Implementation of blended learning in Computer Science

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Abstract – The main objective of this paper is to test the effectiveness of blended learning when compared to the traditional approach in teaching Computer Science. Three hypotheses were formed to measure students’ knowledge levels after attending classes implementing one of the two teaching approaches. The first hypothesis predicted that teaching Computer Science without the use of ICT will meet students’ educational needs and objectives (H1). The second hypothesis predicted that the use of electronic materials in Computer Science classes will enable students to reach a higher level of knowledge in Computer Science (H2), whereas the third hypothesis stated that the students who attend Computer Science classes in which the teaching method included electronic learning will be more satisfied with the acquired knowledge than other students (H3). [5]

I. INTRODUCTION

The primary concern of this paper and the conducted studies is related to the three hypotheses stated in the abstract. Before the research project was conducted it had been assumed that blended learning will be as effective as traditional learning allowing that research data might prove that blended learning increases students’ knowledge level. This paper proves that the implementation of blended learning approach in education helps establish an easier connection between theoretical knowledge and its practical application. [5]

The conducted studies prove that the implementation of blended learning in teaching Computer Science increases students’ knowledge level and meets their educational needs and objectives. [5]

II. THE CONCEPT OF KNOWLEDGE

Having knowledge, which is a symbol of power in the society, should provide an individual with greater ability to manage resources, and consequently, bestow the individual with power. Michel Foucault is one of the sociologists who left a significant mark in the history of sociology of knowledge. According to Foucault, knowledge is "created" under the influence of the surroundings in order to keep the control and stability in the society.

In his view, the society imposes its knowledge mechanisms, and the individual is forced to conform to the norms of the society in order to avoid being "punished". [1]

A modern man's knowledge increases on a daily basis mostly due to the development of the technology we depend on. The education system, as well as any other system developed in the modern societies, has become a part of the knowledge apparatus that in technology sees the future and power of our civilization. All of us belong to that system. Education is part of our lives, from birth to death, with the goal to become as efficient as possible in what we work on, offer and produce. [5]

Different social media, digital tools, social networks have all made an impact on the development and concept of teaching in our modern age. Learning is not oriented only on the traditional teaching method, or face-to-face instruction, nowadays the method of blended learning is used in teaching, a combination of traditional teaching methods and modern technology. The instruction can be delivered as a combination of ICT supported teaching and learning and online teaching, that is fully online. These teaching models are becoming increasingly widespread ways of learning among young generations across the world. [5]

A. Blended learning

Blended learning is a growing trend in many educational institutions. Teachers and students appreciate many advantages of blended learning, some of them include: flexibility of learning anywhere, at any time and individually. Blended learning is becoming the preferred learning method on a large scale, as a system that can keep pace with future. One of the papers on the quality of blended learning presented an evaluation study of the effectiveness of blended learning when compared to traditional learning styles, on the example of software engineering course. The research enabled the comparison of the results of the evaluation of the approaches implemented in the experimental and control group. The research showed that blended learning was as effective as traditional learning. [2]

In another research project focused on the application of modern technologies in teaching it was established that the process of learning was changing its focus from acquiring and adding to objective knowledge to modifying the ingrained knowledge, as well as creating and making new decisions, and creating new resources. [3]

III. RESEARCH ON THE EFFECTIVENESS OF BLENDED LEARNING

The conducted study was supposed to determine the effectiveness of blended learning when compared to traditional learning methods in Computer Science teaching. The research involved two stages, and the application of the experimental method. The research process included measuring knowledge levels of a group attending classes that implemented blended learning model and a group attending classes taught by using a traditional approach. In the first stage of the research a pilot study was conducted. Two groups, control and experimental, were formed for the purpose of both pilot and main studies. The pilot study was conducted to assess student’s prior knowledge by means of a preliminary test, before introducing experimental factors. The acquired
knowledge was measured in the main study by means of a post-test after the introduction of experimental factors.

