Application of Problem Teaching in Lower Grades of Primary Schools and its Impact on the Improvement of Mathematical Knowledge of Students

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Abstract **- In this paper the application of problem teaching mathematics and respect its characteristics was investigated in the lower grades of primary school, in order to demystify its role and importance in enhancing the educational and functional effect. The research was done in the period from September to December 2015, by testing students of fourth grade in five elementary schools.**
Statistical analysis of the selected groups has shown there is no statistically significant difference between groups, and the test normality of distribution was done using the Kolmogorov-Smirnov and Shapiro-Wilk test.
Analysis and comparison of results before and after the experimental program, indicates a significant improvement in students' knowledge and mathematical competencies applying the methodology that has been implemented.

Keywords **- application of problem teaching mathematics, research, analysis, improvement of students' knowledge.**

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1. Introduction

Spotting the representation of problem teaching mathematics and respecting its essential characteristics in the lower grades of elementary school are the first steps towards quality teaching mathematics. Students' problem-solving process, as well as different ways of solutions, contribute to the creative experience of students. In recent years the approach to solving mathematical problems is intensively analyzed [1].
In the report of the European Commission "Mathematics and Education in Europe" (2015) concern due to poor success of pupils in mathematics is expressed, and it proposes reform of the mathematics curriculum , the use of innovative teaching methods, improving education training of teachers. In the world reports they advocate for better math education and focus on the teachers' support, emphasize the application of mathematical knowledge and problem-solving skills that will contribute to the improvement of students' competence in mathematics [2]. In this research the presence of problem teaching mathematics in our schools is investigated by experimental research of regular and irregular application, effects and comparisons.
The research was conducted in five primary schools in the Canton of Sarajevo (in different municipalities), in 2 experimental and 10 control classes. We compared the final results of E and K groups and two classes per each control group with an experimental group. The test was done by 266 students (considering the period of one school term) in 5 Primary school: "Aleksa Šantić" (Nedžarići), "Skender Kulenović", "Velešićki heroji", "Behaudin Selmanović" and "Aleksa Šantić" (Mojmilo).

The students in the experimental classes participated in the work with pleasure and enthusiasm, awaited a new game, a new problem situation, an educational poster, or a new idea that we conducted on tablets and computers in school. Teachers of fourth grade (in the control classes) have also tried to solve the prepared tasks, expressed their willingness to present students certain problematic task, as well as to motivate them to solve them.

Setting mathematical problems, choosing how to display mathematical situation and expressing own opinion on matters with a mathematical content, is very important to present students in an interesting way [3]. Developing the use of this knowledge we achieve the application of mathematical education, which includes the specific skills [4]. In this paper we examined views of teachers, parents and students. Results will be shown related to the students and their progress in applying problem teaching mathematics in lower grades of primary schools.

Modernization of schools and their opening to the newspaper in education, entry in various projects, modern and advanced programs (Child-centered methodology, Step by step, RWCT), "teachers have become more sensitive and more willing for modern approaches" [5]. They are willing to be educated, and in some schools, to actively participate in training programs related to mathematical education [6], to complete problem teaching and accomplish mathematical competence of students.

Class teacher, as a mediator in the child getting to know mathematics content, is one of the most important factors affecting the success of students in the initial teaching of mathematics. Through his views on mathematics, type of mathematical presentation content, the choice of methods, procedures, tasks, textbooks and teaching, he achieves a motivating effect on students.

In the lower grades, it is very important to design and provide quality preparation in problem teaching, as this will enhance the success of their students and engage them in mathematics. "The quantity and especially the quality of students' knowledge is a reliable measure of teacher's work, therefore the success of teaching" [7].

In the experimental classes (52 students), as a basic educational system, problem teaching mathematics was conducted by models, with a combination of interactive, programmed, project, individual and group heuristic teaching. Based on our own empirical research character and values of problem teaching mathematics were determined, and effects of its application in comparison to traditional teaching of mathematics in lower grades of primary school.

The focus of this work is the application of problem teaching mathematics and respect of its characteristics in the lower grades of primary school, all in order to demystify its role and importance in enhancing the educational and functional effect. The research was conducted in the period of one school term, testing the fourth-grade students in five elementary schools, with appropriate statistical data processing. The results presented in this paper represent a continuation of the research presented in Refs. [Implementation of ICT and education, Teaching Modern Approaches]. The first important step to achieve the established is to address primary school teachers on contemporary literature dealing with mathematical content, and to enhance their competence firstly with quality theoretical knowledge, and then practically with concrete methodical approach to mathematics [8].

