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DEVELOPING MATHEMATICAL SKILLS BY GENERATING PROBLEMS WITH COMPUTER

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***Abstract**: This article presents a part of the research results of a study on the developing of mathematical skills by generating mathematical problems with computer. The research training is based on applying integrated didactical model Multimedia Learning and Generating Problems. It is conducted with students from fifth grade. The results of comparative statistical analysis of the achievements of the control and experimental groups are shown.*

***Keywords:** Mathematical Skills, Multimedia Learning, Generating Mathematical Problems, Statistical Comparisons, Experimental Results*

INTRODUCTION

The topicality and theoretical-practical significance of the problem on developing mathematical skills by generating problems using a computer is determined by: low motivation and unsatisfying low average results in mathematics announced by PISA and TIMS international surveys and the national assessment; difficulties associated with the transition from concrete to abstract objects; ubiquitous use of mainly traditional forms of teaching inconsistent with the needs of the new generation growing up with IT; very rarely the task of generating new problems is used in school and on the other hand, the requirements for a high quality education [13, p. 9].

The study was conducted with 104 students from the fifth grade in the school of European languages Ruse.

LAYOUT

The object of this study is the process of forming mathematical skills in students from the fifth grade. The subject of the study is the impact of the implementation of *Multimedia training and generating problems* integrated didactic model on the process of forming mathematical skills of students from the fifth grade.

Hypothesis of the study: The implementation of *Multimedia training and generating problems* integrated didactical model in teaching mathematics to students from the fifth grade will optimize the formation and development of mathematical skills.

The study includes four interrelated stages (*preparatory, primary, final and presentation of results*) composed of 18 sub-stages.

As a result of the conducted theoretical analysis of psychological, pedagogical and methodological literature, basic conclusions are drawn about the development of methodological models, didactic and diagnostic tools.

The developed didactic models *Multimedia formation of mathematical skills* and *Generation problems with Excel* are integrated into a common model named *Multimedia training and generating problems*. They are based on the theories of L. Vygotsky [2], P. Galperin [3], G. Piaget [11], constructivist principles, model of I. Ganchev [4, p. 31], model of P. Petrov [10], traditional principles to develop a lesson in mathematics [7] and the latest principles of the methodology of teaching mathematics - activity, independence and creativity [8]. For any meaningful part of educational content the integrated model is applied. Initially in the first lesson the teacher teaches basic mathematical knowledge and skills. In the next lesson the students are trained how to create problems using previously developed in Excel *Tabular calculators*. The students generate new problems related to the studied subject.

At the beginning of the next lessons the generated problems are reviewed, the students are encouraged to compose new ones in search of interesting and nontrivial problems. New knowledge is introduced and new skills developed. The homework is traditional but in reduced size and at the same time creative for composing new problems.

Requirements are formulated and according to them 22 multimedia lessons and didactical materials by *Microsoft Excel* are developed. A test in two variants with equal level of difficulty for measuring *high cognitive processes, complex skills and creative abilities* [12 p. 165] is developed.

On the base of the theoretical analysis of the scientific and the normative literature two criteria for evaluating the performance of the conducted experiment are designed:

Criterion 1. Degree of formation of mathematical skills related to the specific educational content on the topic *Fractions*.

Criterion 2. Level of meta subject skill formation, related to mathematics education.

The criterions are decomposed in parameters and empirically measured indicators. A three-staged grading scale has been used. The *Cronbach's Alpha coefficients* have been calculated. All indicators correlate with total score, there is a very high internal consistency between indicators and low correlation between items, which is an indicator of the reliability and validity of the research tools [15].

Numerical and visual analyses, using *SPSS* (*Statistical Package for the Social Science*), on the methodology for checking for normality of the empirical distributions [5], found that the data is not close to normal distribution. This requires the use of non-parametric statistical methods [1, p. 224] *Kolmogorov-Smirnov*, *Mann Whitney* [9, p. 83] and *Wilcoxon* [14]. To measure the impact of the implementation of the integrated model and the developed teaching tools necessary statistical comparisons are made using the model for proving the effectiveness of the new methods [6, p. 82].

