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Analysis of Geogebra Activities and Opinions of Primary Mathematics Teacher Candidates

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Abstract

The research aims to examine the activities of primary mathematics teacher candidates with the help of Geogebra, dynamic geometry software, and their perspectives on Geogebra software. The working group consists of a total of 52 teacher candidates who studied in the spring semester of the 2020-2021 academic year of a state university in Eastern Anatolia. Research process that continues for a period (14 weeks - 28 hours); The introduction of Geogebra was made by actively processing the learning areas of triangles, polygons and quadrilaterals, geometric objects and transformational geometry with Geogebra. The mistakes made after the activities given in the middle of the semester and at the end of the semester were carried out by the teacher candidates were explained through intra-classroom discussions. A semi-structured open-ended question form was used as a data collection tool. In line with the findings, it was observed that some teacher candidates structured random shapes without knowing some characteristics that were obligatory to be in geometry and geometric objects. This was due to the lack of knowledge of the teacher candidates. It has been determined that teacher candidates who have the opportunity to think about the causality of rules and formulas have positive opinions such as interest, motivation increase, desire to use again. As suggestions of the research, some recommendations were made in the form of establishing Geogebra software in possible schools, introducing teachers and students, carrying out actions encouraging them to use actively, and teaching geometry and geometric objects by reification them.

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Introduction

Geogebra software, which was carried out in 2001-2002 by a group led by mathematicians Dr. Markus Hohenwarter and Dr. Zsolt Lavicza, was designed as a highly effective interface from primary school desks to top-level mathematics and geometry teaching (Kabaca et al., 2011). Geogebra software, which is configured in a master's thesis as a special dynamic mathematics software, is known to be very effective in embodying disciplines in mathematics and sub-branches and bringing them to the student, benefiting from creative thinking, information technologies, making decisions, planning, analyzing, interpreting and transferring information (Kan, 2014). In addition, both the fact that it can be used in Turkish and that it has a free, public version makes this application useful and interactive (Doğan, 2013; Kabaca et al., 2011; Sümen, 2013). Geogebra computer, which is dynamic geometry software, is very effective in the teaching of geometry, which is a sub-branch of mathematics thanks to its algebra and geometry systems, graphic window, toolbar, algebra window, function input area and menu bar (Küçük, 2019). It is also an application that provides convenience in the selection and drawing of geometric shapes (Hot, 2019), which can be algebraic when working on the shape (Uzun, 2014). The software's ability to show the relationships between these fields by combining the disciplines of geometry, algebra and analysis has resulted in an increase in the variety of mathematical subjects (Hohenwarter & Lavicza, 2007). Package programs such as this offer the learner the opportunity to draw shapes and examine the accuracy of the drawn shape (MEB, 2009).

Geogebra, which offers the opportunity to learn online interactively, is known to be highly effective in discovering and configuring basic concepts. It can also be used effectively in the construction sector (Tamam & Dasari, 2021), fast and accurate drawing, animation, virtual screens, visual experience, proofing methods (Mahmudi, 2010) and measurement evaluation. In addition, geogebra software is preferred by both tutorials and students around the world to have a free, dynamic structure, widespread use and the existence of existing interface functionality (Er & Sağlam-Kaya, 2017), interactively include mathematical concepts such as algebra and table, bring together different aspects of mathematics, and be an easy-to-use software (Hohenwarter & Lavicza, 2007).

There are many studies in this field. Septian and his colleagues (2020) compare the mathematical representation abilities of candidates using GeoGebra in integral with the general and prerequisition abilities among candidates with traditional learning. Within the scope of the study, it was observed that many teacher candidates had difficulty creating graphics and visuals. It has been observed that the representation ability of teacher candidates using GeoGebra is better than that of teacher candidates with traditional learning. Later, his work compared the representation skills of the students who worked with Geogebra and received only project-based training with the representation skills of the teacher candidates. As a result, students who received a GeoGebra-supported project-based learning model were found to have better mathematical representation skills. Wijaya and his colleagues (2020) used Geogebra software to teach plane vectors using Van Hill Theory to showcase abstract geometric knowledge and direct students to perform dynamic operations. As a result of the study, it was seen that geogebra gradually helps students transition to point-to-surface vector processing and increases the efficiency of teaching. Thus, it has been determined that it forms a good geometric basis in geometry teaching. Suryani and his colleagues (2020) conducted a study on the teaching of triangles using GeoGebra in Indonesia. GeoGebra-based geometry learning modules were produced within the scope of the study. This learning module is different from other modules, which requires teachers to use Geogebra in their learning. Especially in the triangle, it has been seen that it supports the creativity of students in learning geometry. In addition, it has been determined that it provides individual learning based on the problems given. As a result, it can be said that this innovative technology-supported teaching method is among the most recommended and used software (Zakaria & Lee, 2012).

The purpose and significance of the study

The aim of the research is to analyze the activities created by primary mathematics teacher candidates with "GeoGebra" software and the opinion analysis for "Geogebra" software. In the field writing, it is seen that dynamic geometry software is usually used in primary and secondary education (Şahin & Kabasakal, 2018; 2021). Considering the large number of studies in which dynamic software reveals significant statistical differences in motivation, success and permanence, it suggests that Geogebra should also be used in higher education (Şimşek & Yaşar, 2019). In line with the studies carried out; it can be said that the fact that there are very few studies in the field of mathematics education in higher education and colleges increases the importance of this study.

