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Influence of the Electronic Classroom as an Interactive Model of Organising Teaching on Student Achievements in Classroom Teaching

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Abstract

The paper presents the results of examining the influence of electronic teaching aids and the electronic classroom as an interactive model of organizing teaching on the level and quality of students' achievements (knowledge, skills, competences) in processing teaching contents of the subject Science and Social Studies. The research included 264 fifth-grade primary school students from Bosnia and Herzegovina (132 students in the experimental and control group). Theoretical analysis was used in the research, along with the descriptive and experimental methods with parallel groups. Testing was used as a research technique, and initial and final knowledge tests as measuring instruments. The results show that by using the electronic classroom, the experimental group of students achieved a better level of knowledge of the "Creation and composition of the Earth" unit, as opposed to the control group taught in a traditional classroom. Better results have also been determined with regard to the three levels of education standards derived from Bloom's taxonomy. Since these are statistically significant, we were able to largely reject the main hypothesis of this research.

Key words: *active learning; level of information complexity; Science and Social Studies; teaching aids; teaching models.*

Introduction

It is very important to point out the need for applying information and communication technology (ICT) in the learning process (Tezci, 2011; Horvat et al.,

2013). The application of computers plays an important role in achieving objectives and tasks of teaching integrated Natural Sciences. Computer-assisted teaching encourages abstract thinking, and enables planning the direction and individual progress of students in adopting knowledge (Greenfield & Yan, 2006). The main objective of introducing contemporary information technology into teaching is to make the road towards gaining knowledge easier and the knowledge itself more permanent. Computer-assisted teaching not only depends on material conditions, but the teacher as well – namely, his/her willingness and training in contemporary technology. (Solaković & Pećanac, 2013, p. 171). Moreover, Pećanac and Rastovac (2011) claim that teacher computer training should enable students to adopt information technology contents and use this knowledge and skills to process contents from different fields.

Nowadays, multimedia educational software, which contain an abundance of information and enable clear-cut and easy navigation through the contents of a certain topic, are being created. Textbook content can be supplemented with teaching software that contain graphic displays and video materials accompanied by animation and sound, which enables the reception of highly versatile information through a precise technical presentation (Grujičić, Solaković, & Spremić Solaković, 2012, p. 76). Multimedia educational contents, as stated by Janković (2015, pp. 131-132), combine all positive qualities of former teaching aids, as well as supporting technical devices, into a qualitatively new teaching technology. They combine – synthetically and qualitatively – words, textual inscriptions, animations, all previously known audio-visual aids, experience exchange and visualisations of all kinds, from reality to virtual reality. By presenting teaching material that is going to be taught in a lesson through a combination of various visual aids and media (images, historical photographs, charts, maps, documentary and sound recordings, etc.), we respond to individual differences between students as well as their different learning styles (Trbojević, Jeremić, & Pećanac, 2015).

The electronic classroom is a type of classroom based on a programmed approach which relies on the application of computers and a learning management system. It is a specially equipped space comprising of a teacher's computer and students' computers, connected by a learning management system via router. As opposed to other organisation solutions and teaching aids, the electronic classroom is characterized by the simultaneous use of multiple electronic teaching aids and media, trustworthiness in displaying the studied contents and phenomena, movement in all directions (in both space and time), interactivity in all relations, dynamics and absence of boredom, permanent ability to control and verify results and promptly receive feedback.

Previous Research

According to Janković (2012), positive influence of computer use on the development of the cognitive sphere was most studied during the 1980s, while more recent studies focus more on the importance of visualisation in teaching, the influence of computers

on social development, interaction and communication, and ways of adapting certain programs and software to users, even pre-school children. Clark (1983) argues that technology is only a means of knowledge transfer and does not influence student achievement to a greater extent. A large number of studies have shown that students achieve better results when using computers and information technology, but Clark attributes these facts to better learning strategies that are built into the electronic teaching material. Brabazon (2007) states that the biggest problem of education today is the fact that clicking has replaced thinking. She also points out that a deep discrepancy has been created between the high level of students' computer literacy and the low level of their information literacy. On the other hand, Kozma (2001) argues that the learning process is significantly affected by the technology and media that is used. He further emphasises that it is not the computer that motivates students to study harder, but their interaction with models of interactive information technology applied in the learning process. Therefore, according to Kozma, information technology and the teaching contents must be created according to specific pedagogical, methodological and aesthetic principles.

Electronic teaching materials, as Rossett believes (2002), must be thought out and designed keeping in mind, above all, the process of learning and the students, while ensuring the best possible programming and technical solutions and quality. According to Solaković (2013), the production of electronic teaching materials is not an easy task and it would be much easier for teachers if they had at their disposal, on the Internet, a kind of database of electronic teaching materials, which could be freely exchanged and downloaded onto their computers and used in teaching. Many experts from around the world studied the role and function of the electronic classroom in the educational reform. Zhang, Zhao, Zhou, and Nunamaker (2004) – a group of authors from the University of Maryland and the University of Texas – highlight how the electronic classroom and the interactive system of teaching activities surpass the traditional classroom. Interesting results were also presented by Thomas (2002), who determined that students who did their exercises in an electronic classroom had better support for problem solving, critical thinking and creative ideas in the performance of their school obligations than students who did their exercises in traditional classrooms. A very small number of regional authors dealt with the use of the electronic classroom in education. Those that can be singled out are, perhaps, Vasiljević (2010), who dealt with historical classroom development, and Adamov and Segedinac (2006), who presented the advantages and disadvantages of computer-supported education in the electronic classroom, as well as a brief overview of electronic education in Serbia.

The focus of our interest was also the question of interactive learning in the classroom as an important determinant of a quality teaching process, but also one of the paradigms of the school of the future. Researchers from the Swansea Metropolitan University from Great Britain – Kennewell, Tanner, Jones, and Beauchamp (2008) – studied how interactive information technology can support interactive teaching.

They concluded that it is necessary to clearly define technical (IT) and pedagogical objectives of the lesson, so that the variety of interactive information technologies – included in teaching activities – do not create confusion when students work independently. By analysing practical experiences in organising and implementing interactive learning in the classroom through interactive information technology use, Hall and Higgins (2005) emphasise that primary school students were delighted by the multimedia capabilities of these technologies, had fun and were interested while learning. On the other hand, they point out some of the weaknesses, such as the technical problems that occurred, insufficient training of teachers for the successful application of these technologies and the inaccessibility of these technologies to all students. The aforementioned prevalent attitudes and opinions presented in relevant sources lead us to conclude that very little is being done on the implementation of information and communication technologies in classroom teaching in our region.

Application of information and communication technology in education, electronic classrooms, learning management systems, multimedia educational software and presentations are topics many authors around the world (e.g. Andre, 2000) dealt with. Many regional pedagogists, didactitians and teaching methodologists also dealt with these topics: Mužić and Rodek (1987); Nadrljanski (1991); Damjanović (1999); Branković and Mandić (2003); Stanković (2009); Nikolić and Veličković (2012), and many others.

Research conducted so far mainly focused on determining the didactic and methodological influence or value of individual multimedia teaching aids, whereas there is a lack of research into their more complex effects, created through their interconnectedness, as well as the organisation enabled by the electronic classroom. This is the case at least in our region and at the level of younger school-age students i.e. students in classroom teaching. This is precisely what motivated our experimental research the most.

Methodological Framework of the Research

Research Problem and Subject

It is to be expected that the electronic classroom, which is the research problem in this paper, should facilitate teaching and learning as it enables easy access to new contents, and provides easy methods for measuring and analysing achievements. Within it, advanced learning methods based on appropriate visualisation, exploration and discovery are applied, which is why it is easiest to achieve not only material but also functional educational teaching objectives and tasks by teaching in the electronic classroom.

In a broader sense, the object of this research is located in the field of educational technology. More specifically, our goal is to determine the didactic and methodological influence of the electronic classroom as an interactive model of organising teaching on the level and quality of student achievements in lower primary school grades, as

well as the electronic teaching aids applicable in the processing of teaching contents of the subject Science and Social Studies.

Research Aim and Tasks

The aim of the research is to determine the influence of teaching by using the electronic classroom as an interactive model of organising teaching and electronic teaching aids (experimental group), compared to the traditional organisational model of teaching (control group) and reflected in the level and quality of achievements (knowledge, skills and competences) of fifth-grade primary school students in the processing of teaching contents of the subject Science and Social Studies. Research tasks have been identified based on the object and aim of the research. The most important ones are: to determine the level and quality of achievements expressed through the knowledge of experimental and control group students, and determine the degree of retention of adopted contents and skills, as well as the ability of experimental and control group students to apply the adopted knowledge 90 days after the realisation of the pedagogical experiment.