1. Establishment of the effect of the traditional method implementation on the control group (CG).

The average value of the skills by *Criterion 1* has risen with 25.11, and by *Criterion 2* with 10.88. The value of median of *growth* by *Criterion 1* is 26.00, and by *Criterion 2* is 12.00. The test of *Wilcoxon* reported that *Asymp. Sig*. is $0.000 < 0.05$ and all ranks are positive. Therefore, the traditional methodology contributes to better development of skills related to a specific subject area but as far as meta subject skills are concerned less development is noticed.

2. Establishment the effect of the new methodology implementation on the experimental group (EG)

A non-parametric test for differences in the two dependent samples – data from measurements of EG's skills before and after *Multimedia training and generating problem* integrated model implementation are performed (Table. 1). 52 positive ranks for EG, i.e. there is progress in the development of skills are reported.

Table 1. Non-parametric test for identifying differences in skill level for Criterion 1 and Criterion 2 for EG

Second comparison	Criterion	Number of students	Average value	Standard deviation	Median	Average rank (Wilcoxon)	z-value (Wilcoxon)	Asymp. Sig.
Before training	1	52	0,94	1,765	0,01	26,50	-6,294	0,000
After training	1	52	29,96	2,863	31,50			
Growth	1	52	29,02	2,755	29,00			
Before training	2	52	6,02	4,142	5,00	26,50	-6,283	0,000
After training	2	52	24,96	5,390	27,50			
Growth	2	52	18,94	3,250	19,00			

The median values in *Criterion 1* are respectively 0.00 and 31.50, while the variable *growth* is 29.00. The median values in *Criterion 2* are respectively 5.00 and 27.50, and the median of the variable *growth* is 19.00. Therefore, the skill level of both of these criteria has increased significantly.

A non-parametric *Wilcoxon*'s test shows that *Asymp. Sig.* is < 0.05, i.e. the differences between the two dependent samples are statistically significant. Therefore, the level of the tested skills in EG has increased significantly due to the training with the integrated *Multimedia training and generating problems* teaching model.

3. Verification of the differences in the estimates of CG and EG at the beginning of the experiment

Calculations show that Asymp. Sig. it is 1.00 > 0.05 for the test of *Kolmogorov-Smirnov* and 0.621 > 0.05 for the test of *Mann-Whitney* for *Criterion 1*. The value of *Asymp. Sig*. is 0.328 > 0.05 for the test of *Kolmogorov-Smirnov* and 0.570> 0.05 for the test of *Mann-Whitney* for *Criterion 2*. Therefore, it is considered null hypothesis H_0: *Between the two samples no statistically significant differences*. This means that the two groups – control and experimental have "equal start".

4. Verification of the differences in the estimates of CG and EG at the end of the experiment

A statistical analysis of two independent samples – the row score of CG and EG after the conducted training in the two different models are compared (Table. 2).

For both of these criteria the values of the median, average rank and average value are higher for EG against CG.

Table 2. Non-parametric test to identify differences in skill level between CG and EG after the training

Group	Criterion	Number of students	Average value	Standard deviation	Median	Average rank	z-value (K-S)	Asymp. Sig. (K-S)	z-value (M-W)	Asymp. Sig. (M-W)
CG	1	52	26,212	0,723	28,50	38,62	2,353	0,000	-4,765	0,000
EG	1	52	29,962	2,863	31,50	66,38				
CG	2	52	17,712	7,453	20,00	36,61	2,648	0,000	-5,383	0,000
EG	2	52	24,962	5,390	27,50	68,39				

The histograms (Fig. 1, Fig. 2) show higher average performance of EG on all indicators. The tests of *Kolmogorov-Smirnov* and *Mann-Whitney* establish that these differences are significant and as a result an alternative hypothesis H_1: *Between the two samples there are statistically significant differences* has been accepted. This means that students from EG, trained with the *Multimedia training and generating problems* integrated teaching model, have formed and developed research skills at a significantly higher level.

5. Establishment of the statistical significance of the differences between the growth of both groups at the end of the experiment

A fifth comparison between the differences in the results before and after the training of both groups is done in educational research.

Calculations show that *Asymp. Sig.* are < 0.05 for both criteria in tests of *Kolmogorov-Smirnov* and *Mann-Whitney*. Therefore, the alternative hypothesis H_1: *Between the two samples there are statistically significant differences* is accepted.

