Croatian Journal of Education
Vol.17; Sp.Ed.No.3/2015, pages: 11-39
Original research paper
Paper submitted: 28th May 2013
Paper accepted: 24th February 2014
doi: 10.15516/cje.v17i0.911

The Efficiency of Student-led and Demonstration Experiments in Initial Physics-Chemistry Education in Primary School

Stanko Cvjetićanin[1], Dušanka Obadović[1] and Ivana Rančić[2]
[1]*Faculty of Education, University of Novi Sad*
[2]*Faculty of Sciences, University of Novi Sad*

Abstract

Contents of materials hold an important place in the realization of the goals and tasks of initial physics and chemistry education in primary school teaching. Fourth grade students (11 years old) adopt basic concepts of various physical and chemical properties of materials. The aim of this paper is to determine the efficiency of student experiments and demonstration experiments in teaching physics and chemistry, in relation to the quality of student knowledge about materials. The research sample consisted of 136 fourth grade students in primary schools in Serbia. Experimental, comparative and descriptive-analytical methods were carried out. The survey instrument was a test (initial, final test and retest were conducted), containing two tasks on each cognitive level (Bloom-Anderson-Kratwohl taxonomy). Students who had independently performed experiments acquired greater knowledge about materials in relation to students to whom experiments have been demonstrated by the teacher. They achieved better results at the level of analysis, evaluation and creation.

Key words: *demonstration experiments; initial physics and chemistry education; student experiments; student knowledge of material properties.*

Introduction

Children begin to adopt basic knowledge of physics and chemistry in early childhood, especially through the integrated contents of science (Cvjetićanin et al., 2013). In the initial physics and chemistry education, it is important to enable students to observe more (Agranović & Assaraf, 2013), directly or indirectly, certain natural processes and phenomena. Indirect observation involves the use of measuring

instruments (Lamar, 2012), which is an intermediary between human senses and the object of observation (measuring instruments often used in classrooms are thermometer, clock, meter tape...). By carrying out physical and chemical contents students should learn (Ahtee et al., 2009) the basic principles of exploring nature: how to set up a problem, how to create a hypothesis, how to explore, how to understand research findings, how to draw conclusions, and finally how to check them (Labaree, 2000). This does not mean that the teacher should ask students to repeat each of the mentioned steps with each problem. The teacher must guide students properly in seeking solutions to the problem as only in that way student progress in the application of principles of scientific problem solving is affected (Cvjetićanin, Segedinac, & Halaši, 2010). It is especially important that students are properly instructed to the methods of exploring nature and interpretation of natural processes, phenomena and other (Thurson, Grant, & Topping, 2006). It is necessary to gradually connect their knowledge about nature with scientific knowledge (Ellen, 2010).

In initial physics and chemistry education observations can be implemented in two forms. The first form of observation is studying objects or phenomena that are in their natural state. The second form of observation is observation in experimental conditions. In initial physics and chemistry education both demonstration experiments and student experiments should be used (Hart et al., 2000). With the help of experiments, students can prepare for the treatment of the lesson, repeat and summarize, and apply the acquired knowledge (Suen, 2004). Demonstration experiments in initial physics and chemistry education are appropriate when students do not have very distinct notions about experiments and how they should be performed, and when a lot of time must be spent if the experiments are performed by students. In most cases, student experiments are simpler than demonstration experiments. These experiments provide all students in the class with a systematic and thorough introduction to experimental techniques. Through experiments students learn not only the scientific contents, but it allows them to construct the required knowledge with the possibility to express their ideas, explanations and thoughts. Experiments enable them to test their hypotheses, and to gradually adopt all steps of the scientific method. In this way they learn that one way to gain knowledge is the use of facts that are logically experimentally validated, which is the foundation of the scientific approach to reality. The use of student experiments meets the children's innate need for physical activity, as well as the tendency of children's spirit to question everything that comes within the scope of their senses. Student experiments maximally activate students as they must pay full attention to what they are doing. Student interest is greater when performing experiments themselves, because they curiously await what will happen in the experiment, whether the experiment will succeed, and so on (Church, 2003). Unsuccessful student experiments do not have a negative impact on students. On the contrary, they motivate them to examine the causes of failure in order to remove them and then repeat the experiment under specific directions (Bognar

& Dubovički, 2012). Independent work on experiments is reflected in developing the following student characteristics: students become more accurate, diligent and committed, they show composure and prudence in their work, gain more confidence and sureness, become more objective in assessing their abilities, etc.

Demonstration experiments and student experiments in initial physics and chemistry education must be simple, and the conditions under which they are performed easily explainable to students. The teacher must choose to implement the simplest experiments for the realization of physical and chemical contents, ensuring that they are appropriate to students' abilities, and that they are absolutely safe for children. When selecting experiments, the following must be taken into account: that the experiment should be methodologically good (meaning that students must come to correct conclusions), methodologically correct (comprehensible, clear and convincing) and methodologically required. Through demonstration experiments and student experiments students should: develop different phases of learning and thinking; get satisfaction of interest (Kirikkaya, 2011) for the physical and chemical contents, have some practice or methods of operation in an appropriate example and so on.

Many studies indicate the importance of implementing experiments in initial physics and chemistry education, for example, Golubović Ilić (2011) examined the effectiveness and student attitudes on the implementation of student-led experiments for the subject Nature and Society and its impact on students' interest and motivation for more intensive studying of this subject. The study involved 115 third grade primary school students. While conducting the research students in the experimental group were adopting contents of inanimate nature by performing various experiments, working together in pairs or groups. Students in the control group were taught in the traditional method. Some experiments by students in the experimental group were conducted at home, as homework, and the results were presented in class. The results show that students who performed experiments have achieved better results than students in the control group. Also, in the questionnaire they indicated that they were highly motivated to perform experiments and expressed their desire to continue to have more independently performed experiments in the future. Similar results were obtained by Cvjetićanin, Segedinac and Halaši (2010). In their paper the impact of the implementation of student experiments on the quantity and quality of knowledge of fourth grade students is analyzed. The research covered the following contents: electrical charges, electrical conductivity, magnetic properties, permeability, solubility of different materials in water, mixtures and their separation and reversible and irreversible changes in the material. The study included 88 fourth grade students: 44 students in the control and 44 students in the experimental group. Students in the control group were taught about contents through the traditional method, while students in the experimental group performed student experiments. In the final test and retest students in the experimental group achieved a higher score than students in the control group. Based on that finding, it was concluded that the implementation

of the experiment, as a method of learning, had a positive effect on the quantity and quality of knowledge of primary school students and because of that experiments should be used in teaching. Similar results were obtained by Logar and Ferk-Savec (2011). Their results indicate that students' content knowledge gained through teacher's demonstration of an experiment is better and better knowledge retention takes place in comparison to students' knowledge gained through students' hands-on experimental work.

Research Methodology

Research Problem and Subject

Based on the analysis of many scientific publications, it is concluded that there are insufficient studies which compare the effectiveness of student experiments and demonstration experiments in the treatment of physical and chemical properties of the materials in grade four. In the interview with the teachers the lack of a unified attitude about which experiments should be used in teaching 4th grade students was observed. Some are of the opinion that demonstration experiments should be replaced with student experiments, while the others' opinion is that they both have the same effect on the quality of student learning. Therefore, in this study the following question was asked: Do 4th grade primary school students (11 years old) acquire better quality knowledge about materials if demonstration experiments are used instead of student experiments?

Aim

The research aim is to determine whether there is a difference in student knowledge about materials, when the contents about materials are taught by means of demonstration and by means of student experiments in grade four.

Research Hypothesis and Variables

The main hypothesis is: Demonstration experiments and student experiments have the same impact on the quality of fourth grade student knowledge about materials. Regardless of what type of experiments is used, students are equally successful in solving problems at all cognitive levels (as identified by Bloom). The independent variable in the research is learning through the use of demonstration and student experiments. The dependent variable is the quality of student knowledge at different cognitive levels. The measure of this variable is the test score on each cognitive level (the final test and retest) and the percentage of students completing one/ both/ no tasks.

Research Methods and Techniques

Experimental, comparative and descriptive-analytical methods were used in this research. Research technique in the form of testing and tests (initial, final and retest) were used as measuring instruments. Each test consisted of 12 tasks which evaluated the six levels of knowledge: remembering (retrieving, recalling, or recognizing knowledge

from memory), understanding, applying, analysing, evaluating and creating (Bloom-Anderson-Kratwohl taxonomy). Different questions were given in the initial test, final test and retest. The reliability of tests was assessed by Cronbach alpha coefficient. Its value was 0.82 in the initial test, final test and at retest. The obtained values indicated that all of the tests used were reliable. At each cognitive level students had two tasks. The t-test questions for various cognitive levels were taken from Smart tasks (Walker, 2004) and were used in the design of tasks on materials. When analysing the level of remembering (knowledge), tasks types: defining terms and marking drawings, were used. For example, in the task of defining the term, students had to list in columns of a particular table two examples of materials that may or may not be electrified. In the second task, students had to, based on the word given, sketch the stage of charging of certain materials. For analysing at the level of understanding, tasks of ordering, drawing and filling empty spaces were used. For example, students were given a task in which they were supposed to fill in the blanks with the words from the table which will show the process of charging a plastic comb and its use to attract pieces of paper. In one type of task of filling empty spaces, students were supposed to list three materials that can be electrified and not altered under the influence of heat and three materials that can be electrified and that are permanently changing under the influence of heat.

