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Pre-Service Elementary Mathematics Teachers' Views On the Applicability of Dynamic Geometry Black Box Activities in Classroom Environment [1]

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ABSTRACT

The Dynamic Geometry (DG) software environment allows students to relate mathematical concepts, create conjectures, rationalize and use different strategies. The DG Environment offers the opportunity to design different activities from paper pencil environment activities thanks to the drag tool. One of these activities is "black box" activities. In this study, it is aimed to determine the pre-service teachers' views regarding the applicability of black box activities in the classroom environment. A sample of the study on qualitative research has been made up of 10 pre-service teachers who have been studying in the last year of a State University's elementary mathematics teaching Bachelor's degree program. Data collected with two feedback forms prepared by the researcher were analyzed using content analysis method. As a result, it was found that the use of black box activities in classroom environment contributed to visualization, concretization and creative thinking within the frame of the pre-service teachers' views.

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1. Background

At the beginning of the lessons most needed to visualise in the teaching of concepts in schools, there is no doubt that mathematics has to contain abstract concepts. Computer-aided instructional environments provide students with opportunities to analyze information, organize data, conduct research-inquiry, think, make decisions, demonstrate and develop problem solving skills within the framework of logic, especially to provide visualization of mathematical ideas (National Council of Teachers of Mathematics [NCTM], 2000). Dynamic Geometry (DG) software environment from computer-aided learning environments gives a different perspective to mathematics with its "dynamic" structure. DG is a technological environment in which the properties of geometrical structures are investigated in experimental processes based on motion and manipulation and the manipulations

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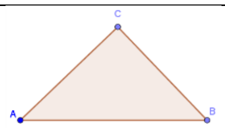
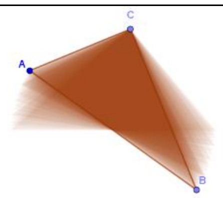
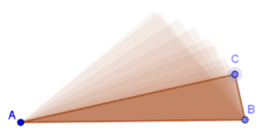
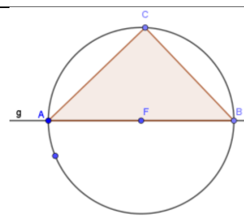
provide visual feedback to the user (Leung, 2008). DG software, such as Cabri Geometry, Sketchpad, provides an interface that makes geometric structures dynamic and includes representation of abstract concepts (Elena & Manuela, 2007). In Mariotti's (2000) statement, DG includes the possibility of direct manipulation of structures compared to the classical world of paper encil drawings, and this manipulation takes place under the framework of Euclidean geometry's logic system. While examining geometrical structures in dynamic software from various angles, determining how they are formed, producing different formation steps, and protecting the structure's characteristics while doing all these steps are followed (Trigo & Perez, 2002). The most significant feature of DG, ensures that geometric structures are constantly changing and transforming. With the drag feature offered by DG environments designed under Euclidean geometry framework, structures do not come out of the framework drawn by Euclidean geometry rules (Hölzl, 1996).

Noss and Hoyles (1996), observed that activities designed in a computer environment developed problem-solving strategies and made generalization easier. Laborde (2001) found that DG activities were effective in the transfer of mathematical concepts to students. The behavior of geometrical structures in the DG Environment contributes to the student’s conjecture by inducing integrative thinking, deductive reasoning and hypothesis (Leung, 2011). Black box activities specific to the DG environment are one of the examples of events designed based on the drag feature in the context of geometric relations with a dynamic structure (Laborde, 2001).

Black box, construction steps unknown to the user a geometric structure, black box activity in this structure to investigate the geometric relations and the same structure is an activity that aims to be created by the user type (Jones, Mackrell & Stevenson, 2010; Laborde, 2000). In Table 1, an example of a black box activity is presented with its background.

Table 1. Black box event example “Triangle” and background

	The black box is given as a triangle. B and C points are dragging points while a point A is a point that cannot be dragged.
	The B point of the triangle is a draggable semi-independent point. As a result of drag in the background, [AB] a diameter of a circle, this circle of the corners of the triangle, is triangle ABC a right triangle, it can be conjectured that.
	The C point of the triangle is a draggable semi-independent point. Similar conjectures can be produced by the drag of point B.
	The black box background is shown on the left. The triangle is a special triangle that essentially accepts the diameter of the inscribed angle as the angle of the apex angle and the diameter as the edge opposite the apex angle.

As shown in the *Triangle* black box activity (**Table *1***), the user can drag to find relationships between structure elements. Galindo (1998), that such activities cannot be applied on geometric drawings in paper, because it emphasized that the drawings were insufficient to reflect all the relations between the components of the geometric structure.

The use of black box activities in classroom environment is important for students to gain mathematical skills such as associating, reasoning and problem solving. In this study, it was aimed to determine the pre-service teachers' views regarding the applicability of black box activities in classroom environment.