The experimental research factors included four teaching units, which are part of the lesson MS Excel Spreadsheets. The test that measured prior knowledge and acquired knowledge contained 34 questions. The same test was given to both experimental and control group of students that were included in the pilot study and the main study. [5]

The control group of students attended classes taught by using the traditional method. They were taught four units that comprise the lesson on Spreadsheets. During the experiment the students attended the classes by listening to the lectures, taking notes, and using a Computer Science textbook. The experimental group of students attended classes that covered four units that are part of the lesson on Spreadsheets in a blended learning environment. During the experiment the students attended the classes by listening to the lectures and taking notes, using an online Computer Science manual. They used the MS Excel spreadsheet program to complete exercises and tasks. The students used an online portal Računalstvo-učimo zajedno (Eng. Computer Science – Let’s learn together) to perform the assigned tasks. [5]

A. Number or study participants

The pilot study involved 90 participants. In the control group there were 45 students, 25 students were attending a lyceum, and 20 were attending a vocational school. There were 22 male students, 9 from the lyceum, and 13 from the vocational school. 23 female students participated, 16 from the lyceum and 7 from the vocational school. The same number of students participated in the pilot study of the experimental group. There were 90 participants included in the main study. In the control group there were 45 students, 25 students were attending a lyceum, and 20 were attending a vocational school. There were 22 male students, 9 from the lyceum, and 13 from the vocational school. 23 female students participated, 16 from the lyceum and 7 from the vocational school. The same number of students participated in the main study of the experimental group. [5]

B. Sample

The average age of the students who participated in the study was 16 years, and both sexes were equally represented in the research (male participants = 48,88%, female participants = 51,11%). A sample identical to the one from the pilot study was used in the main study for both control and experimental group. The age of all participants was 15,63 ± 0,57 years (arithmetic mean ± standard deviation). Lyceum students were on average somewhat older than (16,00 ± 0,40) vocational school students (15,15 ± 0,36). [5]

B. Research plan

Students’ knowledge was measured at the first levels of Bloom’s Taxonomy, that is, students’ factual, conceptual and procedural knowledge were measured. The limiting factor in the preliminary test stage was the prior knowledge of some students.

Most lyceum students who participated in the study had attended Computer Science as elective class in the primary school, ratio being 95% to 5% (attended – did not attend).

The number of students of the vocational school who attended the elective class Computer Science had a ratio of 50:50. Due to the stated limiting factors the students were divided in two groups, control and experimental. That way it was ensured that there is an equal number of students in both groups who did and did not attend Computer Science class in the primary school. [5]

According to the results from the pilot study this distribution of students helped reduce a greater impact of the limiting factors. Knowledge differences after the preliminary test were negligible. After introducing the experimental factors in the main study, the acquired results indicated that the knowledge of the students in the experimental group exceeded the knowledge of the students in the control group. By comparing the prior and acquired knowledge students’ cognitive skills were tested. The preliminary test and the post-test examined the factual, conceptual and procedural knowledge at first levels of Bloom’s taxonomy, the first and second research hypotheses. Students’ attitudes regarding their satisfaction level with the acquired knowledge were also measured, for each group, to test the third research hypothesis. [5]

The following research results are described in the paper: [5]

- Pilot study based on the preliminary test taken by the control and experimental group.
- Main study based on the post-test taken by the control and experimental group.
- Histograms of obtained preliminary test results.
- Histograms of obtained post-test results.
- Research at schools during preliminary test stage.
- Research at schools during post-test stage.
- Average success results analysis.
- Analysis of acquired knowledge satisfaction level for the control group.
- Analysis of the acquired knowledge satisfaction level for the experimental group.
- Questions-based analysis.
- Group-based analysis.

The study analysis was performed via tools Statistica and MS Excel by means of the following statistical procedures: Student’s T-test, Chi-square test, tools for calculation of frequency values and histogram creation. [5]

IV. BLENDED LEARNING EFFECTIVENESS ANALYSIS

This part of the paper presents the study data obtained via programs Microsoft Excel and Statistica. The study was conducted in 45 minutes, and the score range of the test used for the purpose of the study was from 0 to 82. The study data are categorized in two groups. The first group of data encompasses the results of the preliminary test, and the second group the results of the post-test. All data are presented in table form, and part of it is presented graphically. [5]
A. Study results for the control and experimental groups in the preliminary test stage

Preliminary test results represent prior knowledge of the students and are presented in table and graphical form. The study involved 90 students, 45 in the control group and 45 students in the experimental group. Control and experimental group scored similarly on the test, \( p=0.903 \) (Student’s T test). The control group scored on average 35.022 ± 15.972 (arithmetic mean ± standard deviation) points, whereas the experimental group scored on average 35.444 ± 16.939 points (Figure 1).