Method

In this study, an special case from qualitative research methods was used. Special case studies offer the opportunity to examine any subject or concept in detail and in depth. In addition, the data obtained can systematically examine the relationship between each other and explain this relationship within the framework of cause and effect. The data obtained in this process are conceptualized first, then these concepts are properly edited and explanatory themes are created (Yıldırım & Şimşek, 2018). In this direction, special situation method was used to examine in depth and detail the opinions of the GeoGebra software used in the teaching of geometry and geometric objects of teacher candidates.

Participants

The sample of the study consists of a total of 54 primary mathematics prospective teachers who are studying in the spring semester of the 2020-2021 academic year of a state university located in the Eastern Anatolia region.

Data collection tool and application process

In research, the data collection tool consists of activities that are carried out by teacher candidates throughout the semester. Activities are included in Annex 1. In addition, the semi-structured interview form prepared by the researcher was used as an Annex 2 data collection tool.

The first two weeks of the research process have been spent introducing the basic tools in GeoGebra software. In addition, teacher candidates are supported by the course from the https://www.geogebra.org/ site and with links from different youtube channels. Remaining 12 weeks, lessons were taken to configure the concepts given by the teacher candidates and to realize that their basic characteristics should be kept constant. The distortion of the shape was tested if the correctness of the drawn shapes was replaced by the fixed points. New ideas were questioned through in-class discussions. Finally, 45 volunteer teacher candidates were presented with a vision form consisting of three open-ended questions through "Google forms" to reveal their perspectives on mathematics teaching using dynamic mathematics software.

Distribution of activities by learning areas

Activities are collected under 3 learning areas: triangles, polygons and quadrilaterals, geometric objects and Transformation Geometry. These learning areas and the sub-learning areas in each are shown in Table1.

Table 1.
Learning and sublearning areas with activities

Learning	Triangles, Polygons-Quadrilaterals	Geometric objects	Transformation Geometry
Sublearning	Deltoid	Cylinder/cone	Displacement
	Rectangle	Prism/Pyramid	Reflection
	Smooth Hexagonal	Rectangle Prism	
	Parallel edge		
	Trapezoid		

Activities are oriented towards Parallel edge, trapezoid, equiteral quadrilateral, rectangular, square, deltoid from the learning area of triangles, polygons and quadrilaterals; geometric objects are created from activities aimed at prism, cylinder, pyramid, cone and transformational geometry learning area for displacement, reflection and symmetry.

Validity, reliability and analysis of the data

The data were obtained from two different sources: the activities created by the teacher candidates and the answers to the opinion form. The data is analyzed by content analysis method. Content analysis makes sense of the current situation by adding clarity to the further embodiment of the data by categorization and codes (Patton, 2014; Yıldırım & Şimşek, 2018). In the process of analyzing the data, the coding and extraction, category development, validity and reliability and finally the interpretation of the data were followed. During the coding and extraction phase, the data was transferred to the computer environment with the help of the Microsoft Excel program and the information in the opinion form was temporarily listed. The information was examined in terms of question and answer and opinions containing explanation-justification discrepancies were excluded from the analysis. In order to indicate which teacher candidate the data belongs to, teacher candidates were given codes such as Ö1, Ö2, ..., Ö54 based on the sequence numbers. In order for research to be scientifically accepted, the processes and results of research must be clear and consistently transferable (Denzin & Lincoln, 1994; Yıldırım & Şimşek, 2018). After the data is extracted, teacher candidate opinions are made into a list during the category development phase. A review of the list prepared the frequency percentage list with the citation sentences. In this list, opinions are collected under common codes by common concept or meaning. Then similar categories were created in terms of highlighting the views in the same classification as the same or similar quality. Expert opinion was consulted in the process of creating categories and codes in the process of ensuring the validity and reliability of the study. Two experts who are proficient in qualitative research and mathematics were presented with conceptual categories and teacher candidate opinions and asked to match the experts. At the end of this stage, the categories and codes that are not agreed upon are discussed. By comparing the lists created at the end of the discussion, consensus and differences of opinion are determined by the formula "Credibility= Consensus/Consensus Disagreement" developed by Miles and Huberman (2016). The percentage of numbness among encoders was found to be 91%. Since the numbness percentage was above 90%, the research was found to be reliable. Within the scope of the study, direct excerpts of the sample are included. Finally, during the interpretation of the data, the reasons for the citations in each category and the researcher comments are included.

The Findings

In this section; Analysis of the activities of primary mathematics teachers with GeoGebra, a dynamic mathematics software. Below is a percentage and frequency table of the correct and empty number of activities prepared by the teacher candidates. In addition, there are one correct and incorrect sample solutions for the activity made under each table.

Deltoid activity

"Drawing a deltoid on the geogebra is half the area, the diagonal product; on this illustration that the circumferal is equal to the sum of all the edges."

In this question, it is necessary to know that the deltoid consists of two conjoined chrysantial triangles, so the diagonal will be both angle, edge and height, and it should be drawn with the help of Geogebra based on these characteristics. Otherwise, when it is dragged from the corners of the drawn shape, the shape will cease to be deltoid. Thanks to this software, the conditions of deltoidization are tested and the basic features and concepts are easier to understand and configure. Analysis of this problem, which is given to teacher candidates as 1st activity, is given in Table 2.

