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Students Perception of the Mathematical Classroom while Integrating Digital Technologies

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Abstract

In the current research, we were interested in testing the impact of integrating technology on student's perception of different mathematical courses regarding the constructivist versus traditional approach to teaching/learning. The study was performed in the mathematics department of our College of education. We analysed the students' perception of our mode of teaching as well as of their own level of involvement in the learning process with respect to the usage of different digital tools according to the basic characteristics of the traditional versus the constructivist classroom. We compared the students' assessment of the mathematical classroom in different courses that were taught with and without technological tools. The obtained results show that the students' perception of mathematical class while integrating technology corresponds to the basic characteristics of the constructivist class, whereas the class without the use of technology corresponds to the description of the traditional one. This result strengthens our suggestion that the appropriate usage of technology in teaching mathematics enables to transform the classroom from traditional to constructivist one.

Keywords: Mathematical classroom; Digital technologies; Teaching mathematics

Introduction

Over the few last decades the technology has become an integral part in mathematics classroom. Numerous recent studies indicated that integration of technology in teaching mathematics improves significantly mathematical learning [1,2]. Goos, claimed that technology integration offers many opportunities for creativity and a collaborative interactive and dynamic learning experience [3]. She states that embedding technology into mathematical classes can bring the teaching of mathematics to a completely different and much higher level.

Yerushalmy, exemplified how a technology-supported algebra curriculum can assist teachers in making powerful mathematical ideas accessible to learners [4].

Tabach et al. [5] presented a research on learning algebra in a technological environment, which supports students in becoming autonomous learners of algebra. Naftaliev and Yerushalmy [6], found that Narrating Interactive Diagrams can be a form of instruction toward the development of new mathematical knowledge for students.

Hall and Chamblee [7] discussed the benefits of GeoGebra usage in teaching graduate-level geometry and algebra content courses in a teacher education program. The authors' observations were that most mathematics teachers were excited when they first learn about GeoGebra and its various capabilities, and were eager to begin incorporating it in their own classrooms immediately. Budinski and Takaci [8] described their experience of GeoGebra usage in modelling-based teaching of mathematics. Gurevich is currently using GeoGebra to teach plan transformations in geometry course in a teacher education program [9,10]

The use of smartphones technology in classroom improves learning [11,12]. Moreover, Barchilon Ben-Av and Gurevich [13], showed that the use of the GeoGebra Mathematics App for smartphone enhances active students' participation in the lessons and faster assimilation of the course material.

Abramovich presented a detailed review on various usage of modern digital technologies such as GeoGebra, Matematica, the Graphic Calculator, Matlab, Maple in teaching mathematics [14]. He stated that using digital technologies makes it possible to study traditionally difficult and conceptually rich topics in a new way. He noted that the appropriate use of computers in the schools can promote an experimental approach to mathematics that might improve the balance between informal and formal teaching and learning of mathematical ideas. Sachs, stated, that, as a result of integrating technology, even the teachers' way of "doing mathematics" may change - from the belief that in mathematics there are only correct or incorrect statements to the belief that mathematics may mean the process of solving a particular mathematical problem, while refining the understanding and clarifying the correct mathematical ideas [15]. Therefore, teacher educators could foster students' skills of critical thinking by planning a lesson in line with the constructivist approach while integrating technological tools [16]. The constructivist approach to teaching and learning believes that development of pupils' understanding requires the learners' active construction of knowledge. Today, in the era of information explosion, we, as educators, should encourage pupils and students to foster independent learning and to use social communication. The constructivist approach intelligently utilizes a wide variety of computer capabilities to create a computerized learning environment which facilitates constructivist teaching methods [17].

Brooks and Brooks, defined constructivist mathematics classroom as a classroom where a concept development and construction of learner's own solution is more important than memorizing procedures and formulas and using them to get the right answer [18].

According to constructivist approach, teacher behaves in an interactive manner. Brooks and Brooks described constructivist classroom versus traditional as follows:

Traditional Classroom characteristics: strict adherence to a fixed curriculum; curricular activities rely heavily on textbooks and workbooks; students are viewed as 'blank slates' onto which information is etched by the teacher; teachers generally behave didactically, disseminating information to students; teacher seeks the correct answer to validate student learning; assessment of student learning is viewed as separate from teaching and occurs almost entirely through testing.

Constructivist Classroom characteristics: pursuit of student questioning; curricular activities rely heavily on primary sources of data and manipulative materials; students are viewed as thinkers with emerging theories about the world; teachers generally behave interactively, mediating the environment for students; teachers seek the students' point of view in order to understand their present conceptions for use in subsequent lessons; assessment of student learning is interwoven with teaching and occurs through teacher observations of students at work and through student exhibitions.

