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Computer Application in the Initial Education of Children in Natural Sciences

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Abstract

At their young age pupils learn the contents of natural sciences by combining different methods and forms of work. This study examined the effect of computer-aided learning on the quality of pupils' knowledge about the natural habitats. A total of 168 third grade primary school pupils (9-year-old) from the Republic of Serbia took part in this research (84 pupils comprising the control group and 84 pupils comprising the experimental group). Causal, descriptive and comparative methods were used in this study. Initial test, final test and retest were used as tools for the measurement of the pupils' knowledge about the habitats. On the basis of the results obtained, it was concluded that the experimental group of pupils, who had used computers in the learning process, obtained better knowledge about habitats, when compared to the control group of pupils who had been taught in the traditional way. The experimental group pupils achieved better results at the levels of application, analysis, synthesis and the evaluation of knowledge.

Key words: *computer-aided learning; initial learning in natural sciences; habitat; pupils; third-grade elementary school pupils.*

Introduction

Learning about science at a young age in primary school children differs significantly from this process when it takes place at a later age (Church, 2003). Children at a young age cannot distinguish between the essential and unimportant matter and they have difficulties when analyzing and concluding about the whole on the basis of the parts given in a particular situation. They are able to go quite far in understanding concepts and models, especially if they are allowed to access knowledge through experimentation and theory adapted to their abilities or age (Gelman, 2004). Due to this and in order to acquire not only knowledge about the nature but also to develop skills and attitudes necessary for their lives in the society, they are taught about the contents of nature in an integrated form. Children learn to adapt to specific situations, to develop creativity and to confront reality. By studying the nature, children develop interest and enthusiasm, which are the characteristics of an early childhood. They learn to understand their environment, the relationships and laws of nature, the space, the appearance and phenomenal dimensions, the force which nature has over man and so on. By learning about nature and natural processes, children start to perceive and understand the relationships in their immediate environment; they develop their reasoning capacities and other mental functions and enrich their vocabulary (Hodson, 1998). They develop their personality, intelligence, critical spirit and their own attitude to the world. Children discover that the material world is suitable for research and that with their own action they can shape the real world (Chalufour, 2003). They are confronted with objects, natural and technical phenomena, which they examine and control (Solomon, 1993). In this way, they develop logical thinking. This facility is both an obstacle and an opportunity for questioning, reasoning, finding answers and obtaining truth awareness. The integrated contents of natural sciences help children understand and learn how to incorporate the achievements of the scientific and technological development in their cultural, ecological, economical, political and social contexts (Bingle, 1994 and Pedretti 1996). Discovery learning strategies and different teaching strategies are very important in the realization of the contents of the integrated natural sciences.

The application of computers in the learning process has a significant role in achieving the objectives and tasks of the integrated natural science teaching. Teaching by means of computers encourages abstract thinking, enables planning the direction and individual progress of pupils in the process of knowledge acquisition (Greeinfild, 2006). Research has shown that computer-aided teaching helps pupils develop their memory, imagination and independence in learning (Wartela, 2000). It raises the educational level of pupils, develops their sensibility to problems, and encourages openness, flexibility, tolerance and independent work. The quality and effectiveness of computer-aided teaching primarily depends on the quality and type of the programme used, types of materials processed, pupils' cognitive style, their personal characteristics and other factors. By including computers in the teaching process, pupils acquire the ability to manage their cognitive functioning and the development of the metacognitive skills (McInerney, 1997). Computer-aided teaching also provides the ability to evaluate and assess the pupils objectively. It plays an important role in the achievement of individualization. It develops personal initiative in pupils, provides all pupils with an equal chance to work and create opportunities for achieving progress at their own pace (Haugland, 1992). The pupils who master the materials with difficulty always get help, so they can move forward smoothly and develop to their maximum, independently of others (Cardelle-Elawar, 1995). This application in teaching offers a great deal of advantage compared to the traditional forms of teaching. Its main benefits lay in the fact that it allows pupils to follow their own course of progress, and the fact that it creates conditions for the development of self-criticism (Greeinfild, 2006), divergent thinking and the internalization of the efficient operation criteria (Gatewood, 1997). In this way, pupils can create the potential for improvement and development of the cognitive sphere of their personality as well as their metacognitive abilities and skills (Nastasi, 1994). The application of computers and computer educational software in the teaching of the integrated natural sciences should not be seen as the main goal, but only the means which pupils use in the acquisition of knowledge about nature and the environment in which they live. Communication between the pupils and computers is simple and straightforward and can be achieved in different ways (Wartela, 2000). The combination of text, picture and sound incites better motivation for the learning of natural contents (Seel, 2003). The textual information must be clear and tailored to the pupil, in order to provide the explanation of the essence of what is taught (Keeler, 1995). It should be followed by an appropriate picture, photograph or an illustration. The picture must reflect reality, in order to satisfy the principle of obviousness. Information can be given in such a way that the pupil, while reading and watching, combines or reorganizes facts and thus comes to some new insights. Such pieces of information are usually given in the form of a rebus, puzzle, labyrinth, etc.

Research Methodology

The problem and the subject of research: The contents of the integrated natural sciences should help very young pupils understand the notion of the habitat, the elementary causal and consequential relationships in nature, it should help them acquire the basic knowledge about the natural phenomena and processes in a particular habitat, learn about the characteristics of plants and animals living in a particular habitat, the mutual influence of living beings, the influence of the habitat on the living beings residing in it and vice versa. The realization of these contents is difficult to achieve in the Republic of Serbia, because it is hard to enable pupils to observe a habitat directly, together with the phenomena and relationships in it, due to an inflexible class timetable, as well as the organization of teaching. Therefore, two questions are posed: whether or not computer-aided teaching, in which educational software is adapted to the mental and physical characteristics of the third-grade pupils, can contribute to the increase of knowledge about the quality of the habitat, and is this knowledge better than the knowledge gained in the traditional way of learning?

The aim of the research was to assess the impact of teaching by means of computers on the quality of knowledge of the third-grade elementary school pupils about the natural habitat. On the basis of the research objectives the research tasks were designed. The tasks can be grouped into: (1) the preparatory tasks (creating educational software for each natural habitat, training teachers in computer-aided teaching with the purpose of the implementation of the contents of the habitat, and preparing pupils for learning with computers) and (2) the immediate implementation of the research tasks (the implementation of the initial testing and the formation of the experimental and control groups, the introduction of computers into the learning of the experimental group, the implementation of the final test, retest implementation, statistical processing, and data analysis).

