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Effectiveness and Statistical Analysis of Mobile Education Methods

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Abstract: In this article, the processes of forming students' knowledge about "Informatics and information technologies", the effectiveness of using the system of mobile education methods, and statistical analyzes are described in detail. in the course of teaching, the numerical data obtained to determine the levels of formation of their basic and general (subject-related) knowledge with the help of mobile software tools were analyzed by the Student method. Student-Fisher mathematical-statistics was used to check the validity of the general indicators obtained as a result of experimental work and differences, and quantitative criteria indicators were presented.

Keywords: Computers, interpolators, analysis of mathematical statistics, mean value, dispersion, variational series, experimental tests, experimental group, control group, *Xi*-square criterion (criterion).

Introduction

The purpose of the discipline "Computer science and information technology", taught in comprehensive schools, is to provide fundamental knowledge in computer science, implement it with the help of software tools aimed at forming subject competencies of educational institutions by developing general knowledge, skills and abilities, provide an opportunity to successfully integrate some features of research, interdisciplinary, information design, Through the discipline "Computer science and information technology" the development of a scientific worldview and the ability to philosophical observation, the identification of the dialectical relationship between theory and practice, the ability to apply the acquired knowledge in their future professional activities and in life creates a large basis and allows you to correctly formulate ideas about the role of this knowledge. However, the educational process does not always give the expected results.

The experimental testing work was carried out in three stages during the 2020-2023 academic year.

The formative stage of the experimental work was carried out in the process of forming competencies in the subject "Computer Science and Information Technology" based on mobile educational technologies among 11^{th} grade students of comprehensive school № 8 in Chirchik, Tashkent region, comprehensive school № 11 in Bulungur district, Samarkand region, comprehensive school № 3 in Khatyrchi district, Navoi region. Experimental sites were selected and planned work was carried out.

In order to determine the effectiveness of the experimental and test work, respondents were assigned to experimental and control groups. Based on the methodology that promotes the formation of subject competencies of students in the experimental group based on mobile educational technologies, practical activities were established, and in the control groups, the educational process was organized in the traditional order. The results of the experimental and control groups were systematically analyzed at the end of each academic year and compared with each other to draw conclusions.

To determine the effectiveness of teaching the subject “Computer Science and Information Technology” based on mobile software and new pedagogical technologies, the results of final questions, tests and summarizing classes of students were analyzed in terms of quality and quantity on an experimental and testing basis.

The use of mobile technologies in teaching students of comprehensive schools the subject "Computer Science and Information Technology" in the course of experimental work determined the levels of formation of their basic and general competencies based on the established criteria and levels. The analysis of the pedagogical

experiment-control work was initially studied separately for each comprehensive school. Then all the results were summarized and a mathematical and statistical analysis was carried out (Tables 1, 2, 3).

In secondary comprehensive school № 8 in Chirchik, Tashkent region (2020-2023 academic year), pedagogical experimental and test work was carried out on 147 students from the experimental group and 144 students from the control group in parallel. During the experimental work, the levels of formation of basic and general competencies in students of comprehensive schools of the subject "Computer Science and Information Technology" with the help of mobile software were identified and the effectiveness of the experimental work was determined mathematically and statistically (Table 1).

Table 1 Results of pedagogical experimental work conducted in secondary comprehensive school № 8 of the city of Chirchik, Tashkent region

The level of formation of students' subject competencies using mobile technologies	Experimental group				Control group			
	147 students at the beginning of the experiment		147 students at the end of the experiment		144 students at the beginning of the experiment		144 students at the end of the experiment	
	amt	%	amt	%	amt	%	amt	%
High	23	15,6	40	27,2	23	16,0	24	16,7
Medium	35	23,8	62	42,2	32	22,2	34	23,6
Low	89	60,5	45	30,6	89	61,8	86	59,7
Total	**147**	**100**	**147**	**100**	**144**	**100**	**144**	**100**

In the process of teaching students of comprehensive schools the subject "Computer Science and Information Technology" who participated in the experimental group, the level of formation of their basic and general (subject) competencies with the help of mobile software showed a high level of 15.6% at the beginning of the experiment and 27.2% at the end of the experiment. The average level increased from 23.8% at the beginning of the experiment to 42.2% at the end of the experiment, and the low level decreased from 60.5% to 30.6%. [4].

In the process of teaching students of comprehensive schools the subject “Computer Science and Information Technology” who participated in the control group, the level of formation of their basic and general (subject) competencies using mobile software showed a high level of 16% at the beginning of the experiment and 16.7% at the end of the experiment. The average level increased from 22.2% at the beginning of the experiment to 23.6% at the end of the experiment, and the low level decreased from 61.8% to 59.7%.

