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Views of pre-service teachers following teaching experience on use of dynamic geometry software[i]

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The study aims to determine the views of final-year pre-service mathematics teachers towards their experience of the use of dynamic geometry software in teaching, following the implementation processes that they carried out when using this software in a real classroom environment. The study was designed as a case study, which is one of the qualitative research methods. The study was conducted with four pre-service teachers studying in the mathematics teaching department at the education faculty of a university in Turkey during the 2016 to 2017 academic year. As one of the results of the study, it was observed that the pre-service teachers, following the theoretical lessons that they had in the education faculty prior to implementation, gave more limited opinions, whereas during the school experience application of dynamic geometry software, following its application in a classroom environment, they mentioned more features of this software for use in teaching. The pre-service teachers, in relation to their real classroom experiences, expressed their views on the features "concretisation and visualisation", "possibility of presenting many examples", "making students feel that mathematics is valuable", "permanence and facilitation of learning", and "preventing erroneous mental representations" with regard to the role of dynamic geometry software (DGS) use in teaching and learning. Yet, prior to using DGS in the classroom, these pre-service teachers had given importance only to the "concretisation and visualisation" and "permanence and facilitation of learning" characteristics.

Key words: Dynamic geometry, pre-service mathematics teacher, geometric shapes, views.

INTRODUCTION

Teachers' beliefs and views about teaching have a strong influence on their decisions and behaviours (Ernest, 1989; Fang, 1996; Tillema, 2000; Thompson, 1992). Thus, research on teachers' views show that when their views about teaching change their practices in the classroom change also in parallel (Givvin et al., 2001). One of the fields of mathematics where teachers have different views and different beliefs about teaching is the

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field of geometry. Indeed, these differences of views in the teaching of geometry came from the fact that the teaching of the geometry has to treat the concrete and the abstract objects to teach abstract objects (Steinbring, 1988; Laborde, 1994; Houdement and Kuzniak, 2006; Schneider, 2012; Rigaut, 2013).

It is argued that geometry, since it both contributes to mathematics learning and deals with concrete shapes and objects, should begin to be taught from an early age and that rather than being learnt as a separate subject, it will be more useful for it to be incorporated with the other mathematics subjects (Olkun and Toluk, 2003). For this reason, in order to increase the success of students in these fields, mathematics and geometry teaching should be perceived as an indissociable, mutually complementary whole. It may be said that especially during the primary school years, geometry teaching is considerably important (Onal and Demir, 2012). In student learning during the primary school years, the transfer from the concrete to the abstract operational stage is very important. Educational researches stress the importance of concretisation as one of the basic factors in content of lessons prepared for primary school pupils (Aydogdu et al., 2016). Nowadays, technological resources play a part and are in active use in the classroom environment for the concretisation of geometric objects.

Recently, technology is developing at a great speed, therefore changes are also occurring in student learning (Ozdemir, 2012). Nowadays, when students are so responsive towards this technology, it is considered necessary to integrate technology into lessons. It may be said that since technological tools play an effective role in the concretisation of abstract mathematical terms, when teaching of primary school pupils is carried out by making use of suitable technologies; these can ensure that students have a better perception of mathematics and thus make a positive contribution to their learning of mathematics.

National Council of Teachers of Mathematics (NCTM) (2000) also highlights the fact that teachers can improve students' learning by integrating technology; as well as richer learning environments can be set up. The research results show that the environments offered by dynamic geometry software (DGS) have a positive effect on learning, especially concerning the learning of geometric objects (Clements and Battista, 1992). As a reflector of computer technology onto geometry lessons, DGS too, is a beacon of hope for these aims to be realised in mathematics teaching (Guven and Karatas, 2003). Many studies exist in the literature with regard to the use of DGS in geometry teaching at all levels (Akgul, 2014; Topaloglu, 2011; Yavuzsoy-Kose and Ozdas, 2009; Acikgul, 2012; Guven and Karatas, 2009; Dimakos and Zaranis, 2010; Laborde, 2001; Furinghetti and Paola, 2002; Jones, 2000).

Geometer's Sketchpad, Cabri Geometry, Cabri 3D, Geogebra, Logo and 3DMath are regarded as the best-known dynamic geometry programs (Hohenwarter and Jones, 2007). Cabri Geometry, which is regarded as the first and most developed example of dynamic geometry programs, is a micro-world that allows the attempting of different ways to solve a problem, the discovery of a concept and its relationships, and at the same time, the concretisation of many mathematical concepts that cannot be seen in other media (Clarou et al., 2001). The original language of the program is French, and it has been translated into several languages such as English, Italian, Turkish and Japanese. With the Cabri geometry program, all geometric shapes can be drawn and animated. As the shapes can be held and animated, it may be said that the program keeps the students' interest alive, since it provides the opportunity to seek different solution methods and to reach generalisations by controlling the solution methods (Broutin, 2015).

Cabri 3D, another of the dynamic geometry programs, is a new-generation DGS suitable for use with smart boards. Cabri 3D, by which shapes such as points, lines, planes, polyhedrons, spheres, cones, cylinders and prisms can easily be made, fully opens the doors of 3D space for students to explore. Thanks to Cabri 3D, students have the opportunity to see relationships between geometric shapes and their positions in relation to each other, and also to examine the other faces of geometric shapes by turning around the shapes that they have formed whenever they desire. Cabri 3D is a micro-world that allows students to discover and form geometric shapes and which, by making use of these shapes, facilitates their understanding of mathematical concepts. Moreover, the program allows them to form hypotheses on the geometric shapes made and to test the hypotheses formed (Pandiscio, 2002).