Table 2.
Analysis of deltoid activity

Quadrilateral	Category	f	N	%
Deltoid	True	34	Ö1, Ö2, Ö4, Ö5, Ö6, Ö7, Ö8, Ö9, Ö11, Ö12, Ö13, Ö14, Ö15, Ö17, Ö19, Ö20, Ö21, Ö22, Ö24, Ö29, Ö30, Ö31, Ö34, Ö36, Ö38, Ö39, Ö41, Ö43, Ö44, Ö46, Ö47, Ö48, Ö49, Ö50, Ö51, Ö52	65,4
	Falce	16	Ö10, Ö16, Ö18, Ö22, Ö25, Ö26, Ö27, Ö28, Ö32, Ö33, Ö35, Ö37, Ö40, Ö42, Ö44, Ö45	30,8
	Empty	2	Ö3, Ö23	3,8

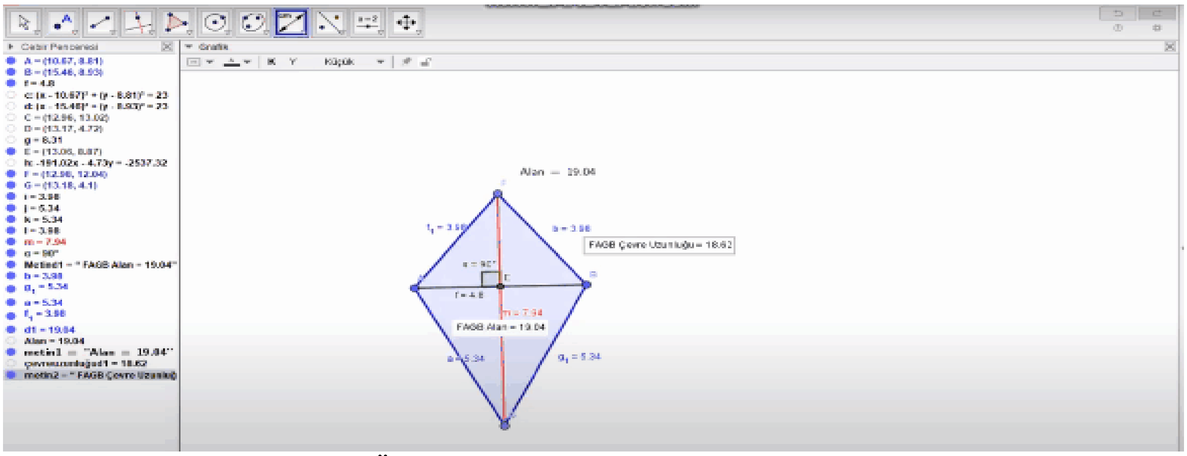


Figure 1. For example code Ö1

As shown in Table 2, 65.4% of teacher candidates (Ö1) successfully ended the activity. Some of the students who completed the activity correctly took advantage of the middle sewing button on the toolbar, and some created two circles by selecting the center of the end of the right part to find the middle point of the right part taken. It found the middle planting by combining the intersections of the intersecting circles.

However, 30.8% of teacher candidates (Ö10) were unable to configure on Geogebra, ignoring the basic properties of deltoids such as being middle base and chsokenous triangle.

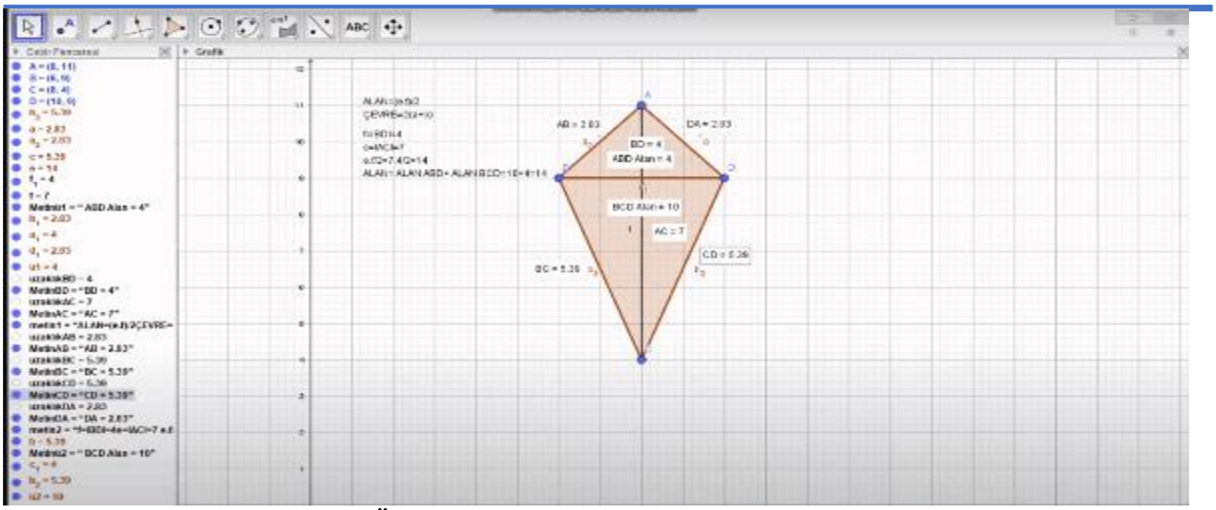


Figure 2. For example code Ö10

Some of the teacher candidates in the wrong category thought that he had created a deltoid by combining the four points he received randomly on the plane and investigated the result of the field and the environment with his simple actions. It was observed that some of the teacher candidates pulled upright from a point approximately determined from a correct part taken, and thought that they formed deltoids with two different triangles that they took from this vertically drawn right.

Rectangular activity

"Draw a rectangle on the geogebra. The sum of squares of the lengths of the correct parts drawn from any point in the inner region of this rectangle to non-adjacent corners is equal to each other. Show me."

In this question, first of all, it is necessary to know that the rectangle consists of parts of the rectangle with equal edge lengths and perpendicular to each other. The analysis of this problem given to teacher candidates as 2nd activity is given in Table 3.

