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PRE-SERVICE ELEMENTARY MATHEMATICS TEACHERS' VIEWS ON GEOMETRIC CONSTRUCTIONS: BUILDING ON PAPER OR INTERACTIVE WHITEBOARD?¹

Research Article

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PRE-SERVICE ELEMENTARY MATHEMATICS TEACHERS' VIEWS ON GEOMETRIC CONSTRUCTIONS: BUILDING ON PAPER OR INTERACTIVE WHITEBOARD?²

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Abstract

This study examined pre-service teachers' views and experiences of building geometric constructions on paper and with the interactive whiteboard. The study group consisted of 26 pre-service elementary teachers in a state university in the Black Sea region of Turkey who took the Geometry Teaching course. The data were obtained from an opinion form consisting of open-ended questions and field notes. Findings revealed that almost all of the teachers had no experience with geometric constructions in their previous education and the majority of pre-service teachers' opinions about geometric construction activities are positive. They experienced more problems when building geometric constructions on the interactive whiteboard so their opinions about building geometric constructions on paper are more positive than building on the interactive whiteboard. Moreover, it was determined that pre-service teachers' views imply that building geometric constructions on the interactive whiteboard makes sense in the affective learning domain, whereas building on paper contributes more to the cognitive learning domain.

Keywords: geometric construction, compass and straightedge, interactive whiteboard

1. Introduction

The basis of the Euclidean geometry is constructions made by using the compass³-straightedge⁴ that Euclid included in the Book of Elements about 2300 years ago (Martin, 2012). The constructions are at the center of the methodology of geometry (Kellison, Bickford & Constable, 2019) and they can also be called compass and straightedge constructions (Erduran & Yeşildere, 2010; Öçal & Şimşek, 2017), basic geometric constructions (Karakuş, 2014) or Euclid constructions. Schreck (2019) stated that in the development of geometry these constructions which were made with only straightedge and compass play a fundamental role. Because of not measuring angles and lengths while drawing geometric figures, construction has a specific meaning (Hartshorne, 2000). Because some geometric concepts are abstract for students, teaching geometric constructions well and linking them to physical constructions makes concepts more concrete in students' minds (Chikwere & Ayama, 2016). Nowadays, although different constructions can be made with

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³ This can be used to draw circles or arcs. The radius can be fixed by placing the pin at one special point and at another special point.

⁴ This is a ruler without markings on it. It can be used to draw straight lines. It cannot be used for measuring.

mathematics teachers about geometric construction activities. The results of this study show that prospective teachers are not very likely to encounter such building activities in their educational backgrounds. He also pointed out that pre-service teachers' thoughts on geometric construction activities were positive and that these activities helped students learn better, but they had difficulty in using the compass and the straightedge when deciding on the construction stages. Gür and Kobak-Demir (2017) examined the effect of basic geometric drawings on pre-service teachers' geometric thinking levels and attitudes towards mathematics. At the end of their study, they stated that constructing basic geometric drawings with ruler and compass improved prospective teachers' geometric thinking levels and attitudes towards mathematics.

With the recent developments in technology, computers, projection devices, interactive whiteboards and tablet computers have started to be used inevitably in the learning-teaching process (Dağhan, Kibar, Akkoyunlu & Atanur-Baskan, 2015). Interactive boards are one of the teaching tools that are widely used in the learning-teaching process (Yanpar Yelken, 2011). Turkey planned to equip all classrooms with interactive boards with the FATİH project (Movement to Enhance Opportunities and Improve Technology) whose goal is to adopt information technology-based education at preschool, primary and secondary education level since November 2010 (MEB, 2011). These interactive boards are equipped with Starboard Software, which provides a variety of tools for teachers and students to use the board efficiently. Some classroom accessories are provided as default functions Menu>Tools>Accessories. Using these tools, geometric drawings can be made on the interactive whiteboard.