The main hypothesis of the research was that by using computer-aided teaching in the implementation of the contents on the habitats in the third grade of elementary schools, pupils would have a higher chance of achieving better knowledge, than when they were taught in the traditional way. Two sub-hypotheses were designed:

- The pupils in the experimental group should obtain a higher quality of knowledge than the pupils in the control group
- When compared to the traditional way of learning, computer-aided learning contributes greatly to the rise of the durability of the pupils' knowledge about the habitat.

Methods and techniques of research: In the study causal (parallel experiment group), descriptive and comparative methods were used. The main measuring instrument in the study was the test (initial, final and retest). Each test had 20 questions. On each test the maximum number of points was 100. The time allowed for test completion was the duration of one lesson (45 minutes). Each test was comprised of questions that included six levels of knowledge: the level of information recall (knowledge), the level of understanding, the level of application, the level of analysis, the level of synthesis and the level of evaluation (Walker, 2004). Tasks such as the definition of notions and marking of drawings were used in the testing of the level of recall (knowledge). In the analysis of the understanding level the following tasks were used: ordering the given elements, drawing, filling in the blanks. Tasks such as connecting information to the pupil's personal experience, the preparation of knowledge caused by the change in the existing situation, the use of other sources of information and debugging tasks were applied in the analysis of the application level. The level of analysis was examined by means of the following types of tasks: finding similarities and differences, the determination of characteristics, classification, and expression of attitudes. Tasks such as: recognition of the advantages and disadvantages, answering the question "what would happen if…", and making conclusions were applied at the levels of analysis and synthesis. For the level of evaluation the main type of tasks used was the interpretation of drawings. During the evaluations of tests, the main rule was that tasks that require higher levels of knowledge were granted a higher number of points. Computer-aided teaching was used to implement the contents of the living communities (terrestrial living communities, forests and meadows, cultivated living communities and aquatic living communities). A simple educational software was created for all types of content and was used in the learning process of the experimental group pupils. Since the pupils had no experience with computer-aided learning, and due to the fact that they were young (9-years-old), they worked in groups of three and received verbal instructions from their teachers and written instructions in the form of instructive (teaching) sheets. The tasks given in the instructive sheets consisted of the steps that were designed to help pupils monitor and understand the slides that appeared on the screen. The general scenario for the implementation of the contents about the habitats in the classroom by means of computer-aided teaching was the following: introductory activities (teacher divides the pupils into groups and gives them verbal instructions on how to use the instructional sheet), central activities (learning in groups by using the computer), and the final activities (pupils and the teacher revise the essential features of the teaching content and eventually the teacher gives the pupils the printed handout with slides which were used in the central part of the class). Each slide contained basic information with environmental conditions and plants and animals typical of a particular habitat. There was a section for the curious and those who wanted to learn more. The slides contained questions that pupils were required to answer. The accuracy of their responses could be verified by clicking the appropriate boxes on the slide. The contents of the slides were organized logically and formed a whole. There were simple sentences and theses presented on the slides. The important concepts and keywords were highlighted (using a different colour than was the colour of the main text), in order to attract the attention of pupils and enable them to memorize more easily. Next to the text, on some particular slides there were embedded pictures, short films and animations. Care was taken to achieve a balance between the text and the other elements on the slide. The pupils were working through the slides using the mouse. This way learning was adapted to the individual characteristics of pupils. The number of slides was controlled. On average, every habitat was treated with 20 slides. The advantage was given to the three pure colours over the mixed ones in slide design. The combination of colours, letters and the background attracted the attention of pupils, as there was a large reflection coefficient of text-background. The background was the same for all the presentation slides, and images or the background patterns were discrete. For the implementation of the mentioned contents in the experimental group, the computer classrooms in the schools were used. Unlike the pupils in the experimental group, the control group pupils learned the contents of the natural habitats in the traditional way. The total number of hours used to process the new teaching material in the two groups was eight. After the revision class, testing was conducted in both groups (final testing). After two months, retesting was conducted. The data were statistically processed by means of the SPSS program.

The study sample consisted of 168 third-grade pupils attending two primary schools in Novi Sad (Serbia) (84 in the experimental and 84 in the control group). In the educational system of the Republic of Serbia pupils aged 7 to 11 learn the integrated contents of natural sciences, through the compulsory subjects the World around us (the first and the second grade) and Nature and Society (the third and the fourth grade). The experimental (E) and the control groups (C) were evenly balanced on the basis of the grade point average obtained at the end of the first semester of the third grade and on the basis of their grades in the subject Nature and Society (Table 1).

Table 1. *Balance between pupils divided into the control (C) and experimental (E) groups on the basis of the grade point average obtained at the end of the first semester and the pupils' grades in the subject Nature and Society*

	Grade point average at the end of the first semester (%)					Grade in the subject Nature and Society (%)				
Group	Excellent	Very good	Good	Sufficient	Insufficient	Excellent	Very good	Good	Sufficient	Insufficient
E	50.0	42.9	7.1	0	0	47.6	31.0	19.0	2.4	0
C	48.9	44.0	7.1	0	0	45.3	33.3	21.4	0	0

Results

The balance between the two participant groups in the pupils' knowledge shown in the initial test is presented in Tables 2 and 3 and in Figure 1.

Table 2. *Balance between the control and experimental groups on the basis of their achievement and the number of points achieved on the initial test.*

	Achieved results for both groups				No. of achieved points on the in. test	
The level of pupils' achievement according to Bloom	E group		C group		E group	C group
	Number of pupils	%	Number of pupils	%		
Recall	38	45.3	36	42.9	6,708	6,722
Understanding	34	40.5	32	38.1		
Application	10	11.9	12	14.3		
Analysis	2	2.4	4	4.7		
Synthesis	0	0	0	0		
Evaluation	0	0	0	0		
Total	84	100	84	100		

Table 3. *Differences between the control and the experimental groups in their achievement on the initial test*

Group	N	$\overline{X}$	S	V	$\overline{X}_1 - \overline{X}_2$	$S_{X_1 - X_2}$	t
E	84	56.43	23.96	0.42	1.3	7.86	0.16
C	84	57.73	23.97	0.45			

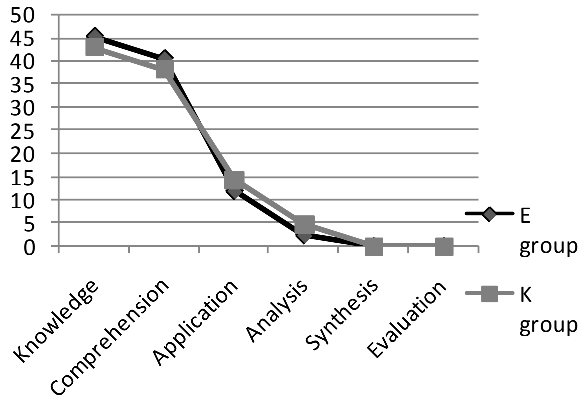

Figure 1. *Percentage of pupils with highest achievement in the cognitive learning skills (according to Bloom's Taxonomy of Learning) for E and C groups as obtained on the initial test.*

The differences in the knowledge of the control and experimental groups presented in the final test are shown in Tables 4 and 5 and in Figure 2.

