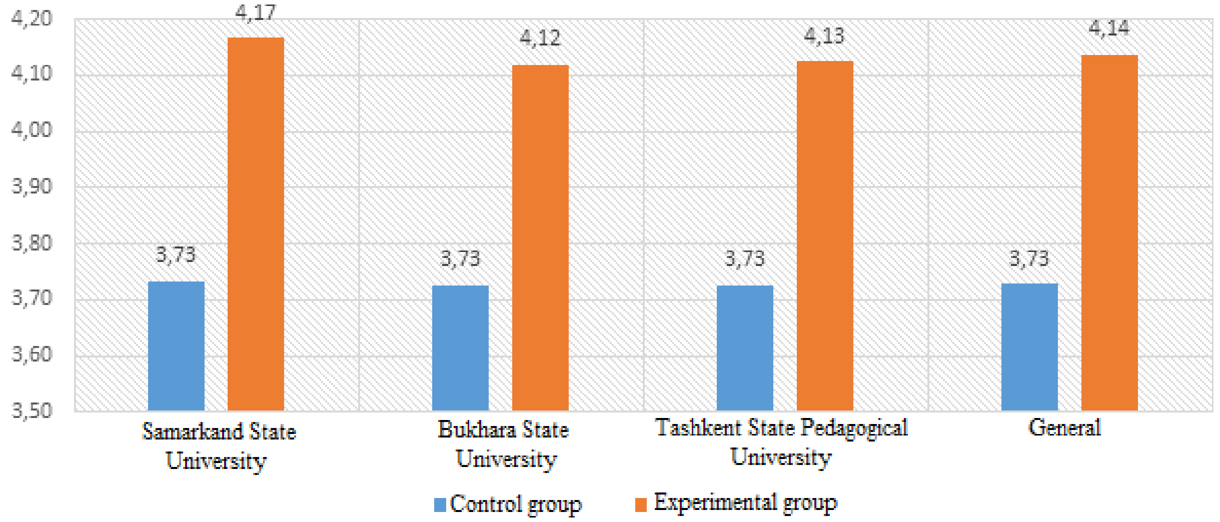

Figure 2. Diagram of average values of experimental and control groups on the organization of independent work.
We consider a statistical analysis of the results obtained from the main indicators of the level of education of students. According to it, each level of education is evaluated on the basis of a five-point system: 1 point for knowledge acquired on the level of separation, recognition (level of acquaintance), 2 points for knowledge acquired on the level of forgetting (reprocessing), level of comprehension (conscious repetition) 3 points for the acquired knowledge, 4 points for the acquired knowledge at the level of basic skills (reproductive level), 5 points for the acquired knowledge at the level of transfer (creative degree) and their results are given in Table 8.

Table 8.

Levels of students' mastery of mathematical knowledge

Evaluation indicators	Experimental group		Control group	
	Control 1	Control 2	Control 1	Control 2
2 points	10	3	13	11
3 points	72	30	70	70
4 points	51	81	50	52
5 points	13	32	14	14

Since there are five types of assessments in this table (there is also a 1-point indicator), the χ^2 criterion was conducted on the basis of 5 types of assessments in the selected control and experimental group students, i.e., C = 5. In this case, if we take $p = 0.05$, $K = C - 1 = 5 - 1 = 4$, and $x^2_{crit.}$ obtained on the basis of the table χ^2 is equal to 9.49.

The following table shows the calculations made during the pedagogical experiment to determine the main indicators of the level of education of students (see Table 9):

Table 9.

Basic indicators of students' education levels

№	Educational institutions	Groups	Average value	Efficiency	$x^2_{crit.}$	$x^2_{obs.}$	Summary
1.	Samarkand State University	**Experimental group**	3.77	1.13	9.49	12.49	H_1
		Control group	3.33				
2.	Bukhara State University	**Experimental group**	3.86	1.14	9.49	25.43	H_1
		Control group	**3.37**				
3.	Tashkent State Pedagogical University	**Experimental group**	3.77	1.14	9.49	21.07	H_1
		Control group	3.31				
General		**Experimental group**	3.80	1.14	9.49	53.53	$\boldsymbol{H_1}$
		Control group	**3.34**				

Hence, according to the statistical calculation of determining the main indicators on the level of education in the groups participating in the pedagogical experiment, $x^2_{obs.} = 53.53$ and $x^2_{crit.} = 9.49$. Since $x^2_{obs.} > x^2_{crit.}$, the results obtained are effective in determining key indicators of education levels in the experimental groups, which leads to the rejection of the H_0 hypothesis and the acceptance of the H_1 hypothesis. The number of grades given to these students by level of education takes the form of the following diagram (see Figure 3):

