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APPLICATION OF INQUIRY-BASED INSTRUCTION IN THE INITIAL SCIENCE TEACHING

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Abstract

Inquiry-based instruction is very important for the development of the pupils' research skills and for easier acquiring of scientific contents. This type of teaching allows the gradual inclusion of pupils in an active learning process that leads to the development and understanding of scientific contents by asking questions and through data analysis and critical thinking. This paper presents the results of the tests of the efficacy of the model of inquiry teaching in the realization of physics contents in the initial teaching of natural sciences. The sample consisted of 112 fourth grade pupils (56 pupils in the experimental group and 56 pupils in the control group) from two elementary schools in Sombor (Serbia). The initial, the final and the repeated knowledge tests are used to measure the quality of knowledge of physics contents. Descriptive, causal and comparative methods were used for results processing. Research results analysis showed that by the use of the model of inquiry teaching higher quality of knowledge was achieved compared to the traditional approaches in the initial teaching of natural sciences.

Key words: classroom teaching, inquiry-based instruction, physics contents in sciences, student achievement.

ПРИМЕНА ИСТРАЖИВАЧКЕ МЕТОДЕ У ПОЧЕТНОЈ НАСТАВИ ПРИРОДНИХ НАУКА

Апстракт

Истраживачка настава (*Inquiry-based instruction*) веома је значајна за развијање истраживачких вештина код ученика и за лакше усвајање научних садржаја. Овај вид наставе омогућава поступно укључивање ученика у процес активног учења, што доводи до развоја и разумевања научних садржаја кроз постављање питања, анализу података и критичко мишљење. У раду су приказани резултати испитивања ефикасности примене модела истраживачке наставе у реализацији физичких садржаја у почетној настави природних наука. Узорак је чинило 112 ученика четвртог разреда (56 ученика у експерименталној

групи и исто толико у контролној) из две основне школе у Сомбору (Србија). За мерење квалитета знања о физичким садржајима коришћени су почетни, завршни и поновљени тестови знања, а за обраду резултата коришћена је дескриптивна, каузална и компаративна метода. Анализа резултата истраживања показала је да се применом модела истраживачке наставе постиже већи квалитет знања у односу на традиционалне приступе реализацији почетне наставе природних наука.

Кључне речи: разредна настава, физички садржаји природних наука, истраживачка настава, постигнућа ученика.

INTRODUCTION

Practical science learning in classroom teaching should enable pupils' development and help them establish a healthy relationship with the world around them. The pupil finds his/her environment easy to research and becomes an active participant instead of a passive observer. S/He figures out the real world, acts and experiments, searching for the answers to the questions s/he asked himself (Јокић, 2004a).

The pedagogical basis of a quality science teaching consists of: ***constructivism*** with the idea of constructing new knowledge on the basis of one's own experience and pre-knowledge, ***inquiry-based learning*** where the pupils acquire knowledge through their own research, collect and analyze the data, test the ideas and come up with the one that best explains what has been found; ***formative assessment*** as a continuous cyclical process of evaluating the pupils' progress and a timely control of learning process (Harlen, 2010).

The inquiry-based instruction is one of the most widely accepted methods for the successful realization of the science teaching goals. It is defined as involving the pupils into the process of active learning by asking questions, data analysis and critical thinking (NRC, 1996). Through inquiry-based teaching, a continuous series of hands-on activities in which the pupil is the central figure is provided. In those activities several different approaches or levels can be applied: *structured inquiry, guided inquiry and open learning cycle*. In each following level, managing the phases of the research oriented teaching practice (topics selection, setting the research questions, formulating hypotheses, preparation and realization of research, results analysis and formulating conclusions) is gradually shifting from the teacher to the pupil, in accordance with the development of the cognitive abilities of the pupils. The final goal is to prepare the pupil for individually scientific research (Colburn, 2000; Bell, Smetana & Binns, 2005; Bonnstett 1998).