In secondary comprehensive school № 11 of the Bulungur district of the Samarkand region (2020-2023 academic year), pedagogical experimental and test work was carried out on 133 students from the experimental group and 136 students from the control group in parallel.

During the experimental work, the levels of formation of basic and general competencies in students of comprehensive secondary schools of the subject "Computer Science and Information Technology" with the help of mobile technologies were identified and the effectiveness of the experimental work was determined mathematically and statistically (Table.2).

Table.2 Results of pedagogical experimental work conducted in comprehensive school № 11 of Bulungur district of Samarkand region

The level of formation of students' subject competencies using mobile technologies	Experimental group				Control group			
	133 students at the beginning of the experiment		133 students at the end of the experiment		136 students at the beginning of the experiment		136 students at the end of the experiment	
	amt	%	amt	%	amt	%	amt	%
High	16	12,0	31	23,3	16	11,8	19	14,0
Medium	28	21,1	59	44,4	24	17,6	27	19,9
Low	89	66,9	43	32,3	96	70,6	90	66,2
Total	**133**	**100**	**133**	**100**	**136**	**100**	**136**	**100**

In the process of teaching students of comprehensive schools the subject "Computer Science and Information Technology" who participated in the experimental group, the level of formation of their basic and general (subject) competencies with the help of mobile software showed a high level of 12% at the beginning of the experiment and 23.3% at the end of the experiment. The average level increased from 21.1% at the beginning of the experiment to 44.4% at the end of the experiment, and the low level decreased from 66.9% to 32.3%. In the process of teaching students of comprehensive schools who participated in the control group in the subject "Computer Science and Information Technology", the level of formation of their basic and general (subject) competencies with the help of mobile software showed a high level of 11.8% at the beginning of the experiment and 14% at the end of the experiment. The average level increased from 17.6% at the beginning of the experiment to 19.9% at the end of the experiment, and the low level decreased from 70.6% to 66.2%.

In secondary comprehensive school № 3 of Khatyrchi district of Navoi region (2020-2023 academic year), pedagogical experimental and test works were carried out on 118 students from the experimental group and 122 students from the control group in parallel. During the experimental work, the levels of formation of basic and general competencies of students of comprehensive schools of the subject "Computer Science and Information Technology" with the help of mobile software were identified and the effectiveness of the experimental work was determined mathematically and statistically (Table 3).

Table 3 Results of pedagogical experimental work conducted in secondary comprehensive school № 3 of Khatyrchinsky district of Navoi region

The level of formation of students' subject competencies using mobile technologies	Experimental group				Control group			
	118 students at the beginning of the experiment		118 students at the end of the experiment		122 students at the beginning of the experiment		122 students at the end of the experiment	
	amt	%	amt	%	amt	%	amt	%
High	15	12,7	29	24,6	18	14,8	19	15,6
Medium	21	17,8	51	43,2	23	18,9	26	21,3
Low	82	69,5	38	32,2	81	66,4	77	63,1

Total	**118**	**100**	**118**	**100**	**122**	**100**	**122**	**100**

In the process of teaching students of comprehensive schools on the subject “Computer Science and Information Technology” who participated in the experimental group, the level of formation of their basic and general (subject) competencies with the help of mobile software showed a high level of 12.7% at the beginning of the experiment and 24.6% at the end of the experiment. The average level increased from 17.8% at the beginning of the experiment to 43.2% at the end of the experiment, and the low level decreased from 69.5% to 32.2.

In the process of teaching students of comprehensive schools who participated in the control group in the subject “Computer Science and Information Technology”, the level of formation of their basic and general (subject) competencies with the help of mobile software showed a high level of 14.8% at the beginning of the experiment and 15.6% at the end of the experiment. The average level increased from 18.9% at the beginning of the experiment to 21.3% at the end of the experiment, and the low level decreased from 66.4% to 63.1%.

The pedagogical experimental work was carried out for three years in 2020-2021, 2021-2022 and 2022-2023 in secondary comprehensive school № 8 in Chirchik, Tashkent region, secondary comprehensive school № 11 in Bulungur district, Samarkand region, secondary comprehensive school № 3 in Khatyrchi district, Navoi region. In the experimental group (EG) - 398 students and the control group (CG) - 402 students, the levels of formation of subject competencies were determined using mobile software and the effectiveness of the experimental work was determined mathematically and statistically (Table 4).