Tasks like making connection to personal experience, preparation of knowledge in order to change the current situation, the use of other sources of information and finding errors were set for the analysis of the level of application. For example, students were given a task where they had to identify which of the available material did not belong to a given range. In the second task, they had to state how it is possible to separate mixtures containing metal and paper, or metal and stones. The level of analysis was examined through the following types of tasks: identifying similarities and differences; determination; classification and tasks where one has to express attitude. For example, students were given tasks in which the starting materials had to be sorted on the basis of similar characteristics (reaction to heat, their magnetic and electrical properties). In the second task, students had to indicate how some materials differ, or how they are similar. Tasks to identify the strengths and weaknesses, for example questions like: what would happen if..., and reasoning tasks that were applied in the analysis of the evaluating level. So, for example, students were supposed to provide reasons why the use of certain materials is important in everyday life, and the reasons for caution when they are being used. In the second task, students had to explain what would happen to certain materials and why if they had been exposed to long-lasting influence of water and air. For the level of creating, tasks such as interpretation of the drawing had been applied. For example, students had to determine the behaviour of certain materials based on drawings showing the temperature on the thermometer. The other drawings showed scenes of fire and the people who put out the fire using blankets or water. Students were asked to explain the reasons for people's behaviour in the drawing.

In the evaluation of tasks, the rule applied was that tasks requiring higher levels of knowledge got a higher score. Students took each test during one school lesson. For the analysis of the results, the following statistical parameters were used: mean test score, the percentage of achieved points in relation to the maximum possible, the standard deviation (SD) and coefficient of variation (CV). The statistical significance of the obtained differences between arithmetic means was determined by the t-test, significant at 1% and 5%. F-test was used to determine whether a difference in student achievement within groups (E and D) at the same cognitive level on the initial, final test and retest was significant.

Research Sample

The sample included 136 fourth grade students (68 in group E and 68 in group D). The percentage of students who had particular overall achievement and particular achievement in subject *Nature and Society* at the end of the first semester, as well as average mark of all students in group are shown in Table 1 below. When evaluating primary school students' achievement, excellent, very good, good, satisfactory and poor success are marked as 5, 4, 3, 2, and 1, respectively.

Table 1

The research sample, the overall achievement of the students and the achievement in subject Nature and Society at the end of the first semester

Group	Student gender		The overall achievement in the first semester						The achievement in the subject *Nature and Society*					
			% of students with mark					Average mark	% of students with mark					Average mark
	M	F	5	4	3	2	1		5	4	3	2	1	
E	32	36	20.6	26.5	36.7	7.4	8.8	3.4	30.9	19.1	33.8	8.8	7.4	3.6
D	30	38	22.1	29.4	33.8	4.4	10.3	3.4	29.4	23.6	30.9	7.4	8.8	3.6
Σ	62	74	21.4	28.0	35.3	5.9	9.6	3.4	30.1	21.4	32.3	8.1	8.1	3.6

Procedure

The research procedure included:

- the analysis of pedagogical documentation of student achievement in subject Nature and Society at the end of the first semester (students in the Republic of Serbia in grade 4 learn contents about the nature within this compulsory subject),
- analysis of overall student achievement at the end of the first semester of grade 4,
- conducting initial test among students in order to determine their knowledge of materials acquired in previous grades,
- equalizing groups (groups D and E) regarding previous knowledge and success. Groups E and D were equalized based on several criteria: student outcomes on the initial test, their achievement in the subject Nature and Society, their overall achievement at the end of the first semester and the number of students in the group,

- the treatment of the contents about materials (in group D by the use of demonstration experiments, in group E by the use of student experiments),
- a comparative analysis of student knowledge in E and D groups after the treatment of the contents about materials (carried out on the basis of the results of the final test,
- analysis of student knowledge about materials, in E and D group carried out on the basis of the results of retest conducted one month after the completion of the final test.

The experiments that were implemented in the D and E groups were the same, they included contents about the materials and were carried out during three weeks (six classes). Two experiments were performed per each class, on average. They were basic (used in acquiring knowledge of the students about the basic properties of materials) and parallel (the comparison of properties of different materials). Through them, the students should learn:

- similarities and differences in the properties of materials: mechanical, thermal, electrical, magnetic, and the permeability,
- the physical and chemical changes in materials caused by heat,
- how to charge certain materials,
- the ways to increase or decrease effects of magnets,
- the relationship between material properties and their use in everyday life.

In group D demonstration experiments were used for the realization of the listed contents. Demonstration experiments were performed in three groups of students. The teacher conducted the experiments for each group of students. Students observed the experiments, without the participation in conducting them. The experiments were conducted by the teachers who taught students from the first grade. Two days before doing the experiments, the teacher gave students written instructions on how the experiments should be performed, in order for students to get familiar with the experiments selected for realization. While performing the demonstration, the methodological guidelines for carrying out demonstration experiments were followed. Before demonstrating the experiments, the teacher had conducted all the experiments in the preparatory room so they could be successfully carried out in the classroom and because an unsuccessful experiment can create distrust in the experiment as a source of knowledge among students. During the lesson, prior to performing each experiment, the teacher, in a conversation with the students, checked whether students understand the instructions given for performing the experiment, and whether they understand every step in the experiment. The teacher particularly emphasized what the students should observe in the experiment. To ensure that all students clearly see the demonstration, the teacher used supplies and materials large enough and allowed students to sit down (in a semi-circle) near the table at which the experiments took place. The teacher performed only one experiment, making sure that nothing else is in the way which

could distract the students from watching the experiment. After each experiment the teacher and students together reached appropriate conclusions based on the results of the experiment. The common findings were written on the blackboard. When students were not sure in their answers, the teacher did the same experiment again. In the final part of the lesson, the students recorded in their experiment diary notebooks the conclusions obtained from the results of the experiment. In doing so, they followed the rules of recording an experiment in a notebook (Wellington & Ireson, 2012).

In the group E the experiments were performed by students. The students formed three groups (17 four-member groups). Each group had a group leader who coordinated the work of the group and presented the results and conclusions obtained to the whole class. All groups were engaged in doing the same experiments. The groups were formed temporarily by the teacher. The groups were heterogeneous according to student knowledge (students in a group differed in the level of knowledge and skills). Two days prior to performing experiments the teacher divided students into groups (each group was named) and gave them written instructions on how to perform experiments, so that the students got familiar with experiments that they should work on in class. During the break, before the class during which the experiments were performed, the teacher prepared supplies and accessories on the desks, and clearly marked the desk for each group. Before performing the experiment, the teacher checked students' knowledge about ways of carrying out experiments. Students performed experiments based on written instructions (in the form of instructional sheets), where they could also find questions that they were supposed to answer after the experiment. The changes that students should observe during the experiment had been highlighted in bold letters. In groups, students summarized the results of the experiment, made certain conclusions and answered questions given in the work sheet. After performing the experiments and drawing conclusions by each group, students from all groups, with the help of teacher provided some conclusions that were written down on the board. In the final part of the lesson students in group E, as did students in group D, properly registered all of the performed experiments in their notebooks for the experiments. Teachers who taught students in group E worked with them from the first grade.

Results

The percentage of students who correctly solved one or two tasks or failed to solve any task at a certain cognitive level on the initial test is shown in the table below (Table 2). Differences in knowledge about materials between students in groups D and E at different cognitive levels are given in the table (Table 3).

The percentage of students who correctly solved one or two tasks or failed to solve any task at a certain cognitive level on the final test, after carrying out the contents about materials through demonstration and student experiments, is shown in the table below (Table 4). Differences in knowledge about materials between students in groups D and E at different cognitive levels are given in the table (Table 5).

Table 2

Achievement of students in D and E group on the initial test tasks

Cognitive level	D group % of students who gave a correct answer in:			E group % of students who gave a correct answer in:		
	One task	Both tasks	None task	One task	Both tasks	None task
Remember	27.9	72.1	0	25.0	75.0	0
Understand	19.1	64.7	16.2	17.6	63.2	19.2
Apply	22.1	61.7	16.2	20.5	60.3	19.2
Analyze	26.5	45.6	27.9	26.5	44.1	29.5
Evaluate	1.5	3.0	95.5	3.0	1.5	95.5
Create	1.5	1.5	97.0	3.0	0	97.0

Table 3

Difference in knowledge of students in D group and students in E group on the initial test

Cognitive level	Group	N	Scores on level	$\overline{x}$	SD	t relation	p
Remember	E	68	238	3.700	1.8073	.868	.368
	D	68	235	3.656	1.8002		
Understand	E	68	294	4.523	.5156	.742	.464
	D	68	300	4.611	.4586		
Apply	E	68	384	5.847	1.4589	1.033	.314
	D	68	396	6.024	1.5057		
Analyze	E	68	546	8.229	2.6546	.529	.587
	D	68	560	8.437	1.9829		
Evaluate	E	68	32	0.671	1.03	.113	.908
	D	68	40	0.787	1.43		
Create	E	68	18	0.464	2.4344	.515	.566
	D	68	27	0.535	1.8627		

Table 4

Achievement of students in D and E group on the final test tasks

Cognitive level	D group % of students who gave a correct answer in:			E group % of students who gave a correct answer in:		
	One task	Both tasks	None Task	One task	Both tasks	None task
Remember	25.0	75.0	0	23.6	76.4	0
Understand	17.6	64.8	17.6	17.6	66.2	16.2
Apply	22.1	61.7	16.2	23.6	61.7	14.7
Analyze	39.6	23.8	36.6	23.6	61.7	14.7
Evaluate	10.3	8.8	80.9	20.6	27.8	51.6
Create	7.4	4.4	88.2	17.6	16.2	66.2

Table 5

Difference in knowledge of students in D group and students in E group on the final test

Cognitive level	Group	N	Scores on level	$\overline{x}$	SD	t relation	p
Remember	E	68	240	3.729	.69	1.762	.075
	D	68	238	3.700	.99		
Understand	E	68	306	4.700	1.03	.742	.434
	D	68	300	4.611	1.36		
Apply	E	68	400	6.082	.6026	.868	.377
	D	68	396	6.024	.5356		
Analyze	E	68	699	10.032	1.37	2.329	.021
	D	68	415	6.300	7.49		
Evaluate	E	68	412	6.257	1.43	6.764	.000
	D	68	154	2.461	7.40		
Create	E	68	305	4.685	2.63	10.157	.000
	D	68	99	1.655	9.21		

The students' knowledge in groups D and E tested on the retest is shown in the table below (Table 6). There is a difference in students' knowledge about materials in groups D and E at particular cognitive levels (Table 7).