Research Hypotheses

The main hypothesis is: It is assumed that there is no statistically significant difference in the level and quality of achievements (knowledge, skills and competences) of fifth-grade primary school students in the processing of teaching contents of the subject Science and Social Studies, with regard to whether the electronic classroom and electronic teaching aids (experimental group) or the traditional classroom and appropriate teaching aids (control group) are used as a model for organising teaching.

Special research hypotheses are:

H_1 – It is assumed that there is no statistically significant difference in the level and quality of achievements (knowledge, skills and competences) of fifth-grade primary school students with regards to the organisation model and appropriate teaching aids used in the processing of contents of the subject Science and Social Studies.

H_2 – It is assumed that there is no statistically significant difference in the degree of retention of adopted contents 90 days after their processing or adoption, with regards to whether the electronic classroom and electronic teaching aids (experimental group) or the traditional classroom and its appropriate teaching aids (control group) were used as a model for organising teaching.

H_3 – It is assumed that there is no statistically significant difference in the level and quality of students' achievements (knowledge, skills and competences) in relation to evaluations conducted on three occasions (initial evaluation, final evaluation and final evaluation repeated after 90 days).

Research Methods, Techniques and Instruments

The following methods were used in the research: theoretical analysis, the descriptive and experimental method.

Theoretical analysis was used to create the theoretical basis for the research, identify research aims and tasks, and formulate research hypotheses. By using this method, the pedagogical material related to the planning, preparation and realisation of teaching Science and Social Studies (curriculum, textbooks, work plans and teacher preparation for the lessons) and the characteristics of the student sample (gender and grades in Science and Social Studies at the end of the fourth grade of primary school) were analysed as well. The descriptive method was used to gather data on respondents, determine the time necessary for conducting the experiment and select experimental factors and research models. This method was also used to realise the planned observations of lessons, conducted in order to ensure that both groups work in approximately the same conditions. The experimental method with parallel groups of one experimental (E) and one control group (C) was applied in the research.

Testing was applied as a research technique and two tests of knowledge (initial and final) were applied as measuring instruments. The initial test was used in the preliminary evaluation of the level and quality of student achievements (knowledge, skills and competences); the final test was used in the final evaluation of the level of the quality of achievements immediately after the processing of teaching contents introduced in the experiment, and the repeated final evaluation conducted 90 days after the first final evaluation. When using the term "quality of student achievement", we refer to the results obtained in the repeated final evaluation, which indicate that students understand the adopted contents well, have the ability to solve practical tasks, retained what they learned and are creative. The level and quality of student achievements in tests were expressed in points, with respect to the amount and degree of the retention of the adopted teaching material, and in relation to the three levels of education standards derived from Bloom's taxonomy of education goals, which is why the tests included three groups of questions/tasks. The first level of education standards presupposes that the student only recalls and reproduces knowledge; the second level presupposes that the student reproduces and, to some extent, understands more complex cause-effect connections or relationships between facts; the third level presupposes that the student understands cause-effect connections and relationships and, most importantly, that s/he applies this knowledge in solving problems or appropriate tasks (Bjekić, Zlatić, & Najdanović-Tomić, 2006). The metric characteristics of the tests were examined by calculating Pearson's correlation coefficient, the reliability coefficient, the task difficulty index and the task discrimination index, and performing factor analysis (Kundačina & Brkić, 2004). Both tests had 12 diverse questions/tasks (true/false, multiple choice, insert the phrase, concise answer, find the appropriate pair and practical solutions to certain problems). The maximum score for each test was 48, and points were given with respect to the group of questions/tasks to which an individual question belongs, keeping in mind the number of correct facts and solutions given by the student and the number of mistakes made. The tests included three groups of questions/tasks, with each group consisting of four questions. The first

group of questions/tasks referred to the first level of education standards and had a maximum of eight points. The second group of questions/tasks referred to the second level of education standards and had a maximum of 16 points, while the third group of questions/tasks referred to the third level of education standards and had a maximum of 24 points. The questions/tasks in all three groups were created in accordance with the standards of the individualisation of teaching, i.e. by applying the tasks to the three levels of complexity derived from the specially defined educational standards of student achievements for primary schools in Bosnia and Herzegovina. A segment of educational standards that focuses on knowledge and expected outcomes, and touches upon the differentiation of school activities, internal and external evaluation, and the manner of comparing student achievements on the individual (comparing individual students' previous and current achievements) and class level (comparing achievements among students), was included.

The contents of the teaching unit "Creation and composition of the Earth" were taught to the experimental group in electronic classrooms as interactive models of organising teaching, using technical and electronic teaching aids. The contents of the same unit were taught to the control group in traditional classrooms, using textbooks and workbooks. The most significant difference between teaching aids used in the electronic and traditional classroom is the degree of their interactivity.

The experimental group applied the Mythware Classroom Management System in electronic classrooms, as well as Intel personal computers as technical aids, which are all a part of the "Learning by modelling 1:1 – Dositej" (project "Dositej") project, as well as multimedia educational software and a multimedia educational presentation. The Mythware Classroom Management System and Intel Classmate personal computers as technical aids used by the experimental group were obtained for use in this research, while the multimedia educational software and multimedia educational presentation were created by the authors of this research. Since project "Dositej" has been carried out since 2012, teachers and students were already familiar with the Mythware Classroom Management System and Intel Classmate personal computers.

The "Creation and composition of the Earth" unit was taught in four lessons: new material was presented in two lessons, two lessons were dedicated to revising and one to systematising knowledge. Teaching preparations differed according to the type of lesson and the application of technical and electronic teaching aids. Teaching preparations for the realisation of all three interactive models of organising teaching by using electronic teaching aids in electronic classrooms were designed. The following concept of teaching preparation was used for lessons in which new material was presented: introductory part of the lesson (teachers and students turn on their computers and the Mythware Classroom Management System; teacher sends the teaching contents to students via the Mythware Classroom Management System); the main part of the lesson (students study the teaching contents on their Classmate personal computers and solve self-evaluation knowledge tests according

to e-learning standards; teacher supervises students' work and analyses their results) and the final part of the lesson (students solve association tasks on their Classmate personal computers; teacher sends the final test consisting of five questions to students via the Mythware Classroom Management System; students solve the final test on their Classmate personal computers and return it electronically to the teacher). The following concept of teaching preparation was used for the revision lessons: introductory part of the lesson (teacher turns on the notebook computer and presents the multimedia educational software via projector to students); the main part of the lesson (teacher and students repeat the teaching contents together using the projector and multimedia educational software; working individually, students solve self-evaluation knowledge tests according to e-learning standards) and the final part of the lesson (students solve association tasks through a frontal form of teaching and solve the final test electronically). The following concept of teaching preparation was used for systematization lessons: introductory part of the lesson (teacher turns on the notebook computer and shows the multimedia educational presentation to students via projector); the main part of the lesson (using the projector and multimedia educational presentation, teacher and students discuss the teaching contents; students create mind maps in their workbooks) and the final part of the lesson (using a frontal form of teaching, teacher and students repeat the most important teaching contents together; students use mind maps to solve a printed final test). In the control group, the same teaching contents were taught in traditional classrooms, using textbooks and workbooks. After that, the final evaluation was conducted in the experimental and control group. After 90 days, a repeated final evaluation was conducted. The research was conducted during the school year 2014/2015. Research results were analysed using the independent samples t-test and single-factor repeated-measures analysis of variance (ANOVA) with the help of the IBM SPSS statistics program. The contribution of the study is reflected in the empirical verification of project "Dositej", which is carried out in Bosnia and Herzegovina, and in defining directions for the further development of the project in primary schools by improving the didactic organisation and methodological practice of teaching in an e-classroom environment.

Research Sample

Primary schools in Bosnia and Herzegovina have a nine-year schooling system, according to which classroom teaching starts in the first and ends after the fifth grade. The subject Science and Social Studies is introduced in the second grade and split into two separate subjects (Science, Social Studies) in the fifth grade. The research included 264 fifth-grade students from six primary schools in Bosnia and Herzegovina: half of the students (132) constituted the experimental group, while the other half constituted the control group. In order to obtain a more representative sample, the research was conducted in 12 fifth-grade classes, i.e. in each school we included two fifth-grade classes in the research. The fifth-grade students were aged 10 and 11. Regardless of the

sample size, the authors concluded that the sample was not sufficiently representative. The sample was taken from primary schools that have agreed to participate in the research. Therefore, this is an intentional sample that is not entirely representative, which must be kept in mind when making conclusions about the population as a whole based on the sample. The experimental and control groups have been matched according to the principle of pairs based on gender and grades in Science and Social Studies at the end of the fourth grade and the initial evaluation (Tables 1 and 2).