Table 3.
Analysis of rectangle activity

Quadrilaterals	Category	f	N	%
Rectangle	True	29	Ö1, Ö2, Ö4, Ö6, Ö7, Ö9, Ö11, Ö12, Ö13, Ö15, Ö16, Ö17, Ö24, Ö27, Ö29, Ö30, Ö31, Ö35, Ö36, Ö37, Ö38, Ö41, Ö43, Ö46, Ö47, Ö48, Ö49, Ö50, Ö52	55,8
	Falce	20	Ö5, Ö8, Ö10, Ö14, Ö18, Ö19, Ö20, Ö21, Ö25, Ö26, Ö28, Ö32, Ö33, Ö34, Ö39, Ö40, Ö42, Ö44, Ö45, Ö51	38,5
	Empty	3	Ö3, Ö22, Ö23	5,7

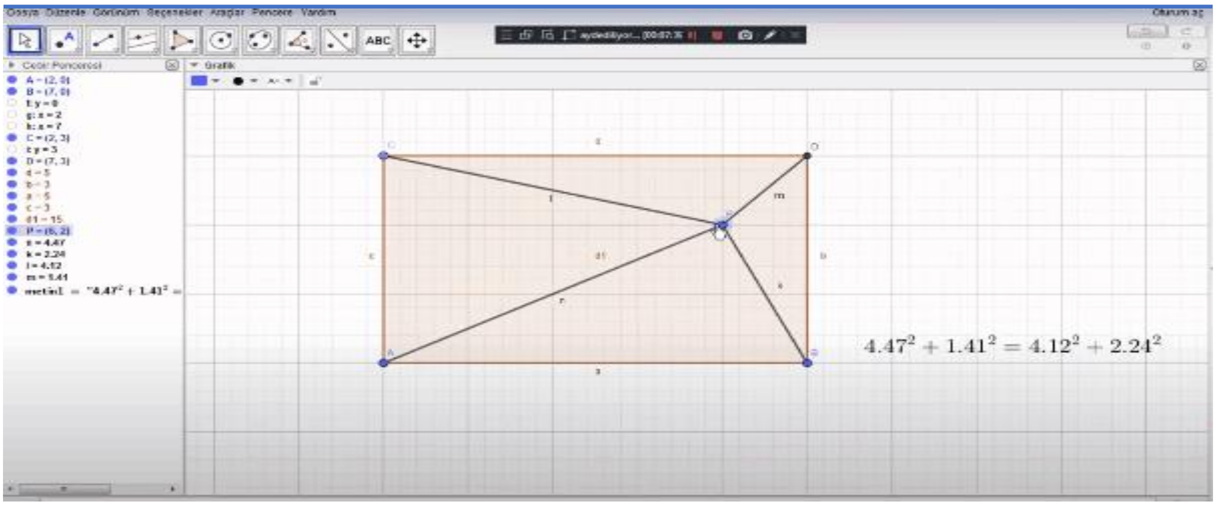


Figure 3. For example code Ö6

When Table 3 was examined, 55.8% of teacher candidates (Ö6) were able to draw the rectangle correctly on Geogebra and show that although the rectangle changed position, grew and shrunk, the sum of the squares of these correct parts was preserved equally. By contrast, 38.5% of teacher candidates made various mistakes when creating the rectangle.

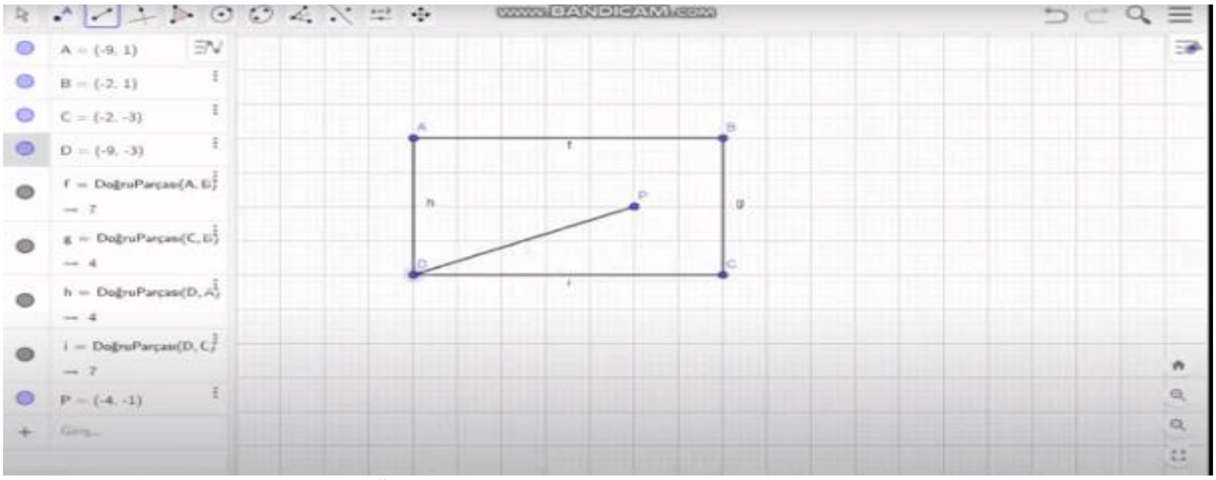
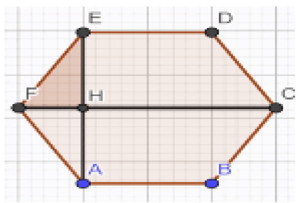


Figure 4. For example code Ö5

Thought that he had created a rectangle by combining four points he took randomly on the geogebra. However, with this error, which occurred as a result of ignoring the characteristics of the rectangle, the teacher candidate was placed in the wrong category.

Hexagonal activity

• "Draw a smooth hexagon on the Geogebra. If the area of the FEH triangle shown in the figure below is unit A square, show on this illustration that the area of the hexagon is 12 A unit squares."