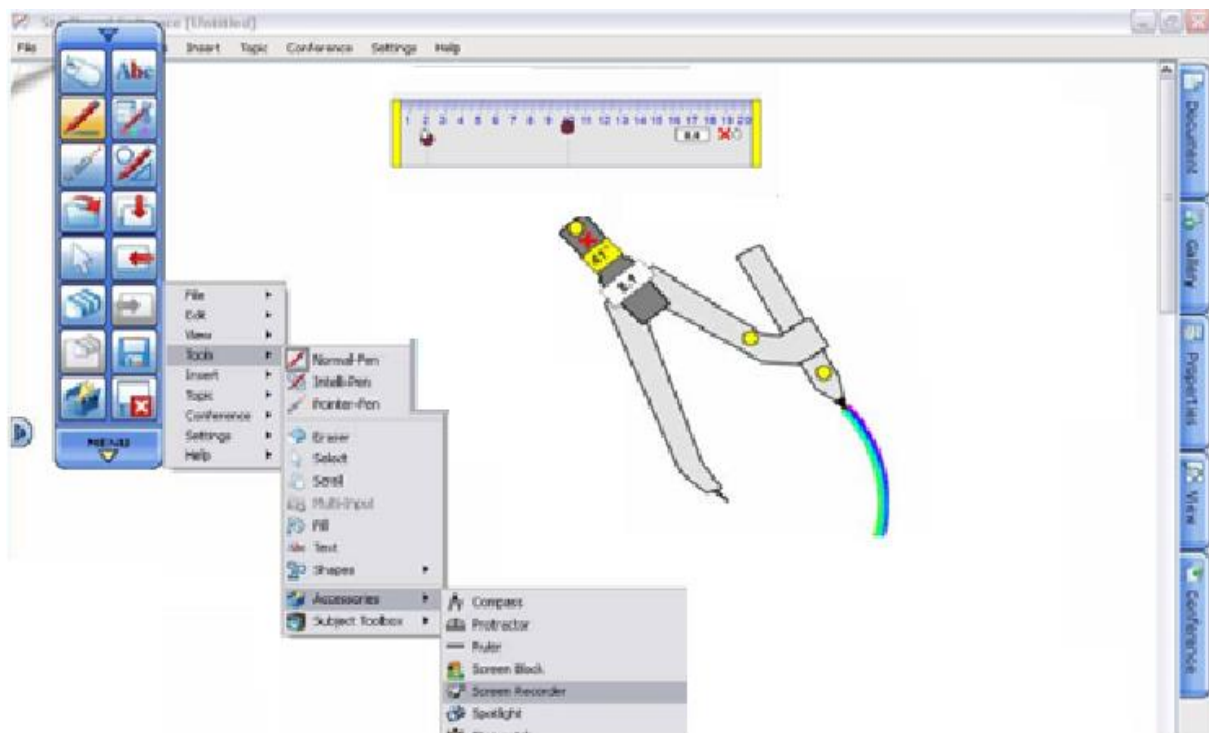


Figure 2. Accessories menu on the interactive whiteboard

The effective use of intelligent whiteboards by teachers in the learning environment will undoubtedly positively contribute to the learning-teaching process. Studies on the use of interactive whiteboards in learning-teaching environments show that, when used together

with materials and activities appropriate to the goals contained in the curriculum, the interactive whiteboard supports learning-teaching, increases student motivation and enables more effective and efficient use of time (Glover, Miller, Averis & Door, 2004; Lewin, Somekh & Steadman, 2008; Smith, Hardman & Higgins, 2006; Smith, Higgins, Wall & Miller, 2005). It is important that prospective teachers, who will be the teachers of the future, are trained in the use of these technologies.

This study focuses on the pre-service teachers' views and experiences of building geometric constructions on paper and with the interactive whiteboard. In this context, the aim is to determine how the pre-service elementary mathematics teachers' opinions about geometric construction activities change according to the tool (concrete material or interactive whiteboard) they use. Within this scope, answers to the following questions were sought:

- 1) What are the past experiences of pre-service teachers about geometric construction activities?
- 2) What are the opinions of the pre-service teachers regarding geometric construction activities on paper and with interactive boards?
- 3) What are the problems faced by pre-service teachers in the process of completing geometric construction activities on paper and with interactive whiteboard?

2. Method

In this study, which aimed to determine the views of pre-service elementary mathematics teachers about geometric constructions, the case study which is one of the qualitative research designs was used. The reason for the use of the case study method is that it gives the researcher the opportunity to describe in detail the particular cases studied by focusing on a very specific topic or situation and to explain the causal relationship between the variables (Patton, 2005; Yin, 2003).

2.1. Study Group

The study group consisted of 26 pre-service elementary teachers in a state university in the Black Sea region of Turkey who took the Geometry Teaching course in the last semester. Participants were purposely selected via criterion sampling. The criterion was taking the Geometry Teaching course.