During the preparation of the high-quality inquiry-based teaching, the teacher should be guided by the following phases and guidelines within each of them:

> **"1. Selection of the initial situation**
> Adjusting project to the curriculum and its objectives, productive character of the questions, local resources, focusing on the actual phenomena in the surroundings, matching the pupils' interests.
>
> **2. Formulation of pupils' questions**
> Activities guided by the teacher, who helps the pupils rephrase the questions to ensure their meaning and improve the pupils' verbal expression, emphasizing the pupils' preconceptions, the confrontation with its possible variations in order to encourage the pupils mastering the posed problem.
>
> **3. Hypothesis elaboration and the research concept**
> The teacher manages the activities of the pupils working in groups and gives them instructions. The pupils formulate the hypotheses, form protocols, textually specify the hypotheses and protocols, exchange their opinions about the hypotheses and eventually suggest the protocols within the class.
>
> **4. Research led by pupils**
> Internal group discussions about the results of the experiment, parameter variability control, description of the experiment (schematic and written), the repeatability of the experiment (a written record of the experimental conditions), taking notes.
>
> **5. Collecting data and structuring knowledge**
> Comparing and linking the results gained by different groups or other classes, confrontation with the established knowledge, research of the possible causes of discordance, critical analyses of the conducted experiments and suggesting related experiments, written formulation of the collected findings at the end of each topic as well as the presentation of the results (text, graphs, models, multimedia document)."
>
> (French Academy of Science, 2004, pp. 8-9)

The teacher's role has changed quite a lot compared to his/her traditional role. In fact, he/she carefully selects the situation, prepares the material and the problem for solving. The pupils then suggest the activities and do them on their own. The experiments they conduct should lead to a small but real finding for them. At any time, the pupils will have the teacher's help; the teacher should ask the pupils helpful questions. The pupils also ask a lot of questions and the teacher should not be afraid if he/she doesn't know all the answers. The answers can be gathered from someone who knows, or from the books (Шарпак Šarpak, 2001).

Benjamin Blum (1956) divided taxonomy of educational objectives into three domains - cognitive (new information, thinking skills), affective (feelings, preferences, interests, values) and psychomotor (physical and perceptual activities and skills). The goals and outcomes in the cognitive domain are sorted hierarchically and arranged into six categories according to

the level of abstraction, that is, from simple to complex: knowledge, comprehension, application, analysis, synthesis and evaluation. During the nineties of the 20th century, a former Bloom's student, Lorin Anderson, organized a new research in order to modernize the existing taxonomy and to adapt it to the educational needs and requirements of both the students and teachers in the 21st century. The revised taxonomy, much like the old one, includes six dimensions of cognitive processes, but in an altered form, where the levels tend to express the verbs: remembering, understanding, applying, analyzing, evaluating and creating. The levels of taxonomy are described as the expressed knowledge, skills and requirements by which you determine the level of realization of the objectives at a given level. The taxonomy of educational objectives is the basis for the design of educational content, the choice of teaching methods and forms of work, but it is also the basis for monitoring and evaluating the pupils' achievement.

METHODS

The main problem in natural science teaching, especially in classroom teaching, is how to make the complex contents of a group of natural sciences (physics, chemistry, biology and geography) more accessible and interesting to the pupils and how to increase the pupils' scientific literacy.

The **problem** of this research is how the application of the inquiry-based instruction in classroom teaching increases the pupils' achievement in the field of natural sciences.

In the teaching practice in the world, the inquiry approach has been present for several decades, at all educational levels. An extensive analysis of previous researches on the effects of this approach (Minner, Levy & Century, 2010) confirms its positive impact on the understanding of the science curriculum, as well as the durability of such knowledge. In our country, a systematic inquiry approach is applicable only with an optional school subject *Hands on – Discovering the World*. Regarding the compulsory subjects in the field of natural sciences it is mainly a question of affinity and enthusiasm of individual teachers (Bosnjak et al., 2010; Bosnjak & Obadović, 2009; Cvjetićanin et al. 2008). Serbia is a part of the EU-FP7-FIBONACCI project which is focused on dissemination and systematic implementation of the IBSE *(Inquiry-Based Science Education*) method in the natural sciences curriculum in primary schools (Jokić, 2004б).