Table 6

Achievement of students in D and E group on the retest tasks

Cognitive level	D group % of students who gave a correct answer in:			E group % of students who gave a correct answer in:		
	One task	Both tasks	None task	One task	Both tasks	None Task
Remember	27.9	73.5	0	26.5	73.5	0
Understand	19.1	61.8	19.1	19.1	64.7	16.2
Apply	23.6	54.3	22.1	25.1	54.3	20.6
Analyze	17.7	19.1	63.2	26.5	41.2	32.3
Evaluate	8.8	5.9	85.3	17.7	19.1	63.2
Create	4.4	1.5	94.1	11.8	10.3	77.9

The difference in the knowledge of students in group D and students in group E in the initial, final test and retest is shown in Table 8. Values of the coefficient of variation of E group and D group at each cognitive level on the initial test, final test and retest are shown in Table 9.

The results given show that groups D and E were equivalent before the treatment of contents about materials (Table 2). Comparison of overall success of the students in groups D and E shows that the average mark is the same for both groups (3.4). However, there is little difference between the groups in the number of students who had an excellent, very good, good, satisfactory or poor achievement. The percentage of students in group D compared to percentage of students in group E is little higher in group D when we considered the students who had: excellent achievement (D-

Table 7

Difference in knowledge of students in D group and students in E group on the retest

Cognitive level	Group	N	Scores on level	$\overline{x}$	SD	t relation	p
Remember	E	68	236	3.858	1.45	1.033	.304
	D	68	238	3.700	1.52		
Understand	E	68	303	4.656	2.86	.531	.597
	D	68	291	4.479	2.11		
Apply	E	68	427	5.008	1.43	1.417	.160
	D	68	323	4.950	1.73		
Analyze	E	68	518	7.817	1.23	2.821	.004
	D	68	265	4.187	7.83		
Evaluate	E	68	303	4.756	2.96	6.234	.000
	D	68	112	1.847	9.78		
Create	E	68	198	3.111	2.94	6.669	.000
	D	68	45	1.061	8.87		

Table 8

Difference in knowledge about materials of students in group D and students in group E on the initial test, final test and retest

Test	Total score		Min		Max		$\overline{x}$		SD		t-test	p
	D	E	D	E	D	E	D	E	D	E		
Initial	1558	1512	18	16	34	32	26.50	25.78	5.459	4.553	1.786	.073
Final	1604	2362	10	38	30	46	23.9	38.30	14.165	18.243	2.46	.032
Retest	1274	1885	8	26	24	34	18.90	29.90	13.684	17.207	2.96	.010

Table 9

Values of the coefficient of variation of group E and group D at each cognitive level on the initial test, final test and retest

Test	Group	Cognitive level					
		R.	U.	Ap.	An.	E.	C-
Initial	E	21.11	21.22	18.55	22.33	19.05	21.48
	D	20.52	19.97	17.63	20.89	18.78	21.16
Final	E	22.33	21.16	19.05	7.25	7.37	5.81
	D	21.48	20.89	18.87	19.27	20.68	19.43
Retest	E	25.64	22.52	19.88	6.13	5.22	5.54
	D	22.31	20.97	18.35	18.83	16.78	17.95

R.- Remember; U.- Understand; Ap.- Apply; An.- Analyze; E.- Evaluate; C. Create

22.1%, E-20.6%), very good achievement (D-29.4%, E-26.5%), and poor achievement (D-10.3%, E-8.8%). Students in group E have achieved a slightly higher percentage of good achievement (D-33.8%, E-36.7%) and satisfactory (D-4.4%, E-7.4%), compared to students in group D. Similar data was obtained when analysing the success of students in groups D and E for the subject Nature and Society. The average mark of students in group E and group D was the same (3.6.) A slightly higher percentage of students in group E, compared to students in group D had excellent (D-29.4%,

E-30.9%), good (D-30.9%, E-33.8%) and satisfactory (D-7.4%, E-8.8%) achievement in subject Nature and Society. A slightly higher percentage of students in group D, compared to students in group E achieved very good (D-23.6%, E-19.1%), and poor achievement (D-8.8%, E-7.4%). The results of the initial test indicate that students in both, group D and group E, have very similar knowledge about materials. When comparing the total score on the initial test for students of each group separately, it can be seen that the students in group D got a 46 points higher score (1558 points) compared to students in group E (1512 points). Statistical data shows that this difference is insignificant (Table 3). When analysing students' performance at each cognitive level it can be seen that there is no difference in prior knowledge of students in group D and group E about materials, that the students acquired in previous grades (t-test values at each cognitive level are at the level of significance greater than 0.05). Comparing the values of arithmetic means (M) and standard deviations (SD) for cognitive levels of students in group D and group E, it is evident that among them there is no significant difference, indicating the equality of prior knowledge about materials among both groups of students. The results clearly indicate that students in E and D groups have gained similar knowledge about materials in previous grades so they are levelled by the quality of knowledge. Students of both groups showed low achievement, especially in the tasks at the level of evaluation and creation.

After carrying out the contents about materials through demonstration or student experiments, student knowledge was tested (Table 4). The difference in the total score on the final test is 758 points in favour of the E group. Students in group E were equally successful as students in group D at the remembering level (t=1.762, p=.075), understanding (t=.742, p=.434) and application (t=.868, p=.377). The difference in scores between students in group D and students in group E at each of those levels was not significant. Students in group E (Table 5) achieved better results than students in group D at the level of analysis (t=2.329, p=.021), evaluation (t=6.764, p=.000) and creation (t=10.157, p=.000). Based on the analysis of the value of coefficient of variation for the level analyse (D-19.27%, E-7.25%) evaluate (D- 20.68%, E-7.37 %) and create (D-19.43%, E- 5.81%), it is concluded that their values are significantly lower in group E than in group D, indicating that students in group E have more equal knowledge in these cognitive levels than students in group D. When analysing the success of students in both groups, it is concluded that the percentage of students who successfully solved both tasks, or only one, decreases with higher cognitive levels.

After a month, students in both groups were tested (retest). This showed that students in group E have acquired more permanent knowledge about materials than students in group D (Table 6). They have shown better results at the same cognitive levels as they did in the final test. A significant difference in students' knowledge (Table 7) at the level of analysis (t=2.821, p=.004), evaluate (t=6.234, p=.000) and create (t=6.669, p=.000) is confirmed by the value of the t-test and p value. The difference in scores between E and D groups at those levels is influenced by the total score difference on the retest, and it is 611 points. Students in both groups were equally

successful at the level of remembering (t=1.033, p=.304), understanding (t=.531, p=.597) and applying (t=1.417, p=.160). When comparing the values of the coefficient of variation of group E and group D, at the level of analysis (D-18.83%, E-6.13%), evaluation (D-16.78%, E- 5.22 %) and creation (D-17.95%, E- 5.54), it is concluded, as in the final test, that students in group E have more equal knowledge at these cognitive levels than students in group D. As on the final test, the percentage of students who did not correctly carry out any task at a certain cognitive level, on the retest increases with higher cognitive levels. The comparison of the students' achievement in each group at the same cognitive level on the initial test, the final test and retest shows that there are no significant differences in the number of students who did the tasks correctly at the level of remembering and understanding (F test value for each level is greater than .005). This difference was significant within each group at the levels of: application (E: F=9.213, sig=.000; D: F=8.203, sig=.000), analysis (E: F=6.575, sig=.001; D: F=1.256 sig=.000), evaluation (E: F=7.221, sig=.002; D: F=9.209, sig=.000) and creation (E: F=11.211, sig=.000; D: F=10.505, sig=.000) on the initial test, the final test and retest. This indicates that the experiments have significantly contributed to the students in both groups to deepen existing and acquire new knowledge about materials.

When comparing the results of student knowledge about the materials at all levels on the final test and retest, it can be noticed that the students had lower scores on the retest than on the final test (Table 8). That was an expected finding, due to the effect of forgetting (spontaneous and active). Students did not repeat the contents about materials between the final test and retest, and in the meantime learned contents on living beings which interfered with the contents on materials (Sternberg & Zhang, 2001). Student experiments have contributed more than demonstration to improving student knowledge about materials (Table 9). A group of students in group D were less successful compared to students in group E on tasks in which they had to:

- categorize and differentiate between different materials, depending on their behaviour in relation to the thermal, magnetic, electrical properties,
- suggest how one can separate the solid components of the mixture, which is a metal material,
- analyse ways to charge certain materials,
- propose how to reduce or increase the effect of the magnets,
- state the difference between physical and chemical changes of materials,
- find similarities and differences between concepts about materials,
- create new knowledge from the information provided about the materials,
- evaluate information about materials based on some criteria (temperature, magnetic and electric properties, etc.),
- give reasons for their answers to be cautious when working with certain materials, or to explain why certain materials are and others are not used, for certain household appliances,
- recommend specific materials, depending on their properties, for use in a variety of daily activities, etc.

