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# The Effect of E-learning on the Acquisition of Learning Outcomes in Teaching Science and Biology

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## Abstract

*The conducted research aimed to identify factors of efficiency of e-learning on the acquisition of learning outcomes in teaching Science and Biology in elementary school. In addition, the differences in the age of pupils were identified as one of the factors of e-learning efficiency. The sample of participants was made up of 162 students, from 5th to 8th grade. Based on the pre-testing results, the pupils were divided into the control and the experimental group. The pupils from the experimental group were acquiring teaching units through the system of e-learning, and pupils in the control group had traditional classes using active working methods. Two-factor 4×2 ANOVA was used with the aim of checking the hypotheses. The results imply that pupils in the 5th and 6th grade differ from pupils in the 7th and 8th grade, i.e. the pupils in the experimental group were found to be more successful. Additionally, the research confirms that e-learning is as successful as traditional teaching, so it can surely be used under the conditions when pupils cannot be present in the regular classes in the classroom. The results of the research can be an incentive for teachers to strengthen their own ICT competencies, implement ICT in the teaching process and create new e-learning scenarios in the teaching of Science and Biology.*

**Key words:** *Biology classes; e-learning; ICT; pupil's age; Science classes.*

## Introduction

Contemporary education that is focused towards the development of necessary competencies needs to help pupils become successful members of society, ready

for life and work in the 21st century. That implies the education of pupils to engage in teamwork, problem solving, critical thinking, analysis and conclusion, decision-making, lifelong learning and acquisition of new competencies (Field, 2000). For the aforementioned, it is of great importance that pupils, along with standard literacy, posses natural sciences, computer sciences (Bediang et al., 2013) as well as IT literacy (Balanskat, Blamire, & Kefala, 2006) that includes ways in which modern Information-Communication Technologies (ICT) are used in order to approach information and use it efficiently. With all of the mentioned, the teacher's role is of crucial importance because the teacher needs to be able to critically judge accessible multimedia contents and their implementation into the teaching process to help the pupils in the acquisition of wanted learning outcomes (Reid, 2002).

Modern society requires that pupils also develop natural science literacy which implies the possibility to use knowledge from natural sciences, analysis, concluding based on evidences, and all that with the aim of understanding and making decision about the natural world and changes caused by humans. Natural science competencies that pupils develop through different activities in the subjects of Science (5th and 6th grade) and Biology (7th and 8th grade) in elementary school enable them to be active and conscientious citizens that responsibly refer to oneself, society and environment (Laugksch, 2000). For society's overall progress, experts of different profiles and competencies are important, with special emphasis on STEM area competencies (science, technology, engineering, mathematics) (Selwyn, 2011). Therefore, in order for pupils to become interested in the STEM area, it is necessary, from the start of the educational process to awaken in them the spirit for research and curiosity using different activities. Because of that, Science and Biology teaching have as their main goal the development of natural sciences literacy (DeBoer, 2000), which needs to be based on contemporary work methods and active pupil engagement (Rutherford, 1991). Active learning is important because it can also have an influence on the increase of pupils' motivation for learning (Sevinc, Ozmen, & Yigit, 2011).

Many authors in their research studies report on the tendency of decrease of pupils' interest for learning of natural sciences (Osborne, Simon, & Collins, 2003). It requires action by all participants in the educational process. The teachers' action needs to be directed towards finding ways to increase pupils' motivation and interest for learning subjects of the STEM area (Hurd, 1958; McCourdy, 1958). It is important to emphasize that pupils' motivation for work and learning is one of the most important components that has an influence on the acquisition of learning outcomes. Motivated pupils are more successful in mastering the teaching contents because they are active during classes, they question, follow experiments, research, use modern ICT tools and are involved in different project activities (Pelgrum, 2001). As pupils are not aware of the connection between natural sciences and everyday life and the benefits of their learning, it is up to the teachers and educational policies to create new ways and methods that will be interesting and sufficiently attractive to pupils in order to increase their motivation (Zoldosova & Prokop, 2006) for work and the acquisition of

new knowledge (Sevinc et al., 2011), skills and competencies (Sanfeliz & Stalzer, 2003). For successful work and control of one's own work, in addition to intrinsic motivation, extrinsic motivation is also crucial, i.e. reward in the form of a good mark or praise (Glynn & Koballa, 2006; Pintrich, 2003). All of the mentioned components that are necessary for carrying out successful work are contained in e-learning. E-learning enables pupils to control their own work as they can learn at their own pace and within an appropriate time frame that caters their needs. Furthermore, e-learning is interesting to pupils because it is a new form of work, which uses ICT, with which they are familiar, provides fast feedback on their work and therefore can have strong influence on the increase of pupil motivation for work and acquisition of necessary learning outcomes.

Garašić (2012) states that 5$^{th}$ grade pupils show high interest in the topics of sustainable development, and that interest decreases with the increase of their age towards the 8$^{th}$ grade when both genders have the least interest in this topic. The same author presents an evident decrease of pupils' affinity for Science and Biology with age during primary school, and the trend continues in grammar school. Other research studies confirm the aforementioned. For example, on a nationally representative sample of Scottish students, it was determined that the interest of students is influenced by age and gender (Stark & Gray, 1999). Furthermore, it showed that younger boys have an affinity towards biology topics and older pupils have an affinity towards physics while girls show great interest for biology topics independent of age. In addition, research studies show that students' interest changes with respect to gender and age (Baram-Tsbari et al., 2009). At an earlier age, girls show greater interest for science, but their interest decreases with age. Research studies also indicate that for boys the interest for physics increases with age, while that is not the case with girls (Bara-Tsbari & Yarden, 2008). Additionally, the same authors believe that the observed difference in interest due to gender should be applied in classes by using interesting topics in the context of learning natural sciences.

Pupils face numerous everyday challenges that they should be prepared to solve. Therefore, parents, teachers, creators of educational policies and the public are interested in whether today's pupils are well prepared for the challenges of the future, whether they can efficiently use ICT, whether they can effectively analyse and implement their ideas, whether they are capable of managing numerous problem situations and whether they are motivated for lifelong learning (Casner-Lotto & Barrington, 2006; Välijärvi et al., 2007).

### *ICT and E-learning in the Teaching Process*

Today's pupils live in a digital society where using ICT they can access a broad spectrum of different information (Reid, 2002). Therefore ICT is included in the educational process and implemented in different forms of learning (Hus, 2011). The application of ICT in the educational process opens numerous possibilities for delivering teaching contents and communicating with the participants involved in

the teaching process, while computer contents are used for assisting pupils in the acquisition of learning outcomes in a familiar and interesting way.

E-learning can be defined as a form of learning, teaching or education supported by using computer technology, more specifically, computer networks based on Internet technologies (Fallon & Brown, 2003). E-learning is an interactive, two-way process between teachers and students using electronic media with emphasis on the learning process, while media are a tool that completes this process. Moore, Dickson-Deane, and Galyen (2011) analyzed the different notions of the learning environment and definitions of the concept of e-learning and distance learning, and they detected an inconsistent use of terminology. The authors note that the e-learning is a kind of on-line learning.

Formal education should not be limited to teaching in the classroom as is currently done, but teaching at a distance as well (Kalamković, Halaši, & Kalamković, 2013), through the internet, without time and space limitations. In the dominating, traditional teaching, there is direct contact of pupils and teachers, i.e. *face-to-face contact (f2f)* while features of e-learning, as a form of distance education, are marked by a separation of teachers and pupils in space and time (Moore, Dickson-Deane, & Galyen, 2011). E-learning, which is conducted using ICT, increases pupils' skills necessary for life and work in the 21st century, and has a growing importance in the education of the pupils and numerous professionals. Research studies that compare the efficiency of e-learning and traditional teaching (Kulik, 2003; Ross, Morrison, & Lowther, 2010) imply that e-learning can be as successful as traditional teaching if suitable methods are used, if there is interaction between the pupils and if there is timely feedback between teachers and pupils (Balanskat et al., 2006; Sun et al., 2008). E-learning is especially useful for pupils who cannot attend regular classes for different reasons: great distance from school, personal or health difficulties, responsibility in families or social reasons (Hölbl & Welzer, 2015).

Kotzer and Elran (2012), in describing the teaching of Mathematics, Science and Technology using the *Moodle* platform, stated that students perceive such learning in a very positive way. Grundler et al. (2012) point out that despite the existence of ICT infrastructure, computer-literate users and advantages offered by e-learning, there is a considerable resistance to the introduction of e-learning in regular classes. The main reason is the lack of competencies of teachers and their lack of readiness for the implementation of e-learning.

From the aforementioned follows that teachers are expected to utilize all advantages of new forms of learning that enable pupils to access teaching contents at anytime and anywhere (Darling-Hammond et al., 2015). Teachers need to communicate with pupils through different communication channels (telephone, e-mail, forum, chat, video-call, social networks) on a daily basis, which is what e-learning indisputably provides. Thus, it is expected and required of teachers to possess specific knowledge and skills necessary for forming quality and interesting teaching scenarios through which the pupils will reach necessary learning outcomes, whether to learn in the classroom or use e-learning. Despite the wide use of e-learning and its benefits,

such as distance learning, 24-hour openness, ability to work at one's own pace and a dynamic interaction between all the participants, there are also disadvantages concerning this form of learning. The disadvantages can be found in the lack of necessary computer knowledge and skills among pupils and teachers, lack of necessary computer equipment, copyrights and the problem of insufficient pupil motivation and accountability for their own work.