Methodical part of teachers' competence in problem teaching mathematics, will be increased with the interest in improving the development of mathematical skills of their students by applying mathematical models, finding or devising problem-solving tasks [9]. This is achieved by the freedom of access to mathematics, creative ideas, cooperation with other teachers (from their or other schools), cooperation with mathematics teachers in the higher grades, monitoring scientific and professional mathematical journals on the application of modern strategies, methods and procedures, resources and technology, and cooperation with the parents, which are important in this period of students development (6 to 10 years), when they are in a class [10].

Many articles and studies have confirmed the influence of teachers on the value and progress of students in mathematics. " Rosenthal and Jacobsen research has shown that students of whom the teachers expected intellectual progress, actually achieved progress " [1].

2. Methodology and Data

Theoretical part of the research was carried out by analyzing available literature and presenting former research of the world and our country. The empirical part of the research started with the assessment of present state of problem teaching mathematics in classes in the fourth grade in which research was conducted by surveying the students (general questions and attitude scale) at the beginning, upon entering the school and with the opinion of the IV class teacher on the problem teaching mathematics (whose department is studied), which we examined with the evidence list.

Afterwards, an agreement was reached on a regular cooperation with 12 teachers from five of our schools in Sarajevo Canton that are part of the Assets of

[1]The effect is known as „Pigmalion effect" (Vizek-Vidović et al, 2003)

fourth grade, based on the approval of the Ministry of Education, Science and Youth, on the application of problem teaching mathematics. Teachers were recommended to apply problem teaching mathematics, and to exchange experiences, suggestions and tasks that will contribute to the efficiency of problem teaching to students of all departments of this class. On September, 30th 2015 an initial test of general knowledge was conducted in the 12 departments of fourth grade students, a test of logical problem-solving tasks and assignments of change, comparing and combining, on the basis of which grouping of students was committed. The initial test consisted of seven tasks.

Two experimental departments of IV class (52 students) in the elementary school "Aleksa Šantić" applied problem teaching mathematics everyday by instructions that included: the selection of tasks (of adopting, repeating and practicing), quality methodical approach to problem teaching mathematics (presentations, image content, the use of ICT through group, tandem and individual work), interactive approach, modeling, task analysis and monitoring of content managing which is in accordance with the NPP in the IV grade.

The study was conducted using the general methods: a causal and descriptive, wherein within the causal a special place took the experiment. Analysis was carried out with qualitative and quantitative statistical methods: Survey method, The theoretical analysis of content, Causal-descriptive method, Experimental and statistical method.

Data processing and analysis was conducted by statistics program IBM SPSS 20, for what we needed mathematical approaches in statistical formulation of the required.

The sum of all results in a variable divided by the number of these results is the **arithmetic mean** ($\bar{X}$, M), calculated using the formula:

$$\overline{X} = \frac{\sum_{i=1}^{n} X_i}{n} \qquad \bar{X} = \frac{\Sigma X}{N} \qquad k = \frac{R+1}{i}$$

X -i - ith result, *n* - number of examinees, $\bar{X}$ or *M* (Mean) - mean, Σ - SUM (sum), X -, particular results and N - sample size or the total number of results, data and etc.

Central result that separates the distribution of results in a variable into two equal parts is the **median** (Md). If a distribution contains an odd number of results, the median is the middle result. If a distribution consists of an even number of results, the median is equal to the average value of two central results. Result in a variable that has the highest frequency is called the **mode** (Mo). At the same time, mod is the dominant value in a variable.

Distribution of frequencies of a variable is performed, if the number is lower, by lining up results by size from smallest to the largest, and then if the number of individual results is determined, a frequency (f) of that variable is given .

But if the number is greater, as in our study, classes are created and grouping of results into classes is performed. The lowest scores in variable X_{min} and the largest in variable X_{max} are identified, the range of the results of $R = X_{max}-X_{min}$, K - number of classes, i- width class are identified and calculates by the formula for k. **Cumulative and relative frequencies** are calculated based on the absolute frequencies, and on the basis of class limit mean are determined. Examples of absolute, cumulative relative frequencies, the middle class variables:

X - results, *CM* - the class mean, *F* - frequency, *FR* - relative frequency, *FC* - cumulative frequency, (*FC)R* - cumulative relative frequency

Tags for frequency: cf - cumulative frequency, f (Md) - class frequency in which the median is determined (median interval).