In order to encourage the application of the inquiry-based methods in schools in Serbia, it is necessary to prepare an adequate teaching model, to organize teacher training, the realization of the prepared models, the analysis of the gained results, the durability of the pupils' knowledge and finally to research and consider the opinions of the pupils, parents and teachers on the innovative teaching process.

The **research subject** is the application of the inquiry-based instruction in teaching the physics contents in the school subject *Nature and Society* and its contribution to the pupils acquiring the knowledge, skills and habits effectively, while increasing the quality and quantity of their knowledge in comparison to the traditional approach.

The research is comprised of both theoretical and empirical study of the application of the inquiry-based methods in teaching the subject *Nature and Society*. The efficiency of the inquiry-based methods is studied on the basis of the acquired knowledge, skills and habits of the pupils in the realization of the physics contents in teaching the subject *Nature and Society* in the fourth grade. The starting point was a guided discovery - learning by seeing, by defining and solving the problems, drawing conclusions and their generalization, that is an encouraging and developing creative thinking. Efficacy is seen in comparison with the traditional manner of teaching the subject Nature and Society (teacher lecturing). The quantity of knowledge is estimated based on the amount of the acquired facts and generalizations. The quality of knowledge is evaluated by the use of the six levels of knowledge: remembering, understanding, applying, analyzing, evaluating, and creating.

The **research aim** is to increase the knowledge about the possibilities of applying the inquiry-based methods in the realization of the physics contents in science teaching and the impact of the application of the inquiry-based methods to improve the pupils' achievement in the school subject *Nature and Society* in the fourth grade. Also, the aim is to offer the teachers innovative models of teaching and thereby facilitate and expand the application of the inquiry-based methods in the teaching practice. From the defined aim following the **research tasks** derives:

- The need to identify the differences in the pupils' achievement regarding the realization of the physics contents in teaching the subject *Nature and Society* in relation to whether the inquiry-based methods are applied or the classes are realized through the traditional means.
- The need to examine the durability of the knowledge of the pupils in the experimental group compared to the durability of the knowledge of the pupils in the control group (retest).

The general hypothesis of this study is that the pupils' achievement in the realization of the physics contents in the subject *Nature and Society* is positively associated with the application of the inquiry-based methods.

It is assumed that the application of the inquiry-based methods in the realization of the physics contents in teaching the subject *Nature and Society* has a positive impact on increasing the quantity and quality of the pupils' knowledge compared to teaching in the traditional way. It is assumed that the application of the inquiry-based methods in teaching the subject *Nature and Society* provides greater durability of knowledge.

The experiment with the parallel groups, in which the hypothesis of introducing the experimental performance factor is tested, is conducted. The experiment should show whether there is a causal link between the inquiry - based instruction and results of the application of this teaching model. This was allowed by the comparison of the initial and final measurements in the experimental and control groups, calculating the level of statistical significance of differences, comparing the results of the initial and final knowledge test in the experimental schools (identifying the pure effect of factor) and an analysis of the sustainability of the acquired knowledge (retest).

The **independent variable** of the research is the **experimental factor** which, in this research, consists of innovative models of the inquiry-based teaching applied in teaching the subject *Nature and Society* in the fourth grade.

The **independent variables** in this study we are trying to control, that is to control and suppress their impact on the outcome of the research, are called **independent control variables** such as:

- The general pupils' knowledge expressed through the overall achievement of the pupils at the end of third grade
- Prior knowledge of the pupils about the contents of the natural and social sciences expressed through the pupils' achievement in the subject *Nature and Society* at the end of third grade
- Prior knowledge of the pupils about the physics contents in the subject *Nature and Society*, expressed through the pupils' achievement on the initial knowledge test.

Dependent variables are the consequences resulting from the introduction of the experimental factors. The effects of learning resulting from the application of the experimental models of teaching are the dependent variables, such as the pupils' achievement and durability of these achievements. The pupils' achievements are evaluated on the basis of the initial and final knowledge test and the durability of these achievements on the basis of the final knowledge test and retest.