In this question, teacher candidates need to know that the smooth hexagon consists of a quadrilateral with equal edge lengths and internal angles. A ready-made toolbar in geogebra software or a fixed radius circle can be used to find drawings and fields. In addition, it can be proved by the field button of Geogebra that 12 co-triangles are formed with the help of diagonals drawn into the hexagon and that the area with the scan is only one of them. The analysis of this problem, which is given to teacher candidates as the 3rd activity, is given in Table 4.

Table 4.
Analysis of smooth hexagonal activity

Quadrilaterals	Category	f	N	%
Smooth hexagonal	True	40	Ö1, Ö2, Ö4, Ö5, Ö6, Ö7, Ö9, Ö10, Ö11, Ö12, Ö13, Ö14, Ö15, Ö16, Ö17, Ö20, Ö21, Ö23, Ö27, Ö28, Ö29, Ö30, Ö31, Ö32, Ö33, Ö34, Ö35, Ö36, Ö37, Ö38, Ö39, Ö41, Ö42, Ö43, Ö46, Ö47, Ö48, Ö49, Ö50, Ö52	76,9
	Falce	5	Ö25, Ö26, Ö40, Ö45, Ö51	17,4
	Empty	3	Ö3, Ö8, Ö18, Ö19, Ö22, Ö24, Ö44	5,7