Table 4. *The results of the experimental and control groups obtained in the final test.*

Group	Number of points achieved	The maximum number of points	The highest obtained level of pupils' achievement (%)					
			Knowledge	Understanding	Application	Analysis	Synthesis	Evaluation
E	7,140	8,400	7.1	26.2	23.8	19.0	14.3	9.6
K	6,078	8,400	38.1	45.2	14.3	2.4	0	0

Table 5. *Differences between the control and experimental groups of pupils in their achievement on the final test.*

Group	N	$\overline{X}$	S	V	$\overline{X}_1 - \overline{X}_2$	$S_{X_1 - X_2}$	t
E	84	82.03	12.45	0.15	18.68	6. 25	3.02
C	84	63.35	25.78	0.41			

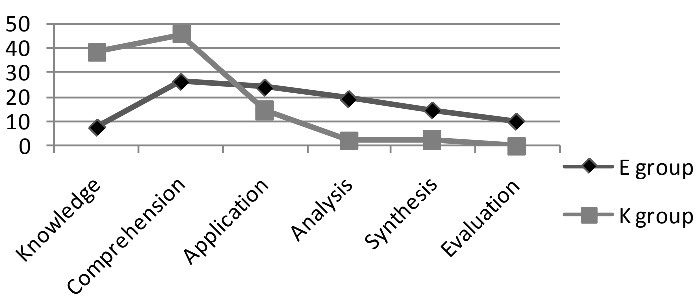

Figure 2. *Percentage of pupils with highest achievements in the cognitive learning skills (according to Bloom's Taxonomy of Learning) obtained in the final test for both, E and C groups.*

The differences in the pupils' knowledge between the control and experimental groups in the retest are shown in tables (Table 6 and Table 7) and in Figure 3.

Table 6. *The results of the experimental and control groups obtained in the retest*

Group	Number of points achieved	Maximum number of points	The highest obtained level of pupils' achievements (%)					
			Knowledge	Understanding	Application	Analysis	Synthesis	Evaluation
E	6,789	8,400	13.1	25.0	26.2	19.7	8.3	7.7
C	4,967	8,400	44.0	39.3	15.5	1.2	0	0

Table 7. *Difference in pupils' knowledge, between the control and experimental groups – retest results*

Group	N	$\overline{X}$	S	V	$\overline{X}_1 - \overline{X}_2$	$S_{X_1 - X_2}$	t
E	84	78.88	13.6	0.17	21.8	6. 01	3.7
C	84	57.08	23.97	0.43			

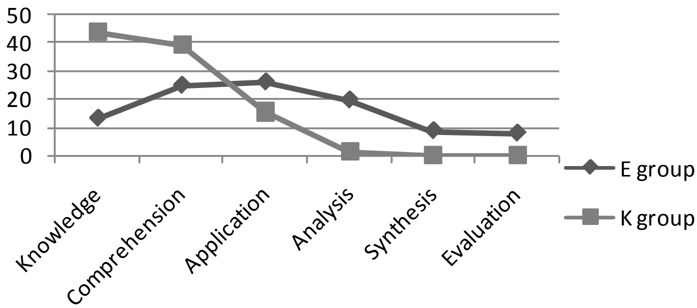

Figure 3. *Percentage of pupils with highest achievements in cognitive learning skills (according to Bloom's Taxonomy of Learning) for both E and C groups as obtained in the retest.*

Discussion

In the preceding two grades, pupils were supposed to have gained knowledge about plants and animals which would allow them to make vertical connections between these contents in the third grade. The pupils were supposed to know the necessary conditions for the growth and development of plants and animals, the appearance of plants and animals, the similarities and differences between plants and animals, the influence of the environment on their lives, the behaviour of plants and animals according to the seasons, the division of animals and plants, the properties of the cultivated and uncultivated plants, the importance of plants and animals to man and the mutual impact of living beings. This knowledge is tested in the initial test. The initial test demonstrated the balance between the experimental and the control groups before the introduction of the experimental factors. Out of the total of 8,400 possible points, 6,708 points (79.6%) were obtained by the experimental group of pupils, and

6,722 points (80.2%) by the control group. On the basis of these data, a satisfactory balance between the tested groups is quite evident (Table 2).

The difference in 14 points in favour of the control group was not statistically significant, as was verified by the t-ratio. In addition, the balance between the experimental and control groups of pupils could be observed when different learning skills, within cognitive domains, were divided according to the Bloom's taxonomy learning scale. In the detailed analysis, the number of pupils who achieved the level of knowledge application in both groups was negligible. None of the pupils managed to perform the tasks at the synthesis and evaluation levels. The results showed that most pupils could only recall the previously adopted knowledge they had had on plants and animals, i.e. they knew the meaning of the content. They were able to: specify the division of plants and animals, classify plants and animals, describe them, give examples, locate them, identify wild and cultivated plants, differentiate between the wild and domestic animals, define the parts of the body of animals and plants, mark them on a drawing and briefly describe their functions. However, most pupils did not know how to use their knowledge in new and concrete situations, or they did not understand the content and the structure of the previously learned topics, since they were not able to answer the questions at the level of analysis and at the level of synthesis. None of the pupils answered the questions at the level of evaluation (Figure 1).

This showed that pupils had learned the contents about plants and animals in the traditional way. The significance in the differences of the mean values was determined by the quotient difference of the mean values and the standard error of the difference that is t – ratio. The threshold value for the confidence level of 5% was $t_{0.05} = 1.96$, and the confidence level of 1% was $t_{0.01} = 2.58$. On the basis of these data it was calculated that the experimental group had 1.3 points less than the control group. Based on the analysis of variance, it could be seen that t-ratio is not significant at the thresholds of significance of 1 and 5% (probability of t-ratio is 0.16). There was no statistically significant difference found between the mean values of the experimental and control groups, i.e. the occurred differences in the achieved number of points could be attributed to random variation. Based on the data presented above, it can be affirmed that the experimental and control groups were matched for prior knowledge demonstrated on the initial test (Table 3).