## Research Aim and Hypotheses

Considering the complexity of using e-learning in the educational process and many factors on which its use depends, the aim of the present research is to examine the efficiency of e-learning on the acquisition of learning outcomes in Science and Biology in the primary school based on precisely designed teaching content, and to identify pupils' age differences as a factor of efficiency of e-learning in Science and Biology.

This type of research can provide insight into the effectiveness of e-learning with clearly operationalized teaching contents of Science and Biology. The research results can be used by teachers and students in order to make the educational process as quality as possible. Scientists can also use the results of this research in other empirical studies, in order to develop models of efficient use of e-learning in the classroom and even in other school subjects.

In order to operationalize and achieve the set aim, the following hypotheses were set:

H1 – pupils in the second educational cycle (5$^{th}$ and 6$^{th}$ grade) will obtain a statistically significantly greater result in the acquisition of learning outcomes in comparison to pupils in the third educational cycle (7$^{th}$ and 8$^{th}$ grade).

H2 – pupils in the experimental group will be more successful in the acquisition of the learning outcomes in all observed grades than pupils in the control group.

## Methods

### *Sample of Participants*

The research sample included 162 pupils of 5$^{th}$, 6$^{th}$, 7$^{th}$ and 8$^{th}$ grades of primary school (Table 1). The research results are presented in the same table because the teaching contents of Science in grades 5 and 6 continue in the subject Biology for 7$^{th}$ and 8$^{th}$ grade. Pupils from each class were divided into a control and an experimental group based on a pre-test, in order to maximize equality of initial differences, which is shown in Table 3.

Table 1

*Sample of Participants*

| Grade | Experimental group | Control group | Total number of pupils |
|---|---|---|---|
| 5 | 20 | 18 | 38 |
| 6 | 23 | 19 | 42 |
| 7 | 21 | 23 | 44 |
| 8 | 18 | 20 | 38 |
| Total | 82 | 80 | 162 |

Prior to the implementation of this research, the parents of all pupils signed a consent allowing their children to participate in the research, take photographs of them and publish the obtained results. The research plan was included into School Curriculum and approved for the implementation by the School Board.

### *Experimental Design*

Before starting with e-learning the pupils were divided into the control and the experimental group based on the pre-test, with the aim of minimizing initial differences. The pre-test tested pupils' knowledge and acquisition of learning outcomes from previous grades relevant for the examined teaching unit in each grade level. With the aim to assign pupils from some grade into the experimental and control group, the results of the pre-test were analysed. The procedure determined equivalent pairs of pupils (one from the experimental, one from the control group) with the closest initial results. The groups were also maximally equalised by gender.

Using the open code platform *Moodle*, the teaching contents were uploaded from the examined teaching units from Science (5$^{th}$ and 6$^{th}$ grade) and Biology (7$^{th}$ and 8$^{th}$ grade) (Table 2).

Table 2
*Examined teaching units by grades*

| Grade | Unit |
|---|---|
| 5 | Puberty |
| 6 | Benefit of sea and inland water |
| 7 | Invertebrates |
| 8 | Respiratory system |

Passwords were created for pupils in the experimental group, and they were further instructed about the basics of *Moodle* (one school lesson). During classes, pupils in the control group were in the biology classroom and worked along with the teacher using contemporary learning methods while pupils from the experimental group were in the IT classroom, and did not have face-to-face (f2f) contact with the teacher. Pupils from the experimental group had access to the teaching contents, presented on *Moodle*, even from their homes when and as long as they wanted.

Preparations for the experimental and control group were equal in the sense of planned aims and achievements of the classes as well as teaching activities for all pupils, regardless if they work through e-learning or traditional classes. The learning outcomes were planned according to the valid Curriculum for primary school (Curriculum for primary school, 2006).

Electronic teaching content, presented through *Moodle*, were presented simply and transparently at the user interface (Figure 1).


*Figure 1.* The layout of the first page of the user interface on *Moodle*

In case vagueness of the task should appear, pupils were instructed to ask for help from the teacher using electronic mail or asking questions at *Forum with news,* which was available to all users even before they started their e-learning.

In order for pupils in the experimental group to be successful in independent learning using *Moodle,* the teaching contents of Science and Biology were divided into smaller, independent logical units named in the *Lesson menu* at the left side of the interface. They could access the content by simple selection of searched area. Textual teaching content of specific teaching units was amended with different visual and audio-visual sources, photographs, illustrations, graphs, 3D model displays and video recordings and animations (Figure 2). The above mentioned was done with the aim to help pupils in the acquisition of necessary learning outcomes.

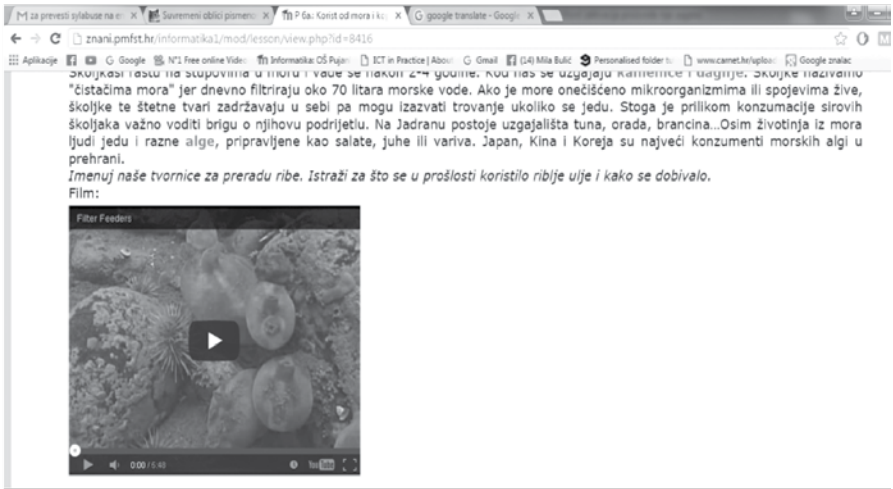


*Figure 2.* Moodle site layout with the teaching contents and video recording

At the end of each teaching unit there was a part for review and practice. Upon finishing the whole teaching unit, pupils in each grade solved a written examination, consisting of different question forms (Figure 3).

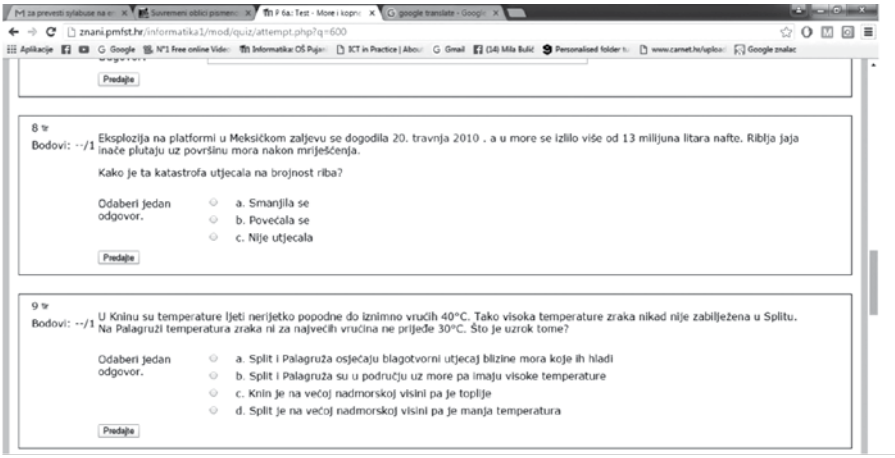


*Figure 3.* Layout of the Moodle site of the test for the examination of acquired knowledge

The unit *Respiratory System* in 8th grade was, for example, divided into lessons: *Respiratory System Organs Structure*, *Keep Your Respiratory Organs Healthy* and *Revision*. The lesson *Respiratory System Organs Structure* was divided into smaller logical parts: Respiratory System Structure, Respiratory System Function, How Do We Breathe and Lung and Cellular Respiration. With the aim of helping pupils comprehend learning outcomes, three films were presented (lungs structure, inhaling-exhaling, pulmonary and cellular respiration), as well as images that accompanied the lessons. The students were asked to actively participate and had a homework task to build a model of the respiratory system, photograph it and prepare it in e-form by a specific deadline. The lesson *Keep your Respiratory Organs Healthy* was divided into smaller sections: Colds and Flu, Bronchitis, Tuberculosis, Asthma, Lung Cancer, First Aid in Case of Choking, How to Preserve the Health of Respiratory System. For homework, students were expected to do their own research about the importance of vaccination against tuberculosis, write a short essay on the subject and turn it in using e-form. The teacher saw all homework assignments, and gave a feedback to the pupils. The control group had the same homework assignments that they brought to the classroom.

As one of the aims of the research was to determine learning efficiency in relation to traditional classes, upon finishing the analysis of examinations of all teaching units for all grades, the acquisition of learning outcomes of pupils in the control and experimental group was examined using the written examination. Pupils in the experimental group wrote the mentioned exam in the IT classroom in e-form while, at the same time, all pupils in the control group (grades 5 - 8) took the identical written exam in the biology classroom.

In order to avoid possible difficulties in parallel communication and simultaneous monitoring of the work of 162 pupils, the research lasted three months in total. Pupils in grade 5 had 1.5 lessons hours of Science weekly, while pupils in grades 6, 7 and 8 had two lessons of Science/Biology every week. Pupils in the control group, who followed lessons in the Biology classroom with the teacher present used contemporary methods of work through active teaching forms.