Table 1

Approximate matching of students from the experimental and control group with respect to their gender, grades in the subject Science and Social Studies at the end of the fourth grade and number of points achieved in the initial evaluation

Group	Sex			Grade in the subject Science and Social Studies at the end of the fourth grade (%)			
	M	F	Total e.g.	5	4	3	2
E	65	67	132	72.73	21.21	3.79	2.27
C	63	69	132	74.24	18.94	6.06	0.76

Note. M=Male; F=Female; Total e.g.=Total number of students with respect to their gender in all groups; 5=Excellent; 4=Very good; 3=Good; 2=Sufficient.

Table 2

Differences between the experimental and control group in the levels of students' knowledge in the initial evaluation

Group	N	M	SD	df	t	MD
E	132	32.57	8.06			
C	132	32.58	5.73	262.00	-.009	-.007

Note. N=Total number of cases; *M*=Sample mean, arithmetic average; *SD*=Standard deviation; *df*=Degree of freedom; *t*=Independent samples t-test; *MD*=Mean difference.

Results

Differences in the values of arithmetic means between the experimental and control group in the levels of students' knowledge identified in the final evaluation are presented in table form (Table 3).

Table 3

Differences between the experimental and control group in the levels of students' knowledge identified in the final evaluation

Group	N	M	SD	df	t	MD
E	132	37.44	4.76			
C	132	36.04	4.53	262.00	2.45*	1.40

Note. N=Total number of cases; *M*=Sample mean, arithmetic average; *SD*=Standard deviation; *df*=Degree of freedom; *t*=Independent samples t-test; *MD*=Mean difference.

* signifies fields for which the independent samples t-test measurements show statistically significant differences between groups ($p < .05$)

Differences in the values of arithmetic means between the experimental and control group in the levels of students' knowledge identified in the repeated final evaluation conducted after 90 days are shown in Table 4.

Table 4

Differences between the experimental and control group in the levels of students' knowledge identified in the repeated final evaluation conducted after 90 days

Group	N	M	SD	df	t	MD
E	132	36.22	4.74			
C	132	34.13	4.68	262.00	3.62*	2.10

Note. *N*=Total number of cases; *M*=Sample mean, arithmetic average; *SD*=Standard deviation; *df*=Degree of freedom; *t*=Independent samples t-test; *MD*=Mean difference.

* signifies fields for which the independent samples t-test measurements show statistically significant differences between groups ($p < .01$, $p < .05$)

Differences in the repeated measures ANOVA for the experimental and control group in the levels of students' knowledge achieved on the three tests (initial evaluation, final evaluation and repeated final evaluation conducted after 90 days) are shown in Table 5.

Table 5

Repeated measures analysis of variance for the experimental and control group in the levels of students' knowledge achieved on the three tests

Group	PT	N	M	SD	df	VL	F	PES
E	IT	132	32.57	8.06	2.13	.66	32.99*	.34
	FT	132	37.44	4.76				
	RFT	132	36.22	4.74				
C	IT	132	32.58	5.73	2.13	.56	50.99*	.44
	FT	132	36.04	4.53				
	RFT	132	34.13	4.68				

Note. PT=Period of time; IT=Initial test; FT=Final test; RFT=Repeated final test taken after 90 days; *N*=Total number of cases; *M*=Sample mean, arithmetic average; *SD*=Standard deviation; *df*=Degree of freedom; VL=Wilks's lambda; *F*=*F* distribution, Fisher's *F* ratio; *PES*=Partial eta squared.

* signifies fields for which the independent samples t-test measurements show statistically significant differences between groups ($p < .05$)

Discussion

Students from the experimental and control groups were matched based on gender, grades in Science and Social Studies at the end of the fourth grade and results in the initial evaluation. The research included 264 students, 180 boys and 184 girls (Table 1). Before the introduction of experimental factors into the research, the uniformity of the experimental and control group was examined as well. The first unit the students studied in Science and Social Studies in the fifth grade was "Celestial bodies". Students' knowledge on this subject was evaluated with the initial test. Statistically significant differences between the experimental and control group were tested with the independent samples t-test. There were no statistically significant differences: the experimental group (M=32.57; SD=8.06); the control group (M=32.58; SD=5.73); t (262)=0.009 is slightly in favour of the control group (Table 2). Limit t values for the groups are 1.97 at the 0.05 level and 2.60 at the 0.01 level.

The differences between the results obtained in the experimental and control group are incidental and insignificant, i.e. the differences that emerged between the

arithmetic means can be attributed to random variation. The aforementioned results confirm that the experimental and control group were matched accordingly, with respect to previous knowledge shown in the initial evaluation. This indicates that students from the experimental and control group have learned previous contents of the subject Science and Social Studies in an identical, traditional way.

The final evaluation was conducted immediately after the experiment was finalized and included the unit "Creation and composition of the Earth". Arithmetic means of the final evaluation results for the experimental and control group were compared. A statistically significant difference was obtained: the experimental group (M=37.44; SD=4.76); the control group (M=36.04; SD=4.53); t (262)=2.45 is in favour of the experimental group (Table 3). A statistically significant difference in favour of the experimental group was obtained for the 0.05 level of significance. Limit t values for the groups were the same as in the initial evaluation.

Analysis of the final evaluation results showed that better results were achieved by students from the experimental group, who processed the contents of the "Creation and composition of the Earth" unit in electronic classrooms as interactive models of organising teaching, using technical and electronic teaching aids, compared to the control group, where the same unit was processed in traditional classrooms, using textbooks and workbooks. Possible factors influencing experimental group students to achieve better results include: better working conditions in the electronic classroom; a model of organising teaching with the highest level of interactivity; better student engagement during the lesson in the electronic classroom; better intrinsic student motivation for studying teaching contents by using information and communication technology; electronic teaching materials specially designed for that particular unit and form of teaching aids; better didactic and methodological effectiveness of applied electronic teaching aids; higher level of student interest and motivation; multimedia design of teaching contents; and taking self-evaluation knowledge tests according to e-learning standards. In general, it can be concluded that a statistically significant difference in favour of the experimental group was obtained only for the 0.01 level of significance. This is what largely contributed to the rejection of the first special hypothesis of this research, in which it was assumed that there was no statistically significant difference in student achievements with regards to whether teaching was conducted in the electronic classroom or in a traditionally organised one, i.e. using electronic multimedia or traditional teaching aids.

After 90 days, a repeated final evaluation (retest) of students from the experimental and control group was conducted. A statistically significant difference was obtained: the experimental group (M=36.22; SD=4.74); the control group (M=34.13; SD=4.68); t (262)=3.62 is in favour of the experimental group (Table 4). A statistically significant difference for the experimental group was obtained for both levels of significance (0.05 and 0.01). Limit t values for the groups were the same as in the initial and final evaluation.

When the results of the repeated final evaluation – conducted 90 days after the final evaluation – were analysed, it was found that students from the experimental group achieved even better results compared to the final evaluation. The authors believe that the permanency of knowledge (retention) of students from the experimental group was mostly influenced, among all previously mentioned possible factors, by solving self-evaluation knowledge tests according to e-learning standards, which provided students with an opportunity to practice solving all types of test questions. For the repeated final evaluation (conducted after 90 days), it can generally be concluded that a statistically significant difference was obtained in favour of the experimental group at both levels of significance (0.05 and 0.01). Therefore, the second special hypothesis has also been rejected.

The results of testing students from the experimental and control group obtained in the initial evaluation (before the introduction of the experimental factor), the final evaluation (after the introduction of the experimental factor) and the repeated final evaluation (three months after the introduction of the experimental factor) were compared by using the repeated measures ANOVA. A statistically significant effect of time was determined. For the experimental group: Wilks's lambda=0.66; F (2.13)=32.99; p<.05; multivariate partial eta squared=0.34; and for the control group: Wilks's lambda=0.56; F (2.13)=50.99; multivariate partial eta squared=0.44 (Table 5). A statistically significant difference was obtained only for the 0.05 level of significance for both groups. Limit *F* values for the groups are 19.49 at the 0.05 level and 99.49 at the 0.01 level.