The reasons for better results achieved by students in group E should be found in how the students acquired knowledge about certain materials (Li & Klahr, 2006). Students in group E acquired knowledge about the materials through individual performance of experiments in small groups, without the help of teachers, but under their leadership (Howe & Tolmie, 2003). They had to solve the given tasks set by the teacher without the teacher's help. They had to properly carry out the experiment on the basis of written instructions, properly record all the results, analyse them, and make independent conclusions based on them to answer given questions. All this required their maximal involvement in all stages of learning. They were really the subject of teaching. Since the groups in which they were learning were heterogeneous, it was observed that during their work better students were helping less successful students in the group. They gave them support and the necessary explanations on the performance of the experiment, the results and conclusions. In this way, successful students have contributed to the quality of knowledge about materials of inferior students. This led to a feeling of satisfaction not only in less successful students, but also the successful ones. Successful students felt that their help and knowledge was needed and valuable to others (Glynn, Yeany, & Britton, 1991). All of this is lacking in group D, which is probably influenced by more inconsistency in levels of knowledge about the materials of students in group D compared to students in group E. In lessons during which contents of materials was learned in group D the activity of teachers was more dominant. In group D students were less engaged than in group E. They were learning about materials by watching experiments that the teacher was performing in front of them. It has reflected with less memorable results and conclusions of some experiments, compared to students in group E, which are important for understanding and acquiring quality knowledge of the physical and chemical changes of materials as well as their electrical and magnetic properties. The D group of students was less in the position, than E group, to implement activities that could help them to better master knowledge about materials, such as the ability of (Ward, Roden, & Hewlett, 2008): mutual dialogue, good presentation of their ideas, solutions, ability of giving good arguments for their point of view, discussion, asking questions, making decisions, taking initiative, better self-knowledge and a more efficient use of their own interests and abilities, which is in line with the principles of active learning. These results are similar with the findings of other studies (McKee, Williamson, & Ruebush, 2007) about the impact of demonstration and student experiments on student knowledge.

Conclusion

Based on these results it is concluded that the demonstration and student experiments have the same contribution to improving the quality of student knowledge about materials at the cognitive level of: remembering, understanding and application. Regardless of what type of experiment is used, students were equally successful in tasks that require: reproducing learned contents about materials, mastering the

meaning of the contents about materials and application of their knowledge in new and concrete situations. Student experiments contributed more than demonstration to successfully solving tasks at the level of analysis, evaluation and creation. By applying student experiments students achieve better results than when using demonstration, in those tasks where it is necessary to: analyse the materials, establish mutual relations between them, find the best solutions to transform and integrate their knowledge about materials, to predict the behaviour of materials depending on environmental conditions, conclude on their application in everyday life and similar. Student experiments contribute more than demonstration when students need to formulate and build new knowledge about the materials on the basis of prior knowledge.

The obtained results show that students who acquired less knowledge about materials in previous grades perform better when doing experiments on their own than when the teacher demonstrates experiments in front of them. Based on that, it is concluded that the teachers should give priority to student experiments over demonstration when carrying out contents about materials. Through student experiments students will be more active, and they will cooperate better each with his/her specific share, to reach certain knowledge about materials. In this way they get better knowledge of materials, compared to the knowledge gained by demonstration experiments, which they will be able to use in their daily lives, and also in later education relating to physics and chemistry. Through student experiments divergent and cooperative learning is developing more rather than through demonstration experiments, and that is an important objective in the initial physics and chemistry education that should be achieved. In order to gain more insight into the effectiveness of student and demonstration experiments in the realization of contents about materials in the teaching of integrated natural sciences, it is important to continue examining their effectiveness on students' knowledge about materials in the first and second grade (7 and 8 yearolds). The existence of differences in the quality of knowledge of students who have all the time (from the beginning to the end of classroom teaching) been exposed to demonstration experiments and the students who learned about materials by carrying out student experiments should also be examined, as well as the contribution of student and demonstration experiments on the quality of students' knowledge in classroom teaching about other physicochemical contents.

Acknowledgements

Research presented in this paper was supported by the Ministry of Education and Science of the Republic of Serbia (Project No. 179010).

References

Agranović, S., & Assaraf, O. (2013). What Makes Children Like Learning Science? An Examination of the Attitudes of Primary School Students towards Science Lessons.*Journal of Education and Learning, 2* (1), 55-69.

Ahtee, M., Supmela, A., Jutti, K., Lampiselka, J., & Lavonen, J. (2009). Primary school student teachers' views about making observations. *Nordina, 5*(2),128-141.

Bognar, L., & Dubovički, S. (2012). Emotions in the teaching process. *Croatian Journal of Education, 14*(1), 135-165.

Church, E. (2003). Step-by-step scientific thinking. *Scholastic Early Childhood Today*, *6*, 35-41.

Cvjetićanin, S., Segedinac, M., & Halaši, T. (2010). Značaj primene metode eksperimenta u razrednoj nastavi. *Nastava i vaspitanje, 2*, 173–189.

Cvjetićanin, S., Pećanac, R., Sakač, M., & Brenesel-Djurendić, M. (2013). Computer Application in the Initial Education of Children in Natural Sciences. *Croatian Journal of Education, 14 (1),* 87-108.

Cvjetićanin, S., & Segedinac, M. (2011). Problems of Teachers Related to Teaching Optional Science Subjects in Elementary Schools in Serbia. *Croatian Journal of Education, 13 (2)* 184-216.

Dragić, R. (1973). *Metodika nastave hemije*. Sarajevo: Svjetlost.

Ellen, D. (2010). *Doing What Scientists Do, Second Edition: Children Learn to Investigate Their World.* Portsmouth: Heinemann.

Glynn, S., Yeany, R., & Britton, B. (1991).*The Psychology of Learning Science University of Georgia.*New Jersey: Lawrence Erlbaum Associates.

Golubović Ilić, I. (2011). Stavovi i mišljenja učenika o primeni laboratorijsko-eksperimentalne metode u nastavi prirode i društva. *Pedagogija*, *4*, 674-685.

Hart, C., Mulhall, P., Berry, A., Loughran, J., & Gunstone, R. (2000). What is the Purpose of this Experiment? Or Can Students Learn Something from Doing Experiments. *Journal of Research in Science Teaching, 37(7),* 655-675. http://dx.doi.org/10.1002/1098-2736(200009)37

Howe, C., & Tolmie, A. (2003). Group work in primary school science: discussion, consensus and guidance from experts. *International Journal of Educational Research*, 51–72. http://dx.doi.org/10.1016/S0883-0355(03)00073-9

Kirikkaya, E. (2011). Grade 4 to 8 primary school students' attitudes towards science: Science enthusiasm. *Educational Research and Reviews, 6*(4), 374-382.

Labaree, D. (2000). On the nature of teaching and teacher education: Difficult practices that look easy. *Journal of Teacher Education, 51*(3), 228-233. http://dx.doi.org/10.1177/002248710051003011

Lamar, M. (2012). Using and developing measurement instruments in science education: A Rasch modelling approach. *Science education, 96* (1), 183-185. http://dx.doi.org/10.1002/sce.20477

Li, J., & Klahr, D. (2006). The Psychology of Scientific Thinking: Implications for Science Teaching and Learning. In J. Rhoton, & P. Shane (Eds.), *Teaching Science in the 21st Century* (pp. 125-131). National Science Teachers Association and National Science Education

Leadership Association: NSTA Press.

Logar, A., & Savec Ferk, V. (2011). Students' Hands-on Experimental Work vs Lecture Demonstration in Teaching Elementary School Chemistry. *Acta Chim. Slov.*, *58,* 866–875.

McKee, E., Williamson, V. M., & Ruebush, L. E. (2007). Effects of a demonstration laboratory on student learning. *Journal of Science Education and Technology, 16*(5), 395-400. http://dx.doi.org/10.1007/s10956-007-9064-4

Sternberg, R., & Zhang, L. (2001). *Perspectives on Thinking, Learning, and Cognitive Styles*. New Jersey: Lawrence Erlbaum Associates.

Suen, M., H. (2004).Teaching about Science Teaching and Learning through an Experimental Inquiry Approach. *Australian Journal of Education, 48*(2), 182-198. http://dx.doi.org/10.1177/000494410404800207

Thurson, A., Grant, G., & Topping, K. (2006). Constructing Understanding in Primary Science: An exploration of process and outcomes in the topic areas of light and earth in space. *Electronic Journal of Research in Educational Psychology, 4* (8), 1-34.

Walker, C., & Schmidt, E. (2004). *Smart tests.* Ontario: Pembroke Publishers.

Ward, H., Roden, J., & Hewlett, C. (2008).*Teaching Science in the Primary Classroom*. London: Amazon.

Wellington, J., & Ireson, G. (2012). *Science Learning, Science Teaching, third edition.*London: Amazon.

Stanko Cvjetićanin
Faculty of Education, University of Novi Sad
Podgorička 4, 25000 Sombor, Serbia
tozchemy@eunet.rs

Dušanka Obadović
Faculty of Education, University of Novi Sad
Podgorička 4, 25000 Sombor, Serbia
dusanka.obadovic@df.uns.ac.rs

Ivana Rančić
Department of Physics, Faculty of Sciences, University of Novi Sad
Trg Dositeja Obradovića 4, 21000 Novi Sad, Serbia
ivanarancic@gmail.com

Učinkovitost učeničkih i demonstracijskih pokusa u početnom fizičko-kemijskom obrazovanju učenika razredne nastave

Sažetak

Sadržaji o materijalima zauzimaju važno mjesto u realizaciji ciljeva i zadataka početnog fizičko-kemijskog obrazovanja u razrednoj nastavi. Učenici 4. razreda (11 godina) usvajaju osnovne pojmove o različitim fizičkim i kemijskim karakteristikama materijala. Cilj rada je utvrđivanje učinkovitosti primjene demonstracijskih i učeničkih pokusa prilikom predavanja sadržaja fizike i kemije, u odnosu na kvalitetu znanja učenika o materijalima. Istraživanje je provedeno na uzorku od 136 učenika 4. razreda osnovnih škola iz Srbije. Korištena je eksperimentalna, komparativna i deskriptivno-analitička metoda. Instrument istraživanja je test (inicijalni, finalni test i retest) koji je sadržavao po dva zadatka putem kojih su se provjeravale sve kognitivne razine (Bloom-Anderson-Kratwohl taksonomija). Učenici koji su samostalno izvodili pokuse ostvarili su veća znanja o materijalima u odnosu na učenike kojima su pokuse demonstrirali učitelji. Postigli su bolje rezultate na razini analize, evaluacije i kreacije.