The Cabri 3D program has features not found in other programs. It enables the concretisation of many mathematical concepts that cannot be seen in other media (Clarou et al., 2001). Indeed, in the Cabri3D environment it is possible to build geometric objects (cylinder, prism, cube, pyramid, etc.) in a few clicks, to rotate them, to show their openings dynamically, and to view them from different locations. The software appears as a solution to problems encountered during the process of conceptualization and mental modelling by students of 3D objects (Hugot, 2005).

When considering that the three basic components of the education process are teaching programmes, students and teachers, it may be said that however healthy the relationship is between these three components, so will education be effective and of good quality (Arslan and Ozpinar, 2008). Therefore, since well-trained teachers are considered necessary to carry out mathematics teaching in an effective way, in recent years the matter of teachers' pre-service learning experiences has been dwelt upon (Açikgül, 2012). When pre-service teachers begin their working lives, they must accept that

they will encounter a student group that is well-informed about technology and that in order to achieve the desired aims of their duties, technology plays a role in education; moreover, they must possess the skills to use technology correctly (Bakirci et al., 2009). For teachers to develop these skills, the faculties of education must also train them on these. The modules that teachers follow during their training have a strong influence on their teaching. There are several researches that indicates the need for training modules on the use of ICT in teaching during the formation of pre-service teachers (Baldin, 2002; Clarke, 2009; Habre and Grundmeier, 2007; Kokol- Voljc, 2007).

The general opinion in pre-service teacher training is that the teacher training period should be increased and that, together with this, it should be realised that the teaching practice carried out in schools must be given as much importance as the theoretical classes in the faculties. It is seen that besides the theoretical courses in teacher training programmes, the presence of lessons in which students can put into practice what they have learnt are important in terms of their development (Beeth and Adadan, 2006; Peker, 2009; Tigchelaar and Korthagen, 2004; Eraslan, 2009; Kahyaoglu and Yangin, 2007; Kablan, 2012). When considering one of the fundamental problems in teacher training, it is observed that field knowledge, that is the theoretical knowledge of the teaching profession obtained in the training, is not sufficiently maintained along with practical studies (Balci, 2007).

Besides, many studies made on pre-service teachers point out that they cannot make sufficient use of technology in their lessons (Güven and Karatas, 2004; Arslan and Ozpinar, 2008; Erdemir et al., 2009). Therefore, it is seen that pre-service teachers, as part of their teaching practice classes, experience some problems while giving lessons in their practicum schools, and that these problems are exacerbated by the integration of technology into the lessons. In this context, it is considered that the views of pre-service teachers with regard to the lessons they carry out in which DGS is employed will be a determining factor in their use of this technology in their professional lives as teachers.

Aim of the study

The aim of this study is to determine the views of primary school mathematics pre-service teachers with regard to the use of DGS in teaching, following the practice they carried out in a real classroom environment when DGS was used. In this context, the problem sentence of the study is as follows:

What are the views of final-year students in a primary school mathematics teaching department with regard to the use of DGS in teaching following implementation of their prepared lesson plans for the subject of learning 5th grade geometric shapes?

METHODOLOGY

Research model

This basis of this research is founded on qualitative research designs, and was designed as a case study. A case study is “a well-established research strategy where the focus is on a case (which is interpreted very widely to include the study of an individual person, a group, a setting, an organization, etc.) in its own right, and taking its context into account” (Robson, 2002). The research was designed as a type of case study known as “a case study consisting of several individuals”. In this type of case study, the characteristics of several individuals are studied and perceptions and attitudes are focused on which serve as the cause of a known result. Any possible experiences, determinants, factors, causes, processes, etc., which might affect the result are researched (Robson, 2002).

Study group

This was made up of final (4th) year students studying in the Primary School Mathematics Teaching department at the Education Faculty of a university in the north-east of Turkey during the 2016-2017 academic year. Four pre-service teachers (three female, one male) took part in the study. As the aim of the study was to understand the viewpoints of final year students of Primary School Mathematics Teaching towards DGS following the implementation of the prepared lesson plans given to them, it was considered that the purposive sampling method would serve the study. The purposive sampling method, consists in choosing cases rich in information concerning the purpose of the research in order to make in-depth analyses. There are six types of purposive sampling of which one type is the maximum variation sampling method. Maximum variation sampling method is obtained through the choice of different cases related to the problem of research (Buyukozturk, 2012).

For the selection of the pre-service teachers participating in the study, a questionnaire was conducted on the pre-service teachers, on a voluntary basis, aimed at determining their frequency of computer use, their self-efficacy with regard to computer use, which dynamic geometry programs they were familiar with and their opinions of the teaching profession. Each student answered six open-ended questions, four questions prepared in categories, and the “Attitude Scale with Respect to Conducting Computer-Assisted Learning”, consisting of twenty Likert-type questions, developed by Arslan (2006). The internal validity and reliability of the scale was analysed and a Cronbach’s Alpha reliability coefficient of 0.93 was determined. The scale and open-ended questions were applied to all final (4th) year students (thirty-eight pre-service teachers), but since seven pre-service teachers did not volunteer for the study, the data of these seven pre-service teachers were disregarded.