Further examination of results of the repeated-measures analysis of variance leads to the conclusion that students from the experimental and control group achieved significantly better results in the final evaluation. Data indicate that a large number of students from the experimental group benefited from learning by using electronic teaching aids in the electronic classroom, given that many of them solved questions/tasks belonging to the third level of complexity which included understanding cause-effect relationships and the application of knowledge in solving practical problems. On the other hand, it is interesting that the results show that students from the control group also achieved better results in evaluations conducted on multiple occasions, which can be subsumed under the influence of parasitic factors related to the fact that teachers in the control group additionally motivated students to study. Students from the control group were excellent at solving questions/tasks belonging to the second level of complexity, which included the reproduction of teaching contents and a partial understanding of cause-effect relationships. This leads to the conclusion that some teachers of classes belonging to the control group motivated their students more (despite precise instructions to realise lessons in a traditional way), by instructing them to additionally study the teaching contents of Science and Social Studies (in addition to regular lessons) and stressing the importance of achieving the best possible results. In general, it can be concluded that statistically significant differences were obtained for

both groups, but only for the 0.05 level of significance. Therefore, the third hypothesis has been partially confirmed.

The results of the research closely resemble the results of the research conducted by Kennewell, Tanner, Jones, and Beauchamp (2008), and Hall and Higgins (2005), who stress that the key to applying information and communication technology in education is the adequate adaptation of information tools to pedagogical principles of teaching, and the principles of interactivity. To some extent, they are also consistent with results obtained by Zhang, Zhao, Zhou, and Nunamaker (2004), who claim that the electronic classroom and an interactive system of teaching activities significantly surpass the traditional classroom. Considering numerous theories of learning, the authors believe that the results obtained have their basis in the socio-cognitive learning theory (Bandura, 1986), i.e. learning by modelling. The experimental group teachers, i.e. teachers of classes in primary schools involved in project "Dositej", have largely voluntarily accepted to participate in the entire project and thus represent "leader teachers". The authors believe that they have transferred their positive attitude and persistence in learning and problem-solving to their students, and that this is what influenced a more intense development of intrinsic motivation of students from the experimental group and led to them achieving better results on knowledge tests, compared to the control group.

Conclusions

The concept of the electronic classroom is not intended to replace traditional pedagogy, but to expand and transform it by creating a new mix between "face-to-face" learning and electronic interaction. New information technology and learning paradigms will be directed towards changing the traditional school system in terms of its improvement and expansion by introducing additional contents and forms of education.

The results of this research have shown that the electronic classroom and electronic teaching aids, as an interactive model of organising teaching, significantly contribute to the increase in student achievements (knowledge, skills and competences) in classroom teaching, compared to the traditional classroom as a model of organised teaching, and that these differences in certain segments are statistically significant, which largely disproves the main hypothesis of this research.

Based on the research conducted, it can be concluded that electronic classrooms and electronic teaching aids definitely have a place and future in 21st century education. The electronic classroom model of the "Learning by modelling 1:1 – Dositej" project has special value because it possesses the capacity for further development, upgrade and improvement. It is necessary to first form a multidisciplinary team of experts in pedagogical and technical sciences, who would consolidate and coordinate the efforts of all educational institutions in the implementation of electronic education in primary schools. This team would aim to design and create a comprehensive system

for introducing electronic classrooms in primary schools, which would include the following: regular professional development of teachers in this field; quality servicing of computer equipment in electronic classrooms; creation of educational web portals as a specific knowledge database for the exchange of electronic teaching materials among teachers; planned introduction of computer education in classroom teaching through a special (mandatory or elective) subject; introduction of new study groups in the field of media design in education; introduction of a media librarian-computer technician at faculties for the education of teachers; and further development of media methodology and beginner-level teaching of computer science.

Until such efforts to implement comprehensive systematic solutions for the introduction of information and communication technologies in primary schools have been made, all attempts will remain at the level of projects which have a limited duration.

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Utjecaj elektroničke učionice kao interaktivnoga modela organizacije nastave na postignuća učenika u razrednoj nastavi

Sažetak

U ovom se radu prikazuju rezultatie istraživanja utjecaja poučavanja primjenom elektroničke učionice kao interaktivnoga modela organizacije nastave i elektroničkih nastavnih sredstava na razinu i kvalitetu postignuća (znanje, vještine, kompetencije) učenika škola u obradi nastavnih sadržaja iz predmeta Priroda i društvo. U istraživanju su sudjelovala 264 učenika (po 132 učenika činila su i eksperimentalnu i kontrolnu skupinu) petih razreda osnovnih škola iz Bosne i Hercegovine. U analizi su upotrijebljene metode teorijske analize, deskriptivna metoda i metoda eksperimenata s paralelnim skupinama. Od istraživačkih tehnika koristilo se testiranje, a kao instrumenti mjerenja upotrijebljeni su inicijalni i finalni test znanja. Dobiveni rezultati pokazuju da je eksperimentalna skupina učenika uporabom elektroničke učionice postigla bolja znanja u okviru nastavne teme Postanak i sastav Zemlje, za razliku od kontrolne skupine koja je radila u tradicionalnoj učionici. Bolji rezultati utvrđeni su i prema tri razine obrazovnih standarda izvedenih iz Bloomove taksonomije i statistički su značajni, što je omogućilo da se u većoj mjeri opovrgne glavna hipoteza našega istraživanja.

Ključne riječi: *aktivno učenje; nastavni modeli; nastavna sredstva; razina informatičke složenosti; Priroda i društvo.*

Uvod

Vrlo je važno istaknuti potrebu za primjenom informacijsko-komunikacijskih tehnologija (IKT) u procesu učenja (Tezci, 2011; Horvat, 2013). Primjena računala ima važnu ulogu u postizanju ciljeva i zadataka poučavanja integriranih prirodnih znanosti. Poučavanje uz pomoć računala potiče apstraktno razmišljanje, omogućuje planiranje smjera i individualni napredak učenika u usvajanju znanja (Greenfield i Yan, 2006). Osnovni cilj uvođenja suvremene informacijske tehnologije u nastavu je da olakša put do stjecanja znanja i da to znanje učini trajnijim. Osim o materijalnim

mogućnostima, to ovisi i o nastavniku, tj. o njegovoj spremnosti i osposobljenosti za rad sa suvremenom tehnologijom (Solaković i Pećanac, 2013, str. 171.). Osim toga, Pećanac i Rastovac (2011) tvrde da informatička osposobljenost nastavnika treba biti funkcionalna za učenikovo usvajanje informatičkih sadržaja i upotrebu tih znanja i vještina za obradu sadržaja iz različitih područja.

U današnje vrijeme izrađuju se multimedijalni obrazovni softveri koji sadrže mnoštvo informacija i omogućuju pregledno i jednostavno kretanje kroz sadržaje određene teme. Udžbenički se tekst može dopuniti nastavnim softverom koji sadrži grafičke prikaze i videomaterijale praćene pokretom i zvukom, što omogućuje prijem najraznovrsnijih informacija preciznom tehničkom prezentacijom (Grujičić, Solaković, i Spremić Solaković, 2012., str. 76.). Multimedijalni obrazovni sadržaji, kako navodi Janković (2015, str. 131. - 132.), objedinili su u kvalitativno novu nastavnu tehnologiju i sve pozitivne kvalitete prijašnjih nastavnih sredstava i pomoćnih tehničkih uređaja. U njima je sintetički i kvalitetno sjedinjena riječ, tekstualni zapis, animacija, sva otprije poznata audiovizualna sredstva, razmjena iskustava, vizualizacija svake vrste, od realne do virtualne stvarnosti. Ako se gradivo koje će se učiti na satu izloži kombinacijom raznih vizualnih sredstava i medija (slike, povijesne fotografije, karte, mape, dokumentarni i zvučni zapisi i dr.), odgovorit ćemo kako na individualne razlike među učenicima, tako i na njihove različite stilove učenja (Trbojević, Jeremić, i Pećanac, 2015).

Elektronička je učionica tip učionice utemeljene na programiranom pristupu uz primjenu računala i sustava za upravljanjem učenjem. To je posebno uređen prostor u čijem su sastavu nastavničko računalo i učenička računala, koje s pomoću rutera povezuje sustav za upravljanje učenjem. Elektroničku učionicu u odnosu na ostala organizacijska rješenja i nastavna sredstva karakterizira istodobno korištenje više elektroničkih nastavnih sredstava i medija, vjerodostojnost u prikazu proučavanih sadržaja i pojava, kretanje u svim pravcima (u prostoru i vremenu), interaktivnost u svim relacijama, dinamika i odsustvo dosade, stalna mogućnost kontrole i provjere rezultata i brzo dobivanje povratnih informacija.