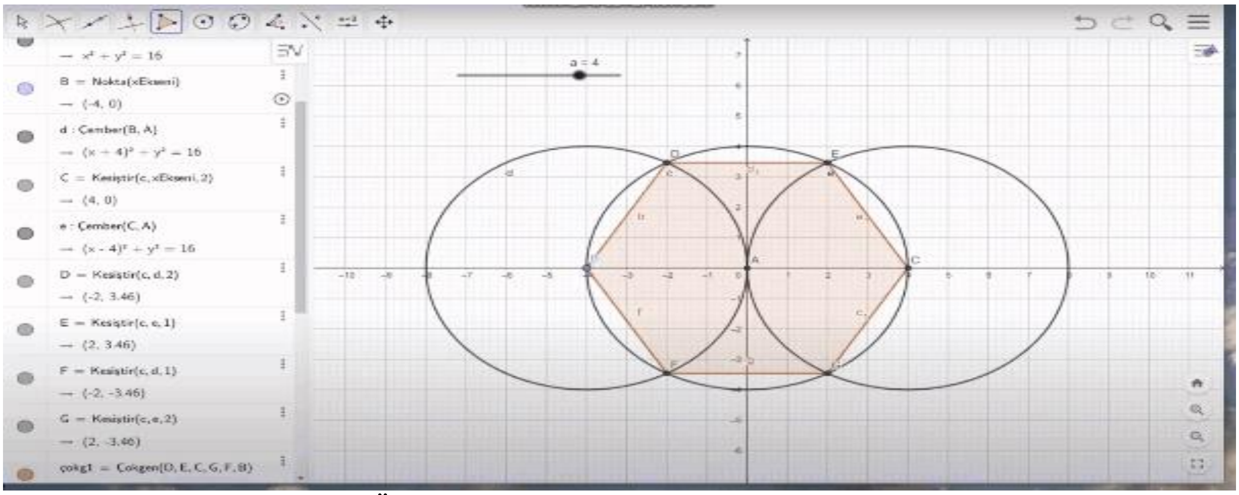


Figure 5. For example code Ö48

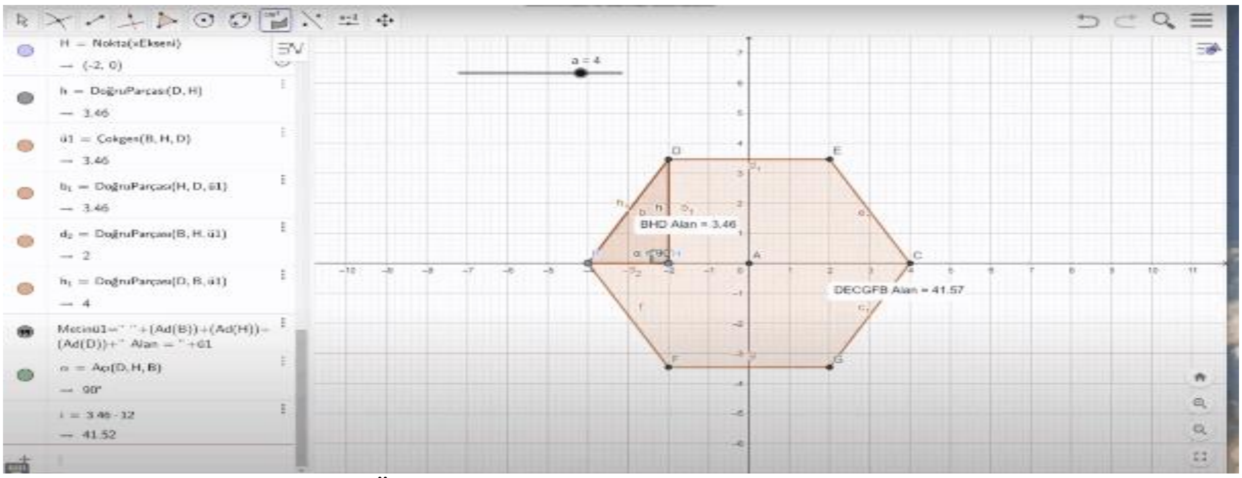


Figure 6. For example code Ö48

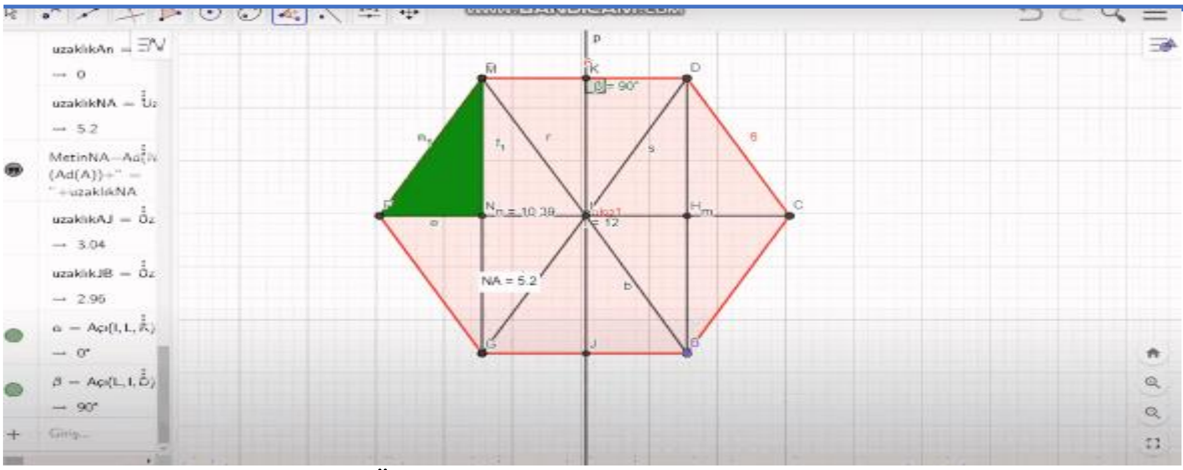
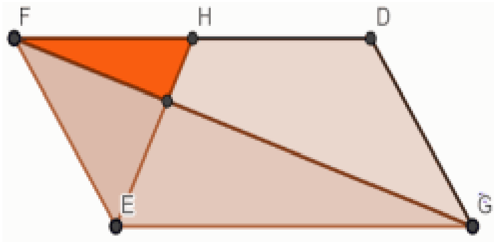


Figure 7. For example code Ö28

However, 17.4% of teacher candidates were found to have combined random four points selected in the window or made mistakes such as this, ignoring the characteristics of the hexagon.

Parallel edge activity

• "Draw a Parallel edge on the Geogebra. If the scanned area shown in [FH]=[HD] is A unit square, show on this illustration that the entire area of the shape is 12 A unit squares."



In this question, it is necessary to know the condition that the opposite sides are parallel to each other. The analysis of this problem given to teacher candidates as 4th activity is given in Table 5.

Table 5.

Analysis of parallel edge activity

Quadrilaterals	Category	f	N	%
Parallel edge	True	35	Ö1, Ö3, Ö4, Ö6, Ö7, Ö9, Ö10, Ö11, Ö12, Ö13, Ö14, Ö15, Ö16, Ö17, Ö21, Ö23, Ö27, Ö28, Ö29, Ö30, Ö31, Ö33, Ö34, Ö35, Ö36, Ö37, Ö38, Ö39, Ö41, Ö43, Ö46, Ö48, Ö50, Ö51, Ö52	67,4
	Falce	15	Ö5, Ö8, Ö18, Ö19, Ö20, Ö22, Ö25, Ö26, Ö32, Ö40, Ö42, Ö44, Ö45, Ö47, Ö49	28,8
	Empty	2	Ö2, Ö23	3,8

When table 5 is examined, it is seen that more than half of the teacher candidates can draw parallel edge on the Geogebra (Ö3) and find the area correctly, and the parallel edge is not disturbed as a result of the shape changing position.

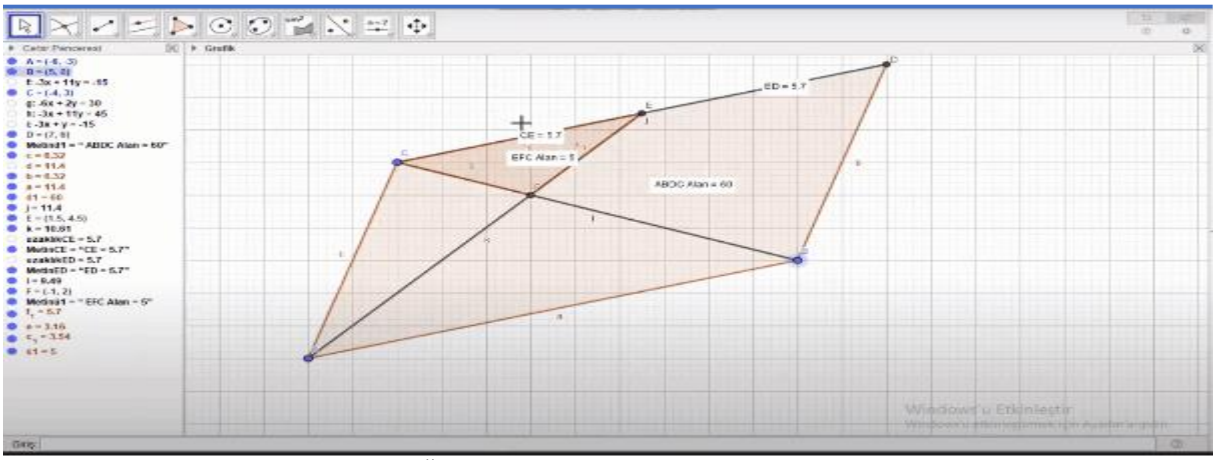


Figure 8. For example code Ö3

However, it is seen that 28.8% of them form parallels from randomly selected points and ignore the characteristic characteristics of the parallels (Ö20).