2.2. Course Content and Process

A part of this elective course included the following basic constructions: congruent segment, segment bisector, congruent angle, angle bisector, a line perpendicular to a given line through a point not on the line, a line perpendicular to a given line through a point on the line, and a line parallel to a given line through a point not on the line. Then activities about construction triangles (Angle-Side-Angle (ASA), Side-Angle-Side (SAS; Figure 3), Side-Side-Side (SSS), Side-Side-Angle (SSA) and Angle-Angle-Side (AAS)) were completed.

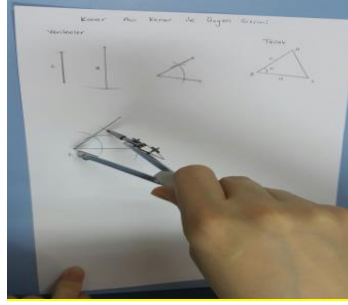


Figure 3. Construction of Side-Angle-Side (SAS) Triangle on paper

After that, the construction of triangles given with auxiliary elements was carried out. Additionally, some challenging problems were included such as inscribing a circle in a triangle and circumscribing a circle around a triangle (Figure 4).



Figure 4. Construction of circumscribed circle on a triangle on the interactive whiteboard

2.3. Data Collection Tools

The data were collected with an opinion form consisting of open-ended questions after the completion of geometric construction activities covered in the Geometry Teaching course. In this form, pre-service teachers were asked about their previous experiences with geometric constructions, their views on building geometric constructions on paper and with the interactive whiteboard and the problems they encountered during the construction process. Pre-service teachers were observed while making the geometric constructions and field notes were kept during this process.

2.4. Data Analysis

The data were organized and interpreted according to the sub-problems of the research. In this context, firstly the answers of each pre-service teacher to each question in the opinion form were examined and the codes and themes were formed by placing the same or similar expressions together. Then the frequency and percentage values of the answers were calculated. The double-coding procedure was used for the reliability of data analysis. The data were re-coded by a mathematics educator who is an expert in qualitative research. The inter-coder reliability coefficient was computed by using the formula recommended by Miles and Huberman (1994) and the subject value was calculated as 83%.

3. Findings

In this section, the findings obtained in the research process are presented according to the sub-problems of the research.

3.1. Pre-service Teachers' Past Experiences of Geometric Construction Activities.

The data obtained from the research showed that almost all (96%) of the pre-service teachers had no experience with geometric construction activities.

I did not make any drawings with interactive whiteboard before this lesson. I did not have any experience with the compass and straightedge (PST-19)

I do not have experience in both. (PST-15)

3.2. Pre-service teachers' opinions regarding the geometric construction activities on paper and the interactive board

After examining elementary pre-service teachers' statements about geometric drawings, a classification was made about positive opinions, negative opinions, and conditional opinions. The codes created by using pre-service teachers' opinions about geometric construction activities formed the theme called *positive opinions* which is presented in Table 1.

Table 1 shows that pre-service teachers have more positive opinions about geometric constructions using concrete material (compass-straightedge) and building geometric constructions on paper. Twenty-nine (53.7%) of the positive opinions were related to the use of compass-straightedge on paper, and 25 (46.3%) to the use of the interactive whiteboard. Some examples of pre-service teachers' expressions are given below:

I think it is useful for students to use compass-straightedge as a concrete material instead of drawing by using the interactive whiteboard.

The use of compass-straightedge can better support learning by doing, rather than the interactive whiteboard.

Table 1. *Pre-service teachers' positive opinions about geometric construction activities*

	Positive opinions	On paper		On the interactive whiteboard		Total	
		f	%	f	%	f	%
Codes	Permanent learning	8	30.8	1	3.8	9	34.6
	Concrete learning	8	30.8	1	3.8	9	34.6
	Support for learning	7	26.9	1	3.8	8	30.8
	Enjoyable	-	-	5	19.2	5	19.2
	Saving time	-	-	4	15.4	4	15.4
	Smooth drawing	-	-	4	15.4	4	15.4
	Motivational	-	-	3	11.5	3	11.5
	Practical	-	-	3	11.5	3	11.5
	Helping to figure out where it originated	3	11.5	-	-	3	11.5
	Remarkable	1	3.8	2	7.7	3	11.5
	Useful	2	7.7	1	3.8	3	11.5
	Developing imagination	-	-	1	3.8	1	3.8
	Total	29	53.7	25	46.3	54	100

Pre-service teachers suggested that the constructions made by both the compass-straightedge and the interactive whiteboard are useful for grasping how the geometric drawings are made (30.8%) and contributing to the concretization of the geometric concepts (34.6%).

The phenomena that are abstract in both our and students' brains will be embodied, and students will understand the rationale of the subject.