The sum of the squared deviations of each result from the mean divided by the number of these results is the **variance**. It is calculated by formula:

$$\sigma^2 = \frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2 = \frac{1}{n}\sum_{i=1}^{n} x_i^2 - \bar{x}^2$$

In research we used: **Rank sum test** (Mann-Witneyev U test, Wilcoxon T-test). The test uses more information, ranks and therefore can be considered better and "more powerful" in comparison to other tests. As with the median test, with rank sum test we determine whether two samples belong to the population with same median. Comparing the E and K groups, in our research we separately gathered together all ranks. Due to the control we checked the sum of ranks by the formula:

$$T1 + T2 = \frac{N(N+1)}{2}, \text{ after that we calculated z value} = \frac{|2Ti - Ni(N+1)| - 2}{2\sqrt{\frac{N1N2(N+1)}{3}}}$$

Ti - any sum of ranks, | | - the absolute value

No - the number of examinees in the group from which we took Ti

z - limit; we compared U values.

3. Data analysis and tests

The main data resource for our research is the evaluation of initial knowledge and also the experiment in which purposely a change was induced with the aim to investigate the efficiency of its

influence. An experimental model was applied, with even parallel groups, in which process was carried out at the same time according to scheme K – classical procedure and scheme E – experimental procedure. The basic experiment model contains parallel groups from which each of them is a carrier of its own experimental factor. In exploring the influence of teaching procedures the recommendation is to equalize the foreknowledge and basic math ability, because they largely contribute to realization of the material. In this research the standardization of E and K group examinees was done according to general accomplishment of students at the end of the third grade, final marks from math and results of the initial test.

In each research the representativeness and impartiality is undoubtedly important. In Primary school "Aleksa Šantić", the experimental group constituted of two classes in parent school in Nedžarići (52 students), and a control group of two classes in local school in Mojmilo (40 students), four classes in Primary school "Skender Kulenović" (93 students), two classes in Primary school "Velešićki heroji" (46 students) and two classes in Primary school "Behaudin Selmanović" (35 students). We compared the final results of E and K groups and two classes per each control group with an experimental group. The test was done by 266 students (considering the period of one school term, 3 students less did the questionnaire at the beginning of the research). The students were divided in three categories, based on general accomplishment, math grade and results on Test 1: below average, average and above average.

4. Questionnaire results of E and K group

Table 1. Student answers (questionnaire results) – M-W test

	Mann-Whitney U	Statistically sig. diff. p
I love to solve math problems	8449.000	.304
I understand math assignments we solve in class	8526.000	.399
In math classes the teacher only talks during assignments	8280.000	.221
I love to cooperate with my schoolmates in solving the assignments	8781.500	.669
It is more interesting to talk about given task, to analyze it and to write a short note	8352.000	.224
While solving the assignments in groups, we try to be the best as we can	8474.000	.119
With text assignment we use pictures, illustrations and a computer	8180.000	.174
Solving math image assignment is interesting	8542.500	.401
Content and experience of assignment we present with an image	8600.000	.517
We invent new words and sentences with which we extend the math assignment	8207.000	.198
We better adopt the math knowledge when we work in pairs in groups	8671.000	.577
In math classes we usually use teaching papers	8146.000	.137

Mann Whitney tests show that there is no statistically significant difference in student answers between group E and K, on any of the listed claims issues by value (p- asymp. sig.), students questionnaire, which is shown in table 1.

5. Results of distributing in three categories

Table 2. Distributing students in three categories

		group control		experimental		
		Number of students N	Percentage N %	Number of students N	Percentage N %	Distribution
General accomplishment, Math grade, Test 01 – Total score	0	2	,9%	0	0,0%	
	2	3	1,4%	0	0,0%	
	3	3	1,4%	0	0,0%	
	4	6	2,8%	1	1,9%	
	5	4	1,9%	0	0,0%	
	6	9	4,2%	2	3,8%	
	7	5	2,3%	4	7,7%	
	8	11	5,1%	1	1,9%	
	9	10	4,7%	6	11,5%	**26,69%**
	10	**18**	**8,4%**	**5**	**9,6%**	
	11	**13**	**6,1%**	**6**	**11,5%**	
	12	**30**	**14,0%**	**8**	**15,4%**	**36,84%**
	13	20	9,3%	5	9,6%	
	14	29	13,6%	4	7,7%	
	15	31	14,5%	4	7,7%	
	16	20	9,3%	6	11,5%	**36,47%**

Of the total 266 surveyed students based on distribution in three categories, 71 (26,69%) were tested below average, 98 average (36,84%) and 97 above average students (36,47%). Students were divided by score norm from 1 to 3 IP, 4P and 5NP, in K group of 214 students. With the same norm we divided the students in E group of 52 students.