Independent T-test was used to establish whether there are significant differences between the two groups, the control and experimental group, regarding the level of prior knowledge, and based on the analysis of points scored in the preliminary test. [5]

The obtained values \( t=0.122 \) with significance level \( p=0.903 > 0.05; \) \( df=88 \) degrees of freedom, standard deviation=15.972 for the control group and 16.939 for the experimental group indicate that at the confidence level of 95% there is no statistically significant difference between the populations the samples come from. According to the T-test results with value of \( p>0.05 \), null hypothesis can be accepted. The obtained results show that there is no difference in prior knowledge level between the control and experimental groups.

The following calculations and data analysis confirm these results. Table 1 gives an overview of the values of T-test and \( p \) values, but also of the highest and lowest values MIN-MAX, and in the Figure 2 the data set range is displayed in lines. [5]

![Figure 1. Preliminary test score differences between the experimental and control group](image1)

\( p=0.903; \) Student’s T-test=0.122

Figure 1. Preliminary test score differences between the experimental and control group

![Figure 2. Participants’ individual results in the pilot study for experimental and control group](image2)

The number of points scored on the preliminary test for the experimental group is within the range of 0 to 70 depending on the number of the study participants and is displayed as a dashed line. The number of points scored on the preliminary test for the control group is within the range of 0 to 70 depending on the number of the study participants and is displayed as a continuous line. Frequencies for the control and experimental group were obtained from the displayed data (Table 1. and Figure 2.). [5]

Table 2. Frequencies for the control and experimental group according to the preliminary test results

<table>
<thead>
<tr>
<th>PRELIMINARY TEST</th>
<th>Control group -frequencies-</th>
<th>Experimental Group -frequencies-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervals Categories</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-9</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>10-19</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>20-29</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>30-39</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>40-49</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td>50-59</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>60-69</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>70-82</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 1. Preliminary test values
Frequencies of occurrence of scores are shown on X-axis as scores organized in categories and intervals, whereas the Y-axis shows the number of participants in a certain category. In the category 0-9 in control group there are 6 participants, and in the same category in the experimental group there are 8 participants. In the category 60-69 there are two participants both in control and experimental groups. Both of these participants have achieved the best results in the preliminary test. (Figure 3).

B. The results of the control and experimental group in the post-test

The results of the main study show students’ knowledge level after introducing experimental factors in the study. The results are displayed both in table and graphical form. 90 students were included in the study, 45 in the control and 45 in the experimental group. Table 3 shows the results achieved by each student. The table consists of two columns of data in the range from the highest value to the lowest value of points scored in the post-test. The control group of the main study received traditional instruction, whereas in the experimental group blended learning was applied.

The comparison of the scores between control and experimental groups shows that there is a statistically significant difference $p=0.039$ (Student’s T-test). The control group had on average significantly lower score of $41,466 \pm 19,836$ (arithmetic mean $\pm$ standard deviation) points, whereas the experimental group had on average better score with $51,200 \pm 23,939$ points (Figure 4).

The independent T-test was used to establish if there are significant differences between the control and experimental groups in the levels of prior knowledge, through the analysis of points gained for the answers to the questions of the post-test. [5]

The gained values $t=2,100$ with the significance level of $p=0.038 < 0.05$; df=88 degrees of freedom, standard deviation=19,836 and 23,939 for the experimental group, show that there is statistically significant difference at the confidence level of 95% between the two samples. The results of the T-test at the level $p < 0.05$ show that the null hypothesis of the research is rejected. The obtained results indicate that there is an increase in knowledge level in the experimental group. These results were confirmed in the following calculations and analysis. The obtained results support the second hypothesis of the research. This result proves that students learn more when blended learning method is applied in Computer Science teaching.