### *Variable Sample*

With the aim to generate the experimental and control group for each individual grade, the standardised pre-test was used having unquestionable validity, and approved by the Education and Teacher Training Agency, and the groups were equal according to the results of the pre-test ($p>0.05$ for all observed subgroups) (Table 3). The pre-test consisted of 10 to 14 questions (depending on the grade level) that had 1-3 points. The pre-test was approved on the basis of expert judgment of the committee in accordance with Article 12 of the *Rules of Procedure of Approval and use of Additional Teaching Resources to Teach Subjects in Primary Schools*, and meets all the scientific, educational, psychological and didactic-methodological requirements.

Table 3

*The results of the pre-test for all observed subgroups*

| | F-test | |
|---|---|---|
| | Group 1<br>AS± SD | Group 2<br>AS± SD |
| 8a | 13.11±0.40 | 13.55±0.64 |
| 8b | 13.63±0.53 | 13.00±0.52 |
| 7a | 12.70±0.13 | 12.10±0.37 |
| 7b | 13.10±0.47 | 13.45±0.49 |
| 6a | 14.10±0.62 | 14.65±0.21 |
| 6b | 13.30±0.49 | 13.65±0.20 |
| 5a | 14.20±0.56 | 14.45±0.12 |
| 5b | 10.12±0.71 | 10.50±0.40 |

All of the participating groups solved the written examination that tested the acquisition of learning outcomes, on a scale of 0-20. Three levels of adopted contents were examined through the questions related to: 1. factual knowledge and literal understanding (the lowest level), 2. conceptual understanding and application of knowledge, 3. problem solving (Crooks, 1988; Webb, 2002). The structure of the points on the written examination was such that nearly 50% of points were the result of the answers to the questions examining the first cognitive level of knowledge. About 30% of the points were the result of the answers to the questions examining the second cognitive level of knowledge, and about 20% of the points were related to the third cognitive level of knowledge.

### Statistical Analysis

For all of the variables, descriptive statistical parameters were calculated: mean ± standard deviation. Single data was considered as inconsistent with other data if it was found to be out of the Mean±2SD interval. Normality of all variables was tested using Kolmogorov–Smirnov test with Lilliefors correction. All observations were mutually independent. Using Levene's test, assumption of homogeneity of variances was not violated. With the aim to identify the significance of the main effect of *Age* factor (5th grade, 6th grade, 7th grade or 8th grade) and the main effect of *Group* factor (control vs experimental) and their interaction, factorial two way 4×2 ANOVA (Age × Group) was used. For significant main effects and/or interactions, the Bonferroni post hoc correction was used. Partial-eta squared ($\eta^2$) was used for effect size assessment. Data was considered significant if $p<0.05$. All results have been calculated using Statistica 12.0. (StatSoft, Tulsa, OK, USA).

## Results and Discussion

In Table 4 descriptive statistic parameters for both monitored groups of examinees and all grades are shown.

Table 4

*Descriptive parameters (Mean±SD) and significance of Kolmogorov-Smirnov normality testing (KS-p)*

| | Experimental | | Control | |
|---|---|---|---|---|
| | M±SD | KS-p | M±SD | KS-p |
| 5th grade | 17.26±2.65 | >0.20 | 16.13±3.17 | <0.20 |
| 6th grade | 17.19±1.34 | <0.10 | 15.86±2.54 | <0.20 |
| 7th grade | 14.77±3.44 | <0.01 | 16.23±4.25 | <0.05 |
| 8th grade | 14.32±3.80 | <0.20 | 15.00±4.16 | <0.20 |

As can be seen in Table 4, small deviations from normality were observed among 7th grade pupils while all other groups show a normal distribution of the observed variables. Additionally, from the results (Table 4) it is evident that pupils in the 5th and 6th grade show greater progress in the acquisition of learning outcomes in the experimental group in relation to the control group. On the other side, pupils in the 7th and 8th grade of the experimental group did not achieve greater progress in relation to the control group in absolute terms.

Using ANOVA, the impact of *Age* factor was found to be significant ($F(154,3)=3.263$; $p=0.023$; $\eta^2=0.057$) while the impact of *Group* factor was not significant ($F(154,1)=0.025$; $p=0.876$; $\eta^2=0.000$). The interaction effect *Age*Group* was also found not to be significant ($F(154,3)=1.780$; $p=0.153$; $\eta^2=0.032$). Bonferroni post hoc test of main effect of factor *Age* revealed no significant differences only between 5th and 6th grade and 7th and 8th grade (Table 5).

Table 5
*Bonferroni post hoc correction of main effect of Age factor*

| | Grade 5 | Grade 6 | Grade 7 |
|---|---|---|---|
| Grade 6 | 1.000 | | |
| Grade 7 | 0.044 | 0.010 | |
| Grade 8 | 0.000 | 0.001 | 0.493 |

From the ANOVA results, it is evident that pupils in the 5th and 6th grade show greater progress in adoption of the educational outcomes in the experimental group in comparison to the control group in the absolute amount. On the other hand, the pupils in the 7th grade of the experimental group do not show greater progress in comparison to the control group in the absolute amount.

The results clearly indicate that the *Age* factor is a significant predictor of success, regardless of belonging to the pupils in the experimental or control group. The age of the pupils is in favour of the application of e-learning in the second educational cycle, which confirms hypothesis 1.

As the factor of *Age* was identified as the predictor of efficient e-learning, in teaching Science and Biology, *Boneferroni post hoc* correction was applied in order to identify grade levels between which the difference exists. The results of *Bonferroni post hoc* correction can be interpreted and identified by two relatively homogeneous subgroups of the examinees: pupils in the 5th and 6th grade on the one side, and pupils in the 7th and 8th grade on the other side. A differentiation of pupils was noticed that clearly divides the pupils in the 5th and 6th grade (the second educational cycle) showing better results in the experimental group in relation to pupils in the 7th and 8th grade (the third educational cycles) where a statistically significant difference between the groups was not identified.

Mechanisms behind such a dichotomous division of the results can be classified into two groups. The first group are mechanisms which make the experimental group better than the control group of the second educational cycle, while the other group is marked by mechanisms because of which the experimental and control groups of the third educational cycle were equal. Thereby, probable factors of larger success of the experimental group of the second educational cycle are: interesting teaching topics in the 5th and 6th grade that encourage interest for work, more motivation for work in the area of natural sciences among younger pupils, operating with ICT tools that represent an additional challenge, awakened interest and influence on the motivation of the experimental group. Probable factors that could lead to equal results of the control and experimental group of the third educational cycle are: working in block lessons in the control group, influence of puberty on attention and concentration, greater reading literacy, general decrease of interest for natural sciences among older pupils.

Research studies conducted earlier show that gender, age, quality of lecturing and interesting features of the teaching content influence pupils' motivation for work in certain subject (Lavonen et al., 2005). The influence of interesting feature of teaching

contents of units presented using *Moodle* should not be neglected. Pupils of the second educational cycle, who have showed the greatest progress, studied teaching units whose content they find very interesting (*Puberty* in the 5th grade and *Benefit of Sea and Inland Waters* in the 6th grade). Therefore, pupils in 5th and 6th grades of the experimental group could be more motivated for studying than pupils in the 7th and 8th grades. Because of this, the setup of the above teaching units on *Moodle* could represent one of the limitations of this research because the teaching units for the 7th and 8th grades (*Invertebrates and Respiratory System*), that are set on the *Moodle*, were not that interesting. The decrease of interest of 7th grade pupils could be connected with the uninteresting systematic-classification approach to the living world in processing the teaching content for that grade. In other conducted studies, the authors also mention that the pupils in the 7th grade have problems with acquiring learning outcomes for concepts related to diversity in animal kingdom (Bell, 1981; Braund 1998; Prokop, Kubiatko, & Fančovičová, 2007). That could be one probable reason why e-learning with 7th grade pupils was not more successful than traditional classes. Pupils in the 7th grade processed the teaching unit *Invertebrates w*ith the teaching lessons *Flatworms and Roundworms.* The researched unit in the seventh grade is related to contents on parasite species in humans. In the previously conducted research (Garašić, 2012), the pupils rank that unit as one of the most uninteresting units for which they do not see the purpose and do not like to study the mentioned contents. Similar attitudes about that teaching unit are expressed by pupils who participated in this research. The other probable reason for more success of the experimental group in the second educational cycle in relation to the experimental group in the third educational cycle is in their age. The younger pupils of that age are more diligent, engage in detailed learning and do their homework at home. This is a particularly important factor for the experimental group because they regulate their work and the length and quantity of studying at home by themselves, so for success, their individual responsibility is crucial.

Research on pupils' interests in the area of natural sciences shows that pupils are attracted to learning by: natural sciences, specific contents of individual subjects, methodology of teaching and the use of information-communication technologies in the classes (Hoffman, 2002). Based on the aforementioned, it follows that working with new technology, ICT and e-learning, could be the third probable reason of larger success of the experimental group of pupils in the 5th and 6th grades. The first encounter with ICT in teaching Science could awaken their curiosity and positively influence motivation for learning.

Pupils in the experimental group from all grades said that visual representations in e-lessons were really helpful in mastering the required learning contents and the acquisition of the required learning outcomes. They are also aware that this kind of work is not easy because it requires them to control and manage their own work and the time they spend in e-learning. The results showed that the experimental group was not more successful in comprehending learning outcomes in all grades and the reasons why Hypothesis 2 was not confirmed were taken into consideration.