Ključne riječi: *demonstracijski pokusi; početno fizičko-kemijsko obrazovanje; učenički pokusi; znanja učenika o osobinama materijala.*

Uvod

Elementarna znanja iz fizike i kemije djeca počinju usvajati u ranom djetinstvu, osobito u razrednoj nastavi putem integriranih sadržaja prirodnih znanosti (Cvjeticanin, Pecanac, Sakac i Brenesel-Djurendić, 2013). U početnom fizičko-kemijskom obrazovanju važno je učenicima omogućiti da što više neposredno ili posredno promatraju određene prirodne procese i pojave (Agranovich i Assaraf, 2013). Posredno promatranje podrazumijeva upotrebu instrumenta (Lamar, 2012) koji je posrednik između osjetilnog organa i objekta promatranja (najčešće se kao mjerni instrument u razrednoj nastavi koristi termometar, sat, metarska traka...).

Putem realizacije fizičko-kemijskih sadržaja u razrednoj nastavi učenici bi trebali naučiti osnovne principe istraživanja prirode (ahte, Supmela et al., 2009), odnosno kako da postave problem, kako da stvaraju pretpostavke, kako da istražuju, prihvaćaju rezultate istraživanja, izvode zaključke i na kraju kako da ih provjeravaju (Labaree, 2000). To ne znači da bi kod svakog problema trebalo tražiti od učenika da idu točno tim putem. Učitelj mora učenike pravilno usmjeravati u traženju rješenja za dani problem jer na taj način utječe na to da učenici napreduju u primjeni načela znanstvenog rješavanja problema (Cvjetićanin, Segedinac i Halaši, 2010). Posebno je važno da učenici budu pravilno upućeni u načine istraživanja prirode, kao i tumačenja prirodnih procesa, pojava i slično (Thurson, Grant i Topping, 2006). Njihova znanja o prirodi neophodno je postupno povezivati sa znanstvenim spoznajama (Ellen, 2010).

U početnom fizičko-kemijskom obrazovanju promatranje se ostvaruje u dva oblika. Prvi oblik podrazumijeva promatranje predmeta ili pojava koje se proučavaju u njihovu prirodnom stanju. Drugi oblik podrazumijeva promatranje u uvjetima pokusa. U početnom fizičko-kemijskom obrazovanju treba se koristiti demonstracijskim i učeničkim pokusima (Hart, Mulhall et. al., 2000). S pomoću njih učenici ae mogu pripremiti za obradu nove nastavne jedinice, za ponavljane i utvrđivanje gradiva, kao i za primjenu stečenih znanja (Suen, 2004).

Demonstracijski pokusi u početnom fizičko-kemijskom obrazovanju pogodni su onda kada učenici nemaju izrazitije predodžbe o pokusima i načinu njihova izvođenja, kao i kada bi se potrošilo mnogo vremena od sata u kojem bi pokuse izvodili učenici. Učenički su pokusi u većini slučajeva jednostavniji od demonstracijskih. Ti pokusi omogućuju da se svi učenici u razredu sustavno i temeljito uvode u eksperimentalne tehnike. Posredstvom učeničkih pokusa učenici ne uče samo o sadržaju nego im se omogućuje da konstruiraju željeno znanje uz mogućnost iskazivanja svojih ideja, objašnjenja i razmišljanja. Oni imaju mogućnost testirati svoje hipoteze, odnosno postupno usvajati sve faze znanstvenog metoda. Na taj način uče da je siguran put do znanja upotreba činjenica koje su eksperimentalno i logički potvrđene, što je osnova znanstvenog pristupa stvarnosti. Upotrebom učeničkih pokusa zadovoljavaju se urođene dječje potrebe za fizičkom aktivnošću, kao i sklonosti dječjeg duha za ispitivanjem svega što dođe u domašaj njihovih osjetila. Učenički pokusi maksimalno aktiviraju učenike, jer kada učenici sami izvode pokuse, moraju dobro paziti na ono što rade. Interes učenika je veći kada sami izvode pokuse jer radoznalo isčekuju što će se u pokusu dogoditi, hoće li pokus uspjeti i slično (Church, 2003). Neuspjeli učenički pokusi ne djeluju negativno na učenike, nego naprotiv. Oni ih motiviraju da ispituju uzroke neuspjeha, kako bi ih uklonili i zatim ponovno izveli pokus po određenoj uputi (Bognar i Dubovički, 2012). Samostalan rad u okviru učeničkih pokusa razvija kod učenika sljedeće osobine: učenici se navikavaju na točnost, savjesnost, ozbiljnost, pribranost i opreznost u radu, stječu sve više samopouzdanja i sigurnosti, postaju objektivniji u ocjenjivanju svojih sposobnosti i slično.

Demonstracijski i učenički pokusi u početnom fizičko-kemijskom obrazovanju moraju biti jednostavni, a uvjeti pri kojima se izvode lako objašnjivi učenicima. Učitelj

za realizaciju fizičko-kemijskih sadržaja mora izabrati najjednostavnije pokuse, vodeći računa o tome da oni budu primjereni mogućnostima učenika, kao i da su za učenike apsolutno sigurni. Pri odabiru pokusa mora se voditi računa o tome da pokus bude: metodički dobar (s pomoću njega učenici dolaze do pravilnih zaključaka), metodički pravilan (dovoljno razumljiv, pregledan i uvjerljiv) i metodički potreban. Putem demonstracijskih i učeničkih pokusa učenicima treba osigurati: razvijanje različitih faza učenja i razmišljanja; zadovoljenje interesa (Kirikkaya, 2011) za fizičko-kemijske sadržaje, osiguravanje vježbe ili metode rada na odgovarajućem primjeru i slično.

O važnosti primjene pokusa u početnom fizičko-kemijskom obrazovanju govore mnoga istraživanja, kao na primjer istraživanje Irene Golubović Ilić (2011) koja je ispitivala učinkovitost i stavove učenika o primjeni učeničkih pokusa na satima Prirode i društva i utjecaju pokusa na zainteresiranost i motivaciju učenika za intenzivnije proučavanje sadržaja tog predmeta. Istraživanjem je obuhvaćeno 115 učenika trećeg razreda osnovne škole. Tijekom istraživanja učenici eksperimentalne skupine usvajali su sadržaje o neživoj prirodi izvodeći različite pokuse, zajedničkim radom u skupinama ili parovima. Učenici kontrolne skupine učili su na tradicionalan način. Pojedine pokuse učenici eksperimentalne skupine izvodili su kod kuće, u obliku domaćih zadataka, a dobivene rezultate predstavljali su na satima. Rezultati istraživanja pokazuju da su učenici koji su izvodili pokuse postigli bolje rezultate od učenika kontrolne skupine. Također, oni su u anketnom listiću naveli da su bili izuzetno motivirani da izvode pokuse i iskazali su želju da i ubuduće što više samostalno izvode pokuse. Slične rezultate dobili su autori Cvjetićanin, Segedinac i Halaši (2010). U ovom se radu analizira utjecaj primjene učeničkih pokusa na kvantitetu i kvalitetu znanja učenika četvrtog razreda. Istraživanjem su obuhvaćeni sadržaji o: naboju i električnoj vodljivosti, magnetskim osobinama, propusnosti i topljivosti u vodi različitih materijala, smjesama i njihovu razdvajanju i povratnim i nepovratnim promjenama materijala. Istraživanjem je obuhvaćeno ukupno 88 učenika četvrtog razreda: 44 učenika u kontrolnoj i 44 učenika u eksperimentalnoj skupini. Učenici kontrolne skupine navedene su sadržaje proučavali na tradicionalan način, a učenici eksperimentalne skupine izvodili su jednostavne učeničke pokuse. Na finalnom testu i retestu učenici eksperimentalne skupine ostvarili su viša postignuća od učenika kontrolne skupine. Na temelju toga može se zaključiti da primjena pokusa, kao metode stjecanja spoznaje, ima povoljan utjecaj na kvantitetu i kvalitetu znanja učenika razredne nastave, zbog čega je treba iskoristiti u razrednoj nastavi. Slične su rezultate dobili autori Logar i Ferk-Savec (2011). Njihovi su rezultati ukazali na to da je učeničko znanje sadržaja stečeno uz pomoć učiteljske demonstracije pokusa slabije i da je slabija retencija znanja u odnosu na znanja učenika koja su stečena učeničkim samostalnim radom.

Metodologija istraživanja

Problem i predmet istraživanja

Na temelju analize mnogih znanstvenih publikacija zaključuje se da nema radova u kojima se uspoređuje učinkovitost učeničkih s učinkovitošću demonstracijskih

pokusa pri obradi fizičko-kemijskih osobina materijala u 4. razredu osnovne škole. U razgovoru s učiteljima uočeno je da nema jedinstvenog stava među njima o tome koje pokuse treba izvoditi u stjecanju znanja učenika o materijalima u 4. razredu. Neki smatraju da učenički pokusi trebaju zamijeniti demonstracijske pokuse, a neki da i jedni i drugi imaju iste posljedice na kvalitetu znanja učenika. Zbog toga je u ovom istraživanju postavljeno sljedeće pitanje: Usvajaju li učenici kvalitetnija znanja o materijalima u 4. razredu (11 godina) osnovne škole ako se umjesto učeničkih izvode demonstracijski pokusi?