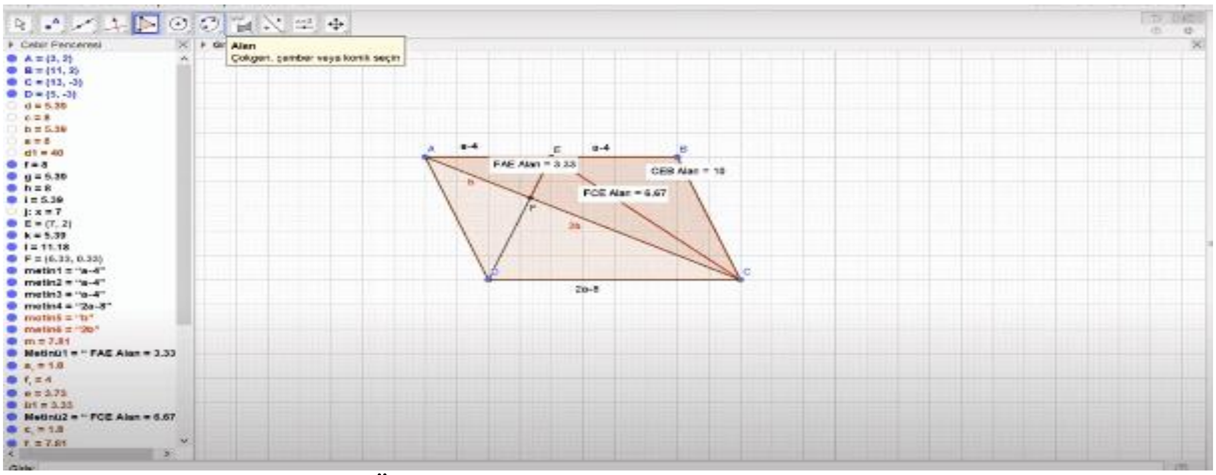


Figure 9. For example code Ö20

Trapezoid avtivity

• "Draw a trapezoid on the geogebra. Show on this drawing that the middle base length of the drawn slope is equal to half the sum of the lower base and upper base length.

"In this question, it should be known that the characteristic feature of the moist is polygon with at least two sides parallel to each other. Geogebra's toolbar can be used to determine the midsole length, as well as different geometric methods that can find the middle point. Thus, both geometric thinking skills and testing of the truth can be ensured. The analysis of this problem, which is given to teacher candidates as the 5th activity, is given in Table 6.

Table 6.

Analysis of trapezoid

Quadrilaterals	Category	f	N	%
Trapezoid	True	32	Ö1, Ö2, Ö4, Ö6, Ö7, Ö9, Ö11, Ö12, Ö13, Ö14, Ö16, Ö17, Ö21, Ö24, Ö27, Ö28, Ö29, Ö30, Ö31, Ö33, Ö34, Ö35, Ö36, Ö38, Ö41, Ö43, Ö46, Ö47, Ö48, Ö50, Ö51, Ö52	61,6
	Falce	18	Ö5, Ö8, Ö10, Ö15, Ö18, Ö19, Ö20, Ö22, Ö25, Ö26, Ö32, Ö37, Ö39, Ö40, Ö42, Ö44, Ö45, Ö49	34,6
	Empty	2	Ö3, Ö23	3,8

When table 6 was examined, it was seen that the general (61.6%) of the teacher candidates were able to draw on Geogebra (Ö11).

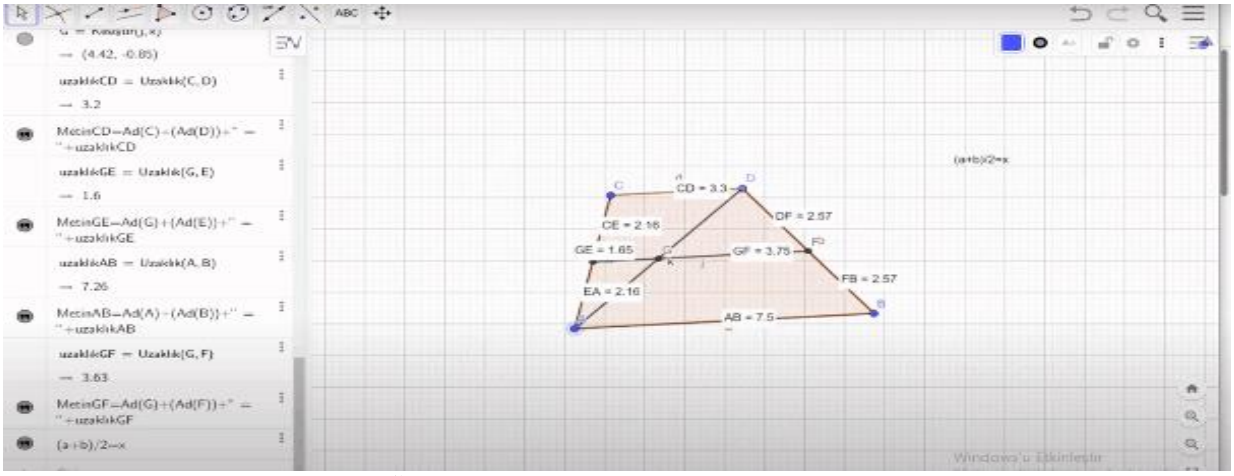


Figure 10. For example code Ö11

However, it is seen that 34.6% (Ö39) fall into different mistakes by ignoring the characteristics of the slope.