Pupils in the third educational cycle of the control group had classes organised as block lessons, using active forms of work, which could contribute to better efficiency of the control group and the absence of a statistically significant difference between the control and experimental groups in these grades. Research that investigated the efficiency of work in a block lessons as opposed to work in a single Biology lesson shows that pupils having a block lessons in the classroom carry out different activities and acquire better results than pupils who have only one lesson (Labak et al., 2013). In support to this, other research studies indicate that pupils in the 7th grade acquire better results at the examinations, are more interested in the contents and invest greater effort into learning if they study biology through active work forms over block lessons (Corley, 2003; Knight, De Leon & Smith, 1999; Schall & Randler, 2004).

Pupils in the third educational cycle are at the beginning of puberty, which brings on physical, psychological, emotional and cognitive changes (Silk et al., 2009). The mentioned changes can also cause problems for pupils in the third educational cycle with attention that disperses and they have more difficulty concentrating on the necessary teaching contents, especially in the shorter time intervals. That can additionally aggravate students in the experimental group as the use of e-learning requires managing one's activity and length of work in *Moodle.* Their problems can be concentration on numerous activities that are required of them, which if not done long enough can diminish concentration on particular contents.

Furthermore, generally poorer results on tests in the third educational cycle could be the result of the influence of their reading literacy (Kirsh et al., 2002). The questions in the written examination were not simply conceived asking for reproductive knowledge only, but there were also questions with graphic displays that needed an interpretation and conclusion, and there were two-three sentences of introduction, which could be an aggravating factor for pupils with weaker reading literacy. The new form of questions, that pupils in the experimental or control group were not used to, could be a limiting factor for their success. While pupils in the control group could ask the teacher for additional explanationat any moment during the written examination, pupils solving the e-test could not do so. Such a conclusion is in favour of compiling questions according to the PISA model where testing showed that the weak result was a consequence of difficulties during reading and understanding of the read text (Braš-Roth et al., 2008). The pupils in the experimental group in the third educational cycle also emphasised that the difficulty in solving the test was also related to grammar since they had to worry about writing *ije/je and č/ć* correctly in the answers since *Moodle* did not accept answers that were grammatically incorrect.

Pupils in the experimental group of all grades stated that the visual displays in e-lessons helped them a lot in mastering the set teaching contents and acquiring necessary learning outcomes. They are also aware that such manner of work is not simple because it demands self-control and management of their own pace of work and time they spend in e-learning.

One of the reasons for such results of pupils in the third educational cycle can be attributed to the decrease of pupils' interest in learning natural sciences in correlation to the increase of their age. In accordance with the results of this research, studies by other authors confirm that pupils' interests for school contents decrease over the years (Barmby, Kind & Jones, 2008; George, 2006; Prokop et al., 2007). Considering that the research was conducted in countries where the integrated subject Natural sciences is taught, it is necessary to carry out additional research for cases when Science and Biology are studied as separate subjects, independent from Chemistry and Physics (Usak et al., 2009). The tendency of decrease of pupils' interest for studying contents of natural sciences is noted by more authors (Osborne et al., 2003), therefore it is important to pay special attention to the development strategy that will increase pupils' interest for learning natural sciences (DeWitt et al., 2013).

As both groups in the third educational cycle achieved equal results, it can be used as an argument in favour of future application of e-learning in the teaching process. Namely, it has been noticed that e-learning is not less efficient than lessons in the classrooms. Even though the experimental group of these grades was not statistically better than the control group, we can say that e-learning was as equally efficient as regular lessons in the classroom. Therefore, e-learning can be used in situations when there is no possibility for pupil(s) to attend regular classes.

Overall, the results show a greater influence of the *Age* factor of pupils as a predictor of success of e-learning in the acquisition of particular learning outcomes in the subject Science/Biology in relation to the factor *Group.* According to the research, the first hypothesis (H1) was confirmed and there is a statistically significant difference in the acquisition of learning outcomes between groups of examinees by grades. The second hypothesis (H2) was not confirmed in relation to the identification of the factor *Group* as statistically insignificant. The final effect between the experimental and control group was not identified. E-learning has proved equally successful as lessons in the classrooms where active forms of work were applied.

## Conclusion

The conducted research examined the efficiency of e-learning in teaching Science and Biology, singling out the factor of pupils' *Age* as a significant predictor of success of the experimental group. The research indicated a clear borderline of pupils' age (the second educational cycle) where they can successfully perform set tasks and have greater motivation for work than the older pupils who are prone to influences of others which in turn can influence the results of their work. The experimental group in the second educational cycle was more successful than the control group in the acquisition of learning outcomes. The possible reasons are interesting topics set up on *Moodle*, encounter with new technologies of work and e-learning that awakens the interest, and in general greater motivation for work among younger pupils. For pupils in the third educational cycle, the success is the same in the experimental as in

the control groups. The research confirmed the first hypothesis (H1) and statistically significant difference in the acquisition of learning outcomes between groups of examinees by grades. The second hypothesis, H2 was not confirmed since the factor *Group* was identified as statistically insignificant. The results of the research indicate that e-learning was nearly as efficient as regular lessons in the classroom. Therefore, e-learning could be efficiently applied when there is no possibility for a pupil(s) to attend regular lessons in the classroom due to different reasons.

The developed forms of e-learning which were carried out showed satisfaction among pupils because of the new, and for them, acceptable manner of learning. Therefore, the results should encourage teachers to further develop computer teaching contents and different computer activities that will train pupils in recognizing and solving real-life problems. The contemporary world seeks to develop an infrastructure for effective and fast computer connection for participants in all branches of human activity. As school prepares pupils for the life and labour market, it is important to implement ICT into the educational process in order to develop new competencies in the pupils and strengthen and develop existing competencies of in-service and pre-service teachers. Thus, educational priorities should begin with changes in the system of education by focusing on education for a healthy and sustainable life and increase of teacher competencies. Considering the abovementioned facts, teaching could be modernized by creating a high-quality curricula and materials with the support of different computer programs and implementation of e-learning. It is possible to implement ICT in all forms of education, as a tool that will promote health and sustainability as a true treasure and base for the progress of humankind.

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# Utjecaj e-učenja na usvojenost ishoda učenja u nastavi Prirode i Biologije


## Sažetak

*Provedeno istraživanje imalo je za cilj identificirati čimbenike učinkovitosti e-učenja na usvajanje ishoda učenja u nastavi Prirode i Biologije u osnovnoj školi. Također su identificirane i razlike u dobi učenika kao jedan od faktora učinkovitosti e-učenja. U istraživanju su sudjelovala 162 učenika od 5. do 8. razreda. Učenici svakoga razreda, na temelju rezultata predtesta, bili su podijeljeni na kontrolnu i eksperimentalnu skupinu. Učenici eksperimentalne skupine nastavne sadržaje ispitivanih nastavnih cjelina usvajali su putem sustava e-učenja, a učenici kontrolne skupine imali su tradicionalnu nastavu u učionici s pomoću aktivnih metoda rada. Dvofaktorska 4x2 ANOVA koristila se s ciljem provjeravanja postavljenih hipoteza. Rezultati pokazuju kako se učenici 5. i 6. razreda diferenciraju od učenika 7. i 8. razreda kao uspješniji u eksperimentalnoj skupini. Dodatno, istraživanje potvrđuje da je e-učenje uspješno kao i tradicionalna nastava pa se zasigurno može koristiti u uvjetima kada učenici ne mogu biti na redovnoj nastavi u razredu. Rezultati istraživanja mogu biti poticaj učiteljima za jačanje vlastitih IKT kompetencija, implementaciju IKT-a u nastavni proces te osmišljavanje novih scenarija e-učenja u nastavi Prirode i Biologije.*


**Ključne riječi**: *dob učenika; e-učenje; IKT; motivacija; nastava Biologije; nastava Prirode.*

## Uvod

Suvremeni odgoj i obrazovanje, koji su usmjereni prema razvoju potrebnih kompetencija, trebaju pomoći učenicima da budu uspješni članovi društva, spremni za život i rad u 21. stoljeću. To podrazumijeva obrazovanje učenika kojim će biti osposobljeni za timski rad, rješavanje problema, kritičko promišljanje, analiziranje i zaključivanje, donošenje odluka, cjeloživotno učenje i stjecanje novih kompetencija (Field, 2000). Za sve navedeno od iznimne je važnosti da učenici uz standardnu pismenost posjeduju i prirodoslovnu, informatičku (Bediang i sur., 2013) i informacijsku pismenost (Balanskat, Blamire i Kefala, 2006) koja uključuje načine na koje se primjenom suvremenih informacijsko-komunikacijskih tehnologija (engl. *Information and Communication Technology* - ICT) pristupa informacijama i učinkovito

ih se koristi. U svemu je tome uloga učitelja od presudne važnosti jer on treba moći kritički prosuđivati dostupne multimedijske sadržaje i njihovom implementacijom u nastavni proces pomoći učenicima u usvajanju traženih ishoda učenja (Reid, 2002).

Moderno društvo traži od učenika i razvijenu prirodoslovnu pismenost koja podrazumijeva mogućnost primjene prirodoslovnih znanja, analiziranje i zaključivanje utemeljeno na dokazima, a sve s ciljem razumijevanja i donošenja odluka o prirodnom svijetu i promjenama izazvanim od ljudi. Prirodoslovne kompetencije koje učenici razvijaju različitim aktivnostima u nastavnim predmetima Prirodi (5. i 6. razred) i Biologiji (7. i 8. razred) u osnovnoj školi omogućuju im da budu aktivni i savjesni građani koji se odgovorno odnose prema sebi, društvu i okolišu (Laugksch, 2000). Za napredak društva u cjelini važni su stručnjaci različitih profila i kompetencija, s posebnim naglaskom na kompetencije STEM područja (science, technology, engineering, mathematics) (Selwyn, 2011). Kako bi se u budućnosti učenici odlučili baviti STEM područjem, potrebno je od početka odgojno-obrazovnog procesa, primjenom različitih aktivnosti, buditi u njima istraživački duh i znatiželju. Upravo stoga nastava Prirode i Biologije, kojoj je glavni cilj razvoj prirodoznanstvene pismenosti (DeBoer, 2000), treba biti utemeljena na suvremenim metodama rada s aktivnim angažiranjem učenika (Rutherford, 1991). Aktivno je učenje važno jer i ono može utjecati na povećanje motivacije učenika za učenjem (Sevinc, Ozmen, i Yigit, 2011).