Cilj istraživanja

Cilj je istraživanja odrediti postoji li razlika u znanju učenika o materijalima kada su sadržaji o materijalima obrađeni primjenom demonstracijskih i učeničkih pokusa u četvrtom razredu osnovne škole.

Hipoteze i varijable istraživanja

Glavna hipoteza istraživanja glasi: Demonstracijski i učenički pokusi imaju isti učinak na kvalitetu znanja o materijalima učenika četvrtog razreda. Bez obzira na to koja vrsta se vrsta pokusa izvodi, učenici su jednako uspješni u rješavanju problema na svim kognitivnim razinama (kognitivne razine koje je klasificirao Bloom). Nezavisna varijabla u istraživanju je učenje putem primjene demonstracijskih i učeničkih pokusa. Zavisna varijabla je kvaliteta znanja učenika na različitim kognitivnim razinama. Mjera te varijable je rezultat koji su učenici ostvarili na svakoj kognitivnoj razini na testu (finalnom i retestu) i postotak učenika koji su riješili jedan / oba / nijedan zadatak.

Metode i tehnike istraživanja

U istraživanju je korištena eksperimentalna, komparativna i deskriptivno-analitička metoda. Tehnika istraživanja je testiranje, a mjerni instrument je test (inicijalni, finalni i retest). Svaki test sadrži 12 zadataka s pomoću kojih se vrednuje šest razina znanja: znanje (prisjećanje, podsjećanje, prepoznavanje znanja iz memorije), razumijevanje, primjena, analiza, evaluacija i kreacija (Bloom-Anderson-Kratwohl taksonomija). U inicijalnom testu, finalnom testu i retestu bili su različiti zadaci. Pouzdanost testa procijenjena je Kronbahovim alfa koeficijentom. Njegova je vrijednost ista 0.82 na inicijalnom testu, finalnom testu i retestu. Dobivena vrijednost ukazuje na to da su korišteni testovi pouzdani. Na svakoj kognitivnoj razini učenici su imali dva zadatka. Tip testovnih zadataka za razne kognitivne razine iz *Pametni zadaci* (Walker, 2004) poslužio je u kreiranju zadataka o materijalima. Pri analizi razine znanja (prisjećanja) korišteni su zadaci tipa: definiranje pojmova i obilježavanje crteža. Tako su, na primjer, u zadatku definiranja pojma učenici u stupcima tablice trebali navesti po dva primjera materijala koji se mogu, odnosno ne mogu nabijati. U drugom tipu zadatka na temelju zadanih riječi crtežom je potrebno prikazati faze naboja pojedinih materijala. Za analizu razine razumijevanja korišteni su zadaci tipa izrada redoslijeda, crtanje i zadaci popunjavanja praznih polja. Tako su, na primjer, učenici imali zadatak u kojem su u

prazna polja tablice trebali upisati riječi s pomoću kojih će pokazati proces naboja plastičnog češlja i njegovu upotrebu u privlačenju komadića papira. U jednom zadatku tipa popunjavanja praznih polja učenici su trebali navesti tri materijala se mogu nabijati a da se pri tome ne mijenjaju s obzirom na djelovanje topline, odnosno tri materijala koja se mogu nabijati a da se pri tome trajno mijenjaju pod utjecajem topline.

Zadaci tipa povezivanja s osobnim iskustvom: pripremanje znanja radi promjene postojećeg stanja, upotreba drugih izvora informacija i zadaci pronalaženje pogrešaka primijenjeni su u analizi razine primjene. Tako su, na primjer, učenici imali zadatak u kojem su trebali otkriti koji od ponuđenih materijala ne pripada odgovarajućem nizu. U drugom su zadatku trebali navesti načine kako je moguće razdvojiti smjesu u kojoj se nalaze metal i papir, odnosno metal i kamenčići. Razina analize ispitana je zadacima tipa: pronalaženje sličnosti i razlika, određivanje osobina, razvrstavanje i zadaci tipa iskazivanje stava. Tako su, na primjer, učenici imali zadatke u kojima su ponuđene materijale trebali razvrstati na temelju sličnih osobina (ponašanje prema toplini, njihovim magnetskim i električnim osobinama). U drugom zadatku učenici su trebali navesti po čemu se pojedini materijali razlikuju, odnosno po čemu su slični. Zadaci prepoznavanja prednosti i mana: *što bi bilo kada bi*... i zadaci zaključivanja primijenjeni su u analizi razine evaluacije. Tako je, na primjer, korišten zadatak u kojem su učenici trebali navesti razloge zbog kojih je važna upotreba pojedinih materijala u svakodnevnom životu, odnosno razloge za oprez pri njihovoj upotrebi. U drugom zadatku učenici su trebali objasniti što bi se dogodilo s pojedinim materijalima i zašto ako bi se izložili dužem djelovanju vode, odnosno zraka. Za razinu kreacije primijenjeni su zadaci tipa tumačenje crteža. Tako su, na primjer, učenici na temelju crteža na kojem je prikazana temperatura sredine s pomoću termometra trebali odrediti ponašanje pojedinih materijala. Na drugom crtežu bili su prikazani prizori požara i ljudi koji gase požar s pomoću deke, odnosno vode. Učenici su trebali objasniti razloge ponašanja ljudi na crtežu?

Pri vrednovanju zadataka primjenjivalo se pravilo da zadaci koji zahtijevaju više razine znanja nose veći broj bodova. Učenici su svaki test izvodili jedan školski sat. Pri analizi rezultata korišteni su sljedeći statistički parametari: srednja vrijednost broja ostvarenih bodova na testu, postotak ostvarenih bodova u odnosu na maksimalno moguć broj bodova, standardna devijacija (SD) i koeficijent varijacije (CV). Statistička značajnost dobivenih razlika između aritmetičkih sredina utvrđena je t-testom, na pragovima značajnosti od 1% i 5%. F-test je upotrijebljen da bi se utvrdilo je li značajna razlika u postignućima učenika unutar skupina (E i D) na pojedinačnim kognitivnim razinama na inicijalnom testu, finalnom testu i retestu.

Uzorak istraživanja

Uzorak istraživanja obuhvatio je 136 učenika četvrtog razreda osnovne škole (68 u E i 68 u D skupini). Postotak učenika koji su ostvarili određeni opći uspjeh i određeni uspjeh iz predmeta Priroda i društvo na kraju prvog polugodišta, kao i prosječna

ocjena svih učenika u skupini prikazana je u tablici (Tablica 1). U ocjenjivanju uspjeha učenika osnovne škole, odličan, vrlo dobar, dobar, dovoljan i nedovoljan uspjeh ocijenjeni su ocjenama 5, 4, 3, 2, 1, respektivno.

Tablica 1.

Postupak istraživanja

Postupak istraživanja obuhvaćao je sljedeće etape:

- Analiza pedagoške dokumentacije o postignućima učenika iz predmeta Priroda i društvo na kraju prvog polugodišta (učenici u Republici Srbiji u 4. razredu uče sadržaje o prirodi u tom obaveznom predmetu),
- Analiza općeg uspjeha učenika na kraju prvog polugodišta 4. razreda,
- Analiza prethodnih znanja učenika o materijalima i njihovoj upotrebi u svakodnevnom životu s pomoću inicijalnog testa,
- Izjednačavanje skupina (skupine D i E) na temelju predznanja i ostvarenog uspjeha. Skupine E i D su ujednačene u pogledu nekoliko kriterija: učeničkih postignuća na inicijalnom testu, uspjeha iz predmeta Priroda i društvo, općeg uspjeha na kraju prvog polugodišta i broja učenika,
- Realizacija sadržaja o materijalima (s pomoću demonstracijskih pokusa u D skupini, odnosno s pomoću učeničkih pokusa u E skupini),
- Komparativna analiza znanja učenika E i D skupine nakon završetka realizacije sadržaja o materijalima (provodi se na temelju rezultata finalnog testa),
- Analiza trajnosti znanja učenika E i D skupine o materijalima (provodi se na temelju rezultata retesta provedenog mjesec dana poslije realizacije finalnog testa).

Pokusi koji su ostvareni u D i E skupini bili su isti, obuhvaćali su sadržaje o materijalima i izvodili su se tijekom tri tjedna (ukupno šest sati). Na svakom satu u prosjeku su izvedena po dva pokusa. Oni su po svojim osobinama bili osnovni (koriste se u stjecanju znanja učenika o osnovnim osobinama materijala) i usporedni (za usporedbu osobina različitih materijala). Posredstvom pokusa učenici su trebali naučiti o:

- sličnostima i razlikama u osobinama materijala na temelju mehaničkih, toplinskih, električnih, magnetskih svojstava i na temelju propusnosti,
- fizičkim i kemijskim promjenama materijala izazvanim djelovanjem topline,
- načinima naboja pojedinih materijala,
- načinima povećanja, odnosno smanjenja djelovanja magneta,
- odnosu osobina materijala i njihove upotrebe u svakodnevnom životu.