As the instruments for measuring the pupils' achievement the knowledge tests (initial, final and retest) designed for the needs of this research are used. The tests consisted of between 19 and 22 questions, and the maximum score on each of the three tests was 60. The pupils were solving each test in one school hour (45 min). The test questions included six levels of knowledge: remembering, understanding, applying, analyzing, evaluating, and creating (Krathwohl, 2002).

In testing the level of **remembering** there are the following tasks: recognition tasks or the tasks that require recalling terms and identifying the objects and phenomena. For the examination of the level of **understanding** the following are offered: the tasks of grouping and connecting the terms by similarity or contrast, discovering the causes or consequences and the

interpretation of the data. For the analysis of the level of knowledge **application** tasks in which the knowledge of the concepts and processes in new situations are designed, in order to explain, conclude, compare, predict, classify and investigate what is given, are designed. The tasks in which it is needed to analyze, explain, or compare the elements in order to come to the correct conclusions or choices, are designed to test the levels of **analyzing**. In order to estimate whether the students have reached the level of **evaluating** the tasks in which, through assessment, verification and judgment, choices are made, conclusions are drawn, comparisons are done and summary of the value of the data, the statements, phenomena and processes that are given or defined is done, have been prepared. In the tasks at the level of **creating** it is expected from the pupils to offer solutions and procedures for resolving the problem situations or to demonstrate some physic law.

During the period of two months (October and November 2012), the pupils have studied physics contents according to an adjusted plan. Within the topic "Investigation of the natural phenomena", during 18 school classes, the pupils studied the following: motion, materials and their changes, magnetic and electrical properties of materials, electric current, light, sound and thermal properties of materials, the solubility and the mixtures, the basic characteristics of water and other liquids, the behavior of the body in water and other liquids, the basic characteristics of air and changes that occur during heating and cooling air.

The pupils in the experimental classes have studied the listed contents through the inquiry-based teaching based on the prepared teaching models, with the prepared material for research (experimental boxes). The general scenario of the applied learning model is as follows: within the **introductory activity**, the pupils form groups and their teacher gives to each group the experimental material and written and verbal instructions; next are the **central activities** in the form of the inquiry-based learning by groups (based on the research question and materials, the pupils formulate hypotheses, conduct research and record the data) and in the end the final activities were carried out through groups reporting, comparing and connecting the results of various groups and formulating conclusions. The pupils in the control classes were presented with the same contents during the traditional lecture classes. The work of both groups, control and experimental, was monitored by the systematic observation protocols.

At the end of the experimental period the final test was conducted, and six months later the retest was conducted. The results were analyzed by the use of the SPSS program for statistics.

The **research sample** consisted of 112 fourth-grade pupils from two primary schools in Sombor (Serbia) with similar work conditions and socio-economic status of parents. The experimental group as well as the control group consisted of 56 pupils.

The assessment of the equality of groups was performed based on three variables: overall school achievement at the end of the third grade, the pupils' achievement in the subject *Nature and Society* at the end of the third grade and the pupils' prior knowledge of the physics contents in natural sciences – initial test.

RESULTS AND A DISCUSSION

Equalization of Groups by Variable Overall School Achievement at the End of the Third Grade

Since the experimental program was realized during the first half of the fourth grade, the initial state was estimated based on the overall school achievement at the end of the third grade. The overall school achievement at the end of the third grade is expressed as the number and percentage of the pupils with sufficient, good, very good and excellent grades.

Table 1. The overall school achievement of the pupils in the E and C group at the end of the third grade

Group			Frequency	Percent	Valid Percent	Cumulative Perc.
Experimental	Valid	Sufficient	1	**1.8**	1.8	1.8
		Good	1	**1.8**	1.8	3.6
		Very good	11	**19.6**	19.6	23.2
		Excellent	43	**76.8**	76.8	100.0
		Total	56	100.0	100.0	
Control	Valid	Very good	12	**21.4**	21.4	21.4
		Excellent	44	**78.6**	78.6	100.0
		Total	56	100.0	100.0	

Based on the data in Table 1 it can be concluded that the experimental (E) and control (C) group are equal according to the number of the pupils with positive success at the end of the third grade (E - 100%, C - 100%). In the experimental group, there are slightly more good pupils (E - 1.8%, C - 0%), while in the control group slightly more very good (E - 19.6%, C - 21.4%) and excellent pupils (E - 76.8% C - 78.6%).

