МАТЕМАТИКА И МАТЕМАТИЧЕСКО ОБРАЗОВАНИЕ, 2012
MATHEMATICS AND EDUCATION IN MATHEMATICS, 2012
Proceedings of the Forty First Spring Conference
of the Union of Bulgarian Mathematicians
Borovetz, April 9–12, 2012

VALIDATING THE USE OF TECHNOLOGY IN MATHEMATICS EDUCATION WITH STATISTICS*

Zoran Trifunov, Linda Fahlberg-Stojanovska

In this paper, we present statistical data validating the use of information-communication technology (ICT) for teaching the construction of a triangle – in particular the free dynamic mathematics software GeoGebra. We demonstrate a significant improvement in the knowledge of the students from the experimental group who were taught using the new integrated information - mathematical approach for visualizing the problems as opposed to the control group who were taught in a traditional manner.

This improvement can be also linked with the increase of motivation for learning math by using computers, video and animations that students can produce themselves. After conclusion of the educational topic, the students completed an anonymous survey in which they were asked questions related to the teaching methods and whether these new techniques should be incorporated into the mathematics curricula. 92% of the students were satisfied and expressed a desire to continue to use this approach in subsequent lessons.

Introduction. The good technical equipment of educational institutions in Macedonia as well as the continuous education of teachers in ICT has resulted in a positive atmosphere towards the use of ICT in teaching for both teachers and students. However, the materials to be used in a new information-mathematical approach must be prepared by active educators who are good mathematicians with good ICT skills and the students must also be ICT proficient.

In the previous papers [1–4] we have written about the preparation for carrying out several educational topics with the help of ICT.

Research purpose. The main purpose of the research being conducted and presented in this paper is to determine the quality of knowledge that students gain by studying the topic "Construction of a triangle", in which ICT and the new information-mathematical approach is applied. This is done by comparing results achieved on the diagnostic and the final test between the experimental and control group. These results are summarized in statistical tests and grades of the hypotheses of the mathematical expectations with known dispersion of data.

Description of the sample. The survey population is 2nd year students in year 2009/2010 from the Gymnasium "Koco Racin" in Veles where the first author is a professor of mathematics. Two classes of 30 (60 students overall) were randomly selected.

*Key words: mathematics, ICT, education, statistics.

26 students from the 1st class (experimental group) and 24 students from the 2nd class (control group) agreed to allow their results to be used in the survey. Thus the sample size is 50 students divided into two target groups.

Students in both groups had studied solving constructive assignments in sixth grade, elementary school. So first we gave a diagnostic test to determine the initial knowledge of the students on the "Construction of a triangle" topic. In this research, the experimental group studied the topic using the free mathematics software GeoGebra, to which the students were previously introduced, and the new information – mathematical approach was used throughout the teaching. The second group, which is the control group, was taught in the traditional way for studying the same topic, that is, with the help of a ruler and a compass. At the end of the topic a final test was made which determined the newly acquired knowledge of the students.

Table 1. Results of the experimental and the control group

Student Number	Diagnostic test (total points)	Final test (points)					Difference
		Phases in resolving constructive tasks					
		1 analysis	2 construct.	3 proof	4 discussion	Total	
Results of the experimental group							
1	90	25	25	20	25	95	**5**
2	60	25	25	10	10	70	**10**
...	...						
Results of the control group							
1	80	25	25	25	10	85	**5**
2	100	25	25	25	25	100	**0**
...	...						

Statistical processing of the data. The data that is particularly relevant for the testing of the statistical hypotheses concerning the main objective of this research in this paper is presented in the table and graphic. In order to preserve the privacy of the students, numbers are used instead of their names as shown in Table 1.

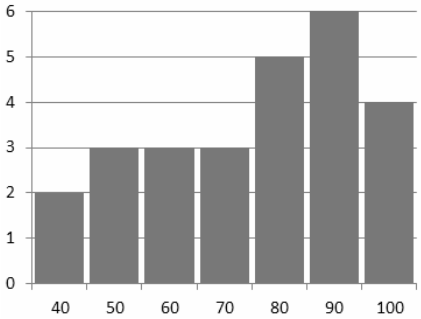
Comparison of mathematical expectations. The results of students from the experimental and control group for the diagnostic test are shown in Histogram 1 and Histogram 2. The average results of the diagnostic test of the two groups are approximately the same. We use the t-test for evaluating the equivalence of the mathematical expectation.