The final verification of knowledge was aimed at by using a variety of tasks (the objective type that determine the level of the recently adopted knowledge) immediately after the completion of the experiment. The results of the final testing of pupils in the experimental and control groups (Table 4) show that 7,140 points (85.0%) out of the possible total of 8,400 points were obtained by the experimental group, while 6,078 points (72.4%) out of possible 8,400 points were achieved by the control group. The difference in the total number of achieved points was 1,062 in favour of the experimental group, indicating more effective knowledge acquisition when computer-aided teaching was used in the implementation of the contents of natural habitats, in comparison with the traditional learning. A great difference was found when observing certain levels of knowledge that pupils had achieved. More experimental group pupils were able to achieve the level of the analysis of knowledge (19.0%), when compared to the pupils in the control group (2.45%). The level of the synthesis of knowledge was achieved by 14.3% of experimental group pupils, while 9.6 % of the experimental group pupils reached the level of evaluation. None of the control group pupils solved the tasks at the level of synthesis or at the level of evaluation (Figure 2).

The data show that a large number of pupils in the experimental group benefited from computer-aided learning, since they were able to solve the tasks which included: analyses, parsing the contents, classification, comparison, establishing differences between the habitat, the establishment of mutual relations between plants and animals and their habitat, drawing conclusions about the behaviour of plants and animals in a certain habitat. On the contrary, the control group of pupils, who were not involved in computer-aided learning, were not able to: formulate and build new structures from the existing knowledge and skills (in the formulation of the forms of food chain in different habitats), judge the importance of the mutual relationship between plants and animals, defend the attitude that healthy environment needs to be maintained in order for plants and animals to be able to exist in their habitats. One part of the experimental group pupils, unlike the control group pupils, managed to perform the tasks where they had to demonstrate that their understanding of the concept was deeper than the knowledge at the level of simple definitions would have been. For example, they solved the tasks in which they were supposed to state the conditions which particular habitats must have in order to provide life for certain plants or animals, or to state that they do not meet the conditions. Comparing the mean value of the experimental and control group results, as well as the values of the t-ratio (3.02), it can be concluded that pupils in the experimental group performed better at the final test (Table 5), when compared to the pupils in the control group. Hereby, the first sub-hypothesis was confirmed.

Two months later, the retest was conducted. The results of the experimental and control groups (Table 6) showed that 6,789 points (80.2%) out of possible 8,400 points were obtained by the experimental group, while the total of 5,712 points (68.0%) out of the possible 8,400 points was achieved by the control group of pupils. The difference in the total number of obtained points was 1,077 points in favour of the experimental group, indicating a greater durability of pupils' knowledge in the experimental group. In the final test, the pupils in the experimental group showed better skills in the analysis of knowledge i.e. the learning domains (19.7 %), when compared to the control group of pupils (1.2 %). A certain number of pupils in the experimental group were able to solve the tasks at the level of synthesis (8.3%) and of evaluation (7.7%). None of the pupils in the control group managed to achieve the level of synthesis and the level of evaluation (Figure 3).

The pupils in the experimental group demonstrated better knowledge of the application of the acquired knowledge in various situations found in the daily life of plants and animals of different habitats. They performed better at the tasks in which they were required to describe how they could improve the life of plants and animals in different habitats. They were better at solving tasks in which errors and confusing situation occurred. In these cases, they needed to find or solve a task by applying the newly acquired knowledge and understanding (to find a plant or animal that does not belong to a particular habitat and explain their choice). The pupils in the experimental group demonstrated greater knowledge in the tasks in which they had to find similarities and differences among the habitats, and differences between plants or animals of the specific habitats. In particular, better success was demonstrated by the experimental group pupils when compared to the control group pupils on those tasks in which they were required to explain what would have happened to certain plants and animals if they had not been adapted to the seasons, as well as on those tasks in which they needed to state the reasons for which one had to take care of natural habitats and living beings in them. A small percentage of the experimental group pupils solved the tasks of evaluation, in which, on the bases of the drawings, they needed to identify the habitat presented, the conditions prevailing in it, the behaviour of plants and animals in these conditions as well as to create the food chain between certain beings in the drawing. Whether or not the pupils in the experimental group achieved a more permanent knowledge was indicated by the mean value of the achievements of the experimental and control groups, as the value of t-ratio (Table 7). The value of t-ratio was 3.7, which indicated that there was a significant difference in the knowledge durability of pupils in the experimental and control groups. Therefore, the second research sub-hypothesis was confirmed.

Conclusion

The results of this research indicated that computer-aided learning had contributed significantly to the better quality of the pupils' knowledge about the natural habitat, than had the traditional way of learning. The main hypothesis of the research was thus confirmed. More precisely, the experimental group pupils demonstrated better results at the final test and retest than did the control group pupils. A large number of experimental group pupils managed to solve tasks in which they had to apply knowledge and perform analysis. They were successful in those tasks in which they had to parse contents, perform classification, compare, differentiate, establish mutual relations between plants, animals and their habitats, draw conclusions about the behaviour of human beings and its influence on the natural habitats. At the final test and retest none of the control group pupils managed to solve the tasks that required knowledge synthesis and evaluation. They mostly acquired knowledge at the level of content understanding. Unlike them, a significant number of pupils in the experimental group were able to solve the tasks of synthesis and evaluation. This was interpreted as the result of the introduction of computer-aided learning.

During computer-aided learning a great motivation for learning was observed among pupils. In the course of the computer-aided teaching process pupils developed feelings of control over a part of the teaching process. Thus, they achieved feelings of security and satisfaction. The obtained results indicate that teachers should use computer-aided teaching when teaching the contents of plants, animals, their mutual relations, the impact of the natural habitat on their lives, the environment-friendly education, etc. However, it should be noted that this form of teaching cannot replace the direct, prolonged observation, which is an important source of acquiring knowledge about the nature. Computer-aided teaching can help when it is difficult to organize pupils' direct observation of phenomena or when it is difficult to apply the proper experiment, which often is the case in the realization of the contents of natural habitats.

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Primjena računala u početnom obrazovanju djece u prirodnim znanostima

Sažetak

Učenici već u ranoj dobi uče o sadržajima prirodnih znanosti povezujući različite metode i oblike rada. Ovaj rad prikazuje rezultate istraživanja utjecaja računalno potpomognutog učenja na kvalitetu učeničkog znanja o životnim staništima. U istraživanju je sudjelovalo 168 učenika trećih razreda osnovnih škola (devetogodišnjaci) iz Republike Srbije (84 učenika činilo je kontrolnu skupinu, a ostalih 84 ispitnu). U analizi su upotrijebljene kauzalna, deskriptivna i komparativna metoda. Inicijalni test, finalni test i ponovljeno testiranje upotrijebljeni su kao sredstva mjerenja znanja o životnim staništima. Na temelju dobivenih rezultata zaključeno je da je ispitna skupina učenika učeći pomoću računala postigla bolje znanje o životnim staništima, za razliku od kontrolne skupine učenika koja je podučavana tradicionalnim načinom. Učenici u ispitnoj skupini postigli su bolje rezultate na razini primjene, analize, sinteze i evaluacije znanja.