6. Initial test 1 results

Table 3. Initial test 1 results

SCHOOL	GROUPS	CLASS	NUMBER OF STUDENTS	CLASS RESULTS
Primary school "Aleksa Šantić"	**Experimental**	**IV 1**	**25**	**3, 52**
		IV 2	**27**	**3, 59**
		IV 3	20	3, 35
	Control	IV 4	20	4, 2
Primary school "Behaudin Selmanović"	Control	IV 1	23	3, 17
		IV 2	23	3, 22
Primary school "Skender Kulenović"	Control	IV 1	24	3, 83
		IV 2	22	3, 5
		IV 3	25	3, 4
		IV 4	22	3, 73
Primary school "Velešićki heroji"	Control	IV 1	17	3, 70
		IV 2	18	3, 16
Total 1 school	2 E	2 classes	52	E-3,55
Total 4 schools	10 K	10 classes	214	K- 3,53
Total 4 schools	2 E i 10 K	12 classes	266	E-3,55 K- 3,53

Table 3. shows the class results on Test 1. In control classes they range from ($\overline{X}$=3,16) to ($\overline{X}$=4,2). Two experimental classes have ($\overline{X}$=3,52) and ($\overline{X}$=3,59), what in total comparison corresponds to $\overline{X}$: E - 3,55, K - 3,53, to what the groups are equal. To make sure that the groups E and K are equal, after the analysis of success by classes, we statistically analyzed the final results of Test 1 to ensure if there is a statistical difference between E and K group. Both results showed no statistical difference between E and K group on initial test. In purpose of analyzing the normal distribution we need to conduct the Kolmogorov-Smirnov (in the following K-S) and/or Shapiro-Wilkov test (in the following S-W test).

Table 4. Test 1 results – groups K and E comparison for Test 1 total score

		Test K-S			**Test S-W**		
group		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic D	df	Statistically sig. diff. p	Statistic D	df	Statistically sig. diff. p
Test 01 – Total score	control	.162	214	.000	.910	214	.000
	experimental	.092	52	.200*	.963	52	.101

Table 4. shows that at least for one group, in our case control group, K-S is statistically significant what indicates that distribution of our results is statistically different from normal distribution, and in following analysis we use nonparametric statistic, more precisely Mann-Whitney test.

Table 5A. Test 1 results in E and K group

Ranks				
Group		N	$\bar{x}$ Of ranks	Σ Of ranks
Test 01 – Total score	control	214	135.11	28914.50
	experimental	52	126.86	6596.50
	total	266		

Table 5B. M-W Test 1 results

Test Statistics[a]	
	Test 01 – Total score
Mann-Whitney U	5218.500
Wilcoxon W	6596.500
Z	-.698
Statistically sig. diff. p	.485

Two tables above show Mann-Whitney test results between control and experimental group of students for total score on Test 1. At value of U=5218,500 and significance of p>0,05 (p=0,485), we conclude that there is no statistically significant difference between these group of students when it comes to Test 1 final score.

7. Test 2 results

Knowledge test as a review of overall activities, after experimental program which was conducted in this period, took place on 30.11.2015. in all schools, as it was agreed with the management and the teachers of class in which experiment took place. Total of 266 students did the test, from which 52 students in 2 classes made the experimental group, and the remaining 214 students divided in 10 classes made the control group. In table 6. are shown results achieved by students of these two groups by class:

Table 6. Test 2 student results by classes

SCHOOL	GROUPS	Class	Number of students	Test 2 result by class
Primary school "Aleksa Šantić"	Experimental	IV 1	25	4, 64
		IV 2	27	4, 62
	Control	IV 3	20	4, 2
		IV 4	20	4, 6
Primary school "Behaudin Selmanović"	Control	IV 1	23	3, 48
		IV 2	23	3, 52
Primary school "Skender Kulenović"	Control	IV 1	24	4, 16
		IV 2	22	3, 86
		IV 3	25	3, 64
		IV 4	22	4
Primary school "Velešićki heroji"	Control	IV 1	17	3, 71
		IV 2	18	3, 44
Total 1 škola	2 E	2 odjeljenja	52	E = 4,63
Total 4 škole	10 K	10 odjeljenja	214	K = 3,86
Total 4 škole	2 E i 10 K	12 odjeljenja	266	E = 4,63 K = 3,86

Experimental classes achieved much better results. After the PTM application in one semester on 30 math classes, students of E class showed much better managing in problematic tasks of change, combining and comparing. Also, we noted that class K students IV_4 OŠAŠ achieved result of 4, 6, which is closest to achievement of E class. The rest K group classes achieved lower scores. After the achievement analysis by classes, results of E and K group were statistically compared.