The difference in the overall school achievement of the experimental and control group at the end of the third grade was tested with the use of the Mann-Whitney test. The results show that the value of the Mann-Whitney test $U = 1528.00$ with $p = 0.818910$ is not statistically significant, indicating that the **experimental and control group do not differ in overall school achievement at the end of the third grade.**

Equalization of Groups by Variable Pupils' Achievement in the Subject Nature and Society at the End of Third Grade

Based on the data in Table 2 it can be concluded that the experimental and control group are equal according to the number of pupils with a positive grade in the subject *Nature and Society* at the end of the third grade (E - 100%, C - 100%). In the experimental group, there are slightly more sufficient (E - 1,8%, C – 0%) and good pupils (E – 10,7%, C – 7,1%), while in the control group slightly more very good (E – 21,4%, C – 23,2%) and excellent pupils (E – 66,1%, C – 69,6%).

Table 2. The achievement in the subject Nature and Society of pupils in E and C group at the end of third grade

Group			Frequency	Percent	Valid Percent	Cumulative Perc.
Experimental	Valid	2	1	**1.8**	1.8	1.8
		3	6	**10.7**	10.7	12.5
		4	12	**21.4**	21.4	33.9
		5	37	**66.1**	66.1	100.0
		Total	56	100.0	100.0	
Control	Valid	3	4	**7.1**	7.1	7.1
		4	13	**23.2**	23.2	30.4
		5	39	**69.6**	69.6	100.0
		Total	56	100.0	100.0	

The difference in achievement in the subject *Nature and Society* of the experimental and control group at the end of the third grade was tested with the use of the Mann-Whitney test. The results show that the value of the Mann-Whitney test U = 1528.00 with p = 0.818910 is not statistically significant, indicating that the **experimental and control group do not differ in achievement in the subject *Nature and Society* at the end of the third grade.**

Equalization of Groups by Variable Prior Knowledge of Pupils about the Physics Contents in Sciences

The equalization of the groups by the variable prior knowledge of the pupils about the physics contents in sciences was performed by testing the differences between the pupils of the experimental and control group by the level of knowledge of the initial test and the initial test as a whole. In doing so, they analyzed the arithmetic mean of the number of points in the initial test, as well as the deviation of individual results from the mean (Table 3 and Table 4).

Table 3. Basic statistical parameters for the six levels of knowledge based on the initial test of the control group

Control group - **Descriptive Statistics**									
	N	Min	Max	Mean	Std. Dev.	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
in- level of remembering	56	1	5	**3.38**	1.356	-.270	.319	-1.131	.628
in- level of understanding	56	5	12	**8.79**	2.078	-.258	.319	-.954	.628
in- level of applying	56	5	8	**6.54**	.914	.187	.319	-.784	.628
in- level of analyzing	56	0	5	**2.14**	1.495	.391	.319	-.889	.628
in- level of analyzing	56	0	10	**5.23**	2.551	-.283	.319	-.599	.628
in- level of creating	56	0	4	**2.57**	1.319	-.530	.319	-.867	.628
Valid N (listwise)	56								

At the initial test, in its entirety, the experimental classes showed better results than the control classes and this difference is proved to be statistically significant. This result on the initial test is very interesting because the pupils of the control group, when equalizing the groups according to the pupils' overall achievement at the end of third grade and the achievement in the subject *Nature and Society* at the end of third grade, although statistically not significant, had slightly better results than the pupils of the experimental group. This could possibly be explained by the less restrictive grading criteria in the control classes.