Ključne riječi: *računalno potpomognuto učenje; početno učenje u prirodnim znanostima; životno stanište; učenici; učenici trećih razreda osnovnih škola*

Uvod

Učenje o području prirodnih znanosti u ranoj dobi u osnovnoj školi znatno se razlikuje od onoga u kasnijoj dobi (Church, 2003). Djeca u ranoj školskoj dobi ne razlikuju bitne od nevažnih stvari te nailaze na poteškoće pri analizi i sklapanju cjeline iz dijelova u određenoj situaciji. Međutim, u stanju su vrlo uspješno razumjeti koncepte i modele, osobito onda kad im je dopušteno pristupiti znanju kroz eksperimentiranje i teoriju prilagođenu njihovim sposobnostima i dobi (Gelman, 2004). Zbog svega navedenoga, a u cilju usvajanja znanja o prirodi i razvoja vještina i stavova neophodnih za život u društvu, učenike se sadržajima prirode podučava u integriranom obliku.

Djeca se uče prilagodbi specifičnim situacijama, razvoju kreativnosti i izravnom suočavanju sa stvarnošću. Proučavajući prirodu djeca razvijaju interes i entuzijazam, što su karakteristike ranog djetinjstva. Oni shvaćaju okolinu, odnose i zakone prirode, prostor, pojave i pojavne dimenzije, snagu prirode nad čovjekom i slično. Poznavanjem okoline, a time i prirodnih odnosa, djeca se uvode u percepciju i razumijevanje odnosa u izravnom okolišu, razvijaju mišljenje i ostale mentalne funkcije te obogaćuju vokabular (Hodson, 1998). Time razvijaju svoju osobnost, inteligenciju, kritički duh i stav prema svijetu. Djeca otkrivaju da je materijalni svijet prikladan za istraživanje te da svojim djelovanjem mogu oblikovati svijet (Chalufour, 2003). Suočeni su s predmetima, prirodnim i tehničkim pojavama koje ispituju i kontroliraju (Solomon, 1993) te na taj način razvijaju logičko razmišljanje. Ova sposobnost predstavlja i mogućnost za postavljanje pitanja, zaključivanje, odgovaranje te spoznavanje istine. Integrirani sadržaji prirodnih znanosti pomažu djeci razumjeti i učiti, uključiti postignuća znanstvenog i tehnološkog razvoja u njihovom kulturološkom, ekološkom, ekonomskom, političkom i društvenom kontekstu (Bingle, 1994 i Pedretti, 1996). Za ostvarenje sadržaja integriranih prirodnih znanosti vrlo su važne strategije učenja otkrivanjem i razne strategije poučavanja.

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 (Greeinfild, 2006). Istraživanja su pokazala da računalno potpomognuto učenje omogućuje učenicima razviti pamćenje, maštu i samostalnost u učenju (Wartela, 2000). Ono podiže obrazovnu razinu učenika, razvija senzibilitet za njihove probleme, potiče otvorenost, fleksibilnost, toleranciju i samostalan rad. Kvaliteta i efektivnost poučavanja uz pomoć računala prije svega ovisi o kvaliteti i vrsti programa koji se koristi, vrstama materijala koji se procesiraju, kognitivnom stilu učenja, karakteristikama učenika i drugim čimbenicima. Uključivanjem računala u proces poučavanja učenici stječu sposobnost upravljanja svojim kognitivnim funkcioniranjem i razvojem metakognitivnih vještina (Mclenerney, 1997). Takav način pouke pruža mogućnost objektivne evaluacije i ocjene učenika. Poučavanje uz pomoć računala ima važnu ulogu u postizanju individualizacije. Računalno potpomognuto učenje u učenika razvija inicijativu, pruža svim učenicima jednaku priliku za rad te stvara priliku da u radu napreduju koliko god mogu (Haughland, 1992). Učenicima koji teško ovladavaju materijalima uvijek se pruža pomoć, tako da mogu lako napredovati i dosegnuti svoj maksimum, neovisno o drugim učenicima (Cardelle-Elawar, 1995). Primjena računala u poučavanju pruža puno prednosti u usporedbi s tradicionalnim oblicima poučavanja. Glavne prednosti su sljedeće: primjena računala omogućuje učenicima praćenje osobnog napretka, stvara uvjete za razvoj samokritike (Greeinfild, 2006), divergentnog razmišljanja i usvajanja kriterija učinkovitih operacija (Gatewood, 1997). Na taj način učenici stvaraju potencijal za poboljšanje i razvoj kognitivne sfere osobnosti te metakognitivnih sposobnosti i vještina (Nastasi, 1994). Primjena računala i računalnog obrazovnog softvera u poučavanju prirodnih znanosti ne bi trebala biti cilj, već samo sredstvo koje će učenici koristiti pri usvajanju znanja o prirodi i okolišu u kojemu žive. Komunikacija između učenika i računala jednostavna je i neposredna te se može ostvariti na različite načine (Wartela, 2000). Kombinacija teksta, slike i zvuka osigurava bolju motivacija za učenje prirodnih sadržaja (Seel, 2003). Tekstna informacija mora biti jasna i prilagođena učeniku da bi objasnila bit onoga što se poučava (Keeler, 1995). Treba biti popraćena prikladnom slikom, fotografijom ili ilustracijom. Slika mora biti odraz stvarnosti kako bi zadovoljila princip očiglednosti. Informacija može biti dana na takav način da je učenik, dok čita i gleda, kombinira ili reorganizira te tako stječe nove spoznaje. Takve informacije se obično prezentiraju u obliku rebusa, slagalice, labirinta i sl.

Metodologija istraživanja

Problem i predmet istraživanja: Sadržaji integriranih prirodnih znanosti trebali bi učenicima rane dobi pomoći razumjeti pojam životnoga staništa i osnovne uzročno-posljedične odnose u prirodi, pomoći im steći osnovno znanje o prirodnim pojavama i procesima u određenom životnom staništu te im pomoći učiti o karakteristikama biljaka i životinja u određenom životnom staništu, međusobnom utjecaju živih stvorenja, utjecaju životnoga staništa na živa bića i obratno. Ove je sadržaje teško ostvariti u Republici Srbiji jer je teško omogućiti učenicima izravno promatranje životnoga staništa te pojava i odnosa u njima zbog nefleksibilnog rasporeda sati i organizacije poučavanja. Stoga se postavljaju sljedeća pitanja: Može li se poučavanjem uz pomoć računala u kojem se primjenjuje obrazovni softver prilagođen mentalnim i tjelesnim karakteristikama učenika trećih razreda steći povišena razina učeničkoga znanja o životnom okolišu? Je li to znanje bolje od znanja stečenog tradicionalnim načinom učenja?