Table 4 Results of the conducted pedagogical experimental and test work

The level of formation of students' subject competencies using mobile technologies	Experimental group				Control group			
	398 students at the beginning of the experiment		398 students at the end of the experiment		402 students at the beginning of the experiment		402 students at the end of the experiment	
	amt	%	amt	%	amt	%	amt	%
High	54	13,6	100	25,1	57	14,2	62	15,4
Medium	84	21,1	172	43,2	79	19,7	87	21,6
Low	260	65,3	126	31,7	266	66,2	253	62,9
Total	**398**	**100**	**398**	**100**	**402**	**100**	**402**	**100**

In the process of teaching students of comprehensive schools the subject "Computer Science and Information Technology" who participated in the experimental group, the level of formation of their basic and general (subject) competencies with the help of mobile software showed a high level of 13.6% at the beginning of the experiment and 25.1% at the end of the experiment. The average level increased from 21.1% at the beginning of the experiment to 43.2% at the end of the experiment, and the low level decreased from 65.3% to 31.7%.

In the process of teaching students of comprehensive schools who participated in the control group in the subject "Computer Science and Information Technology", the level of formation of their basic and general (subject) competencies with the help of mobile software showed a high level of 14.2% at the beginning of the experiment and 15.4% at the end of the experiment. The average level increased from 19.7% at the beginning of the experiment to 21.6% at the end of the experiment, and the low level decreased from 66.2% to 62.9%. [6].

In the process of teaching students of each comprehensive school on the subject “Computer Science and Information Technology”, the obtained numerical data were analyzed to determine the levels of formation of their basic and general (subject) competencies using mobile software using the student method. The numerical data in Table 3.2.4 were subjected to an in-depth comparative analysis using the Student method. For an in-

depth comparative analysis, the corresponding notations and formulas were used. Based on these data, we introduced the following notations:

Designations:

x_i – scores corresponding to the experimental group, i = $\overline{3,5}$;

y_i – scores corresponding to the control group;

$\bar{x}$ and $\bar{y}$ – the corresponding arithmetic mean values for the experimental and control groups.

$$\bar{x} = \frac{\sum x_i m_i}{m}; \qquad \bar{y} = \frac{\sum y_i n_i}{n}, \tag{1}$$

here: x_i, y_i – takes values 3, 4, 5 respectively.

m, n – number of students in the experimental-control group.

m_i, n_i – number of students compared to appropriate grades.

The average value, assessing the effectiveness of the educational process, is the ratio of the average arithmetic values of the assessments of the experimental and control groups, i.e. the efficiency coefficient is obtained as follows:

$$\eta = \frac{\bar{x}}{\bar{y}} \tag{2}$$

Mean squared deviation values:

$$S_x^2 = \frac{1}{m}\sum_i m_i \cdot (x_i - \bar{x})^2; \qquad S_y^2 = \frac{1}{n}\sum_i n_i \cdot (y_i - \bar{y})^2. \tag{3}$$

Standard deviation values:

$$S_x = \sqrt{S_x^2}; \qquad S_y = \sqrt{S_y^2}. \tag{4}$$

Average value determination indicator:

$$C_x = \frac{S_x}{\sqrt{m} \cdot \bar{x}} \cdot 100\,\%; \qquad C_y = \frac{S_y}{\sqrt{n} \cdot \bar{y}} \cdot 100\,\%. \tag{5}$$

Confidence intervals for unknown means of the underlying set:

$$a_x \in \left[\bar{x} - \frac{t}{\sqrt{m}} \cdot S_x; \bar{x} + \frac{t}{\sqrt{m}} \cdot S_x\right];$$
$$a_y \in \left[\bar{y} - \frac{t}{\sqrt{n}} \cdot S_y; \bar{y} + \frac{t}{\sqrt{n}} \cdot S_y\right], \tag{6}$$

here: t – normalized deviation is determined based on the confidence probability P. For example, t=1,96 when P=0,95.

When we hypothesize the equality of means H_0: $a_x = a_y$, we test it using Student's t-statistics based on the data above, which is the opposite of H_1: $a_x \neq a_y$.

$$T_{m,n} = \frac{\left|\overline{y} - \overline{x}\right|}{\sqrt{\frac{S_x^2}{m} + \frac{S_y^2}{n}}}. \qquad (7)$$

If T > Tp = t, hypothesis H_0 is rejected and hypothesis H_1 is accepted.

Based on these data, we will conduct a calculation for each academic year of the analysis of pedagogical experimental work and conduct a comparative analysis.

In this study, the initial assessment of the assessment system was carried out at the beginning of the experiment, and students were assessed using a test based on the knowledge obtained in the educational institution and the initial knowledge obtained during the academic year. At the end of the experiment, however, students' knowledge was determined through written and oral assessments on general subject topics. [5].