Table 4. Basic statistical parameters for the six levels of knowledge based on the initial test of the experimental group

Experimental group - **Descriptive Statistics**									
	N	Min	Max	Mean	Std. Dev.	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
in- level of remembering	56	3	5	**4.20**	.644	-.203	.319	-.596	.628
in- level of understanding	56	4	13	**9.18**	2.099	-.208	.319	-.040	.628
in- level of applying	56	3	10	**7.00**	1.440	-.038	.319	.143	.628
in- level of analyzing	56	0	9	**3.48**	2.071	.198	.319	-.143	.628
in- level of analyzing	56	1	10	**5.29**	1.979	.258	.319	-.071	.628
in- level of creating	56	0	4	**2.75**	1.225	-.485	.319	-.939	.628
Valid N (listwise)	56								

The analysis of the Levene's test of equality of variances (F= 0, 135), t-test (t = 3,106) and their levels of significance (F: p = 0,714; t: p = 0,002) showed the existence of the differences in subpopulations in the dependent variable. The arithmetic means of scores of the experimental and control group for different levels of knowledge on the initial test are shown on Figure 1.

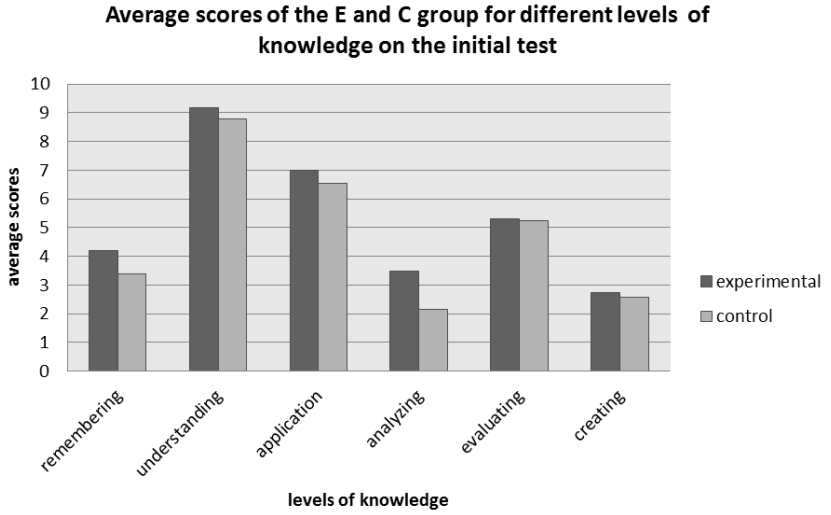

Figure 1. Achievement of the pupils in the C and E group on the initial test (mean of scores for different levels of knowledge)

Testing the differences of the arithmetic means by the level of knowledge showed that the difference in the initial test as a whole is caused by the differences in the levels of remembering, applying and analyzing, while the differences in the levels of understanding, evaluating and creating were not statistically significant between the groups. It can be concluded that the **pupils of the E group and C group are not equal according to the prior knowledge of the pupils about the physics contents in sciences.** When it comes to the highest levels of knowledge, such as evaluating and creating, the E and C groups did not differ, that is they were equal. This fact is important for research, because, among other things, the emphasis of the research is on the effects of the experimental factors on increasing the quality of the pupils' knowledge, which involves the development of a higher level and skills such as evaluation and creation.

Repeated Measures Analysis of Variance

The test results obtained at the initial, final and repeated test- retest were compared by the use of the repeated measures analysis of variance. In Table 5, their mean values and standard deviations are given. We see that the

difference in the average scores obtained in the initial and final test in the control group is 2.64, and in the experimental group 8.86. Similar differences are in the average scores obtained at the initial and repeated test - in the control group it is 2.96, in the experimental group 8.34.

Table 5. The mean values and standard deviations of the initial, final and repeated test

Descriptive Statistics				
	Group	Mean	Std. Deviation	N
Score on the initial test	Experimental	32.00	6.000	56
	Control	28.59	5.614	56
	Total	30.29	6.032	112
Score on the final test	Experimental	40.86	6.601	56
	Control	31.23	9.293	56
	Total	36.04	9.368	112
Score on the retest	Experimental	40.34	7.602	56
	Control	31.55	5.849	56
	Total	35.95	8.066	112

It is obvious that the pupils in the experimental group showed greater knowledge, as well as the durability of this knowledge, even though the initial testing showed just a slight advantage compared to the pupils in the control group. Interestingly, there is almost no difference in the average score in the final test and retest in both, the experimental and control group. This result is explained by the fact that at the end of the school year all fourth-grade pupils are preparing for the national test so that the decline in knowledge due to forgetting is not registered, but a significant difference in the success that the group achieved after the introduction of the experimental factors is maintained. The dependence of the mean values of the scores on the knowledge test of time in the experimental (E) and control (C) group is shown in the Figure 2.