Cilj istraživanja bio je ispitati utjecaj poučavanja uz pomoć računala na kvalitetu znanja učenika trećih razreda osnovnih škola pri učenju sadržaja o životnim staništima. Na temelju ciljeva istraživanja izrađeni su zadaci istraživanja. Zadatke je moguće razvrstati u sljedeće skupine: pripremni zadaci (izrada obrazovnog softvera za svako životno stanište; obuka učitelja u računalno potpomognutom poučavanju u svrhu implementacije sadržaja životnog staništa i pripreme učenika za učenje uz pomoć računala) te neposredna implementacija zadataka istraživanja (implementacija inicijalnog testiranja i oblikovanje ispitne i kontrolne skupine; uvođenje eksperimentalnog čimbenika u učenje ispitne skupine o životnim staništima; implementacija finalnog testa; implementacija ponovljenog testiranja, statistička obrada i analiza rezultata).

Glavna hipoteza istraživanja jest: Uporabom računalno potpomognutog učenja (u implementaciji sadržaja o životnim staništima u trećim razredima osnovnih škola učenicima se pruža bolja prilika za stjecanje više razine znanja, nego kad ih se poučava tradicionalnim načinom. Sekundarne hipoteze su:

- Učenici u ispitnoj skupini trebali bi steći višu kvalitetu znanja negoli učenici u kontrolnoj skupini.
- U usporedbi s tradicionalnim načinom učenja, poučavanje uz pomoć računala izrazito doprinosi trajnosti znanja o životnom staništu.

Metode i tehnike istraživanja: U istraživanju su upotrijebljene: kauzalna metoda (eksperiment paralelnih skupina), deskriptivna i poredbena metoda. U istraživanju je primijenjen test koji je glavni mjerni instrument (inicijalni, finalni i ponovljeni test). Svaki test imao je 20 pitanja. Na svakom je testu maksimalni broj bodova bio 100. Učenici su riješili testove jedan školski sat. Svaki je test sadržavao pitanja koja su uključivala šest razina znanja: razinu prisjećanja, razinu razumijevanja, razinu primjene, razinu analize, razinu sinteze i razinu evaluacije (Walker, 2004). Pri testiranju razine prisjećanja upotrijebljeni su zadaci kao što su definiranje pojmova i označavanje crteža, dok su za analizu razine razumijevanja upotrijebljeni zadaci određivanja točnog redoslijeda, crtanja i popunjavanja praznina. Zadaci kao što su povezivanje s osobnim iskustvom, primjena znanja uslijed promjene postojećeg stanja, uporaba drugih izvora informacije i zadaci pronalaženja grešaka upotrijebljeni su u analizi razine primjene znanja. Razina analize ispitana je zadacima kao što su pronalaženje sličnosti i razlika, određivanje karakteristika, sortiranje te zadacima kao što je izražavanje stavova. Zadaci kao što su prepoznavanje prednosti i mana, predviđanje ishoda te zaključivanje, primijenjeni su na razinama analize i sinteze. Za razinu evaluacije glavni je tip zadatka bio interpretacija crteža. Tijekom vrednovanja zadataka glavno je pravilo bilo to da zadacima u kojima je potrebna viša razina znanja bude dodijeljen veći broj bodova. Računalno potpomognuto poučavanje upotrijebljeno je pri implementaciji sadržaja o životnim zajednicama (kopnene životne zajednice, šume i livade, kultivirane životne zajednice i vodene životne zajednice). Za svaki sadržaj izrađen je jednostavan obrazovni softver koji su potom upotrijebili učenici ispitne skupine. S obzirom na neiskustvo s računalno potpomognutim učenjem te ranu školsku dobi (9 godina starosti), učenici su radili u skupinama od tri učenika te su primili pisane upute u obliku radnog (nastavnog) listića. Radni listić sadrži korake za pomoć učenicima u praćenju i razumijevanju slajdova koji se pojavljuju na zaslonu računala. Opći scenarij za implementaciju sadržaja životnih staništa pomoću računala u nastavi bio je sljedeći: uvodne aktivnosti (učitelj dijeli učenike u skupine ta im daje usmene upute o tome kako koristiti radni listić); središnje aktivnosti (računalno potpomognuto učenje u skupinama) te završne aktivnosti (učenici i učitelj ponavljaju ključne elemente nastavnog sadržaja te učitelj na kraju daje učenicima tiskani materijal sa slajdovima koji su upotrijebljeni u središnjem dijelu nastavnog sata). Svaki je slajd sadržavao osnovne informacije s biljkama i životinjama tipičnim za pojedino životno stanište te vremenskim uvjetima koji u staništu vladaju. Postojao je i dio za znatiželjne i one koji žele znati više. Slajdovi su sadržavali pitanja na koja su učenici trebali dati odgovore, a točnost njihovih odgovora mogla se provjeriti klikom na pripadajuće kućice. Slajdovi su organizirani logičkim redoslijedom te čine cjelinu. Na njima su se nalazile jednostavne rečenice i tvrdnje. Važni koncepti i ključne riječi istaknuti su (bojom različitom od boje glavnog teksta) kako bi privukli pažnju učenika i omogućili im bolje pamćenje materijala. Ne nekim slajdovima su se uz tekst mogle pronaći slike, kratki filmovi i animacije. Pazilo se na ravnotežu između teksta i ostalih elemenata. Učenici su pregledavali slajdove koristeći se mišem. Na taj je način proces učenja prilagođen individualnim karakteristikama učenika. Vodilo se računa o broju slajdova. Svaki životni okoliš obrađen je u prosjeku s 20 slajdova na kojima je prednost dana trima temeljnim bojama (nad miješanim). Kombinacije boja, slova i podloge osmišljene su tako da se privuče pozornost učenika, imale su visok koeficijent istaknutosti teksta nad pozadinom. Upotrijebljena je jednaka pozadina za sve slajdove, a slike i pozadinski uzorci bili su diskretni. Za implementaciju pozadinskih sadržaja u ispitnoj skupini upotrijebljene su informatičke učionice u školama. Za razliku od učenika u ispitnoj skupini, učenici kontrolne skupine učili su o sadržajima životnih staništa na tradicionalan način. Novi nastavni materijali procesirani su u vremenskom periodu od osam sati. Poslije sata ponavljanja, testiranje je provedeno u obje skupine (finalno testiranje). Nakon dva mjeseca provedeno je ponovljeno testiranje. Rezultati su analizirani uz pomoć SPSS programa za statistiku.