The questionnaires of thirty-one pre-service teachers volunteer for the study was numbered from one to thirty-one. For the preselection of the pre-service teachers who were to participate in the study, the answers of thirty-one pre-service teachers to the questions in the Likert-type scale were analysed with the statisitical package for social sciences (SPSS) software package and the open-ended questions were analysed through content analysis. In order to ensure heterogeneity in the selection of the pre-service teachers, three categories were determined by the researchers, namely computer use, dynamic geometry software and view of the teaching profession, by utilising the data obtained.

Based on the analyses of the responses to the questions on the use of the computer, the codes "good" and "low" were determined for the category "frequency of computer use". Using the answers to questions about dynamic geometry software, teachers' skills to use the DGS are coded as "beginner" and "experienced". "Positive" and

Table 1. Characteristics of participating pre-service teachers.

Number	Age	Gender	Type of school graduated from	computer use	Dynamic geometry programs	Teaching profession	GPA
A5=Hatice	21	Female	Anatolian high school	High	Experienced	Positive	3.10
A17=Berke	21	Male	Teacher training school	Low	Experienced	Negative	2.55
A18=Elif	21	Female	Anatolian high school	Low	Inexperienced	Positive	2.70
A31=Miray	21	Female	Teacher training school	High	Inexperienced	Positive	2.57

"negative" codes were identified in the teachers' perspectives on the profession categories by analysing responses to open-ended questions about their views on the teaching profession. The responses of each of the thirty-one teachers were tabulated and eight different combinations were identified to ensure diversity. Thus, thirteen teachers were selected.

As a result of the preselection conducted, and also by utilising other studies related with the subject, interviews were conducted with thirteen pre-service teachers with a semi-structured interview form. Transcripts of the data obtained from the interview forms were made and analysed by the researchers. Some pre-service teachers were eliminated since they were not keen to have their lessons listened to and analysed in detail, the pre-service teachers most willing to take part in the study were selected. Four pre-service teachers who participated in the study used the nicknames that they chose as shown in Table 1, instead of their real name because of confidentiality. The four pre-service teachers selected for the study, the criteria affecting the selection of the pre-service teachers, and other characteristics of the pre-service teachers are presented in Table 1.

Data collection and analysis

Prior to the implementation process with the pre-service teachers, interviews were carried out with a semi-structured interview form related with use of DGS. The semi-structured interview form consisted of two parts: a part where it is about questions with short answers and a part where it is about open questions on the lived experiences in the school.

Information was given to future teachers about the aim of the research during the interviews. Each of the four selected pre-service teachers was interviewed separately and the interviews were recorded so that no data could be lost. At the beginning of the interview, permission to record the voice was requested for each teacher and the length of the recordings ranged from 21 to 79 minutes. The interviews were transcribed word-by-word by the researchers.

To prevent any possible loss of data during the implementation process, lessons were video-recorded and after the pre-service teachers had applied their lesson plans. A preliminary interview was conducted with four selected pre-service teachers to explain the lesson plans and gather teachers' opinions on the plans. After the implementation of each of the plans, short interviews were conducted to analyse teachers' experiences with their teaching. Following the implementation process, interviews were conducted with a semi-structured post-lesson interview form, containing ten open-ended questions. The researcher interviewed the teachers with the interview form after each courses. Each interview was recorded with the permission of the pre-service teacher. The content of the questions was as follows:

Experiences of the lessons in which implementation was made, views on lesson plans, viewpoint of pre-service teachers towards the teaching profession following implementation, and viewpoint of pre-service teachers towards the utilisation of DGS in their teaching careers.

Some of the open-ended questions asked on the post-implementation semi-structured interview form were also questions asked to the pre-service teachers prior to implementation. The pre-service teachers' responses were analysed using the content analysis method. Content analysis, consists of a summary of the basic contents of the data and the messages they contain (Cohen et al., 2007). In the research, the coding was done according to the concepts obtained from the data, and the codes were developed by the researchers. Using the obtained codes, categories were obtained.

Implementation

The researchers went to meet the mathematics teachers, principals and vice-principals in the schools to explain the implementation process and to obtain permission. After all procedures had been completed, the school where implementation was to be carried out was designated. The pre-service teachers who were to carry out the implementation began working in four different classes of the 5th grade at a state school in the Nilüfer district of Bursa.

The pre-service teachers chose their own classes and were each given their own classroom. All pre-service teachers carried out all their lesson plans in the classes that they had chosen for themselves. According to the information given by the school management and the subject teachers, the levels of the students in the classes were evenly distributed in a heterogeneous way. It was considered that the pre-service teachers, having carried out their practicums over a four-month period at the same school as the implementation, would be familiar with the classes they had chosen. The pre-service teachers taught the learning outcomes in the subfield of geometric shapes to the 5th grade students, utilising the Cabri 2 and Cabri 3D software, and concrete material prepared by the researcher.