General comparative analysis of the results of the experiment for the 2020-2023 academic years, here:

m =398, n =402 – number of students in the experimental and control group.

б – at the beginning of the experiment; о – at the end of the experiment

$$\overline{x_б} = \frac{1}{398} \cdot (54 \cdot 5 + 84 \cdot 4 + 260 \cdot 3) = 3{,}4824$$

$$\overline{y_б} = \frac{1}{402} \cdot (57 \cdot 5 + 79 \cdot 4 + 266 \cdot 3) = 3{,}4801$$

Efficiency coefficient: $\eta_б = \frac{\overline{x_б}}{\overline{y_б}} = \frac{3{,}4824}{3{,}4801} = 1{,}0007.$

Mean squared deviations and standard deviations.

$S_x^2 = \frac{1}{398} \cdot (54 \cdot (5 - 3{,}4824)^2 + 84 \cdot (4 - 3{,}4824)^2 + 260 \cdot (3 - 3{,}4824)^2) = 0{,}521;$

$S_x = \sqrt{S_x^2} = \sqrt{0{,}521} = 0{,}7218;$

$S_y^2 = \frac{1}{402} \cdot (57 \cdot (5 - 3{,}4801)^2 + 79 \cdot (4 - 3{,}4801)^2 + 266 \cdot (3 - 3{,}4801)^2) = 0{,}5332;$

$S_y = \sqrt{S_y^2} = \sqrt{0{,}5332} = 0{,}7302.$

Average values of determination indicators:

$$C_x = \frac{S_x}{\sqrt{398} \cdot 3{,}4824} \cdot 100\% = \frac{0{,}7218}{\sqrt{398} \cdot 3{,}4824} \cdot 100\% = 1{,}039\ \%;$$

$$C_y = \frac{S_y}{\sqrt{402} \cdot 3{,}4801} \cdot 100\% = \frac{0{,}7302}{\sqrt{402} \cdot 3{,}4801} \cdot 100\% = 1{,}0465\ \%;$$

$$\mathrm{a_x} \in \left[3{,}4824 - \frac{1{,}96}{\sqrt{398}} \cdot 0{,}7218;\ 3{,}4824 + \frac{1{,}96}{\sqrt{398}} \cdot 0{,}7218\right] = [3{,}41; 3{,}55];$$

$$a_y \in \left[3{,}4801 - \frac{1{,}96}{\sqrt{402}} \cdot 0{,}7302;\ 3{,}4801 + \frac{1{,}96}{\sqrt{402}} \cdot 0{,}7302\right] = [3{,}41; 3{,}55].$$

Let's look at these calculations, what are the learning outcomes at the end of the experiment (m=398, n=402 - the number of students in the experiment and control group):

$$\overline{x_o} = \frac{1}{398} \cdot (100 \cdot 5 + 172 \cdot 4 + 126 \cdot 3) = 3{,}9347;$$

$$\overline{y_o} = \frac{1}{402} \cdot (62 \cdot 5 + 87 \cdot 4 + 253 \cdot 3) = 3{,}5249.$$

relative growth $\eta_o = \frac{\overline{x_o}}{\overline{y_o}} = \frac{3{,}9347}{3{,}5249} = 1{,}116$.

The study found that the level of knowledge and skills acquired by students in the experimental group as a result of the lessons was ultimately 1.116 times, or approximately 12 percent, higher than in the control group.

If we compare it with the beginning of the experience:

in the experimental group (13%)

$$\eta_m = \frac{\overline{x_o}}{\overline{x_б}} = \frac{3{,}9347}{3{,}4824} = 1{,}13;$$

in the control group (1,3%)

$$\eta_n = \frac{\overline{y_o}}{\overline{y_б}} = \frac{3{,}5249}{3{,}4801} = 1{,}013.$$

efficiency achieved.

Let's calculate the value of the standard deviation to determine the degree of accuracy of the achieved result:

$$S_x^2 = \frac{1}{398} \cdot (100 \cdot (5 - 3{,}9347)^2 + 172 \cdot (4 - 3{,}9347)^2 + 126 \cdot (3 - 3{,}9347)^2) = 0{,}5636;$$

$$S_x = \sqrt{S_x^2} = \sqrt{0{,}5636} = 0{,}7507;$$

$$S_y^2 = \frac{1}{402} \cdot (62 \cdot (5 - 3{,}5249)^2 + 87 \cdot (4 - 3{,}5249)^2 + 253 \cdot (3 - 3{,}5249)^2) = 0{,}5578;$$