2. Methods

In this study, a case study was carried out from qualitative research designs that enable the realization of perceptions and events in a realistic and holistic manner in the natural environment in order to determine the pre-service teachers' views regarding the applicability of DG Environment black box activities to the classroom environment (Yıldırım & Şimşek, 2011).

2.1. Participants

The research group is composed of 10 pre-service teachers who are studying in the last year of a State University's elementary mathematics teaching Bachelor's degree program. In the selection of the research group, criteria sampling was used from objective sampling methods. Objective sampling allows in-depth research of information-rich situations based on the purpose of the study; it is preferable to work with one or more specific situations that meet certain criteria or have certain characteristics (Büyüköztürk, Çakmak, Akgün, Karadeniz & Demirel, 2014). As a criterion, the level of use of DG software is sufficient to take the elective course of "computer assisted mathematics teaching" of the undergraduate program of the pre-service teachers.

2.2. Data Collection Tool and Process

In this study, a research process is planned to determine the applicability of black box activities in the classroom environment, which includes presentation, application and design sections on black box activities. After the first two sections and the last section, two views were prepared to be applied to pre-service teachers. *Feedback form I* was applied before the black box design process of pre-service teachers and *Feedback form II* was applied afterwards. Thus, it was aimed to get more information from pre-service teachers after two different processes as practitioners or designers.

Feedback form questions have been prepared in such a way as to have the ability to reveal the pre-service teachers' views regarding the applicability of black box activities in classroom environment. In the research process summarized in Figure 1, pre-service teachers worked in pairs.

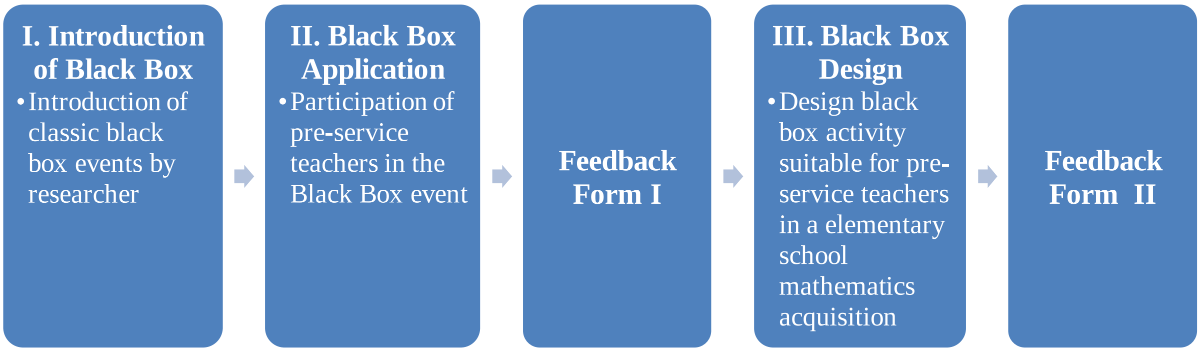
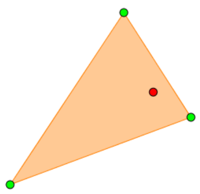
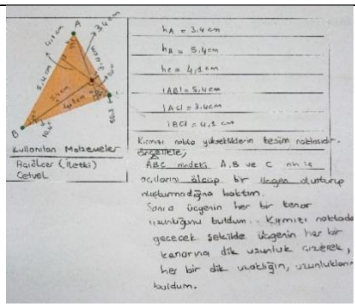
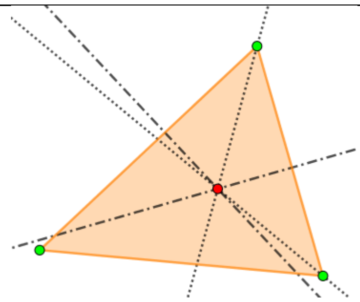


Figure 1. Research process

In the first part, black box logic was introduced to pre-service teachers through classic black box activities.

Then, in the second part, pre-service teachers were asked to solve the effectiveness of three black boxes prepared by the researcher. In order to make pre-service teachers feel that black box activities are powerful activities specific to the DG Environment, the problems involved in black box activities are presented in paper pencil and then in DG GeoGebra software environment. The basic idea in the second part of the paper pencil and DG environments is the conjecture that black box problems can be addressed in the paper pencil environment with more limited solutions. The first activity in this section and a solution to this event in the paper pencil environment are presented in Table 2.

Table 2. The solution of the 1st event in the black box application section by I. group

Activity directive and given figure	Solution in paper pencil environment	Solution in DG Environment
Investigate the relationship between green dots and red dots. 		