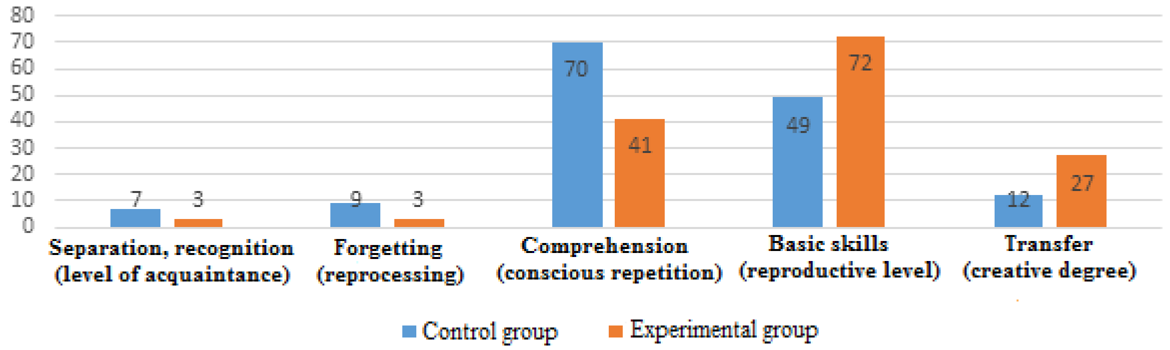

Figure 3. Number of assessments by education level.

It can be seen from this diagram that the fourth and fifth level knowledge indicators of the experimental groups are higher than those of the control groups, which indicates that the quality of knowledge acquisition of the experimental groups is high. This means that the statistical observation value is greater than the critical value. In turn, this proves that the effectiveness of teaching in experimental groups is high.

Table 8 shows the results of the control work conducted to determine the level of mathematical knowledge of students in the experimental and control groups. Its statistical analysis is presented in the following table (see Table 10):

Table 10.

The level of mastery of mathematical knowledge by students of experimental and control groups

№	Educational institutions	Groups	Average value		Efficiency		$x^2_{crit.}$	$x^2_{obs.}$		Summary	
			Control 1	Control 2	Control 1	Control 2		Control 1	Control 2	Control 1	Control 2
1.	Samarkand State University	**Experimental group**	3.50	4.04	1.01	1.14	7.81	0.74	29.79	H_0	H_1
		Control group	3.47	3.53							
2.	Bukhara State University	**Experimental group**	3.42	3.92	1.01	1.15	7.81	0.25	32.64	H_0	H_1
		Control group	**3.39**	**3.41**							
3.	Tashkent State Pedagogical University	**Experimental group**	3.46	3.96	1.00	1.14	7.81	0.25	34.10	H_0	H_1
		Control group	3.47	3.47							
General		**Experimental group**	3.46	3.97	1.00	1.15	7.81	1.05	95.17	$\boldsymbol{H_0}$	$\boldsymbol{H_1}$
		Control group	**3.44**	**3.47**							

Hence, according to the statistical calculation of the indicators of control type 1 according to the obtained results, since $x^2_{obs.} = 1.05$ and $x^2_{crit.} = 7.81$, $x^2_{obs.} < x^2_{crit.}$, knowledge indicators in the experimental and control groups are almost indistinguishable. There is therefore no basis for rejecting the H_0 hypothesis. According to the statistical calculation of the indicators of the control type 2, since $x^2_{obs.} = 95.17$ and $x^2_{crit.} = 7.81$, $x^2_{obs.} > x^2_{crit.}$, in the experimental and control groups there is a difference in cognitive indicators, which leads to the rejection of the H_0 hypothesis and leads to the acceptance of the H_1 hypothesis. It shows that its efficiency is on average 15% higher (see Figure 4).

At the end of the experiment, we look at the calculations based on the results of the final control work presented in Table 11 (see Table 12):

Table 11.

Results of final control work

№	Educational institutions	Groups	Number of students	Evaluation levels			
				«2»	«3»	«4»	«5»
1.	Samarkand State University	**Experimental**	48	**1**	**9**	**29**	**9**
		Control group	45	**4**	**21**	17	3
2.	Bukhara State University	**Experimental**	50	**1**	**11**	**28**	**10**
		Control group	**51**	**4**	**26**	18	3
3.	Tashkent State Pedagogical University	**Experimental**	48	**1**	**11**	**28**	**8**
		Control group	51	**4**	**26**	18	3
General		**Experimental group**	146	**3**	**31**	**85**	**27**
		Control group	**147**	**12**	**73**	53	9