U D skupini za obradu navedenih sadržaja korišteni su demonstracijski pokusi. Demonstracijski pokusi izvođeni su u tri razredna odjela. Pokuse u svakom odjelu izvodio je učitelj. Učenici su promatrali pokuse bez uključivanja u njihovo izvođenje. Učitelj koji je izvodio pokuse predavao je učenicima od prvog razreda. Učitelj je dva dana prije izvođenja pokusa učenicima dao pisane upute za izvođenje pokusa, kako bi

se učenici upoznali s pokusima koje će izvoditi na satu. Pri izvođenju demonstracijskih pokusa poštovane su metodičke upute za izvođenje demonstracijskih pokusa. Prije demonstracije pokusa učitelj je sve pokuse izveo u pripremnoj prostoriji s ciljem da pokus uspješno izvede na satu, jer neuspio pokus stvara kod učenika nepovjerenje u pokus kao izvor znanja. Na satu je učitelj prije izvođenja svakog pokusa, u razgovoru s učenicima, provjerio jesu li učenici razumjeli dobivene upute za izvođenje pokusa, jesu li im jasni svi postupci u pokusu. Posebno je naglašavao učenicima što u pokusu trebaju promatrati. Da bi osigurao da svi učenici jasno vide izvođenje pokusa, učitelj se koristio dovoljno velikim priborom i omogućio je učenicima da sjednu (u polukrug) blizu stola na kome je demonstrirao pokuse. Učitelj je izvodio samo jedan pokus, vodeći računa da pri tome ne izvodi neke druge aktivnosti, kako na taj način ne bi odvraćao pozornost učenika od pokusa. Svaki pokus učitelj je jasno i precizno izveo, vodeći računa o tome da ga učenici aktivno promatraju. Poslije izvedenog svakog pokusa učitelj i učenici su zajedno donosili odgovarajuće zaključke na temelju dobivenih rezultata pokusa. Zajedničke zaključke učitelj je zapisivao na ploču. U slučajevima kada učenici nisu bili sigurni u svoje odgovore, učitelj je pokuse ponovio. U završnom dijelu sata učenici su zapisivali u svoje bilježnice za pokuse izvedene demonstracijske pokuse, sa zaključcima dobivenim na temelju rezultata pokusa. Pri tome su poštovali pravila bilježenja pokusa u bilježnicu (Wellington i Ireson, 2012).

U E skupini izvođeni su učenički pokusi. Učenici su radili u tri odjela i podijeljeni su u skupine (17 skupina po četiri člana). Svaka skupina imala je vođu skupine koji je koordinirao rad skupine i priopćavao cijelom odjelu rezultate i zaključke skupine dobivene poslije izvedenih pokusa. Sve su skupine radile iste pokuse. Skupine su bile po trajanju privremene i oblikovao ih je učitelj. Prema znanjima učenika skupine su bile heterogene (učenici različitih razina znanja i sposobnosti). Učitelj je dva dana prije izvođenja pokusa učenike podijelio u skupine (svaka je skupina dobila naziv) i dao im pisane upute za izvođenje pokusa, kako bi se učenici upoznali s pokusima koje će izvoditi na satu. Na odmoru, prije samoga sata na kojem su izvođeni pokusi, učitelj je postavio materijal i pribor na stolove učenika, i vidno obilježio stol svake skupine njezinim imenom. Prije izvođenja pokusa učitelj je provjerio znanje učenika o načinima izvođenja pokusa. Učenici su izvodili pokuse na temelju pisanih uputa (u vidu instruktivnog listića) na kojima su se nalazila i pitanja na koja su učenici trebali odgovoriti poslije izvođenja pokusa. Posebno je masnim slovima istaknuto koje promjene učenici trebaju promatrati tijekom izvođenja pokusa. Učenici su u skupini zbrojili rezultate pokusa na temelju kojih su donosili određene zaključke, i odgovarali na postavljene zadatke u radnom listiću. Nakon realizacije pokusa i iznošenja zaključaka svake skupine, učenici su uz pomoć učitelja, na temelju rasprave, donosili određene zajedničke zaključke koji su zapisivani na ploču. U završnom dijelu sata, kao i učenici D skupine, učenici E skupine pravilno su bilježili sve izvedene pokuse u svoje bilježnice za pokuse. Učitelj koji je radio s učenicima E skupine njihov je učitelj od prvog razreda.

Rezultati istraživanja

Postotak učenika koji je uspio točno riješiti jedan ili oba zadatka, ili nije riješio nijedan od zadataka, na određenoj je kognitivnoj razini prikazan u narednoj tablici (Tablica 2). Razlike u znanju o materijalima učenika D i E skupine na različitim kognitivnim razinama prikazane su u tablici (Tablica 3).

Tablica 2. i 3.

Ukupan broj ostvarenih bodova učenika D i E skupine poslije realizacije sadržaja o materijalima primjenom demonstracijskih, odnosno učeničkih pokusa na finalnom testu, kao i na pojedinim kognitivnim razinama, prikazan je u tablici (Tablica 4). Razlike u znanju o materijalima učenika D i E skupine na različitim kognitivnim razinama prikazani su u tablici (Tablica 5).

Tablica 4. i 5.

Trajnost znanja učenika D i E skupine, iskazana na retestu, prikazana je u narednoj tablici (Tablica 6). Postoji razlika učenika D i E skupine u trajnosti znanja o materijalima na pojedinim kognitivnim razinama (Tablica 7).

Tablica 6. i 7.

Razlika u znanju učenika D i E skupine na inicijalnom testu, finalnom testu i retestu prikazana je u tablici (Tablica 8). Vrijednosti koeficijenta varijacije E i D skupine na svakoj kognitivnoj razini na inicijalnom testu, finalnom testu i retestu prikazane su u tablici (Tablica 9).

Tablica 8. i 9.

Prikazani rezultati pokazuju da su D i E skupina bile ujednačene prije realizacije sadržaja o materijalima (Tablica 2). Kada se usporedi opći uspjeh učenika D i E skupine uočava se da je srednja ocijena ista za obje skupine (3,4). Međutim, postoji mala razlika u broju učenika između skupina koji su ostvarili odličan, vrlo dobar, dobar, dovoljan, odnosno nedovoljan uspjeh. U D skupini veći je postotak nego u E skupini učenika koji su ostvarili odličan (D-22,1%, E-20.6%), vrlo dobar (D-29,4%, E-26,5%), odnosno nedovoljan uspjeh (D-10, 3%, E-8,8%). U E skupini učenici su ostvarili u neznatno većem postotku dobar uspjeh (D-33,8%, E-36,7%), odnosno dovoljan (D-4,4%, E-7,4%), u odnosu na učenike D skupine. Slični se podaci dobivaju kada se analizira uspjeh učenika D i E skupine iz predmeta Priroda i društvo. Prosječna ocjena učenika E i D skupine je ista i iznosi 3.6. U E skupini neznatno veći postotak učenika, u odnosu na učenike D skupine, ima odličan (D-29,4%, E-30,9%), dobar (D-30,9%, E-33,8%), odnosno dovoljan (D-7,4%, E- 8,8%) uspjeh iz predmeta Priroda i društvo. Učenici D skupine u neznatno većem postotku su od učenika E skupine ostvarili vrlo dobar (D-23,6%, E-19.1%), odnosno nedovoljan uspjeh (D-8,8%, E-7,4%). Dobiveni rezultati na inicijalnom testu ukazuju na to da učenici D

i E skupine imaju vrlo slična znanja o materijalima. Kada se usporedi ukupan broj ostvarenih bodova na inicijalnom testu učenika obje skupine, uočava se da su učenici D skupine (1558 bodova) u odnosu na učenike E skupine (1512 bodova) ostvarile više od 46 boda. Ta razlika, što pokazuju statistički podaci, neznačajna je (Tablica 3). Kada se analiziraju rezultati učenika na svakoj kognitivnoj razini, uočava se da nema razlike u stečenom znanju o materijalima u prethodnim razredima učenika D i E skupine (vrijednosti t-testa na svakoj kognitivnoj razini su na razini značajnosti većoj od 0,05). Usporedbom vrijednosti aritmetičkih sredina (AS) i standardne devijacije (SD) na kognitivnim razinama u D i E skupini uočava se da među njima nema značajne razlike, što ukazuje na ujednačenost znanja o materijalima učenika obje skupine. Dobiveni rezultati nedvojbeno ukazuju na to da su učenici E i D skupine stekli vrlo slična znanja o materijalima u prethodnim razredima, odnosno da su izjednačeni po kvaliteti znanja. Učenici obje skupine ostvarili su loše rezultate, posebno u zadacima na razini evaluacije i kreacije.

Nakon realizacije sadržaja o materijalima primjenom demonstracijskih, odnosno učeničkih pokusa, provedeno je testiranje znanja učenika (Tablica 4). Razlika u broju ukupnih ostvarenih bodova, u korist učenika E skupine, je 758 bodova. Učenici E i D skupine bili su jednako uspješni na razinama znanja (t=1,762, p=,075), razumijevanja (t=,742, p=,434) i primjene (t=,868, p=,377). Razlika u broju ostvarenih bodova učenika D i E skupine na navedenim razinama nije značajna. Učenici E skupine (Tablica 5) postigli su bolje rezultate od učenika D skupine na razini analize (t=2,329, p=,021), evaluacije (t=6,764, p=0,000) i kreacije (t=10,157, p=,000). Na temelju analize vrijednosti koeficijenta variranja na razini analize (D-19,27%, E-7,25%), evaluacije (D-20,68%, E-07,37%) i kreacije (D-19,43%, E-5,81%) zaključuje se da su njihove vrijednosti znatno niže u E skupini nego u D skupini, što ukazuje na to da u E skupini učenici imaju veću ujednačenost u znanju na tim kognitivnim razinama od učenika D skupine. Kada se analizira uspjeh učenika obiju skupina, može se zaključiti da se postotak učenika koji su točno riješili oba zadatka, ili samo jedan, smanjuje kako se povećava kognitivna razina.