Table 3 shows values of T-test and $p$ values as well as the lowest and greatest values MIN-MAX, and the lines in the Figure 5. illustrate their range. [5]

<table>
<thead>
<tr>
<th>Post-test Groups</th>
<th>T-test value</th>
<th>Significant differences</th>
<th>MIN MAX Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control vs. Experimental</td>
<td>$t=2,100$</td>
<td>YES</td>
<td>1- 3 69- 80</td>
</tr>
</tbody>
</table>

Figure 5 below shows the number of points scored on the Y-axis and number of participants for the control and experimental groups in the post-test on the X-axis.

This chart displays the results of the test for the control and experimental group, i.e. the number of points scored by each participant. The dashed line shows more values than the continuous line. The dashed line represents the participants of the experimental group. The continuous line represents the participants of the control group. Based on the presented (Figure 5), we can conclude that the participants who used e-learning method in class have reached a greater knowledge.
level than the participants in the control group. The number of points scored in the test for the experimental group is in the range of 0 to 82, depending on the number of participants. The number of points scored by the participants of the control group is in the range of 0 to 70, depending on the number of participants, and is illustrated with the continuous line. The data shown in Table 3 and Figure 5 were used to calculate the frequencies for the control and experimental group in the post-test. [5]

Table 4. Frequencies of scores for the control and experimental group in the post-test

<table>
<thead>
<tr>
<th>POST-TEST</th>
<th>Control group - frequencies</th>
<th>Experimental group - frequencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-9</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>10-19</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>20-29</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>30-39</td>
<td>14</td>
<td>2</td>
</tr>
<tr>
<td>40-49</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>50-59</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>60-69</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>70-82</td>
<td>0</td>
<td>13</td>
</tr>
</tbody>
</table>

The frequencies on the x-axis represent points scored per category in stated intervals and the frequencies on the y-axis show the number of participants in each category. It is noticeable that there were 7 participants in the category 0-9 in the control group, and 6 participants in the experimental group. There were no participants in the category 70-82 from the control group, whereas 13 participants from the experimental group belong to this group. Therefore, it can be concluded that the students from the experimental group achieved better results in the post-test of knowledge in Computer Science than the control group students (Figure 6). [5]

Figure 5. Post-test results achieved by the participants of the control and experimental group

From the relationship of the frequencies between the scores of the control and experimental groups it is evident that the most participants, 14, of the control group belong to category 30-39, and to the category 50-59, where there are 10 of them, and the most participants from the experimental group, 13 of them, belong to the category 70-82 (Table 4). After comparing the other scores of the main study it can be concluded that the control and experimental group have different frequency scores per category. [5]

Figure 6. Frequencies of scores of the control and experimental group in post-test

Figure 7 shows the results of the preliminary test and the post-test for the control and experimental groups. Study results are shown in the line chart. The highest value has the thicker line that represents the results of the experimental group in the post-test. The dashed line and the continuous thin line display almost equal values, as expected since they represent the pilot study results of the control and experimental group. The post-test values of the control group that the dotted line represents are visibly higher than the values displayed by the preliminary test lines, and closer to the values of the continuous thicker line, however they are 10 points lower on the Y-axis in comparison to the values displayed by the line that represents the experimental group for the post-test. Based on the results of the tests in both studies and groups we can conclude the following: the main study participants in the experimental group achieved the best result. These participants used modern media for e-learning in classroom. The obtained results confirm the second research hypothesis. [5]

Figure 7. Results of the control and experimental groups in the preliminary test and post-tests
C. Preliminary test and post-test results

The comparison of the results of the preliminary test and the post-test in the control and experimental group (Figure 8) yielded the average test success rates for both tests. The average success test rate for the control group for the preliminary test is 42.71%, and for the experimental group 43.22%. The average success rate for the post-test for the control group is 50.67%, which is statistically significantly less than the average values obtained in the experimental group, 62.52% (p<0.001; Chi-square test = 17.405 and df=1).