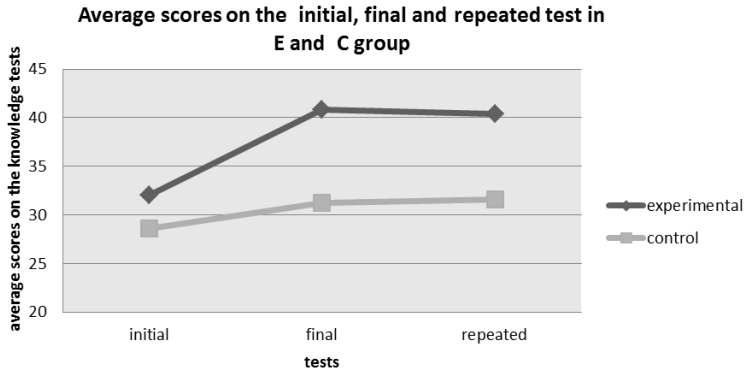

Figure 2. The dependence of the mean values of the scores on the knowledge test of time in the E and C group

The multivariate analysis of variance using several tests, one of which is competent for these results, the Wilks' lambda test, revealed a significant effect of the experimental methods on the test scores. In fact, as can be seen in Table 6, the value of the Wilks' lambda test is 0.537, the value of the Levene's test of equality of variances is F = 47.084 and is statistically significant (p = 0.000 <0.05), while the value of the magnitude of the effects (partial eta squared) is 0.463, which is based on the guidelines proposed by Cohen (Cohen, 1988, pp 284-287) (0.01 = small effect, 0.06 = moderate influence, 0.14 = large impact) large impact.

Table 6. Multivariate analysis of variance tests

		Multivariate Tests[b]					
Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
time	Pillai's Trace	.463	47.084[a]	2.000	109.000	.000	.463
	Wilks' Lambda	**.537**	**47.084[a]**	**2.000**	**109.000**	**.000**	**.463**
	Hotelling's Trace	.864	47.084[a]	2.000	109.000	.000	.463
	Roy's Largest Root	.864	47.084[a]	2.000	109.000	.000	.463

By the use of the repeated measures analysis of variance a large impact of experimental method on the test scores is found. That confirmed the general hypothesis of this research that the achievement of the pupils in the realization of the physics contents in teaching the subject *Nature and Society* is positively associated with the application of the inquiry-based instruction.

The results of the final test confirm that the application of the inquiry-based instruction in the realization of the physics content in teaching the subject *Nature and Society* has a positive impact on increasing the quantity and quality of the pupils' knowledge in regards to the traditional teaching. A significant difference in the success of the groups achieved after the introduction of the experimental factors was recorded and the repeated testing (retest) confirmed that the application of the inquiry-based instruction in teaching the subject *Nature and Society* provides a greater durability of knowledge.

CONCLUSION

The inquiry-based teaching and learning provides the conditions for an independent discovery of scientific truth, the acquisition of the skills needed in solving problems of any kind and, finally, the awareness of the students and teachers of their accomplishments. This research was conducted in order to answer the question on how to use the inquiry-based instruction in classroom teaching to increase the student achievement in the field of natural sciences. For this purpose, innovative teaching models were

designed, then their use on the physics contents in teaching the subject *Nature and Society* was studied as well as their contribution to the efficient acquisition of knowledge, skills and habits of the students, and the increase in the quality, quantity and durability of their knowledge in comparison with the traditional approach.