Zero hypothesis: $H_0 : E(X) = E(Y)$, where the signifier X is the random variable "results of the students from the experimental group on the diagnostic test," the signifier Y is the random variable "results of the students from the control group on the diagnostic test". $E(X)$ and $E(Y)$ are their respective mathematical expectations.

Alternative hypothesis: $H_1 : E(X) \neq E(Y)$.

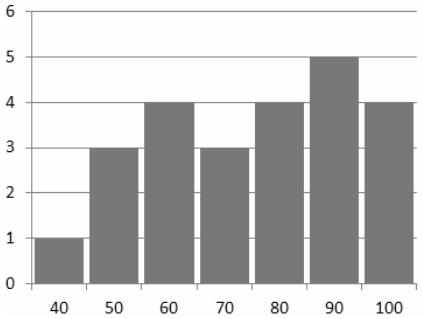
The scope of the samples is $n_X = 26$ and $n_Y = 24$. The standard deviation σ in assessed based on the adjusted standard deviation of samples $s_X = 19.02$ and $s_Y = 18.41$. The estimation of the standard deviation is $\sigma_P = 14.997$. The test value is $t = -0.006$.

Arithmetic average: 75.38
Standard deviation: 18.65
Scope: 26



Histogram 1. Results of the diagnostic test of the experimental group

Arithmetic average: 75.42
Standard deviation: 18.02
Scope: 24



Histogram 2. Results of the diagnostic test of the control group

The level of significance of the test is $\alpha = 0.05$, $t_{n_X+n_Y-2;0.025} = 2.0114$.

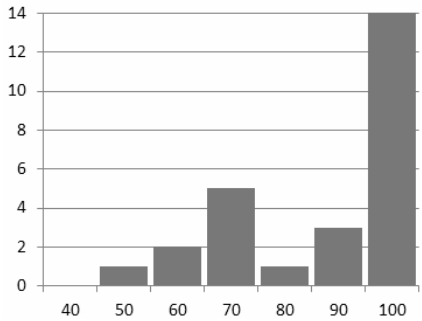
The critical domain is $B = (-\infty; -2.0114) \cup (2.0114; +\infty)$. We get $-0.006 > -2.0114$. Thus t does not belong to the critical domain and we accept the null hypothesis and reject the alternative hypothesis.

With probability of 95% we can conclude that both groups have the same initial knowledge on the given topic.

The results of the students from the experimental and control group for the final test are presented in Histogram 3 and Histogram 4. The average result on the final test of the experimental group is higher than the average score of the control group. We use the t-test for evaluating the equivalence of the mathematical expectation.

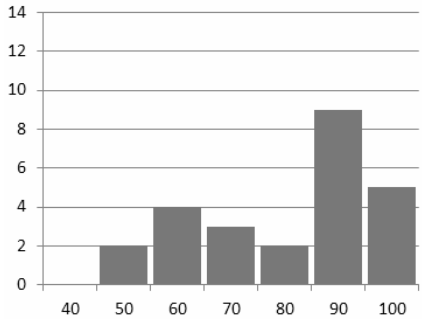
Zero hypothesis, $H_0 : E(X) \leq E(Y)$, where the random variables are "results of the

Arithmetic average: 85.38
Standard deviation: 15.31
Scope: 26



Histogram 3. Results of the final test of the experimental group

Arithmetic average: 78.96
Standard deviation: 14.65
Scope: 24



Histogram 4. Results of the final test of the control group

students on the final test" with signifier X for the experimental group and signifier Y for the control group. $E(X)$ and $E(Y)$ are their mathematical expectations.

Alternative hypothesis, $H_1 : E(X) > E(Y)$.

Standard deviations of the sample $s_X = 15.62$ and $s_Y = 14.96$. Estimation of the standard deviation $\sigma_P = 14.997$. The test value is $t = 2.301$.

The level of significance of the test $\alpha = 0.05$, $t_{n_X+n_Y-2;0.05} = 1.6794$.

The critical domain is $B = (1.6794; +\infty)$. Comparing $2.301 > 1.6794$, we see that t penetrates deeply into the critical domain, and therefore we reject the null hypothesis and accept the alternative hypothesis.

This means that with probability of 95% we can conclude that the results of the students who learnt how to construct a triangle with the new information-mathematical approach and the use of GeoGebra, are significantly better than the results of the students that studied the same content using the classic way.

Does the use of ICT equally affect the quality of the knowledge that students gain at all phases of solving the constructive tasks?