The difference was identified between E and K group in arithmetic mean of total score on Test 2 of $\overline{X}$= 174, 98 (E group) and $\overline{X}$ = 123, 42 (K group), then in sum of ranks Σ = 9099,00 (E group) and Σ = 26412,00 (K group), what further needs to be analyzed with M-W test to see the U difference value, and with W test to see the Z value.

Table 7A. Difference in M and Σ - E i K group Test 2

Ranks				
group		N	$\overline{X}$ Of ranks	Σ Of ranks
Test 02 – Total score	control	214	123.42	26412.00
	experimental	52	174.98	9099.00
	Total	266		
Ranks				
group		N	$\overline{X}$ Of ranks	Σ Of ranks
Test 02 – Total score	control	214	123.42	26412.00
	experimental	52	174.98	9099.00
	Total	266		

Table 7B. M-W testing of E i K

M-W I W Test Statistics[a]	Test 02 – Total score
Mann-Whitney U	3407.000
Wilcoxon W	26412.000
Z	-4.372
Statistically sig. diff. p	.000

In table 7. total score is compared on Test 2, between control and experimental group of students. Value of Man-Whitney test is U=3407 and test is significant on level of p<0,01. That indicates that there is statistically significant difference between control and experimental group in total score of Test 2. In order to determine in what direction there is a difference, we will take a look at the table with sum of ranks and establish that the students from experimental group are achieving statistically significant higher result on Test 2 from the control group students.

Certain classes from K group achieved significant results, because they solved problematic assignments, created sample models, but some classes stayed on the almost exact same level.

8. Difference in Test 1 and Test 2 achieved results

In table 6. we see the results of both tests that students did in E and K groups. By comparing them we see that each group achieved improvement in solving mathematical problematic assignments, in comparison to the first test. Experimental group of students achieved much better results, but we can also indicate the individual improvement in comparison to the first test. Each of the classes achieved progress in Test 2, in comparison to Test 1, what is shown in table 8.

Table 8. Test 1 and Test 2 results by classes

Number of students – Test 1	Results by classes – Test 1	Number of students – Test 2	Results by classes – Test 2
25	3, 52	25	4, 64
27	3, 59	27	4, 63
20	3, 35	20	4, 2
20	4, 2	20	4, 6
23	3, 17	23	3, 48
23	3, 22	23	3, 52
24	3, 83	24	4, 12
22	3, 5	22	3, 86
25	3, 4	25	3, 64
22	3, 73	22	4
17	3, 70	17	3, 71
18	3, 16	18	3, 44
E (52)	E = 3,55	52	E = 4,63
K (214)	K = 3,53	214	K = 3,86
	E = 3,55		E = 4,63
Total 266	K = 3,53	266	K = 3,86

Looking at the average score of classes in E and K group shown in table 7., the improvement is noticeable in E classes. Individually, improvements are seen from 3,52 to 4,64, and from 3,59 to 4,63, which is highly successful. Special results were achieved in K class IV_4 of 4,6 on final test, which is a result of more regular PTM application. The difference in Test 1 and Test 2 results are graphically shown in the relation between means of total test score.