The four pre-service teachers carrying out the implementation used the three-day lesson plan and twelve study sheets prepared by the researcher. During the preparation of the lesson plans and study sheets, relevant to the subject of the study, the learning outcomes in the study field of geometric shapes to be taught during the study were taken by utilising the 5th grade mathematics teaching programme of the Education Ministry. In accordance with the learning outcomes, the lesson plans and study sheets were prepared by the researchers by scanning 5th grade course books, the mathematics lesson teaching programme, source books, books prepared for mathematics teaching, researches carried out in previous years, and the relevant literature. The prepared lesson plans and study sheets were examined separately by five teachers with at least five years' experience, and these teachers expressed their ideas to the researchers. Two of the teachers whose views were sought are also doing postgraduate programmes. After arranging the lesson plans and study sheets with the help of these expert opinions, the researchers gave the final shape to the lesson

plans and study sheets after also consulting the ideas of a lecturer. Video recordings were made of each pre-service teacher while they were giving their lessons. After the lessons were given, these video recordings were examined by the researchers, then the post-lesson interview forms were prepared separately with each pre-service teacher and the semi-structured interviews were made by using the forms. Each interview was recorded after permission had been obtained from the pre-service teachers. The interviews were analysed through content analysis by making transcripts of each post-lesson interview.

Validity and reliability

Some of the points to consider with regard to validity in case studies are listed thus: In order to ensure validity, the following may be utilised: variety of data, extensive time spent in the field, taking the views of an individual or several individuals involved in the research with regard to the prepared report, and consulting an external supervisor with a view to examining the project (Creswell, 2007; Cepni, 2012). Importance has been given to the matter of validity in this study, too, and this is explained in detail below. It is important to share the reports obtained by the researcher with individuals involved in the research and to receive their opinions (Cepni, 2012). In this study, too, the participants were informed in detail about the aim of the researcher, how the data would be used, and how they would be solved, and during the implementation they were included in the academic part of the research. The findings were interpreted both by the researcher doing the research and by a lecturer, and agreement was reached on these interpretations. Reliability of a study is attained when the study is repeated in the same way by another researcher, and the same or similar results are obtained. In order to increase reliability in case studies, researchers should define the processes of the study clearly, should support them with relevant documents, and should in turn develop and explain their research in a systematic way. In this study, too, the researcher took care to explain the details of the process of the same research which she wished to conduct with different teachers or pre-service teachers, and explained in detail the categories revealed as a result of the content analysis made for the solution of the data (Creswell, 2007). Precautions against data loss were taken by the researcher through interviews made on the basis of recordings and transcripts, and behavioural gestures made during the interviews were noted and stated in the transcripts. In the study, in order to reduce the anxiety of the pre-service teachers to a minimum, they were assured at the start that in the publications to be made, names other than their own would be used. Furthermore, it was determined that the study made would in no way affect their academic grades.

RESULTS AND DISCUSSION

The data obtained from the post-implementation semi-structured interviews with the pre-service teachers were analysed, and the views of the pre-service teachers following implementation with regard to use of DGS were revealed; also, comparisons were made with some pre-implementation views with regard to use of DGS.

Following the views of the pre-service teachers with regard to use of DGS that were examined in three categories as a result of the content analysis made prior to implementation, these views were also examined in three categories after implementation, and the categories were determined as “the role of DGS use in teaching and learning”, “positive aspects of operations with the use of DGS”, and “negative aspects of operations with the use of DGS”. In this section, the results will be given separately for each category determined by content analysis.

The codes revealed for the category named “the role of DGS use in teaching and learning”, and the distribution of the pre-service teachers in relation to the codes are given in Table 2. As can be seen in Table 2, with regard to the codes revealed in the research, at the end of the implementation period, by utilising the opinions of the pre-service teachers, the codes for the “role of DGS use in teaching and learning” category were organised as “concretisation and visualisation”, “possibility of presenting many examples”, “making students feel that mathematics is valuable”, “permanence and facilitation of learning”, and “preventing erroneous mental representations”.

As distinct from the pre-implementation views, in line with the views of the pre-service teachers, the codes “possibility of presenting many examples”, “making students feel that mathematics is valuable”, and “preventing erroneous mental representations” were added to the “role of DGS use in teaching and learning” category. The pre-implementation code, “facilitation of learning”, was expanded upon in the light of the opinions of the pre-service teachers and presented as the code “permanence and facilitation of learning”. The “learning through doing and experiencing” code, which was used prior to implementation, was removed. However, it was found that in the comments of the pre-service teacher named Hatice who commented on that code, there were comments in parallel with her comments made prior to implementation.

The pre-service teacher named Hatice, while stating views on the “learning through doing and experiencing” and “facilitation of learning” codes for the “role of DGS use in teaching and learning” category prior to implementation, stated views on the “concretisation and visualisation”, “possibility of presenting many examples”, and “making students feel that mathematics is valuable” codes for this category after implementation.

The pre-service teacher named Berke stated his views on only the “enabling effective learning through concretisation and visualisation” code for the “Role of DGS use in teaching and learning” category in the lessons prior to implementation. However, it is remarkable that after implementation, by expressing views on the “concretisation and visualisation”, “possibility of presenting many examples”, “making students feel that mathematics is valuable”, “permanence and facilitation of learning”, and “preventing erroneous mental representations” codes for this category, he expressed views for all codes.

The pre-service teacher named Elif, while stating views on the “enabling effective learning through concretisation and visualisation” code for the “role of DGS use in

Table 2. The role of DGS use in teaching and learning.