More concrete drawings are made by touching and feeling, learning is provided in practice, not in theory.

There were more positive opinions which claimed that compass-straightedge construction activities contributed more to permanent learning (30.8%), more concrete learning (30.8%) and supported learning (26.7%) more than the interactive whiteboard. Some example views are as follows:

We can focus more on the shape we draw when drawing on paper, so we learn more permanently.

When we draw on paper it becomes more concrete, the drawing steps are better understood.

We can better understand the reason for the drawing steps, which also supports our learning.

On the other hand, the pre-service teachers said that the drawings made on the interactive whiteboard were more enjoyable (19.2%), smooth (15.4%), motivating (11.5%), and practical (11.5%) and also drawing in this way saved time (15.4%) and developed imagination (3.8%). Some sample opinions are as follows:

Drawing on the interactive whiteboard is more enjoyable, you can choose a color, you can get a bigger image when you zoom in, and so you can see the points where the arcs intersect better.

....The shapes that appear on the interactive whiteboard are smoother.

Drawing on the interactive whiteboard is more practical, just enough to choose the appropriate tool.

....It takes little time to draw on the interactive whiteboard.

It is more useful, we can go back, check the steps. We can click “undo” when we make the wrong drawing and try to correct it without using an eraser.

The codes created by using pre-service teachers’ opinions about geometric construction activities forming the theme called *negative opinions* are presented in Table 2.

Table 2. Pre-service teachers’ negative opinions on geometric construction activities

	On paper		On the interactive whiteboard		Total	
	f	%	f	%	f	%
Time-consuming	2	7.7	2	7.7	4	15.4
Difficult	-	-	4	15.4	4	15.4
Total	2		6		8	30.8

Table 2 shows that some pre-service teachers stated it was time-consuming to make geometric drawings on both interactive whiteboard (7.7%) and paper (7.7%). In addition, some of the pre-service teachers used expressions such as it was difficult to draw on the interactive whiteboard (15.4%). Some of these views are given below:

Geometric constructions are time-consuming; we do not know how to get started.

It is very difficult to draw on the interactive whiteboard. It may feel like a different activity to the students but it is time-consuming...

It is difficult to make geometric constructions on the interactive whiteboard. We have difficulty while drawing, especially when holding and rotating the compass...

When drawing on paper, it is easier to cope with the compass; it does not slip from your hands...

The codes created by using pre-service teachers’ opinions about geometric construction activities making the theme called *conditional opinions* are presented in Table 3.

Table 3. *Pre-service teachers' conditional opinions*

	On paper		On the interactive whiteboard		Total	
	f	%	f	%	f	%
Effective when practical	-	-	2	7.7	2	7.7
Loss of time if not used efficiently	-	-	1	3.8	1	3.8
Total	-	-	3	11.5	3	11.5

As seen in Table 3, some of the pre-service teachers indicated that drawing on the interactive whiteboard is more difficult and the inefficient use of the interactive whiteboard leads to a waste of time. A sample view is as follows:

I think it's a good practice. I think that when you draw geometric shapes for those who use the interactive whiteboard actively, you will save both time and form smoother shapes. But for teachers who cannot use it efficiently, it will be a waste of time.

3.3. Problems faced by pre-service teachers in the process of completing geometric construction activities

From the viewpoint of problems encountered, it was understood that the pre-service teachers stated they did not encounter too many problems when using concrete material (building geometric constructions on the paper). On the other hand, it was revealed that pre-service teachers had problems in locating the drawing tools on the board while they were making the same drawings on the interactive whiteboard. They also indicated that measuring the distance between two points using the compass and marking the cut-off points of the arcs (any part of a circle) is more difficult on the interactive whiteboard.

The interactive whiteboard is very sensitive. For example, when drawing an arc with a compass and marking that same arc from a particular point of the line segment, I usually have problems. I experienced no difficulties when I draw using the compass and straightedge.

I had a perception problem because of the interactive whiteboard touch.

When I used it (interactive whiteboard) for the first time, I had difficulties in locating and changing the direction of the drawing tools.

4. Discussion

Findings from the first sub-problem of the study show that almost all of the pre-service teachers have no experience with geometric drawings. This may be due to the fact that the teachers they met in past educational experiences did not attach importance to the purpose and meaning of geometric construction activities (Erduran & Yeşildere, 2010; Karakuş, 2014). This means that the construction process, which is an important component of the geometry learning process (Duval, 1998) is lacking and does not get the necessary attention in mathematics (Pandiscio, 2002). Although there are gains for geometric construction activities at various levels of the education system, it is necessary for teachers to recognize the role of these activities in learning geometry and to plan their lessons by taking the necessary and sufficient time for these activities.