Više autora u svojim istraživanjima ukazuje na tendenciju opadanja interesa učenika za učenje prirodoslovlja (Osborne, Simon, i Collins, 2003). To traži nužnost djelovanja svih sudionika odgojno-obrazovnoga sustava. Smjer djelovanja učitelja treba biti prema pronalasku načina povećanja motivacije i interesa učenika za učenje nastavnih predmeta STEM područja (Hurd, 1958; McCurdy, 1958). Važno je istaknuti kako je motivacija učenika za rad i učenje jedna od najvažnijih komponenti koja ima utjecaj na usvojenost ishoda učenja. Motivirani učenici uspješnije savladavaju nastavne sadržaje jer su aktivni tijekom nastavnoga sata, propituju, rade pokuse, istražuju, koriste se suvremenim IKT alatima i uključuju se u razne projektne aktivnosti (Pelgrum, 2001). Kako učenici ne uočavaju vezu prirodoslovlja i svakodnevnoga života te korisnost njegova učenja, na učiteljima i obrazovnim politikama jest da osmisle nove putove i metodologiju rada koji će učenicima biti zanimljivi i dovoljno atraktivni da povećaju njihovu motivaciju (Zoldosova i Prokop, 2006) za rad i usvajanje novih znanja (Sevinc i sur., 2011), vještina i kompetencija (Sanfeliz i Stalzer, 2003). Za uspješan rad, osim intrinzične motivacije, bitna je i kontrola nad vlastitim radom i ekstrinzična motivacija, tj. nagrada učeniku za rad u obliku dobre ocjene ili pohvale (Glynn i Koballa, 2006; Pintrich, 2003). Upravo sve navedene sastavnice koje su potrebne za uspješan rad sadrži e-učenje. E-učenje učenicima nudi kontrolu vlastitoga rada jer mogu učiti za sebe najprihvatljivijim tempom u prihvatljivom vremenskom trajanju. E-učenje zanimljivo je učenicima jer je riječ o novom obliku rada s kojim se susreću, koje podrazumijeva primjenu IKT-a, što im je blisko, daje im brzu povratnu informaciju

o uspješnosti vlastitoga rada te stoga može imati velik utjecaj na povećanje motivacije učenika za rad i usvajanje potrebnih ishoda učenja.

Garašić (2012) navodi kako visok interes za teme održivoga razvoja pokazuju učenici 5. razreda, a taj interes opada s povećanjem dobi prema 8. razredu kada oba spola imaju najmanji interes za tu temu. Isti autor navodi evidentno opadanje učeničkog afiniteta za Prirodu i Biologiju s godinama tijekom osnovne škole, a pad se nastavlja i u gimnaziji. I druga istraživanja potvrđuju navedeno. Primjerice, na nacionalno reprezentativnom uzorku škotskih učenika utvrđeno je kako na interese učenika utječu spol i dob (Stark i Gray, 1999). Nadalje navode kako mlađi dječaci imaju sklonost prema biološkim temama, a stariji prema fizikalno orijentiranim temama, a da djevojčice pokazuju veliku sklonost prema biološkim temama koja nije ovisna o njihovoj dobi. Slično navedenom, istraživanja pokazuju kako se interesi učenika mijenjaju ovisno o dobi i spolu (Baram-Tsabari i sur., 2009). U ranijim godinama djevojčice pokazuju veći interes za znanost, ali njihov interes opada s godinama. Istraživanja također ukazuju na to kako se kod dječaka s povećanjem dobi povećava interes za fiziku, a da kod djevojčica to nije slučaj (Baram-Tsabari i Yarden, 2008). Također, isti autori navode kako uočenu razliku u interesima s obzirom na spol treba iskoristiti u nastavi nudeći djevojčicama zanimljive teme kao kontekst učenja prirodoslovlja.

Pred učenicima su svakodnevno brojni izazovi koje trebaju biti spremni rješavati. Stoga roditelje, učitelje, kreatore obrazovnih politika i javnost zanima jesu li današnji učenici dobro pripremljeni za izazove budućnosti koji su pred njima, koriste li se učinkovito IKT, mogu li kvalitetno analizirati i provoditi svoje ideje, jesu li sposobni za snalaženje u brojnim problemskim situacijama te jesu li motivirani za cjeloživotno učenje (Välijärvi i sur., 2007; Casner-Lotto i Barrington 2006).

### *IKT i e-učenje u nastavnom procesu*

Današnji učenici žive u digitalnom društvu u kojemu zahvaljujući IKT-u mogu pristupati velikom spektru različitih informacija (Reid, 2002). Stoga se IKT uključuje u odgojno-obrazovni proces i primjenjuju u različitim oblicima učenja (Hus, 2011). Primjenom IKT-a u odgojno-obrazovnom procesu otvaraju se brojne mogućnosti isporuke nastavnoga sadržaja i komunikacije sudionika nastavnoga procesa, a računalni se sadržaji koriste za pomaganje učenicima u usvajanju ishoda učenja na njima blizak i zanimljiv način.

E-učenje se može definirati kao oblik učenja, poučavanja ili obrazovanja potpomognut uporabom računalnih tehnologija, a posebno računalnih mreža utemeljenih na mrežnim tehnologijama (Fallon i Brown, 2003). E-učenje je interaktivan, dvosmjeran proces između učitelja i učenika s pomoću elektroničkih medija, pri čemu je naglasak na procesu učenja, a mediji su sredstvo koje upotpunjuje taj proces. Moore, Dickson-Deane, i Galyen (2011) su analizirali različito poimanje okruženja učenja i definiranje pojmova e-učenja, učenja na daljinu i uvidjeli su nedosljednu uporabu terminologije. Autori navode kako je e-učenje jedna vrsta *on-line* učenja.

Formalno obrazovanje ne treba ograničavati samo na učioničku nastavu jer se danas ono odvija i na daljinu (Kalamković, Halaši i Kalamković, 2013), putem interneta, bez vremenskih i prostornih ograničenja. U tradicionalnoj nastavi, koja još uvijek dominira, postoji izravan kontakt učenika i učitelja, tzv. *kontaktom licem u lice* (*face to face*, f2f), a obilježje je e-učenja, kao oblika obrazovanja na daljinu, odvojenost učitelja i učenika u prostoru i vremenu (Moore, Dickson-Deane, i Galyen, 2011). E-učenje, koje se provodi upotrebom IKT-a, povećava vještine učenika nužne za život i rad u 21. stoljeću, a ima sve veću važnost u obrazovanju učenika i brojnih profesionalaca. Istraživanja koja uspoređuju učinkovitost e-učenja i tradicionalne nastave (Ross, Morrison, i Lowther, 2010; Kulik, 2003) ukazuju na to kako e-učenje može biti jednako uspješno kao i tradicionalna nastava ako se koristi odgovarajuća metodologija, ako postoji interakcija između učenika i ako postoji pravodobna povratna informacija između učitelja i učenika (Sun i sur., 2008; Balanskat i sur., 2006). E-učenje osobito je korisno učenicima koji ne mogu biti nazočni na redovnoj nastavi zbog različitih razloga: velike udaljenosti od škole, osobnih ili zdravstvenih teškoća, odgovornosti u obitelji ili socijalnih razloga (Hölbl i Welzer, 2015). Kotzer i Elran (2012) opisujući učenje matematike, prirodoslovlja i tehnologije primjenom Moodle platforme, navode kako učenici takvo učenje percipiraju vrlo pozitivno. Grundler i sur. (2012) ističu kako usprkos postojanju IKT infrastrukture, računalno pismenim korisnicima i prednostima koje pruža e-učenje postoje značajni otpori uvođenju e-učenja u redovnu nastavu. Glavni je razlog tome nedovoljna kompetentnost učitelja i njihova nespremnost za primjenu e-učenja.

Iz svega navedenoga proizlazi kako se od učitelja očekuje da iskoristiti sve prednosti novih oblika učenja koji učeniku mogu omogućiti dostupnost nastavnih sadržaja bilo kad i bilo gdje (Darling-Hammond i sur., 2015). Učitelj treba moći svakodnevno komunicirati s učenicima putem mnogobrojnih komunikacijskih kanala (telefon, e-mail, forum, chat, videopoziv, društvene mreže), što mu uporaba e-učenja neosporno omogućuje. Stoga se od samih učitelja očekuju i traže specifična znanja i vještine potrebne za oblikovanje kvalitetnih i zanimljivih nastavnih scenarija putem kojih će učenici ostvariti potrebne ishode učenja, bilo da uče u učionici bilo da se koriste e-učenjem. Unatoč sve češćoj primjeni e-učenja i njegovim prednostima, poput nastave na daljinu, 24-satne otvorenosti, mogućnosti rada vlastitim tempom i dinamične interakcije među svim sudionicima, postoje i nedostatci takvog oblika učenja. Nedostatci mogu biti nedovoljna potrebna računalna znanja i vještine učenika i učitelja, neimanje potrebne računalne opreme, autorska prava i problem nedovoljne učenikove motiviranosti i odgovornosti prema vlastitom radu.