Prethodna istraživanja

Prema Jankoviću (2012) osamdesetih godina prošlog stoljeća najviše je istraživan pozitivan utjecaj uporabe računala na razvitak kognitivne sfere, a u posljednje se vrijeme istraživanja više usmjeravaju na važnost vizualizacije u nastavi i utjecaj računala na socijalni razvitak, interakciju i komunikaciju i načine prilagodbe određenih programa i softvera korisnicima, čak i djeci predškolskoga uzrasta. Clark (1983) tvrdi da su tehnologije samo sredstvo za transfer znanja i da ne utječu u većoj mjeri na postignuća učenika. Velik je broj istraživanja pokazao da učenici postižu bolje rezultate uporabom računala i informacijske tehnologije, ali Clark te činjenice pripisuje boljim strategijama učenja koje su ugrađene u elektronički nastavni materijal. Brabazon (2007) navodi da je najveći problem obrazovanja danas u tome što je *klikanje*

zamijenilo mišljenje. Ona ističe i to da je stvoren dubinski nesklad između visoke razine računalne pismenosti učenika i niske razine njihove informacijske pismenosti. Na drugoj strani Kozma (2001) zastupa tezu da na proces učenja značajno utječu i tehnološka sredstva i mediji koji se primjenjuju. On dalje naglašava da nije računalo ono koje učenike motivira na to da bolje uče, već je to njihova interakcija s modelima interaktivnih informatičkih tehnologija koje se primjenjuju u procesu učenja. Zato prema njemu oni i nastavni sadržaji moraju biti konstruirani prema određenim pedagoškim, metodičkim i estetskim načelima.

Elektronički nastavni materijali, kako smatra Rossett (2002), moraju biti osmišljeni i dizajnirani imajući u vidu, prije svega, proces učenja i učenike, uz osiguravanje što boljih programerskih i tehničkih rješenja i kvaliteta. Prema Solakoviću (2013) izrada elektroničkih nastavnih materijala nije jednostavan posao i za nastavnike bi bilo mnogo lakše da na internetu imaju na raspolaganju svojevrsnu bazu elektroničkih nastavnih materijala, koje bi mogli slobodno razmjenjivati i preuzimati na svoja računala i njima se koristiti u nastavi. Ulogu i funkciju elektroničke učionice u reformi obrazovanja proučavali su mnogi stručnjaci iz cijeloga svijeta. Skupina autora Zhang, Zhao, Zhou i Nunamaker (2004) sa Sveučilišta Maryland i Sveučilišta Texas naglašava na koji način elektronička učionica i interaktivni sustav nastavnih aktivnosti nadmašuje tradicionalnu učionicu. Zanimljive rezultate u svojoj studiji iznosi i Thomas (2002), koja je utvrdila da su učenici koji su vježbe realizirali u elektroničkoj učionici, imali bolju potporu za rješavanje problema, za kritičko razmišljanje i kreativne ideje u izvršenju svojih školskih obveza u odnosu na učenike koji su vježbe realizirali u tradicionalnim učionicama. Primjenom elektroničke učionice u obrazovanju bavio se veoma malen broj domaćih autora. Izdvojiti se, možda, mogu Vasiljević (2010), koja se bavila povijesnim razvitkom učionice, i Adamov i Segedinac (2006), koje su predstavile prednosti i nedostatke računalom podržanog obrazovanja u elektroničkoj učionici, kao i kratak pregled stanja elektroničkog obrazovanja u Srbiji.

U fokusu našega zanimanja našlo se i pitanje interaktivnoga učenja u nastavi, kao važne odrednice kvalitetnoga nastavnog procesa, ali i kao jedne od paradigmi škole budućnosti. Istraživači sa Sveučilišta Swansea Metropolitan iz Velike Britanije, Kennewell, Tanner, Jones, i Beauchamp (2008) istraživali su kako interaktivne informatičke tehnologije mogu podržati interaktivnu nastavu. Zaključili su da je potrebno jasno definirati tehničke (informatičke) i pedagoške ciljeve nastavnoga sata kako raznovrsne interaktivne informatičke tehnologije, koje se uključuju tijekom nastavnih aktivnosti, ne bi unijele zabunu kada učenici rade samostalno. Analizirajući praktična iskustva iz organizacije i izvođenja interaktivnoga učenja u nastavi primjenom interaktivne informatičke tehnologije, Hall i Higgins (2005) ističu da su učenici u osnovnim školama oduševljeni multimedijalnim mogućnostima tih tehnologija i da im je bilo zabavno i zanimljivo tijekom učenja. S druge strane, navode kao slabosti tehničke probleme koji su se pojavljivali, nedovoljnu osposobljenost nastavnika za uspješnu primjenu tih tehnologija i njihovu nedostupnost svim

učenicima. Navedeni vladajući stavovi i shvaćanja u literaturi upućuju nas na zaključak da se kod nas vrlo malo radi na uvođenju informacijsko-komunikacijskih tehnologija u razrednu nastavu.

Temama primjene informacijsko-komunikacijske tehnologije u obrazovanju, elektroničkim učionicama, sustavima za upravljanje učenjem, multimedijalnim obrazovnim softverima i prezentacijama bavili su se brojni autori diljem svijeta od kojih izdvajamo još Andre (2000), ali i mnogi pedagozi, didaktičari i metodičari nastave na našim prostorima: Mužić i Rodek (1987); Nadrljanski (1991); Damjanović (1999); Branković i Mandić (2003); Stanković (2009); Nikolić i Veličković (2012) i brojni drugi autori.

Dosadašnja su istraživanja uglavnom bila orijentirana na utvrđivanje didaktičko-metodičkog utjecaja ili vrijednosti pojedinačnih multimedijalnih nastavnih sredstva, a izostala su istraživanja njihova kompleksnijeg djelovanja u međusobnoj povezanosti, kao i organizaciji kakvu omogućuje elektronička učionica. Barem na našem području i na razini učenika mlađe školske dobi, odnosno razredne nastave. Upravo je time najviše bilo motivirano naše eksperimentalno istraživanje.

Metodološki okvir istraživanja

Problem i predmet istraživanja

Može se očekivati da bi elektronička učionica, što je u ovome radu bio problem proučavanja, trebala olakšati poučavanje i učenje, jer omogućuje lak pristup novim sadržajima, a osigurava i jednostavne načine za mjerenje i analizu ostvarenih postignuća. U njoj se primjenjuju napredne metode učenja utemeljenog na odgovarajućoj vizualizaciji, istraživanju i otkrivanju, zbog čega se nastavom u elektroničkoj učionici najlakše ostvaruju ne samo materijalni već i funkcionalni obrazovno-odgojni ciljevi i zadaci nastave.

U širem smislu predmet našega istraživanja bio je lociran na područje obrazovne tehnologije. Konkretnije, na utvrđivanje didaktičko-metodičkog utjecaja na razinu i kvalitetu postignuća učenika razredne nastave elektroničke učionice kao interaktivnoga modela organizacije nastave, a onda i elektroničkih nastavnih sredstava primjenjivih u obradi nastavnih sadržaja u predmetu *Priroda i društvo.*

Cilj i zadaci istraživanja

Cilj istraživanja bio je utvrditi utjecaj poučavanja primjenom elektroničke učionice kao interaktivnoga modela organizacije nastave i elektroničkih nastavnih sredstava (eksperimentalna skupina) u odnosu na tradicionalni organizacijski model nastave (kontrolna skupina), a koji se ogleda u razini i kvaliteti postignuća (znanje, vještine i kompetencije) učenika petog razreda osnovnih škola u obradi nastavnih sadržaja iz predmeta *Priroda i društvo*. Na temelju predmeta i cilja istraživanja proistekli su zadaci istraživanja. Najvažniji su: utvrditi razinu i kvalitetu postignuća koje su izražene u znanju učenika eksperimentalne i kontrolne skupine i utvrditi stupanj zadržavanja usvojenih sadržaja, vještina i sposobnosti primjene usvojenih znanja

učenika eksperimentalne i kontrolne skupine 90 dana nakon realizacije pedagoškog eksperimenta.

Hipoteze istraživanja

Glavna je hipoteza bila: Pretpostavlja se da nema statistički značajne razlike u razini i kvaliteti postignuća (znanje, vještine i kompetencije) učenika petog razreda osnovnih škola u obradi nastavnih sadržaja iz predmeta *Priroda i društvo* s obzirom na to koriste li se elektronička učionica i elektronička nastavna sredstva (eksperimentalna skupina) ili tradicionalna učionica i ista odgovarajuća nastavna sredstva (kontrolna skupina) kao model organizacije nastave.