It was determined that the majority of pre-service teachers' opinions about geometric construction activities are positive. This result is parallel to the results of some studies in the literature (Cheung, 2011; Erduran & Yeşildere, 2010; Karakuş, 2014; Napitupulu, 2001). On the other hand, pre-service teachers suggested that the construction using both methods is beneficial in understanding how geometric drawings are made and contributes to the concretization of geometric concepts. However, it was determined that the pre-service teachers have more positive opinions about the same activities on paper using concrete material. Yazgan-Sağ and Emre-Akdoğan (2016) stated that the use of compass and straightedge provides a more realistic environment for students to see cause-effect relations, reasoning and questioning.

Pre-service teachers suggested that geometric drawings made on the interactive whiteboard are both time-saving and time-consuming. This result is in agreement with the results of studies carried out with the teachers regarding interactive whiteboard usage (Birişçi & Çalık-Uzun, 2014; Kurt, Kuzu, Dursun, Güllüpınar & Gültekin, 2013). Pre-service teachers who evaluated the interactive whiteboard as a time-saver pointed out that shapes such as segment, triangle etc. used in geometric construction are readily available in the interactive whiteboard tools. They stated that the possibility of recording the stages of the drawing made on the interactive whiteboard gives them the flexibility to go back, recall and check the steps of the process. They also described the "undo" feature in the toolbar as a time-saver because of the possibility of being able to remove previous steps without using an eraser. So, we can say that some results of this study are similar to various studies indicating that the use of interactive board helps teachers to save time (Baydaş, Esgice, Kalafat and Göktaş, 2011; Pamuk, Çakır, Ergun, Yılmaz and Ayas, 2013). On the other hand, pre-service teachers stated that geometric drawings on the interactive whiteboard are time-consuming and difficult because of some problems such as locating the tools which are necessary to build constructions, holding and rotating the compass, measuring the distance between the points using the compass and marking the cut-off points of the arcs. We can say that this result is similar to the results of Birişçi and Çalık-Uzun (2014), who stated that teachers experienced difficulties in using the interactive board. This means that pre-service teachers experience more problems when building geometric constructions on the interactive whiteboard.

Türel and Johnson (2012) noted that teachers have the idea that interactive whiteboards enhance student motivation. Some pre-service teachers' views were determined to be similar in this study because they stated that building geometric constructions on the interactive whiteboard was motivating and enjoyable. It was understood that none of these features related to the affective domain were mentioned for drawing geometric constructions on paper. Therefore, we can say that pre-service teachers consider that drawings on the interactive whiteboard contribute to the affective domain of learning. On the other hand, building geometric construction activities on paper was found to contribute more to permanent learning and concrete learning by the pre-service teachers. In terms of the cognitive domain, it is understood that prospective teachers think that geometric constructions on paper are more effective. Erduran and Yeşildere (2010) also stated that compass and straightedge are tools that help students to discover the properties of geometric shapes and gain better insights about these geometric shapes. In this study, we can also say that the subjects mentioned by Erduran and Yeşildere (2010) were expressed by pre-service teachers.

Considering all these results, pre-service teachers believe in the importance of geometric construction activities even though they experienced some problems. Pre-service teachers who will become teachers in the future are advised to deal with more geometric drawing

studies during the undergraduate education process. In teaching mathematics, the integration of suitable tools and technologies is seen to be a very important theme (Kuzle, 2013). So it is thought that pre-service teachers should have experience in geometric constructing tasks with different tools. For example, in order to support the development of the students' geometric reasoning, it is suggested that both geometric software and classical geometric tools should be used in teaching environments (Köse, Tanışlı, Erdoğan & Ada, 2012). But while integrating the tools in mathematics teaching some dimensions such as the relation between the tool and learning, characteristics of technological tools have to be taken into account (Barzel, Drijvers, Maschietto & Trouche, 2005). We believe that geometric construction activities with different tools and dynamic software (Geogebra, Geometer's Sketchpad etc.) will provide a different view on the subject. Moreover, pre-service teachers should have the opportunity to discuss curricular and pedagogical issues before becoming in-service teachers (Kuzle, 2013). In order to minimize the problems encountered in practice, it is recommended necessary and sufficient information is learned and more practical applications are performed.

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