Category	Code	Relevant pre-service teachers prior to implementation	Relevant pre-service teachers following implementation
The role of DGS use in teaching and learning	Concretisation and visualisation	Berke, Elif	Hatice, Miray, Berke
	Possibility of presenting many examples	-	Hatice, Berke, Elif
	Making students feel that mathematics is valuable	-	Hatice, Berke
	Permanence and facilitation of learning	Hatice, Miray	Miray, Berke, Elif
	Preventing erroneous mental representations	-	Berke

teaching and learning" category in the lessons prior to implementation, expressed views on the "possibility of presenting many examples" and "permanence and facilitation of learning" codes for this category following implementation. The pre-service teacher named Miray stated opinions on the "facilitation of learning" code for the "role of DGS use in teaching and learning" category in the lessons prior to implementation, whereas she presented views on the "concretisation and visualisation" and "permanence and facilitation of learning" codes for this category after implementation.

The analysis of the post-implementation views of the pre-service teachers for the "role of DGS use in teaching and learning" category is presented below. While the pre-service teachers named Berke and Elif stated views on the "concretisation and visualisation" code before implementation, it was seen that the pre-service teachers named Berke, Miray and Hatice expressed opinions on this following implementation. The views of the pre-service teachers on the code named "concretisation and visualisation" are given below:

Hatice: *"Children love coloured things and when the surface developments on the board were reformed, they said things like 'Ah, it's really happened', and 'so it means this can really be done with surface developments'."*
Berke: *''When students are at the stage of concrete thought, it's already difficult to explain something abstract to them in words. You have to make use of concrete materials, and we have already made use of them, but in the end, there is a smart board here and we have also utilised that. […] In terms of concretisation, we can say that in the lives of the children this really exists directly. When they see something concrete in front of them they comment accordingly.''*
Miray: *''When teaching the students, it is much more difficult to teach them when an abstract subject appears, and we have concretised this. Especially when reforming the prisms and forming the geometric shapes by using Cabri, their imagination is stretched, they also see things on the screen and these become more concrete.''*

It can be said that according to pre-service teachers, it is very effective to use materials in the teaching of abstract concepts, since students are considered to be in the period of concrete conceptualization. When the pre-service teachers' views before and after the implementation are compared, it can be seen that they expressed their opinions more clearly by giving examples based on their experiences after the application, whereas before the application they had given shorter and more predictive opinions.

For the "possibility of presenting many examples" code, whilst no pre-service teachers expressed views on this prior to the implementation period, it was seen that the pre-service teachers named Hatice, Berke and Elif stated opinions on this following implementation. The pre-service teachers expressed their views that the wide variety of the rectangular prism surface developments prepared through the Cabri Geometry program was beneficial to the students, with the following statements:

Berke: *''The children have seen the shapes visually, and by varying the shapes with different examples, they are reinforced in the children's minds.''*
Elif: *"We have quickly shown more than one shape at the same time, and they have benefited from seeing different things"*
Hatice: *"We were only able to make two or three shapes before, now we have demonstrated about 11 surface developments there, and there are no longer any questions in the children's minds. No questions remain in their minds at all. Look, here is a surface development, or let it be a square, it doesn't change through 90° so that is the square's common feature.''*

Hatice, made similar statements for the "learning through doing and experiencing" code in the "role of DGS use in teaching and learning" category prior to implementation, but it is noteworthy that her explanations were shorter at that time.

It should be noted that there was no opinion before the

application for this code, but three of the four teachers expressed their opinions after the application and they supported their opinions with their experiences during the application. The pre-service teachers have pointed out the advantage of offering several examples of the same geometric figure. In addition, they also explained that this advantage makes it possible to process several openings without loss of time.

While the code "making students feel that mathematics is valuable", was not present prior to the implementation process, this code was added in line with the pre-service teachers' views, and the pre-service teachers named Hatice and Berke presented their opinions. The views of the pre-service teachers for the "making students feel that mathematics is valuable" code are as follows:

Hatice: *"I saw this at university, for example, we made squares with the Cabri program for the first time there. There is definitely a logic to this, you see, 90° really doesn't change, or look, the sides don't change, they are the same; even I was surprised in the second and third years of university. When children see this, they will show appreciation towards mathematics, they will give value to it, I believe."*

It is seen that Hatice was of the view that the use of DGS in classes can make students feel that mathematics is valuable, and that even they themselves expressed the view that they were affected by the situation. The pre-service teacher named Berke mentioned that when mathematical operations are carried out with their causes, it will be meaningful for students and they will feel the value of mathematics.

Berke: *"Mathematics is not like it used to be, that is to say, now everyone says 'I perform this function, but why do I perform it?' Mathematics is life, mathematics is everywhere now and they are really able to see this."*

The "Permanence and facilitation of learning" code was examined under the code "facilitation of learning" prior to implementation, and the pre-service teachers named Hatice and Miray gave their views, while after the implementation process, Miray, Elif and Berke expressed their opinions. The pre-service teacher named Berke stated that DGS programs, since they concretise what is taught and appeal to more than one of the students' senses, make the things that are learnt permanent, and therefore facilitate understanding.

Berke: *"They will see what is in front of them directly and concretely. When calculating surface area, the students will understand and learn why in fact we have performed that function. With the expansion of the surface, they see directly why we have made that shape, for example, in our day there were no such programs and a formula was given, we did it with a formula, if we didn't l earn the formula we couldn't do it, and we couldn't understand why it was like that. The children see this along with its cause, they know why they perform that function."*

The pre-service teacher named Miray was of the opinion that use of DGS in lessons enables permanence and facilitation of learning by students. Miray explains her views on this topic very briefly before the application, but after the application, she explains her views with different expressions as shown in the excerpt below.

