Cypriot Journal of Educational Sciences

Volume 10, Issue 1, (2015) 12-17

CJES
2004

www.awer-center/cjes

GeoGebra 3D from the perspectives of elementary pre-service mathematics teachers who are familiar with a number of software programs

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Suggested Citation:
Baltaci, S. & Yildiz, A. (2015). GeoGebra 3D from the perspectives of elementary pre-service mathematics teachers who are familiar with a number of software programs. *Cypriot Journal of Educational Sciences*, *10(1), 12-17.*

Received October 14, 2014; revised November 14, 2014; accepted February 20, 2015
Selection and peer review under responsibility of Prof. Dr. Huseyin Uzunboylu & Assist. Prof. Dr. Cigdem Hursen, Near East University.

Abstract

Each new version of the GeoGebra dynamic mathematics software goes through updates and innovations. One of these innovations is the GeoGebra 5.0 version. This version aims to facilitate 3D instruction by offering opportunities for students to analyze 3D objects. While scanning the previous studies of GeoGebra 3D, it is seen that they mainly focus on the visualization of a problem in daily life and the dimensions of the evaluation of the process of problem solving with various variables. Therefore, this research problem was determined to reveal the opinions of pre-service elementary mathematics teachers who can use multiple software programs very well, about the usability of GeoGebra 3D. Compared to other studies conducted in this field, this study is thought to add a new dimension to the literature on GeoGebra 3D because the participants in the study had received training in using the Derive, Cabri, Cabri 3D, GeoGebra and GeoGebra 3D programs and had developed activities throughout their undergraduate programs and in some cases they were held responsible for those programs in their exams. In this research, we used the method of case study. The participants consisted of five elementary pre-service mathematics teachers who were enrolled in fourth year courses. We employed semi-structured interviews to collect data. It is concluded that pre-service elementary mathematics teachers expressed a great deal of opinions about the positive contribution of the GeoGebra 3D dynamic mathematics software.

Keywords: GeoGebra 3D, interview, mathematics software, pre-service mathematics teachers.

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1. Introduction

Developing mathematics software to improve the mathematics education has been a central focus of recent studies. As a result of those studies, computer algebra systems based on numerical and mathematical graphics and dynamic geometrical software based on geometrical terms have been introduced (Kokol-Voljc, 2007). It can be said that one of these software programs at the basic level is the GeoGebra dynamic mathematics software. Among the existing mathematics software, this one is free, open-source coded, has multiple representation (e.g., different windows for algebraic and geometrical input), and offers individualized language options, interactive commentary and internet options, through which the sources can be shared (Hohenwarter, Hohenwarter, Kreis & Lavicza, 2008; Kutluca & Zengin, 2011).

Three-dimensional geometry instruction is not at the desired level. The major reason for this is that students face difficulty interpreting the static representations of three-dimensional (3D) geometric objects (Accascina & Rogora, 2006). However, as the GeoGebra dynamic mathematics software is open-source coded, this software offers continuous improvement (Hohenwarter, Hohenwarter, Kreis & Lavicza, 2008). Thus, each new version of the GeoGebra dynamic software goes through updates and innovations. One of these innovations is the GeoGebra 5.0 version. This version aims at facilitating 3D instruction by offering opportunities for students to analyze 3D objects. This version has a separate window for 3D objects and this window can be used together with the other two-dimensional window. Thanks to this window, most of the 3D objects are visible (Baltaci, 2014). It should be kept in mind that, to help them visualize 3D objects and carry out operations, students should be provided with opportunities to work with dynamic diagrams rather than static ones (Kosa, 2011).

While scanning the previous studies of GeoGebra 3D, it is seen that they mainly focus on the visualization of a problem in daily life (Aktumen, Baltaci & Yildiz, 2011; Aktumen, Doruk & Kabaca, 2012; Souza, 2014) and the dimensions of the evaluation of the process of problem solving with various variables (Yildiz, Baltaci & Aktumen, 2012; Baki, Yildiz & Baltaci, 2012). Therefore, this research problem was determined to reveal the opinions of pre-service elementary mathematics teachers who can use multiple software programs very well, about the usability of GeoGebra 3D. Compared to the studies already conducted in this field, this study is thought to add a new dimension to the literature on GeoGebra 3D. The participants in the study had received training in using the Derive, Cabri, Cabri 3D, GeoGebra and GeoGebra 3D programs and had developed activities throughout their undergraduate programs, and, in some cases, they were held responsible for those programs in their exams. From the perspective of those participants, at the end of some dynamic software-assisted courses, attempting to discover the potential of the GeoGebra 3D could be instrumental for educationalists with respect to instruction about 3D objects, which are found to be difficult.