Uzorak: U istraživanju je sudjelovalo 168 učenika trećih razreda dviju osnovnih škola u Novom Sadu (Srbija). Od toga je polovica učenika (84) činila ispitnu, a druga polovica (84) kontrolnu skupinu. U obrazovnom sustavu Republike Srbije učenici između 7 i 11 godina starosti uče integrirane sadržaje prirodnih znanosti u okviru obveznih predmeta Svijet oko nas (prvi i drugi razred) i Priroda i društvo (treći i četvrti razred). Ispitna (T) i kontrolna (K) skupina uravnotežene su na temelju općeg uspjeha učenika na kraju prvog polugodišta trećega razreda te na temelju ocjene iz predmeta Priroda i društvo (Tablica 1).

Tablica 1.

Rezultati

Izjednačenost učenika kontrolne i ispitne skupine na temelju stečenog uspjeha i ostvarenog broja bodova na inicijalnom testu prikazana je u tablicama (Tablica 2 i Tablica 3) i na slici (Slika 1).

Tablica 2. i 3.

Slika 1.

Razlike između ispitne i kontrolne skupine u učeničkom znanju postignutom na finalnom testu prikazane su u tablicama (Tablica 4 i Tablica 5) i na slici (Slika 2).

Tablica 4. i 5.

Slika 2.

Razlike između kontrolne i ispitne skupine u učeničkom znanju pokazanom pri ponovljenom testiranju prikazane su u tablicama (Tablica 6 i Tablica 7) i na slici (Slika 3).

Tablica 6. i 7.

Slika 3.

Rasprava

U prethodna dva razreda učenici su trebali steći znanja o biljkama i životinjama koja im omogućuju vertikalno povezivanje novih sadržaja u trećem razredu. Ta znanja su sljedeća: nužni uvjeti za rast i razvoj biljaka i životinja, izgled biljaka i životinja, sličnosti i razlike između biljaka i životinja, utjecaj okoline na njihove živote, ponašanje biljaka i životinja s obzirom na godišnja doba, podjela životinja i biljaka, karakteristike kultiviranih i nekultiviranih biljaka, važnost biljaka i životinja za čovjeka i uzajamni utjecaj živih organizama. To se znanje testira inicijalnim testom. Inicijalni je test trebao pokazati izjednačenost ispitne i kontrolne skupine prije uvođenja eksperimentalnih čimbenika. Učenici ispitne skupine postigli su 6708 bodova (79,6%), dok su učenici kontrolne skupine postigli 6722 boda (80,2%) od ukupno 8400 mogućih bodova. Iz tih rezultata vidljiva je zadovoljavajuća izjednačenost testiranih skupina (Tablica 2).

Razlika od 14 bodova koja je išla u prilog kontrolnoj skupini nije bila statistički značajna. Osim toga, ujednačenost ispitne i kontrolne skupine postala je očita kad su različite vještine učenja, s kognitivnim domenama, razvrstane prema skali Bloomove taksonomije učenja. Zanemariv je broj učenika koji su postigli stupanj primjene znanja u objema skupinama. Ni jedan učenik nije uspio riješiti zadatke na razinama sinteze i evaluacije. Na temelju dobivenih rezultata može se zaključiti da se većina učenika samo prisjeća prethodno usvojenoga znanja o biljkama i životinjama. Učenici mogu odrediti podjelu biljaka i životinja, klasificirati biljke i životinje, opisati ih, navesti primjere, locirati ih, identificirati divlje i kultivirane biljke, razlikovati divlje od domaćih životinja, definirati dijelove tijela životinja i dijelove biljaka, označiti ih na crtežu i kratko opisati njihove funkcije. Međutim, većina učenika ne zna kako upotrijebiti svoje znanje u novim i konkretnim situacijama, niti razumije sadržaj i strukturu prethodno naučenih lekcija, što se vidi iz nemogućnosti učenika da odgovore na pitanja razine analize i razine sinteze. Ni jedan učenik nije odgovorio na pitanja iz polja evaluacije (Slika 1).

Sve navedeno ukazuje na to da su učenici naučili sadržaje o biljkama i životinjama na tradicionalan način. Značajnost u razlikama aritmetičkih sredina može se odrediti kvocijentom razlika aritmetičkih sredina i standardnom devijacijom, odnosno t-omjerom. Granična vrijednost stupnja sigurnosti od 5% je $t_{0.05} = 1{,}96$, dok je granična vrijednost stupnja sigurnosti od 1% $t_{0.01} = 2.58$. Na temelju dobivenih podataka zaključeno je da je ispitna skupina postigla lošije rezultate negoli kontrolna. Na temelju analize varijance, vidi se da vrijednost t-omjera nije bila značajna na stupnju značajnosti od 1% i 5% (vjerojatnost t-omjera je 0,16). Nije bilo statistički značajne razlike između aritmetičke sredine ispitne i kontrolne skupine, odnosno razlike u postignutom broju bodova mogu biti pripisane slučajnoj varijaciji. Navedeni rezultati potvrđuju da su ispitna i kontrolna skupina bile izjednačene prema prethodnom znanju pokazanom na inicijalnom testu (Tablica 3).

Konačna provjera znanja postignuta je uporabom raznolikih testnih zadataka (zadaci objektivnog tipa koji određuje razinu tek stečenog znanja) provedenih odmah po završetku eksperimenta. Rezultati finalnog testiranja učenika ispitne i kontrolne skupine (Tablica 4) pokazuju da su učenici ispitne skupine postigli 7140 bodova (85,0%), a učenici kontrolne skupine 6078 bodova (72,4%) od ukupno 8400 bodova. Razlika u ukupnom broju stečenih bodova (1062) išla je u prilog ispitnoj skupini, što upućuje na učinkovitije usvojeno znanje stečeno uz pomoć računalno potpomognutog poučavanja pri implementaciji sadržaja o životnom staništu u usporedbi s tradicionalnim učenjem. Velika razlika uočena je pri osvrtu na određene razine znanja koja su učenici stekli. Veći broj učenika ispitne skupine postigao je stupanj analize znanja (19,0%) u usporedbi s učenicima kontrolne skupine (2,45%). U ispitnoj je skupini 14,3% učenika uspjelo postići razinu sinteze znanja, dok je 9,6% učenika te skupine doseglo razinu evaluacije. Niti jedan od učenika kontrolne skupine nije riješio zadatke na razini sinteze ni na razini evaluacije (Slika 2).