Ertmer, claims that the effectiveness of technology integration into teaching is strongly related to instructors' pedagogical beliefs, which is in good agreement with the constructivist approaches to building knowledge [19-21].

However, Abboud-Blanchard and Lagrange [22] noted that although many technology-based innovations for improving the teaching and learning of mathematics have been developed and tested by research methodologies, still a common impression is that there is a wide gap between these innovations and the actual situation of classroom use of technology.

Educational researchers widely agree that one of the critical factors that can lead to the effective integration of technology into teaching is teachers' belief that technology can improve learning [23-26]. Unfortunately, a lot of mathematics teachers still worry that technology might harm the development of formal thinking in math students although they accept the advantages of computer visualization.

Motivation of the Study

Our research is based on a series of studies on the integration of technology into mathematics teaching conducted over the past approximately 15 years. The obtained results point to the improving both students' usage of digital software and their overall achievement. In addition, we observed a significant improvement in students' attitudes towards integrating technology in mathematical courses [27]. We observed that the students while experimenting with the dynamic mathematical software created their own knowledge based on their findings. Moreover, the students' questions led to additional elaborations of the studied topics, i.e. the learning activity became interactive. Thus, we as instructors realized that due to the integration of digital tools into our teaching, our classroom went through significant changes in both the mode of our teaching and the level of involvement of our students in the learning process [10].

Based on our own teaching experience, we believe that teaching mathematics in a computerized environment contributes to better understanding the formal subjects taught in mathematical courses. The students understand that although ultimately there must be a formal answer to a mathematical problem, there are various ways to reach the solution. Thus, we suggest that a computerized environment can improve both learning in class and working at home while preparing assignments.

In the current research, we were interested in testing whether our perception of the classroom as a constructivist one, coincides with the corresponding perception of our students.

Our research questions were:

What are the students' attitudes towards integrating digital technologies into the teaching process?

How the students perceive the impact of digital tools on:

a. The mode of our teaching;

b. On the level of their involvement in the learning process?

Referring to these questions, we designed a research project in which we analysed several courses we taught embedding different digital tools if at all.

Methods

The research was conducted over the academic year 2017-2018. The participants were 47 student-teachers in the educational program for secondary-school mathematics teachers in the Mathematics Teaching Department at a College of Education. The students participated in the following courses: Calculus, Analytic Geometry, and Function Theory. These courses were classified into two categories according to whether digital tools were used or not in the teaching process:

Control Group (18 participants in the Calculus course) - no digital tools were used.

Digital Tools Group (29 participants in Analytic Geometry and Function Theory courses) – two digital tools were used, namely, GeoGebra and Socrative Smartphone App. Socrative was used at the beginning of each lesson. This application enables creating a set of questions that can be deployed during the class. At the beginning of the class the students were instructed to answer a quiz composed of three to five review questions referring to the material of previous lectures. GeoGebra was used in most of the lessons. New topics were explained and presented both analytically and using GeoGebra.

To answer the research questions, we built a multiple-choice questioner. The questioner was formulated regarding basic characteristics of the constructivist versus traditional classroom defined by Brooks and Brooks [18]. All the students in the courses that took part in the study, were asked to answer the questioner (more than one answer could be marked). The questioner was:

Does any digital application is used in the course?

No.

Yes, Geogebra.

Yes, Socrative.

Do the computerized tools help you?

No.

Yes, helps to understand the material.

Yes, increases motivation to learn.

Yes, gives a didactic model to emulate.

Lesson plan:

Determined in advance by the lecturer.

Flexible and might be updated according to the students' questions.

Teaching material:

Relies on textbooks/work pages.

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Includes active participation of the students in experiential/research activities.

Learning method.

Students are not involved in the process of imparting knowledge.

Students take an active part in the process of building the knowledge.

The lecturer teaches:

In a frontal manner without involving the students.

Interactively and contributes to the students' active participation.

Solving exercises in class:

The lecturer asks a question and waits for a correct answer.

The lecturer refers to student responses attempting to understand their way of thinking and thus accordingly adapt the course.

The above questions aimed to test both the mode of our teaching (questions 3,4,6) and the level of our students' involvement into learning process (questions 5,7). In addition, in question 2 we asked about the students' perception of the contribution of digital technology to their learning.

Data collection and analysis

The data consisted of the students' answers to the questioner. All the data were collected at the end of each academic semester. The data from the questioner were analysed and the frequencies of each answer were calculated for each question in each group. We grouped all the results according to three following categories:

Students' attitudes towards digital technologies in teaching;

Students' perception of mode of our teaching;

Students' perception of their own involvement in learning process.