At the beginning of the experimental program the initial state of the control (C) and experimental (E) group was estimated. The equality of the groups was assessed based on three variables: the overall school achievement at the end of third grade, the pupils' achievement in the subject *Nature and Society* at the end of third grade and the prior knowledge of the pupils about the physics content in sciences (initial test). It was found that the E and C groups do not differ in the overall school success at the end of third grade nor in the pupils' achievement in the subject *Nature and Society* at the end of third grade. Based on the initial test it was concluded that the students of E and C groups are not equal in prior knowledge regarding the topic of the physics contents in sciences. When it comes to the knowledge at the highest levels, such as evaluation and creation, the E and C groups did not differ, i.e. they were equal.

At the final test as a whole, the experimental classes showed better results than the control classes and this difference is proved to be statistically significant. At the retest as a whole, the experimental classes showed better results than the control classes and this difference is also proved to be statistically significant. It is obvious that a significant difference between the groups obtained at the final test was maintained after six months as well, which was shown at the repeated test.

The multivariate analysis of variance showed a significant effect of the experimental method on the test scores. It is obvious that the pupils in the experimental group showed greater knowledge, as well as a greater durability of this knowledge, even though the initial testing showed just a slight advantage compared to the pupils in the control group. The fact that at the end of the school year the fourth-grade pupils are preparing for the national testing, influenced the results of the retest so that the decline in knowledge due to forgetting is not registered, but a significant difference in the success that the group achieved after the introduction of the experimental factors is maintained.

The research results showed that the implementation of the inquiry-based instruction in learning the physics contents in classroom teaching affects positively the quality and quantity of the acquired knowledge and skills of pupils, as well as the durability of that knowledge. The results confirm the need for a broader and more frequent use of the inquiry-based learning in classroom teaching. Hereby tested and validated innovative teaching models can find their place in the teaching practice and thus contribute to a better realization of the teaching science, and thus increase the scientific literacy of a larger population of pupils.

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ПРИМЕНА ИСТРАЖИВАЧКЕ МЕТОДЕ У ПОЧЕТНОЈ НАСТАВИ ПРИРОДНИХ НАУКА

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Резиме

Истраживачко учење и поучавање обезбеђује услове за самостално откривање научних истина, стицање вештина потребних при решавању проблема било које врсте и, на крају, свест и ученика и наставника о оствареним постигнућима. Ово истраживање требало је да одговори на питање како да се применом истраживачке методе у разредној настави повећају постигнућа ученика у области природних наука.

У теоријском делу рада анализирани су облици, карактеристике и модели истраживачког учења и поучавања, компетенције наставника и начини праћења и вредновања постигнућа ученика. У емпиријском делу рада приказани су резултати педагошког експеримента са паралелним групама у коме је проучавана примена истраживачке методе на физичким садржајима у настави Природе и друштва, те њен допринос ефикаснијем стицању знања, умећа и навика ученика, повећању квалитета, квантитета и трајности њиховог знања у поређењу са традиционалним приступом. За потребе истраживања обликовани су иновативни наставни модели и тестови знања. Узорак истраживања чинило је 112 ученика из осам одељења четвртих разреда две основне школе у Сомбору.

Утврђено је да се експериментална и контролна група не разликују по општем школском успеху на крају трећег разреда, као ни по успеху из предмета Природа и друштво на крају трећег разреда. Резултати почетног теста показали су да експериментална и контролна група нису уједначене по предзнању о физичким садржајима из природних наука, али је на највишим нивоима, као што су евалуација и креација, остварена уједначеност. Анализом варијансе поновљених мерења утврђен је велики утицај експерименталне методе на резултате тестова, чиме је потврђена претпоставка да су постигнућа ученика приликом реализације физичких садржаја у настави Природе и друштва у позитивној спрези са применом истраживачке методе.

Добијени резултати истраживања потврђују потребу за свеобухватнијом и учесталијом применом истраживачког учења у разредној настави. Овим путем проверени и потврђени иновативни наставни модели могу наћи своје место у наставној пракси и тако могу допринети квалитетнијој реализацији наставе природних наука, а тиме и повећању научне писмености веће популације ученика.