$$S_y = \sqrt{S_y^2} = \sqrt{0{,}5578} = 0{,}7469.$$

Average values of determination indicators:

$$C_x = \frac{S_x}{\sqrt{398} \cdot 3{,}9347} \cdot 100\% = \frac{0{,}7507}{\sqrt{266} \cdot 3{,}9347} \cdot 100\% = 0{,}9563\ \%;$$

$$C_y = \frac{S_y}{\sqrt{402} \cdot 3{,}5249} \cdot 100\% = \frac{0{,}7469}{\sqrt{402} \cdot 3{,}5249} \cdot 100\% = 1{,}0568\ \%;$$

$$\mathrm{a_x} \in \left[3{,}9347 - \frac{1{,}96}{\sqrt{398}} \cdot 0{,}7507;\ 3{,}9347 + \frac{1{,}96}{\sqrt{398}} \cdot 0{,}7507\right] = [3{,}86; 4{,}01];$$

$$a_y \in \left[3{,}5249 - \frac{1{,}96}{\sqrt{402}} \cdot 0{,}7469;\ 3{,}5249 + \frac{1{,}96}{\sqrt{402}} \cdot 0{,}7469\right] = [3{,}45; 3{,}60].$$

The estimated indicators identified for the 2020-2023 academic year were calculated mathematically. Based on these results, the following expression was obtained by testing using the Student's t-test.

$$T_m = \frac{|\overline{x_б} - \overline{x_o}|}{\sqrt{\frac{S_{x_б}^2}{m} + \frac{S_{x_o}^2}{m}}}; T_n = \frac{|\overline{y_б} - \overline{y_o}|}{\sqrt{\frac{S_{y_б}^2}{n} + \frac{S_{y_o}^2}{n}}}.$$

Experimental group for the 2020-2023 academic year:

$$\overline{x_б} = 3{,}4824;\ \overline{x_o} = 3{,}9347.$$

efficiency coefficient $\eta_m = 1{,}13$.

$$T_m = \frac{|3{,}4824-3{,}9347|}{\sqrt{\frac{0{,}521+0{,}5636}{398}}} = \frac{0{,}452}{\sqrt{0{,}00273}} = 8{,}664.$$

T_m =8,7 > T 0,96 (t) = 1,96. Therefore, hypothesis H_1 is accepted.

Control group for the 2020-2023 academic year:

$\overline{y_6} = 3{,}4801$ and $\overline{y_0} = 3{,}5249$.

$\eta_n = 1{,}013$ – efficiency coefficient.

$$T_n = \frac{|3{,}4801-3{,}5249|}{\sqrt{\frac{0{,}5332+0{,}5578}{402}}} = \frac{0{,}0448}{\sqrt{0{,}00271}} = 0{,}86.$$

At T_n = 0,86 < 1,96 the hypothesis H_0 is accepted. [4].

To check the conformity and reliability of differences in the general indicators obtained as a result of the experimental work, the Student's t-test mathematical statistics was used, and the indicators of the quantitative criteria are given in Table 5.

Table 5 Quantitative criteria of indicators

№	Indications	At the beginning of the experiment		At the end of the experiment	
		Experimental group m=398	Control group n=402	Experimental group m=398	Control group n=402
1.	Arithmetic mean	3,4824	3,4801	3,9347	3,5249
2.	Identificator efficiency	1,0007 (0,7%)		1,116 (12%)	
3.	Confidence interval of the mean	[3,41;3,55]	[3,41;3,55]	[3,86;4,01]	[3,45;3,60]
4.	Standard error mean	0,7218	0,7302	0,7507	0,7469
5.	Student statistics (t)	0,86 (0,86 < 1,96)		8,66 (8,66 > 1,96)	
6.	Summary of indicators	the H_0 is accepted		the H_1 is accepted	

When determining the validity of pedagogical experimental work and the effectiveness of the developed methodology, it is advisable to use the χ^2 – xi criterion - the square of mathematical statistics.

Conclusion

During the writing of this scientific article, a pedagogical experiment-test consisting of three steps was conducted: experiment-research, experiment-analysis and experiment-test. At the end of the experiment, the following conclusions were reached:

1. In order to improve the quality of the analysis of experimental test results in pedagogical research, an electronic program was developed and introduced into the experimental work. The experimental results were analyzed in MS Excel and MathCAD software.

2. The results of the experimental work show that during the teaching of "Informatics and Information Technologies" to students of the general secondary school, their knowledge of the subject was formed with the help of mobile technologies compared to the control groups 1,116 mathematically and statistically proven to be twice as high (12%).

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