Posebne hipoteze istraživanja bile su:

H_1 Pretpostavlja se da nema statistički značajne razlike u razini i kvaliteti postignuća (znanje, vještine i kompetencije) učenika petog razreda osnovne škole s obzirom na to koji se organizacijski modeli i njima prilagođena nastavna sredstva koriste u obradi sadržaja predmeta *Priroda i društvo*.

H_2 Pretpostavlja se da nema statistički značajne razlike u stupnju zadržavanja usvojenih sadržaja nakon 90 dana od njihove obrade ili usvajanja s obzirom na to koriste li se elektronička učionica i elektronička nastavna sredstva (eksperimentalna skupina) ili tradicionalna učionica i njoj odgovarajuća nastavna sredstva (kontrolna skupina) kao model organizacije nastave.

H_3 Pretpostavlja se da nema statistički značajne razlike u razini i kvaliteti postignuća (znanje, vještine, kompetencije) učenika u odnosu na testiranja realizirana u tri navrata (inicijalno testiranje, finalno testiranje i ponovljeno finalno testiranje nakon 90 dana).

Metode, tehnike i instrumenti istraživanja

U istraživanju su primijenjene sljedeće metode: metoda teorijske analize, deskriptivna metoda i metoda eksperimenta.

Metoda teorijske analize koristila se za stvaranje teorijske osnove istraživanja, utvrđivanje ciljeva i zadataka istraživanja i oblikovanje istraživačkih hipoteza. Tom je metodom, također, analiziran i pedagoški materijal koji se odnosio na planiranje, pripremu i realizaciju nastave iz predmeta *Priroda i društvo* (nastavni plan i program, udžbenici, planovi rada i priprema nastavnika za nastavne sate), kao i karakteristike uzorka učenika (spol i ocjene iz predmeta *Priroda i društvo* na kraju četvrtog razreda osnovne škole). Deskriptivna se metoda koristila za prikupljanje podataka o ispitanicima, utvrđivanje vremena za provođenje eksperimenta, izbor eksperimentalnih čimbenika i modela istraživanja. Tom je metodom realizirano i plansko promatranje nastavnih sati kako bi obje skupine radile u približno istim uvjetima. U istraživanju je primijenjena eksperimentalna metoda s paralelnim skupinama s jednom eksperimentalnom skupinom (E) i jednom kontrolnom skupinom (K).

U istraživanju je, kao istraživačka tehnika, primijenjeno testiranje, a kao mjerni su instrumenti primijenjena dva testa znanja (inicijalni i finalni). Inicijalni je test poslužio

za prethodno ispitivanje razine i kvalitete postignuća (znanje, vještine i kompetencije) učenika, finalni test za finalno ispitivanje razine kvalitete postignuća neposredno nakon obrade u eksperiment unesenih nastavnih sadržaja, kao i za ponovljeno finalno testiranje 90 dana poslije prvog finalnog testiranja. Pod kvalitetom postignuća učenika podrazumijevali smo rezultate koje smo dobili ponovljenim finalnim testiranjem, u smislu dobrog razumijevanja usvojenih sadržaja, sposobnosti za rješavanje praktičnih zadataka, zadržavanja naučenog i kreativnosti. Razina i kvaliteta postignuća učenika u testovima izražene su bodovima, s obzirom na količinu i stupanj zadržavanja usvojenoga gradiva, a u odnosu na tri razine obrazovnih standarda izvedenih iz Bloomove taksonomije odgojno-obrazovnih ciljeva, zbog čega su testovi sadržavali tri skupine pitanja/zadataka. Prva razina obrazovnih standarda podrazumijeva da se učenik samo prisjeća i reproducira znanje, druga razina da učenik reproducira i donekle razumije složenije uzročno-posljedične veze ili odnose među činjenicama, treća razina da učenik razumije uzročno-posljedične veze i odnose i, što je najvažnije, da primjenjuje znanje u rješavanju problema ili odgovarajućih zadataka (Bjekić, Zlatić, i Najdanović-Tomić, 2006). Metrijske značajke testova ispitane su putem Pearsonova koeficijenta korelacije, koeficijenta pouzdanosti, indeksa lakoće zadataka, indeksa diskriminativnosti zadataka i faktorske analize (Kundačina i Brkić, 2004). Oba testa imala su po 12 raznovrsnih pitanja / zadataka (istinito / neistinito, višestruk izbor, umetanje izraza, sažeti odgovor i pronalaženje odgovarajućega para i praktično rješavanje određenih problema). Na svakom testu maksimalan broj bodova bio je 48, a dodjeljivali su se s obzirom na skupinu pitanja / zadataka kojoj pojedino pitanje pripada, imajući pri tome u vidu broj točnih činjenica i rješenja koje je učenik iznio i broj učinjenih pogrešaka. Testovi su sadržavali tri skupine pitanja / zadataka, od kojih je svaka skupina imala po četiri pitanja. Prva skupina pitanja / zadataka podrazumijevala je prvu razinu obrazovnih standarda i nosila je maksimalnih osam bodova. Druga skupina pitanja / zadataka podrazumijevala je drugu razinu obrazovnih standarda i nosila je maksimalnih 16 bodova, a treća je skupina pitanja / zadataka podrazumijevala treću razinu obrazovnih standarda i nosila je maksimalna 24 boda. Pitanja / zadaci za sve tri navedene skupine oblikovani su u skladu sa standardima individualizacije nastave, tj. primjenom zadataka na tri razine složenosti koji su izvedeni iz posebno definiranih obrazovnih standarda postignuća učenika za osnovne škole u Bosni i Hercegovini. Mi smo obuhvatili segment obrazovnih standarda koji je usmjeren na znanja i očekivane ishode i koji su se doticali diferencijacije školskih aktivnosti, interne i eksterne evaluacije i načina usporedbe međusobnih postignuća učenika i usporedbe postignuća učenika s onim što su prije postigli.

Sadržaji nastavne teme *Postanak i sastav Zemlje* realizirani su za eksperimentalnu skupinu u elektroničkim učionicama kao interaktivnim modelima organizacije nastave, uporabom tehničkih i elektroničkih nastavnih sredstava. Sadržaji iste nastavne teme realizirani su za kontrolnu skupinu u tradicionalnim učionicama uporabom udžbenika i radne bilježnice. Najvažnija razlika između nastavnih sredstava koja su se koristila u elektroničkoj i tradicionalnoj učionici jest stupanj njihove interaktivnosti.

Eksperimentalna skupina primjenjivala je u elektroničkoj učionici, ovisno o tipu nastavnih sati, sustav za upravljanje učenjem Mythware i kao tehnička sredstva Intel Classmate osobna računala, koji su dio projekta „Učenje po modelu 1:1 – Dositej" (projekt Dositej), zatim multimedijalni obrazovni softver i multimedijalnu obrazovnu prezentaciju. Sustav za upravljanje učenjem Mythware i kao tehnička sredstva Intel Classmate osobna računala, kojima se koristila eksperimentalna skupina, dobiveni su na korištenje za potrebe realizacije ovoga istraživanja, a multimedijalni obrazovni softver i multimedijalnu obrazovnu prezentaciju oblikovali su autori ovoga istraživanja. Učitelji i učenici bili su otprije upoznati sa sustavom za upravljanje učenjem Mythware i Intel Classmate osobnim računalima, jer se projekt Dositej realizira od 2012. godine.