Rezultati pokazuju da je velikom broju učenika ispitne skupine pomoglo računalno potpomognuto učenje s obzirom na to da su mogli riješiti zadatke koji su uključivali analizu, raščlambu sadržaja, klasifikaciju, usporedbu, razlikovanje životnih staništa, uspostavljanje međusobnih odnosa između životnih staništa, uspostavljanje međusobnih odnosa između biljka i životinja i njihova životnog staništa, izvođenje zaključaka o ponašanju biljaka i životinja u određenom životnom staništu. S druge strane, učenici kontrolne skupine, koji nisu bili uključeni u računalno potpomognuto učenje, nisu mogli formirati i graditi nove strukture iz postojećih znanja i vještina (u slučaju formiranja oblika hranidbenih lanaca u različitim životnim staništima), prosuditi o važnosti međusobnih odnosa između biljaka i životinja, braniti stav o važnosti zdravog okoliša za život biljaka i životinja u njihovom životnom staništu. Dio učenika ispitne skupine, za razliku od kontrolne skupine, riješio je zadatke u kojima je trebalo pokazati razumijevanje koncepta dublje od razine znanja potrebnog za davanje jednostavnih definicija. Primjerice, riješili su zadatke u kojima su trebali navesti uvjete koje mora imati određeno životno stanište da bi bio osiguran život određenim biljkama i životinjama ili navesti da uvjeti nisu zadovoljeni. Usporedbom aritmetičkih sredina ispitne i kontrolne skupine te s obzirom na vrijednosti t-omjera (3,02), može se zaključiti da su učenici u ispitnoj skupini pokazali veći uspjeh na finalnom testu (Tablica 5) u usporedbi s učenicima iz kontrolne skupine. Prema tome, prva hipoteza je potvrđena.

Nakon dva mjeseca provedeno je ponovljeno testiranje s učenicima kontrolnih i ispitnih skupina. Rezultati ispitne i kontrolne skupine (Tablica 6) pokazali su da su učenici ispitne skupine postigli 6789 bodova (80,2%), dok su učenici kontrolne skupine postigli 5712 boda (68,0%) od 8400 mogućih bodova. Razlika u ukupnom broju stečenih bodova bila je 1077 boda u korist ispitne skupine, što upućuje na veću trajnost učeničkog znanja u ispitnoj skupini. Na finalnom testu učenici ispitne skupine pokazali su bolje vještine u analizi znanja, odnosno u domenama učenja (19,7%) u usporedbi s kontrolnom skupinom (1,2%). Određen broj učenika ispitne skupine riješio je zadatke na razini sinteze (8,3%) te evaluacije (7,7%). Niti jedan učenik kontrolne skupine nije mogao doseći razinu sinteze i razinu evaluacije (Slika 3).

Učenici ispitne skupine bili su bolji od učenika kontrolne skupine u primjeni stečenoga znanja u različitim situacijama iz svakodnevnog života biljaka i životinja različitih životnih staništa. Bolje su rješavali zadatke u kojima su trebali opisati kako mogu unaprijediti život biljaka i životinja u različitim životnim staništima. Bolje su rješavali zadatke u kojima su trebali ispraviti greške te zadatke koji su uključivali zbunjujuće situacijama. U ovim slučajevima, trebali su pronaći ili riješiti zadatak promijenivši novostečeno znanje i razumijevanje (pronaći biljku ili životinju koja ne pripada određenom životnom staništu i dati razlog svojega izbora). Učenici ispitne skupine pokazali su bolje znanje u zadacima u kojima su trebali pronaći sličnosti i razlike među životnim staništima te razlike među biljkama ili životinjama određenih životnih staništa. Naročito dobar uspjeh postigli su učenici ispitne skupine u odnosu na učenike kontrolne skupine u zadacima u kojima su trebali objasniti što bi se dogodilo određenim biljkama i životinjama kad ne bi bile prilagođene godišnjim dobima te u zadacima u kojima su trebali navesti razloge zbog kojih se treba brinuti o životnim okolišima i živim bićima u njima. Mali postotak učenika u ispitnoj skupini odgovorio je na pitanja evaluacije, u kojima su na temelju crteža trebali odrediti životno stanište o kojemu se radi, uvjete koji u njemu vladaju te izraditi hranidbeni lanac među određenim živim bićima predstavljenim na crtežu. Vrijednosti aritmetičkih sredina ispitne i kontrolne skupine pokazale su da postoji statistički značajna razlika u trajnosti znanja učenika ispitne i kontrolne skupine, što se vidi i iz vrijednosti t-omjera (3,7). Učenici ispitne skupine postigli su trajnije znanje od učenika kontrolne skupine. Dakle, druga sekundarna hipoteza istraživanja je potvrđena.

Zaključak

Rezultati istraživanja pokazali su da je računalno potpomognuto učenje značajno doprinijelo većoj kvaliteti učeničkog znanja o životnim staništima od tradicionalnog načina učenja, čime je potvrđena glavna hipoteza istraživanja. Učenici ispitne skupine postigli su bolje rezultate od učenika kontrolne skupine u finalnom testu i ponovljenom testiranju. U većem su broju uspjeli riješiti zadatke u kojima su trebali primijeniti znanje i izraditi analizu. Bili su uspješni u zadacima u kojima su trebali raščlaniti sadržaj, izraditi klasifikaciju, usporediti, razlučiti, utvrditi međusobne odnose među biljkama, životinjama i njihovim životnim staništima. Ni jedan učenik kontrolne skupine nije na finalnom testu i ponovljenom testiranju uspio riješiti zadatke koji zahtijevaju sintezu znanja i evaluaciju. Uglavnom su usvojili znanja na razini razumijevanja sadržaja. Za razliku od njih, značajan broj učenika u ispitnoj skupini riješio je zadatke sinteze i evaluacije. Takav uspjeh bio je rezultat računalno potpomognutog učenja.

Tijekom računalno potpomognutog učenja uočena je velika motivacija učenika za učenje. Poučavanje učenika uz pomoć računala razvija osjećaj kontrole nad dijelom procesa poučavanja što osigurava osjećaj sigurnosti i zadovoljstva. Dobiveni rezultati pokazuju da učitelji trebaju koristiti računalno potpomognuto poučavanje pri pouci o biljkama, životinjama, njihovim međusobnim odnosima, utjecaju životnog staništa na njihove živote, ekološkom odgoju i obrazovanju itd. Međutim, treba napomenuti da takvo poučavanje ne može zamijeniti izravno, dugotrajno promatranje koje je važan izvor stjecanja znanja o prirodi. No, može pomoći onda kad je teško organizirati izravno promatranje pojava ili kad je teško primijeniti stvarni eksperiment, što je često slučaj u realizaciji nastavnih sadržaja o životnim staništima.