Miray: *"Because of these programs, they perceive things faster and more easily. […] I am talking about a visual material, namely Cabri. When using this material, from a visual point of view, or going to the board and it's a question of an activity, there's an animation, reforming a shape and by doing this it makes it more permanent. Students do not easily forget when lessons are given with such material and their learning is made easier since they are still in 5th grade and making something abstract from something concrete makes things difficult for them. If we can make sure these prisms are animated in their imaginations and support this visually by doing them on the board, the students will have something very permanent there. […] The lessons are very suitable for the students and they have very nice lessons. They understand things more quickly. For the prisms, seeing the surface developments and their reformed shapes with Cabri, even doing this themselves, is very beneficial for their perception of the subject."*

Miray mentioned that learners' motivation increased due to the visual and dynamic properties of the software Cabri. In addition, she explained that students easily understood abstract concepts since they were active during the lessons.

Elif stated that especially when the students saw the geometric shapes converted with Cabri 3D, it was beneficial for them as students. Elif's views based on her experiences are as follows:

Elif: *"I have seen the benefit of two-dimensional shapes, for example when we do them with the coordinate system, and it's lovely from a visual angle. Yes, seeing the conversion of prisms with three-dimensional Cabri 3D is also a very nice thing, it's lovely to see the rear surface if you haven't got material with you. Generally, I cannot say that it wasn't useful."*

The "preventing erroneous mental representations" code was also added after the implementation process, and the pre-service teacher named Berke stated his opinions. Berke was of the opinion that when material is not presented in a concrete way to students, and abstract subjects are taught, students will think according to their own imaginations and therefore, errors or deficiencies may occur in their learning.

Table 3. Positive aspects of operations with the use of DGS.

Category	Code	Relevant pre-service teachers prior to implementation	Relevant pre-service teachers following implementation
Positive aspects of operations with the use of DGS	Efficient use of time	Elif, Miray	Berke, Miray
	Facilitation of teaching	-	Berke

Berke: *"Normally if I teach squares, prisms, or rectangles, etc. to children orally for two or three hours, maybe even at the end of that period the subjects will not be formed in the children's minds, since I explain to them but maybe in each of their minds something else will be formed; they will interpret things according to their own worlds. But this will be concretised and will limit their imaginations a little. Everyone's imagination is different, everyone can produce a different product in their minds, but now this can be limited as we don't direct them to wrong ideas. For pointing them in the right direction, it's a good thing."*

Pre-service teachers expressed shorter and more positive views before implementation. On the other hand, it was noticed that after implementation they often used a wider variety of expressions about their experiences. The codes revealed as a result of the content analysis for the second main category, named "positive aspects of operations with the use of DGS", and the distribution of pre-service teachers with regard to the codes, are shown in Table 3.

For the category named "positive aspects of operations with the use of DGS", from the pre-service teachers' views, only the code ''efficient use of time'' was found before implementation, whereas after implementation, the code named ''facilitation of teaching'' was added to this. It was seen that Hatice did not have any view related with this category when considering her expressions before and after implementation. For the "efficient use of time" code, Miray expressed opinions prior to implementation and stated his view on this category following implementation as well.

The pre-service teacher named Elif presented views on the ''efficient use of time'' code in the "positive aspects of operations with the use of DGS" category prior to implementation, whereas after implementation, she did not give any opinion in this category. While no comments were made by the pre-service teacher named Berke for this category before implementation, it was seen that he made comments on the ''efficient use of time'' and ''facilitation of teaching'' codes following implementation. For the ''efficient use of time'' code, while the pre-service teachers named Elif and Miray expressed opinions before implementation, the pre-service teachers named Berke and Miray stated their views on this after implementation.

Berke: *"As these are abstract subjects, they are really difficult subjects to concretise in the children's minds. Since I presented these visually to the children, I didn't have to deal with them again and again. I saved some more time."*

Berke also argued that the visualization feature of the DGS facilitates the concretisation of the abstract concepts by the students, which leads, according to him, to a faster learning.

Miray: *"In terms of teaching, we have used the time period correctly"*

Miray showed a similarity in his opinions before and after the implementation. According to Miray, by using DGS in teaching, teachers will be able to correctly use the didactic time, be planned and programmed. For the code named ''facilitation of teaching'', which was added in the light of the pre-service teachers' views post implementation, it was seen that the pre-service teacher named Berke expressed views on this.

Berke: *"I have made my teaching a little easier. Indeed, from my point of view, while teaching, it has become more comfortable. Otherwise, it would have been more difficult."*

Berke said that the use of DGS has contributed positively to his teaching, it has facilitated his way of teaching. In the study, the codes revealed as a result of the content analysis for the category named "negative aspects of operations with the use of DGS", and the distribution of pre-service teachers with regard to the codes, are shown in Table 4.

According to the analysis of the views of the pre-service teachers following implementation, the codes ''large class sizes'', "lack of physical facilities in the schools", "worrying about keeping up with the subjects", "inadequacy of teachers", and "preparation period of teachers prior to lessons" were determined for the category named "negative aspects of operations with the use of DGS".

The codes common to the periods before and after implementation for the category named "negative aspects of operations with the use of DGS" were seen to be "lack of physical facilities in the schools" and "inadequacy of teachers". In the light of the views of the pre-service teachers following implementation, the codes "large class sizes" and "worrying about keeping up with the subjects"

Table 4. Negative aspects of operations with the use of DGS.