* ***Handwriting:*** *"Materials Used Angle gauge Ruler) The Red Dot is the cutting point of the heights. First of all, I looked at the internal angles of A, B and C in ABC and looked at whether it creates. Then I found the length of each edge of the Triangle. I found the lengths of each vertical distance by drawing a vertical length on each side of the Triangle in the form of a red dot."*

If we examine the information in Table 2, it is possible to think that different relationships can be determined between the points with the drag tool in the DG Environment while focusing on the measurement results in the paper pencil environment.

Following the second part of the research process, pre-service teachers were asked to fill out a written form of two questions about the contribution of activities to mathematics teaching and applicability to the classroom environment. Feedback form I from the feedback forms used as data collection tool *"Compare activities in terms of contribution to mathematics teaching in the context of paper pencil environment and Dynamic Geometry (DG) Environment"* and *"What do you think about the use of activities in a school environment?"* made up of questions.

In the third and final part of the research process, pre-service teachers were asked to choose again from the elementary school mathematics course curriculum and design a black box activity suitable for this gain. The purpose of this section is to pre-service teachers with an idea of applicability in classroom environments by experiencing the process of black box activity at the elementary school level.

Finally, to the pre-service teachers *"What are the points you pay attention when choosing to win for black box activity?"* and *"Please write down the difficulties you face during the preparation of the event"* is presented in the Feedback form II. With the questions of Feedback form II, it is aimed to get the experiences of designing black boxes and ideas of pre-service teachers for application in the classroom environment.

2.3. Data Analysis

The data of the study were analyzed using the content analysis technique from the document review methods. Content analysis is one of the most important techniques in the field of Social Sciences and is defined as a systematic, repeatable technique in which some words of a text are summed up with smaller content categories by coding based on specific rules. (Büyüköztürk vd., 2014). By examining the written data obtained from the Feedback forms, the data are encoded in accordance with the purpose of the research and the data is encoded at the general level. The determined categories are formed as tables and interpreted by giving the direct quotations from the pre-service teachers' views. Pre-service teacher groups were named G1, G2, G3, G4, G5 respectively.

3. Results

The pre-service teachers' views about the applicability of the black box activities to the classroom environment were collected in three categories as *"contribution to mathematics teaching"*, *"black box activity design/relation between elementary school mathematics"* and *"black box activity design/implementation challenges"* on the basis of the information obtained from the Feedback forms and presented in **Table 3**.

Table 3. Pre-service teachers' views on the applicability of black box activities to classroom environment

Codes	Categories	Groups				
		G1	G2	G3	G4	G5
Contribution to mathematics teaching	Using the dynamism and drag feature	x	x	x	x	x
	Visualizing and embodying	x	x	x	x	x
	Effective use of time		x	x	x	x
	Constructivist approach	x			x	x
	Measuring using the tools		x	x		x
	Mathematical relationships	x		x		
	Making conjectures	x				x
	Creative thinking				x	x
Black box activity design/ elementary school mathematics relationship	Transference to DG environment	x	x	x		x
	Configurability of information	x		x		x
Black box activity design and application difficulties	DG technical usage adequacy	x	x	x		x
	Transference of acquisition to DG Environment	x		x		x
	Time neccessity	x				x

The findings are organized into three titles considering these categories.

3.1. The pre-service teachers' views on the contribution of black box activities to mathematics teaching

When Table 3 is examined, it is observed that all of the groups have included the view that black box activities contribute to mathematics teaching with the *"benefiting from dynamism and drag characteristics"* and *"visualization and concretization"*. These views are followed by four groups with *"efficient use of time"*, three groups with *"capability of measuring"* and *"constructivist approach"*, and two groups with *"mathematical association"*, *"assumption/development of strategy"* and *"creative thinking"*.

For example, the views of G1 and G5 are given below.

> *"We have tested the accuracy of our conjectures in the paper and pen environment in the DG Environment. We saw dynamically that some of our conjectures were not true. We have seen the relationship between the DG Environment and the dots more clearly. While we could not move the dots in a paper environment, we had the opportunity to test our conjectures by moving the dots in the DG environment." (G1).*
>
> *"It can be difficult to see shapes because they cannot be played on a fixed shape using different tools in a paper pencil environment. However, exploring in a DG Environment is easier than in a paper pencil environment, and it is easier to see the shape's formation stages using the tools in the toolbox in GeoGebra, moving the points where the shape is formed." (G5)*

The subjects that the pre-service teachers are generally agree (*benefiting from dynamism and drag characteristics, visualization and concretization, efficient use of time, capability of measuring*) is about the specific characteristics of DG environment. The fact that the paper and pencil environment is not dynamic to disclose mathematical relations and cannot allow for precise measurements on mathematical structures is indicated as a disadvantage compared to DG environment.