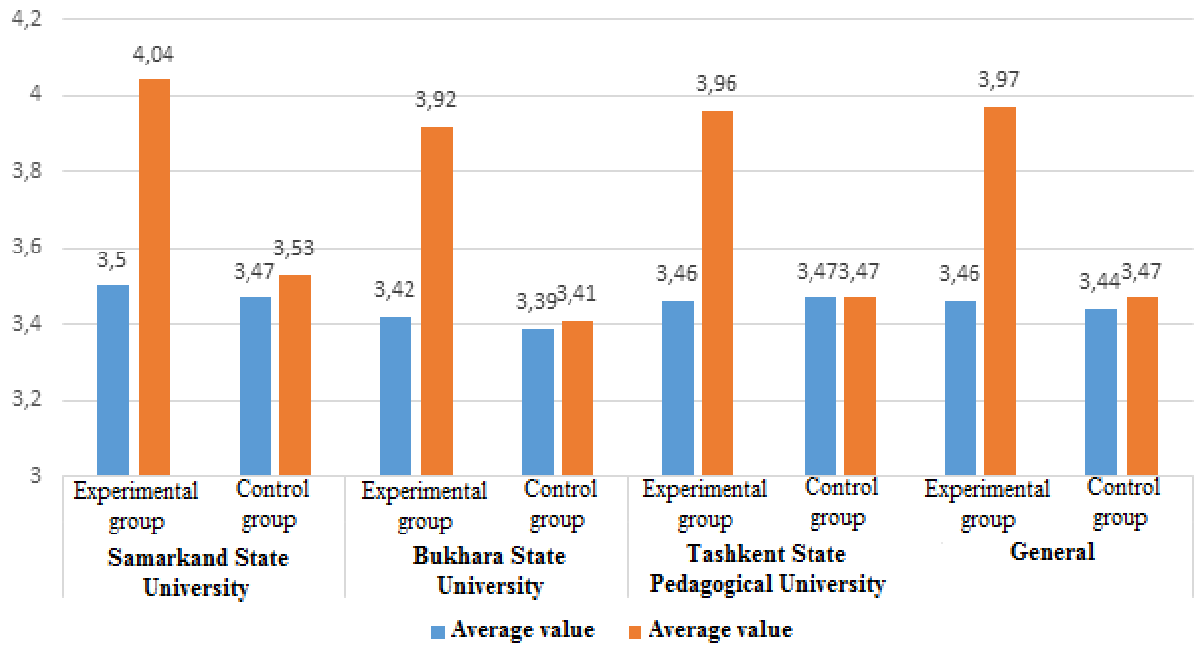

Figure 4. Analysis of the results obtained on control work.

Table 12.

Calculations on the results of the final control work

№	Educational institutions	Groups	Average value	Efficiency	$x^2_{crit.}$	$x^2_{obs.}$	Summary
1.	Samarkand State University	**Experimental group**	3.96	1.16	7.81	33.97	H_1
		Control group	3.42				
2.	Bukhara State University	**Experimental group**	3.94	1.16	7.81	37.93	H_1
		Control group	**3.39**				

3.	Tashkent State Pedagogical University	**Experimental group**	3.90	1.15	7.81	36.15	H_1
		Control group	3.39				
General		**Experimental group**	3.93	1.16	7.81	107.95	$\boldsymbol{H_1}$
		Control group	**3.40**				

Therefore, according to the results obtained, since $x^2_{obs.} = 107.95$ and $x^2_{crit.} = 7.81$, $x^2_{obs.} > x^2_{crit.}$, the difference in knowledge in the experimental and control groups existing, which leads to the rejection of the H_0 hypothesis and the acceptance of the H_1 hypothesis. It shows that its efficiency is on average 16% higher (see Figure 5):

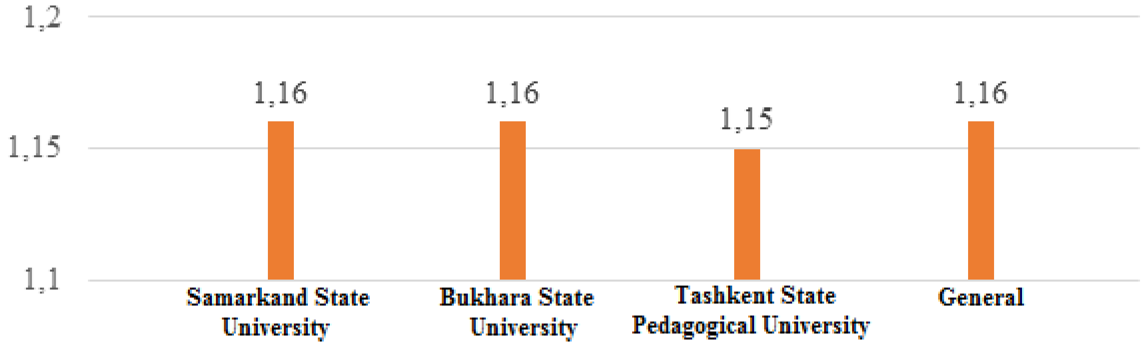

Figure 5. Effectiveness of knowledge indicators in experimental and control groups.

The positive results of the pedagogical experience helped us to conclude that the developed methodology contributes to the development of professional competencies, ie the formation of professional knowledge based on the integration of mathematics and specialty sciences. The following conclusions can be drawn from research on the teaching of mathematics based on its integration with the special disciplines:

- The role and importance of career-oriented tasks in the development of professional competencies of students is enormous.
- It is necessary to develop a set of career-oriented tasks that combine mathematics and specialty sciences in each specialty. Based on them, the methodology for developing students' professional competencies should be improved through consolidation (consolidation), federalization (generalization) and data dissemination methods.
- The use of computer programs (MathLAB, MathCAD, MapleV, AutoCAD and C++) in career-oriented tasks and their solution in practical training is the basis for students to consciously understand the need for in-depth study of mathematics and information technology to acquire professional competencies.

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