![Figure 8. Average success rates for preliminary test and post-test](image)

Figure 8. Average success rates for preliminary test and post-test

The control group improved its knowledge level by 7.96 percentage points, which is statistically significantly less than the experimental group, which improved its knowledge level by 19.30 percentage points (p<0.001; Chi-square test =17.405; df=1), which is well illustrated in Figure 8. This result refutes the first research hypothesis (Hypothesis 1: Computer Science instruction without the use of ICT satisfies student’s educational possibilities and aims.) [5]

D. Results of measurements of students’ satisfaction levels with the acquired knowledge

At the end of the study sessions students filled out a questionnaire designed to check their satisfaction level with the acquired knowledge and following results were obtained. The students in the experimental group are more satisfied with the acquired knowledge and mostly because blended learning method was applied in the teaching process. There were 48.89% students satisfied with the attained knowledge, 22.22% partially satisfied, and 28.89% of the students were not satisfied with the knowledge they acquired (Figure 9.). [5]

![Figure 9. Post-test results regarding the satisfaction level with the acquired knowledge for the experimental group](image)

Figure 9. Post-test results regarding the satisfaction level with the acquired knowledge for the experimental group

The students of the control group were not satisfied with the acquired knowledge, 37.77% of them, 26.67%, were partially satisfied, and 35.56% were fully satisfied (Figure 10.). [5]

![Figure 10. Post-test results regarding the satisfaction level with the acquired knowledge for the control group](image)

Figure 10. Post-test results regarding the satisfaction level with the acquired knowledge for the control group

The questionnaire the students were asked to complete consisted of two questions. The first question was related to the satisfaction level with the acquired knowledge (three answer choices provided), and in the second question students were asked why they were satisfied with the acquired knowledge. By comparing the charts (Figure 9. and Figure 10.) it can be concluded that the students from experimental group are considerably more satisfied with the acquired knowledge, even though there is no statistically significant difference. (Table 5), i.e. p=0.436 (Chi-square test =1.663; df=2). A number of students wrote that they are satisfied with their acquired knowledge because the blended learning method was used in class. The control group students were less satisfied than the experimental group students because they consider that learning Computer Science without the use of computers makes no sense. In their view learning theory is useless because it will not help them improve their computer skills. [5]
Table 5. Comparison between control and experimental group regarding their satisfaction level with the acquired knowledge

<table>
<thead>
<tr>
<th></th>
<th>Control group</th>
<th>Experimental group</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>16 (36%)</td>
<td>22 (49%)</td>
<td>0.436</td>
</tr>
<tr>
<td>No</td>
<td>17 (38%)</td>
<td>13 (29%)</td>
<td></td>
</tr>
<tr>
<td>Partial</td>
<td>12 (27%)</td>
<td>10 (22%)</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>45 (100%)</td>
<td>45 (100%)</td>
<td></td>
</tr>
</tbody>
</table>

*Chi-square test=1.663; df=2

The third research hypothesis was not statistically proven, the analysis results, however, show that there is a great difference in satisfaction levels between the control and experimental groups. [5]

V. CONCLUSION

According to the research results it can be concluded that blended learning encourages young generations to be creative and explore. The main reason obviously lies in the multimediability of the e-content that in an interactive way provides feedback to the student and offers greater opportunities for practical application. The analysis results refuted the first hypothesis. The second hypothesis, which is the main hypothesis of this research was confirmed and supported by results of the statistical analysis. The third hypothesis was not statistically confirmed, but higher values are observable in the experimental group in which the students were more satisfied with the acquired knowledge. In similar studies in the field of e-learning that might be conducted in future, it should be taken into consideration that a greater sample would ensure better statistical validity of the data. Smaller samples are of less statistical value when compared to the whole population which can lead to statistical deviation from the real life situation. [5]

Nowadays, education is a lifelong process of key importance for the labor market. People involved in the process of education are faced with a challenging, demanding and arduous aim. A society that wants to succeed and survive as modern, technologically developed, knowledge society has to be capable to recognize the skills needed for the progress of its community. It needs to be able to connect the theoretical knowledge with its practical application and direct people towards progress. In order to adjust the education to the real needs of the society, clear development guidelines need to be defined. It may be assumed that the technology, which is increasingly taking over power over the individuals will become the strongest link in the system that constantly aspires to new achievements guided by the desire for improvement. [5]

REFERENCES