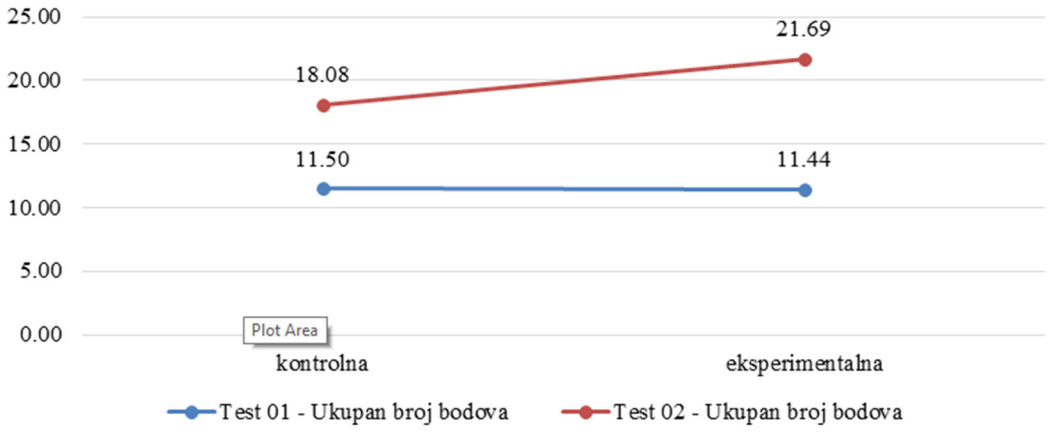

Figure 1. Chart display of difference in means of Test 1 and Test 2 (y axis – total sum score)

Chart results show that the initial Test 1 results between E and K groups were unified by means of 11,50 and 11,44. However, after the regular application of problem teaching mathematics, a model which contributed to students' improvement, modern methods, tools and means of work, the Test 2 results are significantly different between these two groups. Mean (rank) of K group on Test 2 is 18,08, of E group is 21,69, what makes a difference of means between these two groups of 3,61, what shows that a regular PTM application contributes to a much better qualitative and quantitative results of mathematical knowledge, respectively abilities of our students in math. This analysis confirms our next hypothesis that students who often work in problem teaching mathematics achieve **much better results** in adopting math content, respectively there is a statistically **significant difference** of $p<0.01$ in adopting the mathematical content in classes where teaching is performed with common (traditional) math methods and procedures where problem-solving teaching is applied.

9. Conclusion

After analysis and research in our school, it has been shown that problem teaching as a modern teaching strategy can be successfully applied in math classes in class, and this teaching as an efficient and productive way of learning, influences the increase of overall educational performance in the early teaching mathematics. It was noted that students of all departments showed interest and advancement in mathematics. Researching and monitoring reactions of students showed that the problem teaching is more interesting for them and they were more motivated to work and learn in comparison to traditional teaching.

Teacher is there to help, guide and facilitate the fulfillment and reaching of goals, both to students and to math teaching, in more qualitative mathematical and creative approach of solving the mathematical problems and assignments, as well as understanding and adopting the mathematical concepts. Analyzing particular parts of teaching: advantages and disadvantages, an advantage in problem teaching with regards to other methods is noted. The student is intellectually engaged in problem teaching, he freely tells his opinion, uses previous knowledge and enriches next experiences. Advantages are seen from analysis and research results of problem teaching, and therefore it is recommended to practice in lower grades.

In some schools, depending on the management, teachers use more modern educational tools, technology and creative didactic materials, and in other schools teachers themselves take care of and buy materials that will enable them to better teach students. Not in a single school a problem teaching math is highlighted, but it is implied in GPP for all classes, which means that it is on teachers whether they will represent and realize it.

Research announcement encouraged teachers on the application of problem teaching, and in math we optionally approached modern methods and procedures, means of work and better problem-solving tasks that will influence mathematical approach in general. Research and presentation of the results will give at least a small contribution in improving the quality of this course, which always has the worst results on tests and final exams.

The primary objective of this study is to develop a problem teaching mathematics as an ever-present in classes, as a good strategy for teaching math in lower grades of primary school, and to improve the teaching results based on the principle of independence and creativity. A significant progress is achieved, which is evident in the research results.

Through the experimental model application of problem teaching, an improvement of math teaching is submitted and thus interest and results of students in math are increased. Progress in PTM can be achieved with quality teaching activities, thought-out

and well planned and conducted with mathematical content.

The teacher must encourage creativity in the students, find opportunities and ways for them to think and create. From this research we expect improvement in mathematical teaching approaches as something omnipresent around us, students, and as a school subject that is used every day, so that the students can realize that "Mathematics is everything that surrounds us".

Research in school established all disadvantages related to the lack of education of primary school teachers in mathematics, as well as parental education, whose competence in this students' age is also essential. Some schools do not have means for work and computers, and the teacher tries to organize a quality mathematical class without the support of management.

Suggestions for further research are the analysis of the entire students' population, from first to fifth grade of primary school, to determine the state of the initial teaching of mathematics, and to conclude about current and possible mathematical curriculum. Next, a mathematical ability of students in schools could be explored, and the results could be compared so that the instructions could be given to schools who do not achieve significant results. In order to improve the teaching of mathematics PPZ and MONKS could organize competitions at class level, and then all would strive to achieve better results.

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