Nastavna tema *Postanak i sastav Zemlje* obrađena je tijekom četiri nastavna sata novoga gradiva, dva nastavna sata ponavljanja i jednog nastavnoga sata usustavljivanja. Nastavne su se pripreme razlikovale prema tipu nastavnoga sata i primjeni tehničkih i elektroničkih nastavnih sredstava. Osmišljene su nastavne pripreme za realizaciju sva tri interaktivna modela organizacije nastave uporabom elektroničkih nastavnih sredstava u elektroničkim učionicama. Koncept nastavne pripreme za realizaciju nastavnog sata novoga gradiva bio je sljedeći: uvodni dio sata (učitelji i učenici pokreću računala i sustav za upravljanje učenjem Mythware, učitelj putem sustava za upravljanje učenjem Mythware šalje učenicima nastavne sadržaje), središnji dio sata (učenici proučavaju na svojim Classmate osobnim računalima nastavne sadržaje i rješavaju testove za samoprocjenu znanja po *e-learning* standardima, učitelj prati rad učenika i analizira njihove rezultate) i završni dio sata (učenici na svojim Classmate osobnim računalima rješavaju asocijacije, učitelj učenicima putem sustava za upravljanje učenjem Mythware šalje završni test od pet pitanja, učenici na svojim Classmate osobnim računalima rješavaju završni test i vraćaju ga elektroničkim putem učitelju). Koncept nastavne pripreme za realizaciju nastavnoga sata ponavljanja bio je sljedeći: uvodni dio sata (učitelj pokreće prijenosno računalo i putem projektora predstavlja učenicima multimedijalni obrazovni softver), središnji dio sata (učitelj i učenici zajedno putem projektora i multimedijalnog obrazovnog softvera ponavljaju nastavne sadržaje, učenici individualnim oblikom rada rješavaju testove za samoprocjenu znanja po e-learning standardima) i završni dio sata (učenici frontalnim oblikom rada rješavaju asocijacije i elektronički završni test). Koncept nastavne pripreme za realizaciju nastavnoga sata usustavljivanja bio je sljedeći: uvodni dio sata (učitelj pokreće prijenosno računalo i putem projektora predstavlja učenicima multimedijalnu obrazovnu prezentaciju), središnji dio sata (učitelj i učenici zajedno putem projektora i multimedijalne obrazovne prezentacije razgovaraju o nastavnim sadržajima, učenici izrađuju mape uma u svojim radnim bilježnicama) i završni dio sata (učitelj i učenici frontalnim oblikom rada zajedno ponavljaju najvažnije nastavne sadržaje koristeći se umnim kartama, učenici rješavaju završni test). U kontrolnoj skupini isti nastavni sadržaji realizirali su se u tradicionalnim učionicama uporabom udžbenika i radne bilježice. Nakon toga je u eksperimentalnoj i kontrolnoj skupini provedeno finalno testiranje. Nakon 90 dana provedeno je ponovljeno finalno testiranje. Istraživanje je

provedeno tijekom školske 2014./2015. godine. Rezultati istraživanja analizirani su uporabom *t*-testa neovisnih uzoraka i jednofaktorskom analizom varijance (ANOVA) ponovljenih mjerenja uz pomoć IBM SPSS programa za statistiku. Doprinos studije ogleda se u empirijskoj provjeri projekta Dositej koji se realizira u Bosni i Hercegovini i definiranju daljnjih pravaca razvitka projekta u osnovnim školama unaprjeđenjem didaktičke organizacije i metodičke prakse nastavnoga rada u okruženju e-učionice.

Uzorak istraživanja

Osnovne škole u Bosni i Hercegovini imaju devetogodišnji sustav školovanja prema kome razredna nastava počinje s prvim, a završava na kraju petog razreda. Nastavni predmet *Priroda i društvo* proučava se u drugom, trećem, četvrtom i petom razredu, kada se proučavaju odvojeno kao dva zasebna nastavna predmeta (*Poznavanje prirode* i *Poznavanje društva*). U istraživanju su sudjelovala 264 učenika petih razreda iz šest osnovnih škola u Bosni i Hercegovini. Od toga je polovina učenika (132) činila eksperimentalnu skupinu, a druga polovina kontrolnu skupinu. Zbog veće reprezentativnosti uzorka istraživanje smo obavili u 12 odjela petih razreda, odnosno u svakoj smo školi istraživanjem obuhvatili po dva odjela petih razreda. Učenici petih razreda bili su starosne dobi 10 i 11 godina. Neovisno o veličini uzorka, konstatiramo da je riječ o nedovoljno reprezentativnom uzorku. Uzorak je uzet iz osnovnih škola koje su pristale na sudjelovanju u istraživanju. Zbog toga je riječ o namjernom uzorku koji nije potpuno reprezentativan, što se mora imati u vidu prilikom zaključivanja na relaciji uzorak – populacija u cijelosti. Eksperimentalna i kontrolna skupina ujednačene su prema načelu parova na temelju spola, ocjene iz predmeta *Priroda i društvo* na kraju četvrtoga razreda i inicijalnoga testiranja (Tablica 1. i 2.).

Tablice 1 i 2

Rezultati

Razlike vrijednosti aritmetičkih sredina između eksperimentalne i kontrolne skupine u znanju učenika postignutom na finalnom testiranju prikazane su tablicom (Tablica 3.).

Tablica 3

Razlike vrijednosti aritmetičkih sredina između eksperimentalne i kontrolne skupine u znanju učenika postignutom na ponovljenom finalnom testiranju nakon 90 dana prikazani su u Tablici 4.

Tablica 4

Razlike ANOVA-e ponovljenih mjerenja eksperimentalne i kontrolne skupine u znanju učenika postignutom na tri testiranja (inicijalnom testiranju, finalnom testiranju i ponovljenom finalnom testiranju nakon 90 dana) prikazani su u Tablici 5.

Tablica 5

Rasprava

Učenici eksperimentalne i kontrolne skupine izjednačeni su na temelju spola, ocjene iz predmeta *Priroda i društvo* na kraju četvrtoga razreda i rezultata inicijalnog testiranja. U istraživanju su sudjelovala 264 učenika, 180 dječaka i 184 djevojčice (Tablica 1.). Prije uvođenja eksperimentalnih čimbenika u istraživanje provjerena je i ujednačenost eksperimentalne i kontrolne skupine. Prva nastavna tema kojoj su učenici bili poučavani iz predmeta *Priroda i društvo* u petom razredu osnovne škole je *Nebeska tijela*. Znanje učenika iz tog područja testirali smo inicijalnim testom. Statistički značajne razlike između eksperimentalne i kontrolne skupine testirali smo t-testom neovisnih uzoraka. Nije bilo statistički značajne razlike, eksperimentalna skupina (M=32,57; SD=8,06), kontrolna skupina (M=32,58; SD=5,73); $t(262)$=0,009 ide neznatno u prilog kontrolne skupine (Tablica 2.). Granične t vrijednosti skupina iznose na razini 0,05=1,97 i na razini 0,01=2,60.

Dobivene razlike kod eksperimentalne i kontrolne skupine su slučajne i neznatne, odnosno razlike koje su se pojavile između aritmetičkih sredina možemo pripisati slučajnoj varijaciji. Navedeni rezultati potvrđuju da su eksperimentalna i kontrolna skupina bile dobro ujednačene prema prethodnom znanju pokazanom na inicijalnom testiranju. To nam ukazuje na to da su učenici eksperimentalne i kontrolne skupine prije sadržaje iz predmeta *Priroda i društvo* učili na isti tradicionalan način.

Finalno testiranje provedeno je odmah nakon završetka eksperimenta i obuhvatilo je nastavnu temu Postanak i sastav Zemlje. Usporedili smo aritmetičke sredine rezultata finalnog testiranja eksperimentalne i kontrolne skupine. Dobili smo statističku značajnu razliku, eksperimentalna skupina (M=37,44; SD=4,76), kontrolna skupina (M=36,04; SD=4,53); $t(262)$=2,45 ide u prilog eksperimentalne skupine (Tablica 3.). Statistički značajna razlika u prilog eksperimentalne skupine dobivena je na razini značajnosti 0,05. Granične t vrijednosti skupina bile su iste kao i kod inicijalnog testiranja.

Analiza rezultata finalnog testiranja pokazala je da su bolje rezultate postigli učenici eksperimentalne skupine koja je sadržaje nastavne teme *Postanak i sastav Zemlje* realizirala u elektroničkim učionicama kao interaktivnim modelima organizacije nastave, uporabom tehničkih i elektroničkih nastavnih sredstava, u odnosu na kontrolnu skupinu koja je iste nastavne sadržaje realizirala u tradicionalnim učionicama, uporabom udžbenika i radne bilježnice. Mogući čimbenici koji su utjecali na učenike eksperimentalne skupine da ostvare bolja postignuća su: bolji uvjeti rada u elektroničkoj učionici, model organizacije nastave s najvećim stupnjem interaktivnosti, bolja angažiranost učenika tijekom nastavnoga sata u elektroničkoj učionici, bolja unutarnja motiviranost učenika za proučavanje nastavnih sadržaja primjenom informacijsko-komunikacijske tehnologije, posebno oblikovani elektronički nastavni materijali za tu nastavnu jedinicu i taj oblik elektroničkih nastavnih sredstava, bolja didaktičko-metodička učinkovitost primijenjenih elektroničkih nastavnih sredstava, veća zainteresiranost i motiviranost učenika, multimedijalnost nastavnih sadržaja

i rješavanje testova za samoprocjenu znanja po *e-learning* standardima. Općenito, možemo zaključiti da smo dobili statističku značajnu razliku u prilog eksperimentalne skupine samo na razini značajnosti od 0,01. Time je u velikoj mjeri odbačena prva posebna hipoteza našega istraživanja, kojom se pretpostavljalo nepostojanje statistički značajne razlike u postignućima učenika s obzirom na to izvodi li se nastava u elektroničkoj učionici ili u klasičnoj organizaciji, odnosno uporabom elektroničkih multimedijalnih ili klasičnih nastavnih učila.