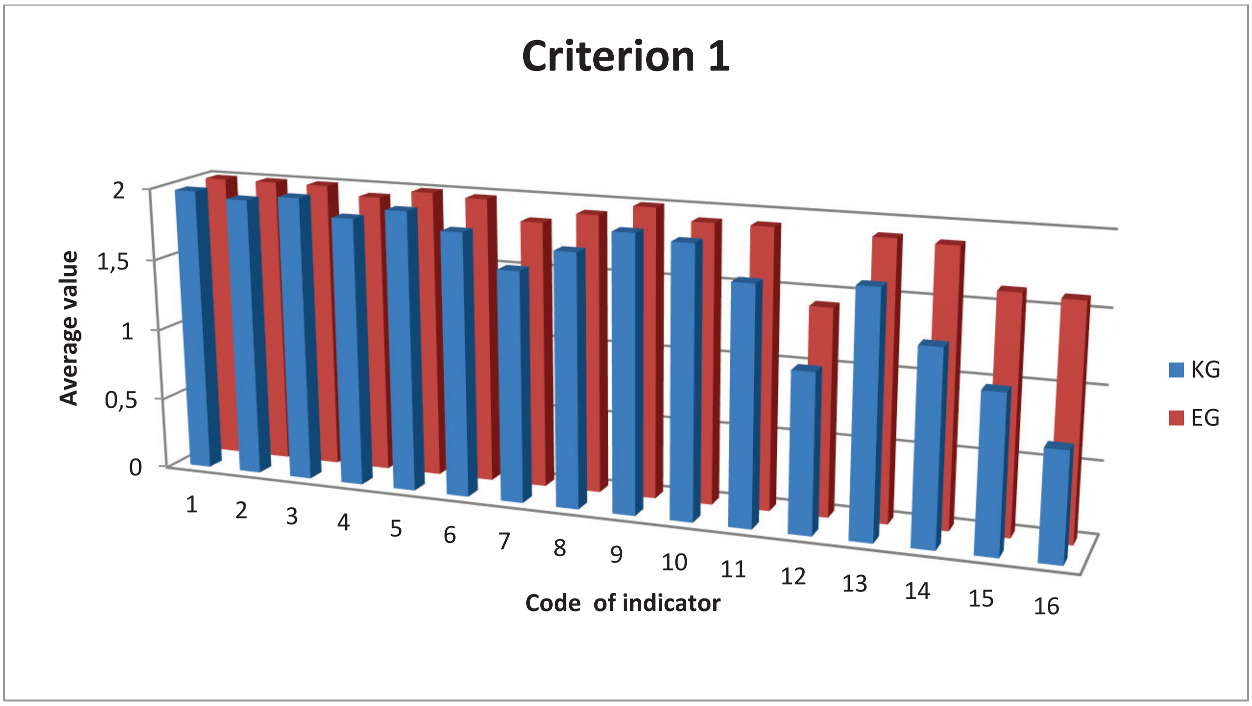

Figure 1. Differences in mean values for the different indicators of Criterion 1 for CG and EG