3.2. Pre-service teachers' views regarding the suitability of black box activity design for elementary school mathematics teaching program

It was observed that the pre-service teachers, about the suitability of the black box activity design to mathematics teaching program, expresses the views of "transferability to DG environment" (four groups) and "configurability of the knowledge" (three groups) (Table 3). Below are the views of G1, G3 and G5 groups.

> *"I make sure that the students are capable of being able to understand visually, to be able to solve a variety of conjectures. I'm careful to choose the right acquisition of Geogebra tools." (G1)*
>
> *"We have chosen a topic that we can pour more easily into the visual gain. That's why we took care to choose about geometry. (G3)*
>
> *"It is more appropriate to choose abstract topics that are easy to visualize, which can be created in accordance with the Geogebra tools, which are difficult for students or which are not fully visualized in their minds. These things need to be taken care of." (G5)*

The *"transferability to DG environment"* of the achievements means that the achievement can be visualized and the created black box visual will be suitable for the student. And the determination of the achievements according to *"configurability of the knowledge"* is seen as an important characteristic for student to live processes of assumption and strategy producing in DG environment.

3.3. Pre-service teachers' views on design and implementation difficulties in black box activity

The pre-service teachers state that they had a hard time in black box activity design and implementation processes in *"transferability to DG environment"* and *"configurability of the knowledge"* subjects (Table 3). For example, the views of G1, G3, and G5 are given below.

> *"Students may have to spend a lot of time because it is an activity that needs reasoning and thinking." (G1)*
>
> *"It was hard to think of events and adapt them to win. Or choosing the win and narrowing the boundaries narrowed my sample area. I had difficulty adapting some of my favorite ideas to GeoGebra because of my lack. This is back as a waste of time and effort." (G3)*
>
> *"The stage of designing the event and the steps to be followed in creating the event was the part that I had difficulty thinking about how to create it. In addition, after I chose to win, I had difficulty in using which tools I could create […] It may take some time to learn about black box activities. This may change according to the win we choose. But some students can be difficult to achieve and can lead to a loss of time." (G5)*

The process of designing a black box activity requires a technical knowledge accumulation beyond the basic level. The fact that the activity type was different from the paper and pen environment as a kind of activity, forced the pre-service teachers to mathematically adaptation and therefore the design process took time.

4. Discussion, Conclusion, and Suggestion

In this study, it is aimed to determine the pre-service teachers' views about the practicability of DG environment black box activities to the classroom environment.

When the pre-service teachers' views about the contribution of black box activities to mathematics education are examined, it is observed that the dynamic and drag contributes to the learning of the students, and that they have a positive effect on the mathematical association, hypothesis and strategy development skills. In this respect, Baccaglini-Frank and Mariotti (2010) examined the cognitive processes caused by the drag feature and concluded that the activities designed based on the drag feature contribute to the reasoning, conjecturing and testing of the students by using them in the classroom environment. Leung and Lee (2014) found that design and implementation of activities in the DG environment provided a rich information about how students perceive geometrical relationships and provided better understanding.

Here presented pre-service teachers' views about the black box activity design was compatible with elementary school mathematics curriculum, and according to this, they stated that they see them as an important feature in terms of visualization of achievements, visualization of the black box image to be formed, and that the student being able to experience the assumption and strategy production processes in the DG environment. Komatsu and Jones (2018) concluded that DG is an important instrument in terms of activity design in educational environments, and that it provides students a learning environment through discovery and provides the opportunity to obtain information successfully with different strategies. Laborde (2001) states that DG black box activities are a type of activity that supports the emergence and validation process of the assumptions and the dynamic invariants of the geometrical structures. Also, Mogetta, Olivero and Jones (1999) concluded that DG environment activities can increase students' motivation during the proof process and can be used in cognitive development process.

In the research, pre-service teachers stated that the use of black box activities in the classroom environment contributed to the visualization and concretization of abstract mathematical structures and the students' creative thinking. Similarly, Barrera and Santos (2001) found that it helps on seeing different dynamic representations of the structures, visualization and concretization of connections by the students and recognizing the other solutions of the problem. The paper and pencil environment is disadvantageous with respect to the DG environment since it is not dynamic and is not suitable for precise measuring on mathematical structures. In their study, Clements and Battista (1994) concluded that computer environments help to break down the stereotypes arising from the limited responses in the mind of the students (previously formed well-defined schemes), to make discoveries and to bring about the dynamism of structures.

According to the results of the research, some suggestions are made to the following researches and mathematics educators about the DG environment black box activities. Documents and activities that introduce the DG environment and its use can be prepared. In order to give teachers an idea that mathematics subjects can be transferred to the DG environment, suitable activities to the curriculum outcomes can be designed and integrated into the lesson sources.

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