Nakon 90 dana provedeno je ponovljeno finalno testiranje (retest) učenika eksperimentalne i kontrolne skupine. Dobili smo statističku značajnu razliku, eksperimentalna skupina (M=36,22; SD=4,74), kontrolna skupina (M=34,13; SD=4,68); $t(262)$=3,62 ide u prilog eksperimentalne skupine (Tablica 4.). Statistički značajna razlika eksperimentalne skupine sada je dobivena na obje razine značajnosti (0,05 i 0,01). Granične t vrijednosti skupina bile su iste kao i kod inicijalnog i finalnog testiranja.

Kada smo analizirali rezultate ponovljenog finalnog testiranja, 90 dana nakon finalnog testiranja, uočili smo da su učenici eksperimentalne skupine postigli još bolje rezultate u odnosu na finalno testiranje. Smatramo da je na trajnost znanja (retenciju) kod učenika eksperimentalne skupine među svim prije nabrojanim mogućim čimbenicima najviše utjecalo rješavanje testova za samoprocjenu znanja po *e-learning* standardima, putem kojih su učenici eksperimentalne skupine imali priliku vježbati testna pitanja svih tipova. Kod ponovljenog finalnog testiranja, nakon 90 dana, možemo uopćeno zaključiti da smo dobili statistički značajnu razliku u prilog eksperimentalne skupine na obje razine značajnosti (0,05 i 0,01). Dakle, time je odbačena i druga posebna hipoteza.

ANOVA-om ponovljenih mjerenja uspoređeni su rezultati testiranja učenika eksperimentalne i kontrolne skupine koji su dobiveni na inicijalnom testiranju (prije uvođenja eksperimentalnog čimbenika), na finalnom testiranju (nakon uvođenja eksperimentalnog čimbenika) i ponovljenom finalnom testiranju (tri mjeseca nakon uvođenja eksperimentalnog čimbenika). Utvrđen je statistički značajan utjecaj vremena. Za eksperimentalnu skupinu, Wilksova lambda=0,66; $F(2,13)$=32,99; p<.05; multivarijacijski parcijalni eta kvadrat=0,34 i za kontrolnu skupinu, Wilksova lambda=0,56; F (2,13)=50,99; multivarijacijski parcijalni eta kvadrat=0,44 (Tablica 5.). Statistički značajna razlika dobivena je samo za razinu značajnosti 0,05 u obje skupine. Granične F vrijednosti skupina iznose na razini 0,05=19,49 i na razini 0,01=99,49.

Daljnjim razmatranjem rezultata analize varijance ponovljenih mjerenja možemo uočiti da su učenici i eksperimentalne i kontrolne skupine postigli znatno bolje rezultate na finalnim testiranjima. Podaci ukazuju na to da je velikom broju učenika eksperimentalne skupine pomoglo učenje s pomoću uporabe elektroničkih nastavnih sredstava u elektroničkoj učionici s obzirom na to da su mnogi rješavali pitanja / zadatke treće razine složenosti, koji su uključivali razumijevanje uzročno-posljedičnih odnosa i primjene znanja u rješavanju praktičnih problema. S druge strane, zanimljivo

je da su rezultati pokazali da su i učenici kontrolne skupine postigli bolje rezultate na testiranju u više navrata, što možemo podvesti pod utjecaj parazitarnih čimbenika koji se odnose na to da su učitelji u kontrolnoj skupini učenike posebno motivirali da dodatno uče. Učenici kontrolne skupine odlično su rješavali pitanja / zadatke druge razine složenosti, koji su uključivali reproduciranje nastavnih sadržaja i djelomično razumijevanje uzročno-posljedičnih veza. To nas navodi na zaključak da su pojedini učitelji odjela koji su činila kontrolnu skupinu, i usprkos preciznim uputama da nastavne sate realiziraju na tradicionalan način, bolje motivirali svoje učenike tako što su im zadali da nastavne sadržaje iz predmeta *Priroda i društvo* dodatno proučavaju, osim na redovitim nastavnim satima, naglašavajući važnost ostvarenja što boljih rezultata. Općenito, možemo zaključiti da smo dobili statistički značajne razlike u obje skupine, ali samo na razini značajnosti od 0,05. Prema tome, treća je hipoteza djelomično potvrđena.

Rezultati našega istraživanja najpribližniji su rezultatima istraživanja Kennewell, Tanner, Jones i Beauchamp (2008) i Hall i Higgins (2005), koji ističu da je ključ primjene informacijsko-komunikacijske tehnologije u obrazovanju u adekvatnoj prilagodbi informatičkih alata pedagoškim načelima nastave i načelima interaktivnosti, a donekle su usklađeni s rezultatima autora Zhang, Zhao, Zhou, i Nunamaker (2004) koji tvrde da elektronička učionica i interaktivni sustav nastavnih aktivnosti značajno nadmašuju tradicionalnu učionicu. Sagledavajući brojne teorije učenja, smatramo da dobiveni rezultati svoje uporište nalaze u socio-kognitivnoj teoriji učenja (Bandura, 1986), odnosno učenja po modelu. Nastavnici odjela eksperimentalne skupine, odnosno odjela osnovnih škola koje su uključene u projekt Dositej, u najvećoj mjeri dobrovoljno i na volonterskoj osnovi, prihvatili su sudjelovanje u cjelokupnome projektu i tako predstavljaju „nastavnike predvodnike". Vjerujemo da su svoj pozitivan stav i upornost pri učenju i rješavanju problema prenijeli i na svoje učenike, te da je i to utjecalo na snažniji razvitak unutarnje motivacije učenika eksperimentalne skupine i dovelo do njihovih boljih rezultata na testovima znanja u odnosu na kontrolnu skupinu.

Zaključci

Koncept elektroničke učionice nema za cilj zamijeniti cjelokupnu tradicionalnu pedagogiju, već je proširiti i transformirati, stvarajući novu mješavinu učenja „licem u lice" i elektroničke interakcije. Nove informacijske tehnologije i paradigme učenja bit će usmjerene na mijenjanje klasičnoga školskog sustava u smislu njegova unaprjeđenja i proširenja dopunskim sadržajima i oblicima obrazovanja.

Rezultati našega istraživanja pokazali su da elektroničke učionice i elektronička nastavna sredstva kao interaktivni model organizacije nastave u značajnoj mjeri doprinose povećanju postignuća (znanje, vještine i kompetencije) učenika u razrednoj nastavi u odnosu na tradicionalnu učionicu kao model organizacije nastave, te da su te razlike u određenim segmentima statistički značajne, čime je u većoj mjeri odbačena glavna hipoteza ovoga istraživanja.

Na temelju realiziranog istraživanja zaključujemo da elektroničke učionice i elektronička nastavna sredstva zasigurno imaju svoje mjesto i budućnost u obrazovanju 21. stoljeća. Posebnu vrijednost ima model elektroničke učionice projekta „Učenje po modelu 1:1 – Dositej" jer posjeduje kapacitet za daljnji razvitak, nadogradnju i unaprjeđenje. Potrebno je na prvom mjestu formirati multidisciplinaran tim sastavljen od stručnjaka iz pedagoških i tehničkih znanosti, koji bi objedinili i koordinirali rad svih obrazovnih ustanova na uvođenju elektroničkoga obrazovanja u osnovne škole. Taj bi tim imao za cilj osmisliti i kreirati cjelovit sustav uvođenja elektroničkih učionica u osnovne škole, koji bi podrazumijevao redovito stručno usavršavanje nastavnika u tom području, kvalitetno servisiranje informatičke opreme u elektroničkim učionicama, oblikovanje obrazovnih web-portala za razmjenu elektroničkih nastavnih materijala između nastavnika kao svojevrsnih baza znanja, plansko uvođenje informatičkoga obrazovanja u razrednu nastavu s pomoću posebnoga redovnog ili izbornog predmeta, uvođenje novih studijskih skupina dizajnera medija u obrazovanju i medijatekara – informatičara na nastavničke fakultete i daljnji razvitak metodike medija i početne nastave informatike.

Sve dok se ne pristupi sveobuhvatnim sustavnim rješenjima na uvođenju informacijsko-komunikacijskih tehnologija u osnovne škole, svi pokušaji ostat će na razini projekata koji imaju svoje ograničeno trajanje.