Poslije mjesec dana učenici obiju skupina su testirani (retest). Pokazano je da su učenici E skupine usvojili trajnija znanja o materijalima od učenika D skupine (Tablica 6). Bolje rezultate pokazali su na istim kognitivnim razinama kao na finalnom testu. Značajna razlika u znanju učenika (Tablica 7) na razini analize (t=2,821, p=,004), sinteze (t=6,234, p=,000) i evaluacije (t=6,669, p=,000) potvrđena je vrijednostima t-odnosa i p vrijednostima. Razlika u broju ostvarenih bodova na tim razinama utjecala je na ukupnu razliku u ostvarenim bodovima na retestu i ona iznosi 611 bodova. Učenici obiju skupina bili su jednako uspješni na razinama znanja (t=1,033, p=,304), razumijevanja (t=,531, p=,597) i primjene (t=1,417, p=,160). Kada se usporede vrijednosti koeficijenta variranja u E i D skupini, na razini analize (D-18,83%, E-6,13%), evaluacije (D-16,78%, E-05,22%) i kreacije (D-17,95%, E-05,54 %), zaključuje se, kao i na finalnom testu, da na tim razinama znanja učenici E skupine

imaju više ujednačena znanja od učenika D skupine. Kao i na finalnom testu, tako i na retestu postotak učenika koji nije točno izveo nijedan zadatak na određenoj kognitivnoj razini raste s povećanjem kognitivne razine. Kada se usporede postignuća učenika u svakoj skupini na istoj kognitivnoj razini na inicijalnom testu, na finalnom testu i na retestu, pokazuje se da ne postoje značajne razlike u broju učenika koji su točno riješili zadatke na razini znanja i razumijevanja (značajnost F-testa za svaku je razinu veća od .005). Ta je razlika bila značajna u okviru svake skupine na razinama: primjene (E: F=9,213, sig=,000; D: F=8,203, sig=,000), analize (E: F=6,575, sig=,001; D: F=1,256, sig=,000), evaluacije (E: F=7,221, sig=,002, D: F=9,209, sig=,000) i kreacije (E: F=11,211, sig=,000 D: F=10,505, sig=,000) na inicijalnom testu, finalnom testu i retestu. To ukazuje na to da su pokusi značajno doprinijeli tome da učenici u obje skupine produbе postojeća i steknu nova znanja o materijalima.

Kada se usporede rezultati znanja učenika o materijalima na svim razinama na finalnom testu i retestu uočava se da su učenici postigli lošiji uspjeh na retestu od uspjeha koji su postigli na finalnom testu (Tablica 8). To je za očekivanje zbog efekta zaboravljanja (spontanog i aktivnog). Učenici nisu ponavljali sadržaje o materijalima između finalnog testa i retesta, odnosno u tom su vremenu učili sadržaje o živim bićima, zbog čega je došlo do ometanja sadržaja o materijalima (Sternberg i Zhang, 2001). Učenički su pokusi više od demonstracijskih doprinijeli u unapređenju znanja učenika o materijalima (Tablica 9). Učenici D skupine bili su manje uspješni u odnosu na učenike E skupine u zadacima u kojima su trebali:

- kategorizirati, odnosno napraviti razlike između pojedinih materijala ovisno o njihovu ponašanju u odnosu na termička, magnetska, električna svojstva,
- predložiti način kako mogu odvojiti sastojke čvrste smjese, u kojoj je jedan materijal metal,
- analizirati načine naboja pojedinih materijala,
- predložiti kako da se smanji, odnosno poveća učinak magneta,
- navesti razliku između fizičkih i kemijskih promjena materijala,
- pronalaziti sličnost i razlike među pojmovima o materijalima,
- od ponuđenih informacija o materijalima stvoriti nova znanja,
- procijeniti podatke o materijalima na temelju nekog kriterija (temperature, magnetskih i električnih osobina i sličnog),
- obrazložiti svoje odgovore za oprez pri radu s pojedinim materijalima, odnosno obrazložiti zašto se pojedini materijali koriste, a drugi ne, za izradu pojedinih uređaja u kućanstvu,
- preporučiti pojedine materijale, ovisno o njihovim osobinana, za upotrebu u raznim svakodnevnim aktivnostima i slično.

Razloge za bolji uspjeh učenika E skupine treba tražiti u načinu na koji su učenici došli do određenih znanja o materijalima (Li i Klahr, 2006). Učenici E skupine su do znanja o materijalima, došli putem samostalno izvođenih pokusa u malim skupinama, bez pomoći učitelja, ali pod njegovim vodstvom (Howe i Tolmie, 2003). Rješavali

su zadatke koje je učpitelj postavio bez njegove pomoći. Morali su paziti na to da pravilno izvedu pokus, na temelju pisanih uputa, da pravilno zabilježe sve dobivene rezultate, da ih analiziraju, donesu samostalno zaključke i da na temelju njih odgovore na postavljena pitanja. Sve to zahtijevalo je njihovo maksimalno angažiranje u svim etapama nastave. Oni su u pravom smislu riječi bili subjekt nastave. Budući da su skupine u kojima su radili bile heterogene, uočeno je da su tijekom rada uspješniji učenici pomagali manje uspješnim učenicima u skupini. Oni su im pružali podršku i pomoć u objašnjavanju izvođenja pokusa, dobivenih rezultata i donošenju zaključaka. Na taj su način uspješniji učenici utjecali na kvalitetu znanja o materijalima lošijih učenika. To je utjecalo na osjećaj zadovoljstva ne samo lošijih nego i uspješnijih učenika. Uspješniji su učenici imali osjećaj da su njihova pomoć i znanje potrebni i dragocjeni drugima (Glynn, Yeany, i Britton, 1991). Sve je to izostalo kod učenika D skupine, što je vjerojatno i utjecalo na veću neujednačenosti u znanjima o materijalima učenika D skupine u odnosu na učenike E skupine. Na satima obrade sadržaja o materijalima u D skupini više je dominirala aktivnost učitelja nego na satima u E skupini. Učenici D skupine usvajali su znanja o materijalima gledanjem pokusa koji je učitelj izvodio pred njima, zbog čega su bili manje angažirani od učenika E skupine. To je utjecalo na slabije pamćenje rezultata i zaključaka pojedinih pokusa u odnosu na učenike E skupine, važnih za razumijevanje i stjecanje kvalitetnih znanja o fizičkim i kemijskim promjenama materijala, kao i o njihovim električnim i magnetskim svojstvima. Učenici D skupine bili su, u odnosu na učenike E skupine, manje u prilici da ostvare aktivnosti koje im mogu pomoći u boljem i kvalitetnijem ovladavanju znanjem o materijalima, kao što su sposobnosti (Ward, Roden, i Hewlett, 2008): međusobnog dijaloga, dobrog prezentiranja vlastite ideje, rješenja, argumentiranja vlastitog stava, raspravljanja, postavljanja pitanja, donošenja odluka, preuzimanja inicijative, samopoznanja i djelotvornije promicanja vlastitih interesa i sposobnosti, što je u skladu s principima aktivnog učenja. Dobiveni su rezultati slični rezultatima dobivenim u drugim istraživanjima (McKee, Williamson, i Ruebush, 2007) o utjecaju koji demonstracijski i učenički pokusi imaju na znanje učenika.

Zaključak

Na temelju dobivenih rezultata zaključuje se da demonstracijski i učenički pokusi podjednako doprinose unapređenju kvalitete znanja o materijalima učenika na kognitivnoj razini: znanja, razumijevanja i primjene. Bez obzira na to koja se vrsta pokusa izvodi, učenici su podjednako uspješni u zadacima koji zahtijevaju: reprodukciju naučenih sadržaja o materijalima, ovladavanje značenja sadržaja o materijalima, odnosno u zadacima u kojima stečena znanja treba primjeniti u novim, konkretnim situacijama. Učenički pokusi više od demonstracijskih doprinose uspješnom rješavanju zadataka na razini analize, evaluacije, odnosno kreacije. Primjenom učeničkih pokusa učenici postižu bolje rezultate nego primjenom demonstracijskih, odnosno primjenom zadataka u kojima trebaju: anlizirati materijale, raščlaniti ih, uspostaviti uzajamne

odnose među njima, naći najbolja rješenja, transformirati i integrirati stečena znanja o materijalima, predvidjeti ponašanje materijala ovisno o uvjetima sredine, zaključiti o njihovoj primjeni u svakodnevnom životu i slično. Učenički su pokusi više od demonstracijskih pridonijeli učeničkom oblikovanju novih znanja o materijalima na temelju postojećih znanja.

Dobiveni rezulati ukazuju na to da učenici koji su stekli lošije znanje o materijalima u prethodnom razredu postižu bolje rezultate kada pokuse izvode samostalno nego kada se oni pred njima demonstriraju. Na temelju svega rečenog zaključuje se da bi učitelji pri realizaciji sadržaja o materijalima trebali dati prednost učeničkim pokusima u odnosu na demonstracijske. U učeničkim pokusima učenici će se više aktivirati nego u demonstracijskim, odnosno više će ulaziti u kooperacije, svatko sa svojim specifičnim udjelom, da bi došli do određenih znanja o materijalima. Na taj način oni stječu kvalitetnija znanja o materijalima u odnosu na znanja stečena primjenom demonstracijskim pokusa, kojima će se moći koristiti u svakodnevnom životu, ali i u kasnijem obrazovanju iz područja fizike i kemije. Putem učeničkih pokusa više se razvija divergentno i kooperativno učenje nego putem demonstracijskih, što je važan cilj u početnom fizičko-kemijskog obrazovanju koji treba ostvariti. Kako bi se dobio bolji uvid u učinkovitost učeničkih i demonstracijskih pokusa u ostvarenju sadržaja o materijalima u učenju integriranih prirodnih znanosti, važno je nastaviti s ispitivanjem znanja učenika o materijalima u prvom i drugom razredu (7. i 8. godina). Također, treba ispitati postoje li razlike u kvaliteti znanja učenika koji su sve vrijeme (od početka do kraja razredne nastave) učili putem demonstracijskih pokuse i učenika koji su učili o materijalima izvođenjem učeničkih pokusa. Važno je ispitati doprinos učeničkih i demonstracijskih pokusa kvalitetu znanja učenika o drugim fizičko-kemijskim sadržajima u razrednoj nastavi.

Napomena

Istraživanje prikazano u ovom radu podržano je od *Ministarstva prosvete, nauke i tehnološkog razvoja Republike Srbije* (Projekt br. 179010).