2. Methodology

2.1. Research method

In this research, we used the method of case study as it enabled us to examine a particular group in depth and to assess the data obtained through data collection tools without being concerned about generalization.

2.2. Participants

The participants consisted of five pre-service elementary mathematics teacher who were enrolled in fourth year courses in the department of mathematics education. Purposive sampling was used when choosing participants and the participants consist of 2 males and 3 females. One of these participants was 21, another was 22, and three of them were 23.

These participants were informed about different software programs by various lecturers during their university education. In this education process, the participants were asked to produce some projects in order to actively study the software. In addition, they were asked to use these software programs in their exams or to comment about the given questions. Thus the pre-service teachers who were expected have the skills to use the software programs as a result of these stages were selected in accordance with the opinions of the lecturers. Within this research period, voluntary participants were carefully selected.

2.3. Data collection

The study makes use of semi-structured interviews conducted at the end of dynamic software-assisted courses to obtain data. In the development of the semi-structured interviews, the questions were carefully phrased in order to be comprehensible. During the interviews, some questions were asked to participants, such as “How do you describe the advantages of the software?”, “Was the three-dimensional window of the software effective in learning?”, “Did the software contribute to solving problems in your daily life?”, “Would you consider using the software in your professional life?”, “If yes, how?”, “Are there any differences between GeoGebra software and other software?” and “If so, what are they?”

2.4. Data analysis

Before starting the interviews, participants were briefly informed about the aim of the research. After that the interviews were carried out with pre-service teachers and the responses were recorded. Each of the interviews was conducted in about an hour; all of them were performed in the counseling room, which was quiet enough to feel comfortable for the participants.

The recorded data was transcribed verbatim. Next, the themes developed by the researchers separately were discussed and finalized. While presenting the data, we coded each pre-service teacher. For example, T1 stands for the first pre-service teacher.

3. Findings

When their statements are examined, all the pre-service teachers said that the GeoGebra dynamic mathematics software is applicable. For example, T1 and T2 expressed their thoughts below:

T1: I can see the menu tools easily as the software language is Turkish. This facilitates me using the software.

T2: If geometrically speaking, in other software programs, in Cabri for instance, we do not see graphical equations.

In addition, the pre-service teachers expressed that the software facilitated their learning of three-dimensional objects from different perspectives and helped them go through the process successfully. On this theme, pre-service teachers expressed that the software could help the acquisition of age-dependant cognitive level of younger students to learn about three-dimensional objects. For example, T1 expressed his thoughts as follows:

T1: For example, a student is in the sixth grade. A sixth grade subject can be taught to this student easily. However, a sixth grade subject cannot be taught to a fifth grade student easily. With this software, the learning age can be lowered and that subject can be taught to a younger student.

Among the statements under this theme, it is a striking result for us that the pre-service teachers expressed that the GeoGebra software transformed their instruction in three-dimensional objects, hence they have effectively learned some subjects they could not learn in the past and they no longer have difficulty in thinking three-dimensionally:

T2: Because I was not able to understand some geometrical forms, such as parabola, hyperbola and ellipse, I used to learn them by rote. But now, thanks to the software, I can easily observe and grasp those conics obtained from two cones intersecting in a plane.

T3: According to me, the advantage of GeoGebra software over Cabri software is its Excel page, which enables calculation. Also the transition between screens is another advantage of it over Cabri. Thanks to these advantages, I have effectively learned some subjects which I was not able to learn in the past.

T4: Thanks to the software, I can think three-dimensionally now. For example, I can easily see what originates from the intersection of a plane cutting a cone or an object in a cylinder. Previously I had difficulty in intellectualizing such expressions.

Two of the pre-service teachers told us that they had made use of the software to help their siblings study. T1 pointed out that he used the software to help his brother.

T1: I have a brother at home. He and his friends are taking the geometry course as well. With the software, I taught him in which cases two straight lines intersect and in which cases they do not intersect.

Further into the interview, we asked the pre-service teachers about how they would use the program in their professional life. Among the many answer to this question, it was seen that some of the pre-service teachers said it would provide the opportunity to learn by structuring whereas the rest of them said that they would use the software in order to demonstrate three-dimensional objects. It was also seen that the belief that the use of software causes a loss of time has changed. For example, T2 stated that one needs to learn by structuring the knowledge and T4 stated that better understanding of three-dimensional objects via the software would save time:

T2: It is essential to learn by structuring. For example, if we think of x+y=2 straight line, students ought not to draw the line through the software. They ought to reach that line after tracking the points whose sum is 2 and combining those points. In this way, they structure and learn the data logically without committing it to memory.