## Cilj i hipoteze istraživanja

Imajući u vidu kompleksnost uporabe e-učenja u odgojno-obrazovnom procesu, zatim brojne činitelje o kojima uporaba ovisi, postavljen je cilj istraživanja. Cilj je ovoga istraživanja ispitati učinkovitost e-učenja na usvajanje ishoda učenja u nastavi

Prirode i Biologije u osnovnoj školi na temelju precizno dizajniranoga nastavnog sadržaja te identificirati dobne razlike učenika kao faktora učinkovitosti e-učenja u nastavi Prirode i Biologije.

Takav tip istraživanja može dati uvid u učinkovitost e-učenja s jasno operacionaliziranim nastavnim sadržajima Prirode i Biologije. Rezultati istraživanja mogu biti od koristi učiteljima i učenicima kako bi odgojno-obrazovni proces bio što kvalitetniji. Znanstvenici se također rezultatima ovoga istraživanja mogu koristiti u drugim empirijskim istraživanjima kako bi što bolje razvili modele učinkovite upotrebe e-učenja u nastavi i u drugim nastavnim predmetima.

Sa svrhom operacionalizacije i postizanja utvrđenoga cilja postavljene su sljedeće hipoteze:

H1 – učenici drugoga obrazovnoga ciklusa (5. i 6. razred) ostvarit će statistički značajno veći rezultat u usvojenosti ishoda učenja u odnosu na učenike trećega obrazovnog ciklusa (7. i 8. razred).

H2 – učenici eksperimentalne skupine bit će uspješniji u usvajanju ishoda učenja od učenika kontrolne skupine u svim promatranim razredima.

## Metode

### *Uzorak ispitanika*

U istraživanju su sudjelovala 162 učenika 5., 6., 7. i 8. razreda osnovne škole (Tablica 1.). Rezultati istraživanja prikazani su u istoj skupnoj tablici jer se nastavni sadržaji Prirode u 5. i 6. razredu nastavljaju u nastavi Biologije 7. i 8. razreda. Učenici svakoga razreda bili su podijeljeni u kontrolnu i eksperimentalnu skupinu na temelju predtesta, s ciljem maksimalnog ujednačavanja početnih razlika, što se može iščitati iz tablice 3.

Tablica 1

Prije provedbe istraživanja roditelji svih učenika potpisali su suglasnost kojom odobravaju svojoj djeci sudjelovanje u istraživanju, njihovo fotografiranje i objavljivanje rezultata. Plan istraživanja uvršten je u Školski kurikul i odobren za provedbu od Školskoga odbora.

### *Eksperimentalni postupak*

Prije početka e-učenja učenici su podijeljeni u kontrolnu i eksperimentalnu skupinu na temelju predtesta s ciljem minimaliziranja početnih razlika. Predtestom su ispitivana znanja učenika i usvojenost ishoda učenja iz prethodnih razreda važnih za ispitivanu nastavnu cjelinu pojedinoga razreda. S ciljem podjele učenika iz pojedinoga razreda na eksperimentalnu i kontrolnu skupinu analizirani su rezultati predtesta. Tim su postupkom određeni ekvivalentni parovi učenika (jedan iz eksperimentalne, jedan iz kontrolne skupine) sa što sličnijim početnim rezultatima. Skupine su bile maksimalno ujednačene i po spolu.

Na platformu otvorenoga koda *Moodle* postavljeni su nastavni sadržaji iz ispitivanih nastavnih cjelina Prirode (5. i 6. razred) i Biologije (7. i 8. razred) (Tablica 2.).

Tablica 2

Za učenike eksperimentalne skupine izrađene su lozinke, a dodatno su bili instruirani o osnovama rada na *Moodle*-u (jedan školski sat). Za vrijeme nastave učenici kontrolne skupine nalazili su se u učionici biologije i radili su s učiteljicom koristeći se suvremenim metodama rada, a učenici su eksperimentalne skupine bili u učionici informatike i nisu imali kontakt s učiteljicom licem u lice (f2f). Učenici eksperimentalne skupine nastavnim su sadržajima, postavljenima na *Moodle*-u, pristupali i od kuće kada su i koliko dugo željeli.

Pripreme za eksperimentalnu i kontrolnu skupinu bile su jednake u smislu planiranih ciljeva i postignuća nastave, nastavnih aktivnosti za sve učenike, bez obzira na to jesu li sudjelovali u e-učenju ili tradicionalnoj nastavi. Planirani su ishodi učenja prema važećem Nastavnom planu i programu za osnovnu školu (Nastavni plan i program za osnovnu školu, 2006).

Elektronički nastavni sadržaji, postavljeni na *Moodle*-u, bili su jednostavno i pregledno prikazani na korisničkom sučelju (Slika 1.).

Slika 1

Kako su prije početka e-učenja učenici dobili instrukcije ako se i tijekom rada pojavi nejasnoća, mogli su zatražiti pomoć učiteljice putem elektroničke pošte ili postavljanjem pitanja na *Forumu s vijestima,* koji je bio dostupan svim korisnicima.

Kako bi učenici eksperimentalne skupine mogli uspješno samostalno učiti primjenom *Moodle*-a, nastavni sadržaji Prirode i Biologije bili su podijeljeni u manje zasebne logičke cjeline imenovane u izborniku *Lesson menu* na lijevoj strani sučelja. Sadržajima su mogli pristupiti jednostavnim odabirom traženoga područja. Tekstualni nastavni sadržaji pojedine nastavne jedinice bili su nadopunjeni različitim vizualnim i audiovizualnim izvorima, fotografijama, ilustracijama, grafovima, prikazima 3D modela, videozapisima i animacijama (Slika 2.). Sve je navedeno napravljeno s ciljem pomoći učenicima u usvajanju potrebnih ishoda učenja.

Slika 2

Svaka je nastavna jedinica na kraju sadržavala dio za ponavljanje i vježbanje, a po završetku cijele nastavne cjeline učenici svakoga razreda rješavali su pisanu provjeru znanja, sastavljenu od različitih oblika pitanja (Slika 3.).

Slika 3

Cjelina Dišni sustav u 8. razredu je tako, npr. bila podijeljena na lekcije: *Građa dišnih organa, Čuvajmo zdravlje dišnih organa* i *Ponavljanje*. Lekcija *Građa dišnih organa* bila je podijeljena na manje logičke cjeline: građa dišnoga sustava, funkcija dišnoga sustava, kako dišemo, plućno i stanično disanje. Kako bi se učenicima pomoglo u usvajanju ishoda učenja, postavljena su i tri filma (građa pluća, udisaj – izdisaj, plućno i stanično disanje), kao i slike koje su pratile nastavne sadržaje. Od učenika se tražilo aktivno sudjelovanje pa su za domaću zadaću trebali izraditi model dišnoga

sustava, fotografirati ga i predati ga u e-obliku do određenoga roka. Lekcija *Čuvajmo zdravlje dišnoga sustava* bila je podijeljena na manje cjeline: prehlada i gripa, bronhitis, tuberkuloza, astma, rak pluća, prva pomoć pri gušenju, kako očuvati zdravlje dišnoga sustava. Za domaću zadaću učenici su trebali istražiti važnost cijepljenja protiv tuberkuloze, o tome napisati kratak esej i predati ga u e-obliku. Učiteljica je sve domaće radove pregledala i učenicima davala povratne informacije. Učenici kontrolne grupe imali su iste domaće radove koje su donosili u razred.

Kako je jedan od ciljeva istraživanja bio utvrđivanje učinkovitosti e-učenja u odnosu na tradicionalnu nastavu, po završetku obrade ispitivanih nastavnih cjelina svih razreda izvršena je provjera usvojenosti ishoda učenja učenika kontrolne i eksperimentalne skupine primjenom pisane provjere znanja. Učenici eksperimentalne skupine navedenu su pisanu provjeru znanja pisali u učionici informatike u e-obliku, a učenici kontrolne skupine svih razreda (5. – 8.) identičnu pisanu provjeru pisali su u isto vrijeme u učionici biologije.

Zbog izbjegavanja mogućih poteškoća u paralelnoj komunikaciji i istodobnom praćenju rada svih 162 učenika, istraživanje je ukupno trajalo tri mjeseca. Učenici 5. razreda imali su 1.5 nastavni sat Prirode tjedno, a učenici 6., 7. i 8. razreda imali su 2 nastavna sata Prirode/Biologije svaki tjedan. Učenici kontrolne skupine, koji su nastavu pratili u učionici biologije uz prisutnost učitelja, koristili su se u radu suvremenim metodama rada putem aktivnih oblika nastave.

### *Uzorak varijabli*

S ciljem generiranja eksperimentalne i kontrolne skupine za svaki pojedini razred koristio se standardizirani predtest, neupitne valjanosti, odobren od nadležne Agencije za odgoj i obrazovanje, pa su skupine izjednačene po rezultatu predtesta ($p>0,05$ za sve promatrane podgrupe) (Tablica 3.). Predtest se sastojao od 10 do 14 pitanja (ovisno o razredu) koja su bila vrednovana od 1 do 3 boda. Predtest je odobren na temelju prosudbe stručnoga povjerenstva u skladu s člankom 12. *Pravilnika o postupku odobravanja i uporabi pomoćnih nastavnih sredstava za nastavne predmete u osnovnim školama*, a zadovoljava sve znanstvene, pedagoške, psihološke i didaktičko-metodičke zahtjeve.