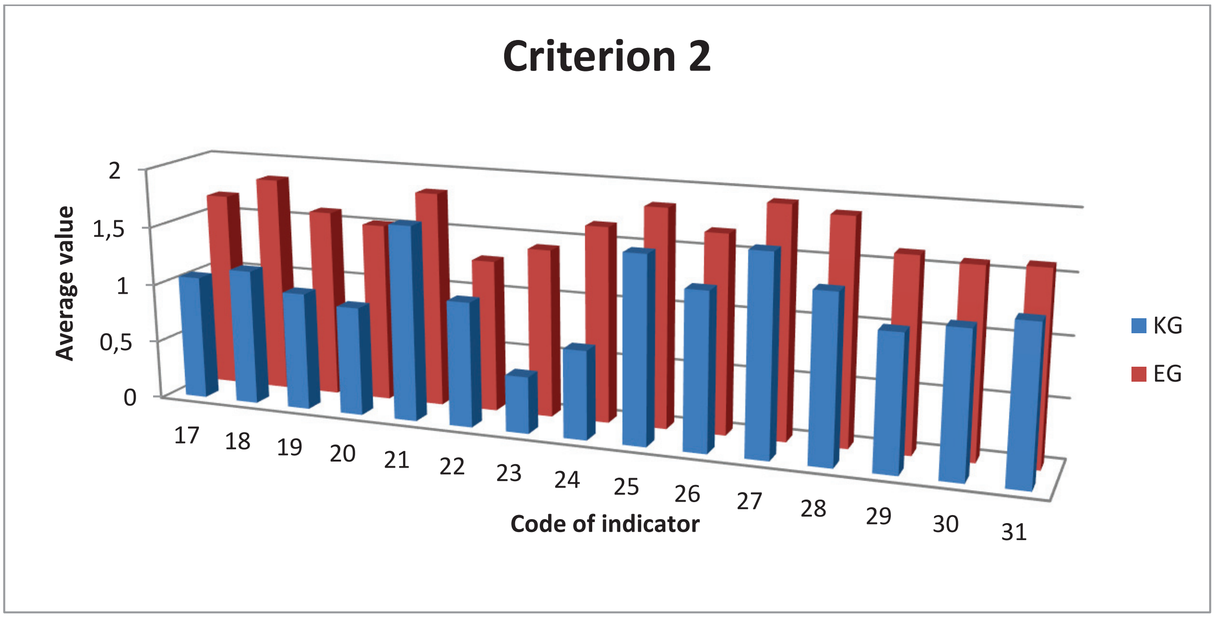

Figure 2. Differences in mean values for the different indicators of Criterion 2 for CG and EG

The value of the median growth for the *Criterion 1* is 26.00 for CG but for the EG is higher - 29.00. Average rank 66.84 is significantly higher for EG compared to 38.16 for CG. The average value of the growth in the raw score of each pupil is less than in *Criterion 2* for CG value of the median 12.00 is significantly lower than the value of the median for EG – 19.00. Average rank 75.62 is significantly higher for EG compared to 29.39 for CG. The average value of the growth of a second criterion is smaller than the average value of the EG. Consequently, the growth both of these criteria was significantly higher for EG compared to the CG.

6. Tracing the durability of knowledge

A decline in skill levels after a period of time is equal to the difference of the number of points in the control experiment and delay inspection. The analysis of the frequencies shows that they are not normally distributed, so nonparametric tests are used (Table. 3).

Table 3. Nonparametric tests to establish the differences between CG and EG on the decline of skills for Criterion 1 and Criterion 2

Group	Criterion	Number of students	Average value	Standard deviation	Median	Average rank	z-value (K-S)	Asymp. Sig. (K-S)	z-value (M-W)	Asymp. Sig. (M-W)
CG	1	52	6,750	0,369	7,000	66,798	2,451	**0,000**	-4,856	**0,000**
EG	1	52	3,596	0,434	3,000	38,202				
CG	2	52	4,827	0,463	5,000	60,350	0,015	**1,569**	-2,669	**0,008**
EG	2	52	3,231	0,351	3,000	44,654				

From the carried out calculations follow the acceptance of the alternative hypothesis H_1: *Between the two samples there are statistically significant differences*.

The median, average value, average rank of the variable *Decline* are lower for the EG. Therefore the decline in skills levels for both criterions are significantly higher for CG than EG. This means that the skills of the trained students with the *Multimedia training and generating* *problems* integrated teaching model are more durable compared to the skills of students from CG trained with traditional methods.

The qualitative analysis of the results shows that the integrated model contributes to the formation and development of relevant skills for building a mathematical model, formulating further questions to a problem, for creative transformation of a problem. These skills are highly valued in modern society.

CONCLUSIONS AND FUTURE WORK

Initially, both groups have equal opportunities. Following a traditional training CG have developed fewer meta subject skills. Students from EG trained with the integrated model have developed significantly higher skills related to specific content, and meta subject skills related to mathematics education. Growth in skill level is much higher and the decline is lower for EG against CG.

The directed application of the *Multimedia training and generating problems* integrated model and the developed teaching tools leads to a significant increase in the level of skills related to a specific field of science and in meta subject skills that are essential for the contemporary society. Training with this model also contributes for more durable skills.

We will develop additional training materials and didactical models that will be implemented in the upper classes.

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