Category	Codes	Relevant pre-service teachers prior to implementation	Relevant pre-service teachers following implementation
Negative aspects of operations with the use of DGS	Large class sizes	-	Hatice, Elif
	Lack of physical facilities in the schools	Hatice	Hatice, Elif
	Worrying about keeping up with the subjects	-	Hatice
	Inadequacy of teachers	Elif	Hatice
	Preparation period of teachers prior to lessons	Elif	Miray

were added to the category “negative aspects of operations with the use of DGS”. After implementation, in the views of the pre-service teachers, the code named “loss of time” in the use of DGS was removed, as no data for this code was encountered.

The pre-service teacher named Hatice, while stating her views on the “loss of time” and “lack of physical facilities in the schools codes for the “negative aspects of operations with the use of DGS” category in the lessons prior to implementation, expressed opinions on “large class sizes”, “lack of physical facilities in the schools”, “worrying about keeping up with the subjects”, and “inadequacy of teachers” for this category following implementation. The pre-service teacher named Berke, whilst expressing his opinion about the “loss of time” code in the “negative aspects of operations with the use of DGS” category prior to implementation, was not seen to make any comment related with this category in his opinions after implementation. This pre-service teacher stated that he did not see any negativity or disadvantage in the use of DGS.

The pre-service teacher named Elif, stated her views on “inadequacy of teachers”, and ‘‘preparation period of teachers prior to lessons’’ in terms of negative aspects of DGS use in the lessons before implementation, whereas she did not mention anything about these subjects after implementation, and expressed her opinions on the “large class sizes”, and ‘‘lack of physical facilities in the schools’’codes following implementation. The pre-service teacher named Miray, who did not express any views related with the category “negative aspects of operations with the use of DGS” prior to implementation, expressed opinions on the “preparation period of teachers prior to lessons” code for this category in her comments after implementation.

The pre-service teachers stated that because the class sizes were too large for use of DGS in lessons and that it could not be carried out for each student, loss of interest in lessons occurred. They were of the opinion that if a tablet had been available in front of each student for carrying out the activity, it would have been much more productive. ‘‘Large class sizes’’ and ‘‘lack of physical facilities in the schools’’ codes are discussed together in the light of the views of the pre-service teachers. Examples of the pre-service teachers’ comments related with this view are given below:

Hatice: *‘‘Our classes are very crowded; if only I do it on the computer, I cannot maintain their interest, but if they dealt with the tablets themselves, as they are coloured, their attention would be drawn and the one beside the other will say things like ‘I’ve done it, you couldn’t’, and this will encourage the other and so the situation will be turned to our advantage. […] It’s difficult to do it on the board, while I deal with it, they can’t and they start chatting right away. If everyone does it themselves it can be much more effective. If each student has his/her own tablet and everyone can do it, then no disadvantages will remain, in short.’’*

Before the implementation, Hatice mentioned the problem of finding computers for all students; which had been coded in the category '' lack of physical facilities in the schools ''. After the implementation, as she used the common computer of the classroom via a video projector, she expressed her fears about student motivation. According to Hatice, students would have less problem concerning the motivation if they worked with concrete materials.

Elif: *‘‘As a teacher, I close the surfaces of the prism, but it seems to me that if there was a tablet in front of each student for such an activity and if they could all perform that action at the same time, it would be productive. When some of them come up to the board, it gets crowded there, which means that the children want to play this themselves, so if that was possible it would be learnt better, it seems to me. They will experiment themselves, as they experiment with so many things that for technology they only seek to research into things.’’*

Elif also said that students are very interested in technology. According to her, when students are on the board, the interest that is scattered in the classroom begins to revive. Elif also expressed that if each student

has its own tablet, students will complete activities individually and activities will become more meaningful for students. Another code for which the pre-service teachers expressed views on the negative aspect of DGS use was determined as “worrying about keeping up with the subjects”. The pre-service teacher named Hatice mentioned the intensiveness of the teachers’ syllabus and was of the opinion that when lessons were conducted in this way, she could not keep up with the subjects. The pre-service teacher mentioned that she was giving importance to the constructivist teaching model and that she wanted to follow this model. The views of this pre-service teacher on the “Worrying about keeping up with the subjects” code are as follows:

Hatice: *“We say ‘let’s use constructivism’, but if we use it one lesson lasts two lessons, and Cabri is like this; if I use it I have to give two lessons only for this; I will fall behind my fellow teachers. Okay, this is not important either but we do the exams together in this way and they say, ‘why are you behind us?’ In fact, if the state gave us a bit more chance with regard to this, if, for example, they told us that square prisms are a really important subject… So, they will show us the Cabri programs or it is down to the teacher’s own style. If they said, ‘let’s give two or three weeks to this’, I could do this, but in order to keep up with the syllabus I can immediately omit some subjects. Not being able to keep up with the subjects is a disadvantage, in my opinion.”*

Before implementation, the pre-service teacher named Elif stated views on the “inadequacy of teachers” code, but after implementation, the pre-service teacher named Hatice expressed her opinions by relating her own experiences. This pre-service teacher, starting out from her own experiences, explained that the negative aspect of operations with the use of DGS may derive from inadequacy of the teacher, as follows:

Hatice: *“There were a lot of surface developments for rectangular prisms, and I could not even do two of these on the board. As I didn’t have such a program on my computer, I could not repeat them, and the children, because I couldn’t do it this time, changed the page. I think this was a disadvantage from my point of view. I think I displayed negative behaviour here.”*

Prior to the implementation process, no pre-service teachers expressed their opinions on the “preparation period of teachers prior to lessons” code, whereas after the implementation period, the pre-service teacher named Miray stated her views.

