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Effects of Blended Learning in Teaching Mathematics in Higher Education

Introduction

In recent years we observe a huge expansion of modern information and communication technologies across a wide range of areas in the modern world. So it is absolutely natural that schools and universities try to utilize their potential benefits to improve teaching and learning environments, as well as students' achievement.

ICT infrastructure investments in educational institutions have been one of the key priorities of education policy during the last decade. Most countries have invested (and still are investing) considerable amounts of public resources in ICT equipment such as computers, whiteboards, connectivity, software, etc. [De Witte, Rogge 2014]. For example, in our country official state institutions pay attention to integrating ICT into education. Digipedia 2020, which is a new policy document on the conception of integration of ICT into education till 2020, defines the needs of Slovak schools in this area. One of the aims is to increase the amount of the digital content available for kindergartens, primary schools, secondary schools and universities. However, with enormous amounts of public resources being invested in educational technology, an important question is whether this investment has paid off in terms of higher efficiency and effectiveness in school administration, teaching and learning (De Witte, Rogge 2014].

There are many studies that compare effects of traditional learning, e-learning and blended learning on students' achievement in education. E-learning has been defined in a range of different ways and definitions of e-learning, online learning, technology enhanced learning and distance learning often overlap [Moore *et al.* 2011]. For example, B. Khan [2005] defines e-learning as an innovative approach for delivering well-designed, learner-centered, interactive, and facilitated learning environment to anyone, anyplace, anytime by utilizing the attributes and resources of various digital technologies along with other forms of learning materials suited for open, flexible, and distributed learning environment. Many educators try to combine the benefits of traditional learning and e-learning. There is a wide number of definitions of blended learning in the existing literature. For example, A.F. Mayadas and A.G. Picciano [2007] define blended learning as simply a combination of online learning and face-to face instruction. In our paper blended learning take the form of a combination of face-to-face classroom teaching and the use of e-learning courses.

It is possible to say that there are two opposite findings concerning the impact of ICT on the effectiveness and efficiency of educational process. While one group of studies found a positive impact of ICT on teaching effectiveness, the researchers of the second group state that the return of using ICT in teaching in terms of increasing pupil performances is not significantly positive.

As for mathematics teaching, A.C. Cheung and R.E. Slavin [2013] found that ICT applications produce modest but positive effects on mathematics achievements in comparison to traditional methods. The study of P. Híc [2012] proved that blended learning of the subject Arithmetic is a good alternative to classical way of teaching, which enables to increase the level of knowledge of students and their ability to pass the final exam. It is clear that the importance of ICT in teaching mathematics is frequently growing. By P. Hanzel [2004] e-learning frequently occurs in solving problems in education and represents a new approach to execution of education, which is based on utilization of software products. According to P. Klenovčan [2004] nowadays we can observe a huge expansion of teaching methods supported by computers and different net systems. These methods should stop the decrease of the education level. K. Žilková [2009] in her summarizing study about mathematics teaching using ICT underlines the need for creation of interactive environment and for utilization of dynamic activities in mathematics teaching.

One of the key advantages of ICT utilization is interactivity. There is a huge amount of materials that can be found on Internet and used in mathematics teaching. Unfortunately, many of them only check the correctness of student answers, but if the answer is wrong, they do not analyse why the answer is wrong and do not help student to find the correct solution. Moreover, they often prefer only one way of solution. So the level of their interactivity is really low.

Description of the experiment

At the Faculty of Education, Trnava University, we also prepare future mathematics teachers. During the first year of the bachelor study they have to master six subjects entitled Elementary Mathematics 1–6. The content of the subjects includes the summary of mathematical knowledge taught at high school. In past, the subjects were taught by a traditional way of teaching. In the academic year 2014/2015 we decided to teach the subject Elementary Mathematics 6 by blended learning and to analyse the results of the experiment. The rest of the subjects were taught by a traditional way of teaching.

The content of the subject Elementary Mathematics 6 consists of three parts: combinatorics, probability, number theory (divisibility, primes). We designed e-learning courses for these parts and used them in a combination with a traditional way of teaching. Unfortunately, we have only 19 students who attended the subjects. So we were not able to divide them into an experimental and control group. Instead, we compare their results in the subjects Elementary Mathematics 2–5 taught by a traditional way to the results in the subject Elementary

Mathematics 6 taught by blended learning and analyse their opinions of both methods of teaching. (The assessment in Elementary Mathematics 1 is totally different, so it cannot be compared).

In our opinion, the main advantage of blended learning of Elementary Mathematics 6 is a possibility to use interactive programs to better understand the content of the course. The courses contain over 70 interactive elements that can support the teaching of combinatorics, probability and divisibility. These elements not only check the correctness of student's solution, but also provide a spread feedback about the reasons why the solution is wrong or incomplete. Another advantage of blended learning is the possibility for students to check the level of their knowledge. The courses contain interactive electronic tests with graduate difficulty, which provide an immediate feedback about the level of knowledge, as well as further recommendation.

First of all, we focus on the results of students in the above mentioned subjects. The average assessment from the subjects is depicted on Fig. 1. As we can see, the best results are from Elementary Mathematics 6, which was taught by blended learning. Since we had only a little sample of 19 students, we do not test the statistical significance of differences of the results.