The results were compared between the two groups, χ2 tests were conducted for each category.

Results

Table 1 presents the frequencies of students' answers to each question, separately for each group.

Group Question	Control Group (18)	Digital Tools Group (29)	χ2 test by course
Q1 Technology was used: No Yes, GeoGebra Yes, Socrative	100%	3% 79% 52%	
Q2 Technology helps: No Yes, helps to understand the material Yes, increases motivation to learn Yes, gives a didactic model to emulate		10% 79% 38% 55%	
Q3 Lesson plan: Is determined in advance by the lecturer Is flexible and might be updated according to the students' questions	72% 28%	28% 72%	χ2=8.9525, p=0.00277* χ2=8.9525, p=0.00277*
Q4 Teaching material: Relies on textbooks/work pages Includes active participation of the students in experiential/research activities	72% 28%	21% 79%	χ2=12.2467, p=0.000466* χ2=12.2467, p=0.000466*
Q5 Learning method: Students are not involved in the process of imparting knowledge Students make an active part in the process of building the knowledge	67% 33%	7% 93%	χ2 = 18.9712, p = 000013* χ2 = 18.9712, p = 000013*
Q6 The lecturer teaches: In a frontal manner without involving the students	67% 33%	0% 100%	χ2>22.18, p<0.000002* χ2>22.18, p<0.000002*

Interactively and contributes to the students' active participation			
Q7 Solving exercises in class: The lecturer asks a question and waits for a correct answer The lecturer refers to student responses attempting to understand their way of thinking and thus accordingly adapt the course	33% 67%	10% 90%	χ2=3.7911, p=0.051526 χ2=3.7911, p=0.051526

Table 1: The rate of the students' answers to each question by two groups.

The results corresponding to the significant differences between the two courses (p0.05) are marked by *.

The results obtained with respect to the denoted categories are described as follows:

1) Students' attitudes towards digital technologies in teaching

Most of the students of the Digital Tools Group found the digital tools being helpful in their learning, especially for understanding the material (79% of the students). In addition, 38% of the students noted that technology increases the motivation to learn, and 55% of them indicated that technology provides a didactic model to emulate.

2) Students' perception of our mode of teaching

The students' answers referring to this category, namely lesson plan, teaching material and the lecturer teaches revealed significant difference between the groups: most of the students' answers of the Control Group (about 70% of the students) indicated that the lesson plan was determined in advance by the lecturer and the teaching material mostly relies on the textbooks, while most of the students of the Digital Tools Group (about 70% of the students) think that the lesson plan is flexible, depends on the students questions and implies their active participation in learning activity. Furthermore, most of the students of the Control Group (67% of the students) considered the mode of teaching being frontal, while all the students of Digital Tools Group indicated that the mode of teaching was interactive.

3). Students' perception of their involvement in learning process

The results referring to this category, namely, learning method and solving exercises revealed significant difference only in the students' perception of the learning methods. Most of the Control Group (67%) indicated that they are not involved in the process of imparting knowledge, while most of the Digital tools Group (93%) believed that they make an active part in the process of building the knowledge. Besides that, 90% of the Digital tools Group students believed that the lecturer attempted to understand their way of thinking and thus accordingly adapt the course.

Discussion

We, as instructors, understand how difficult is to change the method of teaching established for years. At the same time, it is obvious that in our day classroom, students become an active part in building knowledge process.

Based on our own teaching experience, we believe that teaching mathematics in a computerized environment contributes to understanding of the formal subjects taught in mathematical courses. The students understand that although ultimately there must be a formal answer to a mathematical problem, there are various ways to reach it. Thus, a computerized environment can improve both learning in classroom and working at home while preparing assignments.

The obtained results indicated that according to the students' opinion, digital technologies help to understand the material and provide a didactic model to emulate, make teaching more flexible in matching the students' needs and making it possible for students to become an active part in the process of building the knowledge. Moreover, it was observed that students believe that the use of technology affects the mode of teaching and the level of their involvement in the learning process. Thus, the obtained results strengthen our suggestion that integrating technology in teaching mathematics enables to transform the classroom from a traditional to a constructivist one.

Conclusion

We believe that integration of digital technology enables to combine the formal teaching of mathematics with the constructivist approach in teaching. Our findings concur with relevant studies, demonstrating the ability of the instructor to take advantage of the dynamic environment when the pedagogy of the course was entirely technology-oriented, claiming that the constructivist approach intelligently utilizes a wide variety of computer capabilities to create a computerized learning environment that facilitates constructivist teaching methods [1,17].

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