T4: Previously our teachers used to review their lesson through slides on an overhead projector. Even though some expressions take time, something can be prepared in advance with this software. Students may regard it as a waste of time at first. But, in my opinion, it is not a waste of time and learning comes to fruition better in this way.

Under this theme, it is surprising to note that some pre-service teachers thought of just the visual aspects or software training when they were asked how they would employ this software. The opinions of T4 and T1 about this finding are as follows:

T4: We can present a lot of expressions to students visually with GeoGebra 3D.

T1: Instructing on how to use the software in classrooms will be more reasonable in terms of giving it a place in courses.

The pre-service teachers stated their opinions about what kind of a class environment they want, what they expect from their students, their roles in this process and the need for this software to be popularized in every university. The statements of T3 and T5 on this finding are as follows:

T3: First of all, I expect my students to do the given operations on their own. While they try to form the necessary things on the software, I take on the task of guiding and helping them with what they cannot do.

T5: In my opinion, if these programs are taught to all students of mathematics in every university and are made compulsory, each student will learn them beginning from the first grade.

On the other hand, three of the pre-service teachers stated that the software should be improved further. These statements mentioned some 3D images, being closed or open and some of the sound effects inserted. The opinions of T3 and T2 on this are as follows:

T3: I think it would be nicer to open the closed images. I mean that it would be better to hold one edge of a simple cube, and to open it. Our teacher showed us a clear state of a cube, holding one edge of it, in Cabri 3D.

T2: Sound effects can be added to the software. Micro sounds such as tumbling effects. In this way, we can achieve a more effectual learning. For example, suppose that a straight line will pass through a sphere, we can have a sound like a worm piercing an apple when that line passes through.

4. Conclusion and Discussion

All of the pre-service teachers said that the program is usable. Hohenwarter, Preiner and Yi (2007) and Baydas (2010) also state that the GeoGebra software is easy to use in accordance with the opinions of pre-service teachers. Our pre-service teachers said that the software facilitates learning about three-dimensional objects from different points of view and helps them be successful in the process. In fact, most of the dynamic software programs are lacking in teaching three-dimensional objects (Bertoline & Miller, 1990; Kosa, 2011). In the same vein, the pre-service teachers in this research stated that GeoGebra makes it convenient to learn about three-dimensional objects.

Furthermore, the pre-service teachers expressed that the software can help the acquisition of age-dependant cognitive level of learners to understand three-dimensional objects at an earlier age. Rincon (2009) points out that GeoGebra increases the maturity level of students. With these programs being used in courses, students attain higher levels of knowledge, notice the good side of mathematics, and take more interest in mathematics. The pre-service teachers stated that they learnt some subjects better thanks to this software, whereas they were not able to learn them adequately in the past. Galindo (1998) states that students can form the desired figures and see the changes thanks to the dynamic software programs, hence these programs contribute to learning process. In addition, Yildiz, Baltaci and Aktumen (2012) emphasize that GeoGebra is a dynamic mathematics software program that one can use to increase one’s knowledge regarding three-dimensional objects.

When the pre-service teachers were asked about how they would use the software in their professional lives, some of them said that they would use it to enable students to learn by structuring knowledge. Dikovic (2007) emphasizes that each teacher ought to be a guide while using this kind of software and to encourage their students to solve problems. Hohenwarter et al. (2008) state that students ought to be provided with GeoGebra in order to enable them to structure their knowledge. In this structuring process, as Sinclair and Crespo (2006) and Kutluca and Zengin (2011) argue, students can observe the mutual interaction of mathematical objects and their figures thanks to the dynamism of the software. In the same vein, the pre-service teachers said that they would structure their students’ knowledge in their professional life, which may result from the fact that they also learnt in this way in the past.

In addition, it is seen that the belief that using this kind of software is a waste of time has changed. Alkan and Ozgu (1989) and Ciftci and Tatar (2014) point out that teachers can achieve their ultimate goals by using time effectively with computer-aided education. Aktumen, Baltaci and Yildiz (2011) and Baltaci (2014) emphasize that teachers can use their time effectively with the GeoGebra software as well. In this way, teachers can conduct activities that are useful for students’ learning process and use their time well. However, teachers should be attentive and use GeoGebra efficiently in their classrooms; for this, researchers should establish an environment for teachers to realize the better aspects of GeoGebra mentioned above.

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