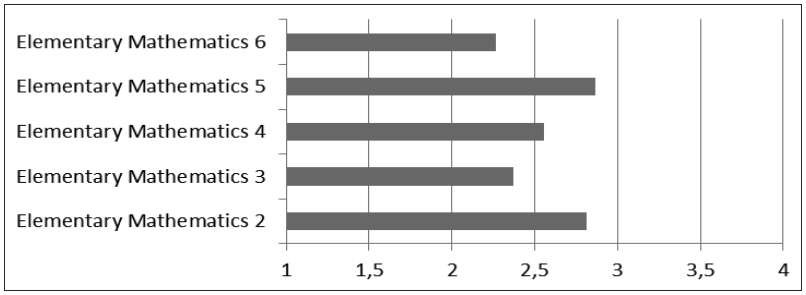

Fig. 1. The average assessment from the subjects

Secondly, let us focus on the number of students who were not able to successfully pass the subject. This number of students is depicted on Fig. 2. As we can see, the best results are from Elementary Mathematics 6, where all students were able to fulfil the requirements.

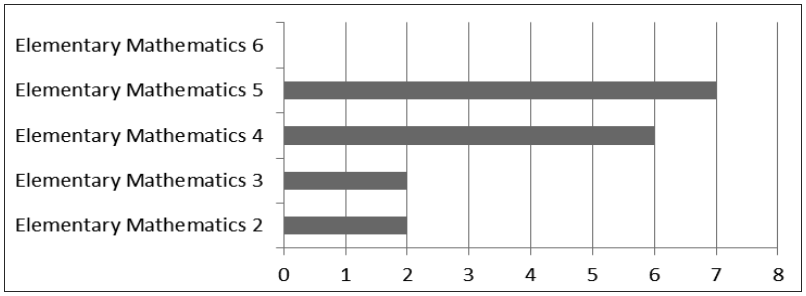

Fig. 2. Number of students who were not able to successfully pass the subject

Thirdly, we analyse the answers of students about teaching of Elementary Mathematics 2–6. The students have to express their opinion (1 – strongly agree, 2 – agree, 3 – neither agree nor disagree, 4 – disagree, 5 – strongly disagree) with 10 statements about teaching Elementary Mathematics 6 and 7 statements about teaching Elementary Mathematics 2–5. The main results are:

1. In Elementary Mathematics 6, the students strongly agree that they exactly knew what they have to master (average of their responses is 1,26). In Elementary Mathematics 2–5, the students neither agree nor disagree with the same statement (average of their responses is 2,74). In our opinion, the positive difference is caused by electronic tests and interactive programs integrated in the e-learning courses, so students could check the level of their knowledge in advance.
2. In Elementary Mathematics 2–5, students did not think that they had enough well-done study materials. (The average of their responses to the statement 'We had enough well-done study materials' was 3,32).
3. The students consider the e-learning courses to be much clearer than printed materials. (The average of their responses to the statement 'The text in the study materials was clear' was 1,32 for Elementary Mathematics 6 and 2,74 for Elementary Mathematics 2-5. The average of their responses to the statement 'The text contained information that I did not understand' was 3,89 for Elementary Mathematics 6 and 2,79 for Elementary Mathematics 2–5). In our opinion, the positive difference is caused by interactive programs integrated in the e-learning courses. The students could immediately apply obtained knowledge on solving interactive tasks.
4. The average of their responses to the statement 'The teacher led the lessons clearly' was 1,21 for Elementary Mathematics 6 and 2,89 for Elementary Mathematics 2–5. We think that integration of ICT into lessons enabled teacher to lead the lessons clearer.
5. The average of their responses to the statement 'We had enough possibilities to understand the content of study materials' was 1,42 for Elementary Mathematics 6 and 2,58 for Elementary Mathematics 2–5. In our opinion, the positive difference is again caused by electronic tests and interactive programs integrated in the e-learning courses.
6. The average of their responses to the statement 'My assessment from the subject is objective' was 1,42 for Elementary Mathematics 6 and 2,26 for Elementary Mathematics 2–5. In our opinion, the positive difference is caused by electronic tests integrated in the e-learning courses.
7. As for Elementary Mathematics 6, students do not think that they had technical problems (average score 4,0). Majority of students think that blended learning suits them better than traditional teaching (average score 2,58) and that blended learning saves their time (average score 2,26). Majority of students agree that 'Interactive programs helps me to master the content of the course and to obtain a better assessment' (average score 2,11).

Conclusion and limitations

From the results of many researchers, as well as from our research, it follows that proper integration of ICT into teaching can make the teaching process more efficient. Both we and our students were satisfied with teaching of Elementary Mathematics 6 by blended learning, so we will continue to teach this way also in the future.

We are aware of the fact that this study has several limitations and the results of the study should be deeply verified in future, since the study was administered within only one academic year to a small group of students. Of course, these limitations might limit the generalizability of our findings.

Acknowledgement

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Abstract

Blended learning represents a combination of online learning and face-to-face instruction. While one group of researchers advocates the use of blended learning in teaching, others are more critical to the use of ICT in education. The paper deals with utilization of blended learning in teaching mathematics at Faculty of Education, Trnava University. From the results it follows that proper integration of ICT into teaching can make the teaching process more efficient.

Keywords: blended learning, improving classroom teaching, ICT in education, mathematics teaching, higher education.