Miray: *“We have to set up those programs one by one beforehand, the teacher has to continually prepare those materials one by one in the evenings, and before the lessons, detailed work has to be done.”*

CONCLUSION AND SUGGESTIONS

In this study, an attempt has been made to determine the views of primary school mathematics pre-service teachers towards their experiences of the use of DGS in teaching, following their practicums carried out by using DGS in authentic classroom situations.

Following the results obtained, the views of the pre-service teachers related with their experiences of the use of DGS were separated into three categories, namely the “the role of DGS use in teaching and learning”, “positive aspects of operations with the use of DGS”, and “negative aspects of operations with the use of DGS” categories.

As a result of the study, it was revealed that the pre-service teachers, following the theoretical lessons that they had in the education faculty and prior to their actual teaching practice, gave more limited opinions for all three categories, whereas during the teaching practice period for DGS, following its use in real classroom situations, they expressed more features of the use of DGS. In fact, it was seen that pre-service teachers often expressed their views by giving examples from their own classroom experiences.

The pre-service teachers, in relation to their real classroom experiences, expressed their views on the features “concretisation and visualisation”, “possibility of presenting many examples”, “making students feel that mathematics is valuable”, “permanence and facilitation of learning”, and “preventing erroneous mental representations” with regard to the role of DSG use in teaching and learning.

Yet, prior to using DGS in the classroom, these pre-service teachers had given importance only to the “concretisation and visualisation” and “permanence and facilitation of learning” characteristics. In some researches examining the views of pre-service teachers with regard to computer use in mathematics learning and teaching, similar results like ensuring permanent learning in students, visual quality and concretisation were also obtained (Corbalan et al., 2010; Jassó, 2004; Karatas, 2011; Olkun et al., 2005; Tatar et al., 2014; Usluel and Umay, 2005; Yildiz et al., 2012).

In this study, the future teachers also expressed the view that the DGS would give students the idea that mathematics is valuable. According to the results obtained, following implementation, the pre-service teachers gave their opinions that DGS made positive contributions to geometry lessons in terms of ‘‘efficient use of time’’ and ‘‘facilitation of teaching’’, whereas before implementation, they had mentioned only the ‘‘efficient use of time’’ contribution of DGS. In the literature, several studies report that teachers and pre-service teachers were aware of the positive contributions of use of DGS and that they have expressed views on this (Yesilyurt, 2006; Ayvaci et al., 2007). In this context, the results of this study are in line with the results in the literature.

Another result of the study was that the pre-service teachers, after implementation, expressed their views on several negative aspects related to operations with the use of DGS. These negative aspects expressed by the pre-service teachers cover the subjects “large class sizes”, “lack of physical facilities in the schools”, “worrying about keeping up with the subjects”, “inadequacy of teachers”, and “preparation period of teachers prior to lessons”. While the “lack of physical facilities in the schools”, “worrying about keeping up with the subjects”, and “preparation period of teachers prior to lessons” factors were mentioned only in the interviews following implementation, the “large class sizes” and “inadequacy of teachers” factors appeared in the interviews both before and after implementation.

The studies carried out, despite mentioning negative aspects of DGS for in-service teachers, report that pre-service teachers are not aware of negative aspects related to DGS use (Baki et al., 2009). In contrast, in this study, the pre-service teachers express quite varied opinions on the negative aspects of DGS. In may be considered that in this study, this difference appeared due to the fact that the views of the pre-service teachers were taken based on their actual teaching experiences with DGS. Moreover, unlike the unsupported views of pre-service teachers prior to implementation, their post-implementation views changed based on their classroom experiences. Indeed, after the implementation, the pre-service teachers criticized themselves at the level of the effective use of DGS in the classroom. This may result in a reticence in the use of DGS when they begin to practice their profession.

It can be argued that teachers' experiences in the classroom have helped to clarify their views on the DGS. Niess and Garofalo (2006) argue that experiences with the use of technology as students influence their ways of teaching once they become teachers. In this research it was brought to light that the opinions and beliefs of the pre-service teachers oriented their practice in the classroom. For example, Hatice, although she did not show a negative attitude towards the DGS and she indicated many positive features of the DGS on student learning. However, given that the high school mathematics curriculum is intensive, she expressed her anxiety about not being able to complete the programs because of the time spent on the DGS; she said that she would not use often DGS in her lessons. In this research it was found that teachers' opinions on the use of DGS in teaching had some consistency before and after their classroom experiences. Indeed, Jedeskog and Nissen (2004) also show that teachers' interests, beliefs and opinions directly influence how they build and implement their courses.

Therefore, in order for pre-service teachers, when taking their first steps in teaching, to evaluate the negative aspects of DGS together with its positive aspects, it is important for them to experience learning and teaching environments that integrate DGS in their practicum schools during their teaching practice periods. In this context, it is suggested that the training for the use of DGY in theoretical and practical courses in the undergraduate program will be more positively affect the opinions of the pre-service teachers about the use of DGS.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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