To answer this question, we compared the mathematical expectations for each of the phases separately and determined which of the stages in solving constructive tasks statistically differs from the results obtained in Table 1. In the first three phases: analysis, construction and proof, we use zero hypothesis $H_0 : E(X) = E(Y)$, where the random variables are: "results of the students on the final test at the appropriate phase" with X for the experimental group and Y for the control group and alternative hypothesis $H_1 : E(X) \neq E(Y)$. The level of significance of the test $\alpha = 0.05$ giving the critical domain $B = (-\infty; -2.0141) \cup (2.0141; +\infty)$ and whether the hypothesis is rejected H_0 or not is given in Table 2.

The fourth phase: discussions, we use zero hypothesis $H_0 : E(X) \leq E(Y)$ and alternative hypothesis $H_1 : E(X) > E(Y)$. The level of significance of the test $\alpha = 0.05$ giving the critical domain $B = (1.6794; +\infty)$ and whether the hypothesis is rejected H_0 is given in Table 3.

Table 2. Comparing the results of the first three phases

	t	Comparison	Is rejected H_0
1 Analysis	0.062	$0.062 < 2.0141$	No
2 Construction	0.085	$0.085 < 2.0141$	No
3 Proof	-0.174	$-0.174 > -2.0141$	No

Table 3. Comparing the results of the fourth phase

	t	Comparison	Is rejected H_0
4 Discussion	2.828	$2.828 > 1.6794$	Yes

In the results that the students scored in the first three phases, the zero hypothesis is not rejected and with 95% probability the results statistically do not differ and depend on the method of teaching. In the fourth phase, the null hypothesis is rejected and with accuracy of 95% the alternative hypothesis is accepted showing that the results from the first group statistically differ when compared to the results of the second group. **The**

results achieved in the final test of the experimental group are better than the results of the control group, which were confirmed by the *t*-test.

Conclusion. In this paper, we statistically demonstrated a significant improvement in the knowledge of students using the new integrated information-mathematical approach for visualizing the mathematical problems.

REFERENCES

[1] Л. Стојановска, В. Стојановски, З. Трифунов. Екстреми и нивна визуелизација во геометриски задачи од математика. МНД, Битола, 2009.

[2] L. Fahlberg-Stojanovska, V. Stojanovski. Compass and Straightedge with GeoGebra. 7th Intl CIIT, February 2010, Bitola, MK, Proceedings, 103–106.

[3] L. Fahlberg-Stojanovska, Z. Trifunov. (2010). Constructing and Exploring Triangles with Geogebra. *Annals, Computer Science Series*, **VIII** (2010) No II, Tibiscus, 45–54.

[4] L. Fahlberg-Stojanovska, Z. Trifunov. Izucuvanje nekoi svojstva na trigonometriski funkcii so pomos na Geogebra. International GeoGebra Conference for Southeast Europe, Novi Sad, Serbia, http://sites.dmi.rs/events/2011/gcse/

Zoran Trifunov
Linda Fahlberg-Stojanovska
Faculty of Technical Sciences
Univ. St. Clement of Ohrid
ul. I. L. Ribar bb. p.f. 99
7000 Bitola, R. Macedonia
e-mail: zorantrifunov@gmail.com
e-mail: lfahlberg@gmail.com

СТАТИСТИЧЕСКО ВАЛИДИРАНЕ НА ИЗПОЛЗВАНЕТО НА ТЕХНОЛОГИИ В ОБРАЗОВАНИЕТО ПО МАТЕМАТИКА

Зоран Трифунов, Линда Фалберг-Стояновска

В тази статия представяме валидиране чрез статистически данни на използването на информационни и комуникационни технологии (ИКТ) за преподаване на построяване на триъгълник – в частност, чрез софтуерът за динамична математика GeoGebra. Показано е значително подобрение на познанията на учениците от експерименталната група, които са обучавани с помощта на новия интегриран информационно-математически подход за визуализиране на задачите, в сравнение с контролната група, която е обучавана по традиционния начин.

Подобрението може да се свърже единствено с повишената мотивация за изучаване на математика чрез използване на компютри, видеоклипове и анимации, които учениците могат сами да създават. След завършване на преподаваната тема, учениците попълниха анонимна анкета, в която отговориха на въпроси, свързани с методите на преподаване и дали тези нови техники трябва да станат част от учебната програма по математика. 92% от учениците са удовлетворени и изразяват желание да продължат да използват този подход в следващите уроци.