Sve skupine ispitanika rješavale su pisanu provjeru znanja kojom se ispitivala usvojenost ishoda učenja, na skali od 0 do 20. Pitanjima su se ispitivale 3 razine usvojenosti nastavnih sadržaja: 1. činjenično znanje i literarno razumijevanje (najniža razina), 2. konceptualno razumijevanje i primjena znanja, 3. rješavanje problema (Crooks, 1988; Webb, 2002). Struktura bodova pisane provjere znanja bila je takva da je približno 50 % bodova bio rezultat odgovora na pitanja kojima se ispituje prva kognitivna razina znanja. Oko 30 % bodova bio je rezultat odgovora na pitanja kojima se ispituje druga kognitivna razina, a oko 20 % treća kognitivna razina znanja.

### *Statistička analiza*

Za sve promatrane varijable izračunati su deskriptivni statistički parametri: aritmetička sredina ± standardna devijacija. Pojedini podatak je promatran kao

nekonzistentan s ostalim podatcima ako je bio izvan intervala AS±2SD. Normalitet svih varijabli testiran je s pomoću Kolmogorov-Smirnovljeva testa primjenom Lilliefors korekcije. Svi podatci međusobno su bili nezavisni. Upotrebom Levenova testa potvrđen je uvjet homogenosti varijance. S ciljem identifikacije značajnosti glavnog efekta faktora *Dob* (5. razred, 6. razred, 7. razred ili 8. razred) i glavnog efekta faktora *Grupa* (Kontrolna ili Eksperimentalna) i dvofaktorske interakcije, koristila se 4 × 2 ANOVA. Za značajne glavne efekte i/ili interakcije koristila se Bonferronijeva post hoc korekcija. Parcijalni- eta kvadrat ($\eta^2$) koristio se za procjenu veličine učinka. Podaci su smatrani signifikantnima ako je $p<0.05$. Svi rezultati izračunati su s pomoću softvera Statistica 12.0. (StatSoft, Tulsa, OK, SAD).

## Rezultati i rasprava

U Tablici 4. prikazani su deskriptivni statistički pokazatelji za obje promatrane skupine ispitanika i sve razrede.

Kako može biti uočeno iz tablice 4, blaga odstupanja od normaliteta uočena su kod rezultata učenika sedmoga razreda, a rezultati svih drugih grupa učenika imali su normalnu distribuciju promatranih varijabli. Dodatno, iz rezultata (Tablica 4.) je vidljivo kako učenici petoga i šestoga razreda pokazuju veći napredak u usvojenosti ishoda učenja u eksperimentalnoj u odnosu na kontrolnu skupinu. S druge strane, kod učenika sedmoga i osmoga razreda eksperimentalna skupina nije ostvarila veći napredak u odnosu na kontrolnu skupinu u apsolutnom smislu. Također se može uočiti kako je kod učenika sedmoga razreda blago narušen normalitet distribucije podataka za obje promatrane skupine ispitanika.

Primjenom ANOVA-e, identificiran je značajan utjecaj faktora *Dob*($F(154,3)=3,263$; $p=0,023$; $\eta^2=0,057$), a utjecaj faktora *Grupa* nije bio značajan ($F(154,1)=0,025$; $p=0,876$; $\eta^2=0,000$). Interakcijski efekti *Dob*Grupa* također nisu značajni ($F(154,3)=1,780$; $p=0,153$; $\eta^2=0,032$). Bonferroni post hoc test glavnih efekata faktora *Dob* ukazao je na to da razlike koje nisu značajne postoje samo između učenika petih i šestih razreda, kao i učenika sedmih i osmih razreda (Tablica 5.).

Iz rezultata ANOVA-e evidentno je kako učenici petoga i šestoga razreda pokazuju veći napredak u usvajanju obrazovnih ishoda u eksperimentalnoj skupini u odnosu na kontrolnu skupinu. S druge strane, učenici sedmoga i osmoga razreda eksperimentalne skupine ne pokazuju veći napredak u odnosu na kontrolnu skupinu u apsolutnom iznosu.

Rezultati jasno ukazuju na to kako je faktor *Dob* značajan prediktor uspjeha, neovisno o pripadnosti učenika eksperimentalnoj ili kontrolnoj skupini. Dob učenika ide u korist primjene e-učenja u drugom obrazovnom ciklusu, čime je potvrđena hipoteza 1. Kako se u radu identificirao faktor *Dob* učenika kao prediktor učinkovitijeg e-učenja, u nastavi Prirode i Biologije primijenjena je *Bonferroni post hoc* korekcija s ciljem identifikacije razreda između kojih postoji razlika. Rezultati *Bonferroni post hoc* korekcije mogu se interpretirati identificiranjem dviju relativno homogenih

podskupina ispitanika: učenika 5. i 6. razreda s jedne strane i učenika 7. i 8. razreda s druge strane. Uočena je diferencijacija učenika kojom se jasno odvajaju učenici 5. i 6. razreda (drugi obrazovni ciklus) koji pokazuju bolje rezultate u eksperimentalnoj skupini u odnosu na učenike 7. i 8. razreda (treći obrazovni ciklus) kod kojih nije identificirana statistički značajna razlika među skupinama.

Mehanizmi u pozadini takve dihotomne podijeljenosti rezultata mogu se grupirati u dvije skupine. Prvu skupinu čine mehanizmi zbog kojih je bolja eksperimentalna od kontrolne skupine drugoga obrazovnoga ciklusa, a drugu skupinu čine mehanizmi zbog kojih su ujednačene kontrolna i eksperimentalna skupina trećega obrazovnoga ciklusa. Pri tome su vjerojatni čimbenici veće uspješnosti eksperimentalne skupine drugoga obrazovnoga ciklusa: zanimljivije nastavne teme u 5. i 6. razredu koje potiču interes za rad, veća motiviranost za rad u području prirodoslovlja kod mlađih učenika, rad s IKT alatima koji predstavlja dodatan izazov, budi zainteresiranost i utječe na motivaciju eksperimentalne skupine. Mogući čimbenici koji su mogli dovesti do ujednačenih rezultata kontrolne i eksperimentalne skupine trećega obrazovnoga ciklusa jesu: rad u blok satu kontrolne skupine, utjecaj puberteta na pažnju i koncentraciju, potrebna veća čitalačka pismenost, općenit pad zanimanja za prirodoslovlje kod starijih učenika.

Prije provedena istraživanja pokazuju kako na motiviranost za rad učenika u pojedinom nastavnom predmetu utječu spol, dob, kvaliteta poučavanja i zanimljivost nastavnih sadržaja (Lavonen i sur., 2005). Utjecaj zanimljivosti nastavnih sadržaja ispitivanih nastavnih cjelina postavljenih na *Moodle*-u ne smije se zanemariti. Učenici drugoga obrazovnoga ciklusa, koji su ostvarili najveći napredak, učili su vrlo zanimljive nastavne cjeline (*Pubertet* u 5. razredu, *Korist od mora i kopnenih voda* u 6. razredu) koje su im zanimljive već po svome sadržaju. Stoga su učenici 5. i 6. razreda eksperimentalne skupine mogli biti motiviraniji za učenje u odnosu na učenike 7. i 8. razreda. Upravo je postavljanje navedenih nastavnih cjelina na Moodle moglo predstavljati i jedno od ograničenja ovoga istraživanja jer nastavne cjeline 7. i 8. razreda (*Beskralježnjaci* i *Dišni sustav*), koje su postavljene na *Moodle*, nisu bile tako zanimljive. Pad zanimanja učenika 7. razreda može se povezati i s prisutnim nezanimljivim sistematsko-klasifikacijskim pristupom živom svijetu u obradi nastavnih sadržaja toga razreda. U drugim provedenim istraživanjima autori također navode kako učenici 7. razreda imaju problema s usvajanjem ishoda učenja u konceptima vezanim uz raznolikost unutar životinjskoga carstva (Bell, 1981; Braund 1998; Prokop, Kubiatko i Fančovičová, 2007). To je mogao biti jedan od vjerojatnih razloga zašto e-učenje kod učenika 7. razreda nije bilo uspješnije od klasične nastave. Učenici sedmoga razreda obrađivali su nastavnu cjelinu *Beskralježnjaci* s nastavnim jedinicama *Plošnjaci* i *Oblići*. Istraživana cjelina sedmoga razreda odnosi se na sadržaje o parazitskim životinjama u čovjeku. U provedenim istraživanjima (Garašić, 2012) učenici tu cjelinu rangiraju kao jednu od najnezanimljivijih cjelina kojima ne vide svrhu i ne vole učiti navedene nastavne sadržaje. Slične su stavove o toj nastavnoj cjelini iznijeli i učenici

koji su sudjelovali u ovome istraživanju. Drugi je vjerojatni razlog veće uspješnosti eksperimentalne skupine drugoga obrazovnoga ciklusa u odnosu na eksperimentalnu skupinu trećega obrazovnoga ciklusa u samoj njihovoj dobi. Mlađi su učenici te dobi još vrijedni, detaljnije uče i kod kuće pišu domaću zadaću. To je posebno važan faktor za eksperimentalnu skupinu jer oni sami reguliraju svoj rad kod kuće, vrijeme koliko će i kada učiti te je za uspjeh bitna njihova samoodgovornost. Istraživanja učeničkih interesa u području prirodoslovlja pokazuju kako učenike učenju privlači: samo prirodoslovlje, određeni nastavni sadržaji pojedinoga nastavnog predmeta, metodologija poučavanja i primjena informacijsko-komunikacijske tehnologije u nastavi (Hoffman, 2002). Iz navedenoga proizlazi kako je rad s novom tehnologijom, IKT-om i e-učenje, mogao biti treći vjerojatni razlog veće uspješnosti eksperimentalne skupine učenika 5. i 6. razreda. Prvi susret s informatikom i IKT-om u nastavi Prirode mogao je pobuditi njihovu znatiželju i utjecati na veću motiviranost za rad.

Učenici eksperimentalne skupine svih razreda izjavili su kako su im vizualni prikazi u e-lekcijama jako pomogli u savladavanju traženih nastavnih sadržaja i usvajanju potrebnih ishoda učenja. Oni su također svjesni da takav način rada nije jednostavan jer od njih traži samokontrolu i upravljanje vlastitim tempom rada i vremenom koje provode u e-učenju. Rezultati su pokazali da eksperimentalna skupina nije bila uspješnija u usvajanju ishoda učenja u svim razredima te su razmotreni razlozi koji su mogli dovesti do nepotvrđivanja hipoteze 2.

Kako su svi učenici trećega obrazovnoga ciklusa kontrolne skupine imali nastavu organiziranu u blok satu, a u radu su koristili aktivne oblike rada, tako oblikovana nastava mogla je doprinijeti boljoj učinkovitosti kontrolne skupine i nepostojanju statistički značajne razlike između kontrolne i eksperimentalne skupine ovih razreda. Upravo istraživanje koje je proučavalo učinkovitost rada u blok-satu u odnosu na rad u jednom satu nastave biologije pokazuje kako učenici koji rade u blok-satu u razredu neometano izvršavaju različite aktivnosti i postižu bolje rezultate od učenika koji rade u jednom satu (Labak i sur., 2013). U prilog tome govore i druga istraživanja koja ukazuju na to kako učenici 7. razreda postižu bolje rezultate na provjeri znanja, zainteresiraniji su za nastavne sadržaje i ulažu veći napor u učenje ako uče biologiju aktivnim oblicima rada u blok-satu ( Corley, 2003; Knight, De Leon i Smith, 1999; Schaal i Randler, 2004).

Učenici trećega obrazovnoga ciklusa na početku su puberteta koji im donosi fizičke, psihičke, emocionalne i kognitivne promjene (Silk i sur., 2009). Učenicima trećega obrazovnog ciklusa navedene promjene mogu izazvati i probleme s pažnjom koja se raspršuje te se teže koncentriraju na tražene nastavne sadržaje, posebno u kraćim vremenskim intervalima. To učenicima eksperimentalne skupine može dodatno otežavati rad primjenom e-učenja jer sami rukovode vlastitom aktivnošću i duljinom rada na *Moodle*-u. Problem učenicima eksperimentalne skupine može biti koncentriranje na brojne aktivnosti koje se od njih zahtijevaju ako ne rade dovoljno dugo vremena da bi se kvalitetno koncentrirali na tražene nastavne sadržaje.

Nadalje, općenita lošija riješenost testova u trećem obrazovnom ciklusu mogla je biti rezultat utjecaja njihove čitalačke pismenosti (Kirsh i sur., 2002). Pitanja u pisanoj provjeri znanja nisu bila jednostavno koncipirana tako da se u njima traži samo reproduktivno znanje, već su postojala i pitanja s grafičkim prikazom koje je trebalo protumačiti i izvesti zaključak, kao i pitanja s dvije-tri rečenice uvoda, što je učenicima sa slabijom čitalačkom pismenosti mogao biti otežavajući čimbenik. Novi oblik pitanja, na koji nisu navikli ni učenici eksperimentalne ni kontrolne skupine, mogao je biti ograničavajući faktor njihova uspjeha. Dok su učenici kontrolne skupine u svakom trenutku pisane provjere mogli pitati učiteljicu dodatno pojašnjenje, to učenici koji su rješavali e-test nisu mogli. Takav zaključak ide u prilog sastavljanju pitanja prema PISA modelu gdje se nakon testiranja vidjelo da je slaba riješenost posljedica teškoća pri čitanju i razumijevanju pročitanoga teksta (Braš-Roth i sur., 2008). Učenici eksperimentalne skupine trećega obrazovnoga ciklusa također su naglasili kako im je poteškoću u rješavanju testa predstavljao i pravopis jer su u točnim odgovorima trebali paziti na pisanje *ije/je, č/ć* budući da im Moodle sustav napisanu pravopisnu netočnost nije priznavao.

Jedan od razloga takvih rezultata učenika trećega obrazovnoga ciklusa može biti i pad zanimanja učenika za učenje prirodoslovlja u korelaciji s porastom njihovih godina. U skladu s rezultatima ovoga istraživanja su i istraživanja drugih autora koja također potvrđuju kako se zanimanje učenika za školske sadržaje smanjuje tijekom godina (George, 2006; Prokop i sur., 2007). Kako se u zemljama u kojima su provedena ta istraživanja uči integrirani nastavni predmet Prirodoslovlje, potrebna su dodatna istraživanja za slučajeve kada se Priroda i Biologija uče kao posebni nastavni predmeti, neovisni o Kemiji i Fizici (Usak i sur., 2009). Tendenciju opadanja zanimanja učenika za učenje sadržaja prirodoslovlja konstatira više autora (Osborne i sur., 2003), stoga je važno posebnu pažnju posvetiti razvoju strategija koje će povećati zanimanje učenika za učenjem prirodoslovlja (DeWitt i sur., 2013).

Kako su obje skupine trećega obrazovnoga ciklusa postigle jednako dobar rezultat, to se može koristiti kao argument u prilog budućoj uporabi e-učenja u nastavnom procesu. Naime, uvidjelo se da e-učenje nije manje učinkovito u odnosu na nastavu u razredu. Iako eksperimentalna skupina tih razreda nije bila statistički bolja u odnosu na kontrolnu, može se reći kako se e-učenje pokazalo jednako učinkovitim kao i redovna nastava u razredu. Stoga se e-učenje može koristiti u situacijama kada ne postoji mogućnost da određeni učenik ili učenici prisustvuju redovnoj nastavi.

Iz rezultata se općenito može uočiti veći utjecaj faktora *Dob* učenika kao prediktora uspješnosti e-učenja u usvajanju potrebnih ishoda učenja u nastavi Prirode/Biologije u odnosu na faktor *Grupa*. Istraživanjem je potvrđena hipoteza H1 te je identificirana statistički značajna razlika u usvojenosti ishoda učenja među skupinama ispitanika po razredima. Druga hipoteza H2 nije potvrđena s obzirom na identificiranje faktora *Grupa* kao statistički neznačajnog. Konačni efekt između eksperimentalne i kontrolne

grupe nije identificiran. E-učenje se pokazalo jednako uspješno kao i nastava u učionici u kojoj su primijenjeni aktivni oblici rada.

## Zaključak

Provedeno istraživanje, kojim se ispitivala učinkovitost e-učenja u nastavi Prirode i Biologije, pokazuje kako je faktor *Dob* učenika značajni prediktor uspjeha eksperimentalne skupine. Istraživanje je pokazalo jasnu granicu dobi učenika (drugi obrazovni ciklus) koji uspješno izvršavaju postavljene zadatke i imaju veću motivaciju za rad u odnosu na starije učenike, na koje djeluju brojni čimbenici koji mogu utjecati na rezultate njihova rada. Eksperimentalna skupina drugoga obrazovnoga ciklusa bila je uspješnija od kontrolne u usvojenosti ishoda učenja. Mogući su razlozi zanimljive teme postavljene na Moodle, susret s novim tehnologijama rada i e-učenjem, što im budi interes, te općenito veća motiviranost za rad mlađih učenika. Kod učenika trećega obrazovnoga ciklusa jednaka je uspješnost eksperimentalne i kontrolne skupine. Istraživanje je potvrdilo hipotezu H1 jer je identificirana statistički značajna razlika u usvojenosti ishoda učenja među skupinama ispitanika po razredima. Druga hipoteza H2 nije potvrđena jer je faktor *Grupa* identificiran kao statistički neznačajan. Rezultati istraživanja ukazuju na to kako se e-učenje pokazalo približno jednako učinkovitim kao i redovna nastava u razredu. Stoga bi se e-učenje moglo učinkovito primjenjivati kada ne postoji mogućnost da određeni učenik ili učenici prisustvuju redovnoj nastavi u razredu zbog različitih razloga.

Upravo izrađeni i provedeni oblici e-učenja pokazali su zadovoljstvo učenika novim i njima prihvatljivim načinom učenja, stoga treba biti poticaj nastavnicima za daljnje osmišljavanje računalnih nastavnih sadržaja i različitih računalnih aktivnosti kojima će se učenici osposobljavati za prepoznavanje i rješavanje stvarnih životnih problema. Suvremeno društvo traži razvijanje infrastrukture za djelotvorno i brzo računalno povezivanje sudionika u svim granama ljudske djelatnosti. Kako škola priprema učenike za život i tržište rada, važno je i u odgojno-obrazovni proces implementirati IKT s ciljem razvijanja novih kompetencija kod učenika, kao i jačanja i razvijanja postojećih kompetencija sadašnjih i budućih učitelja. Stoga obrazovni prioriteti trebaju biti promjene sustava obrazovanja usmjerene prema obrazovanju za zdrav i održiv život i povećanju kompetencija učitelja. S obzirom na sve navedeno nastava se može osuvremeniti izradom kvalitetnih nastavnih programa i materijala koji će podršku imati u različitim računalnim programima i provođenju e-učenja. U sve oblike obrazovanja moguće je implementirati IKT kao alat kojim se promiče zdravlje i održivost kao istinsko bogatstvo i temelj budućega napretka čovječanstva.