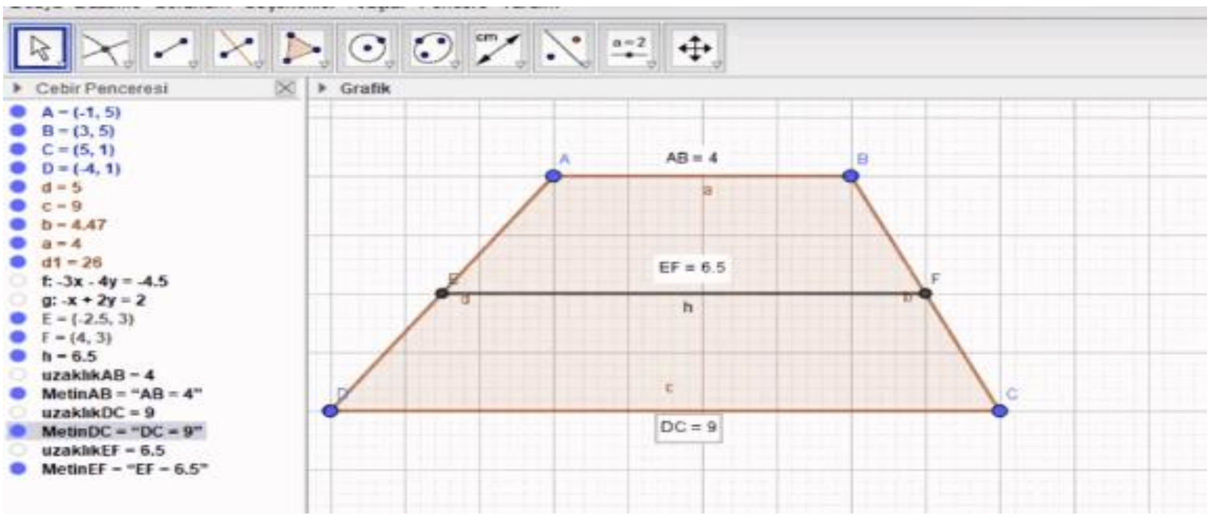


Figure 11. For example code Ö39

Cylinder and cone activity

• "In GeoGebra, use sliders to create "Cylinder" and "Cone" with the same base (r radius) and height (h) in "one window". With the help of the Latex formula, show that the ratio between volumes is 1/3."

In this question, it is aimed to evaluate the drawn cylinder and cone with the same base and height at the same time as the volume. It is easier to examine geometric objects in three dimensions thanks to the radius and height attached to the slider. The analysis of this problem, which is given to teacher candidates as the 6th activity, is given in Table 7.

Table 7.
Analysis of cylinder/cone activity

Geometric objects	Category	f	N	%
Cylinder/Cone	True	46	Ö1, Ö2, Ö3, Ö4, Ö5, Ö6, Ö7, Ö9, Ö10, Ö11, Ö12, Ö13, Ö14, Ö15, Ö16, Ö17, Ö21, Ö22, Ö24, Ö25, Ö26, Ö27, Ö28, Ö29, Ö30, Ö31, Ö32, Ö33, Ö34, Ö35, Ö36, Ö37, Ö38, Ö39, Ö40, Ö41, Ö42, Ö43, Ö45, Ö46, Ö47, Ö48, Ö49, Ö50, Ö51, Ö52	88,5
	Falce	5	Ö8, Ö18, Ö19, Ö20, Ö44	9,6
	Empty	1	Ö23	1,9

When table 7 is examined, it is seen that almost all of the teacher candidates (88.5%) can evaluate the volumetric relationship between the cylinder and the cone with the help of Geogebra by using a slider. The reason for this increase in the correct category can be said that teacher candidates can be more successful with time in the learned software.

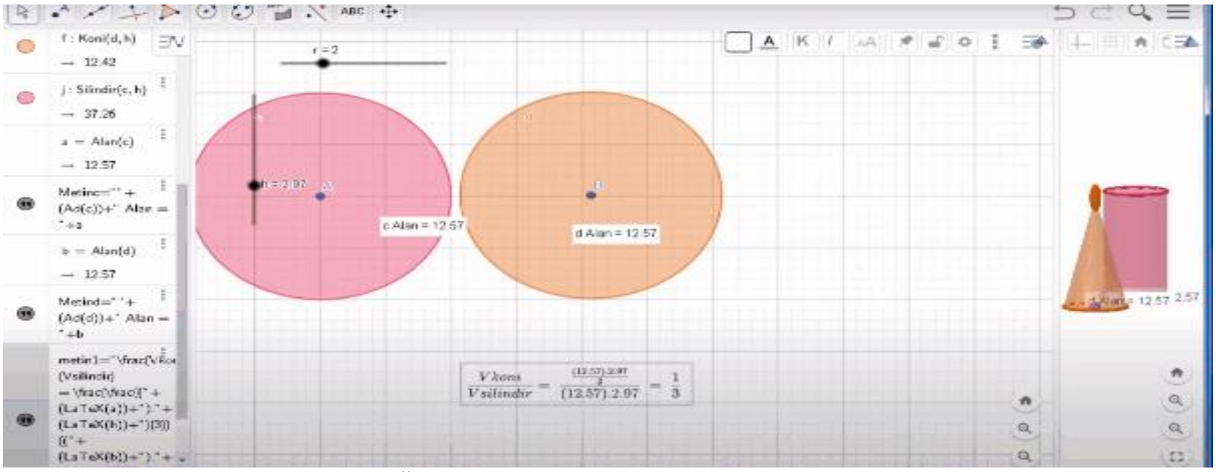


Figure 12. For example code Ö17

However, although a small number (9.6%) tried to evaluate the cylinder and cone independent of the slider separately, it was found that it was not successful (Ö8).

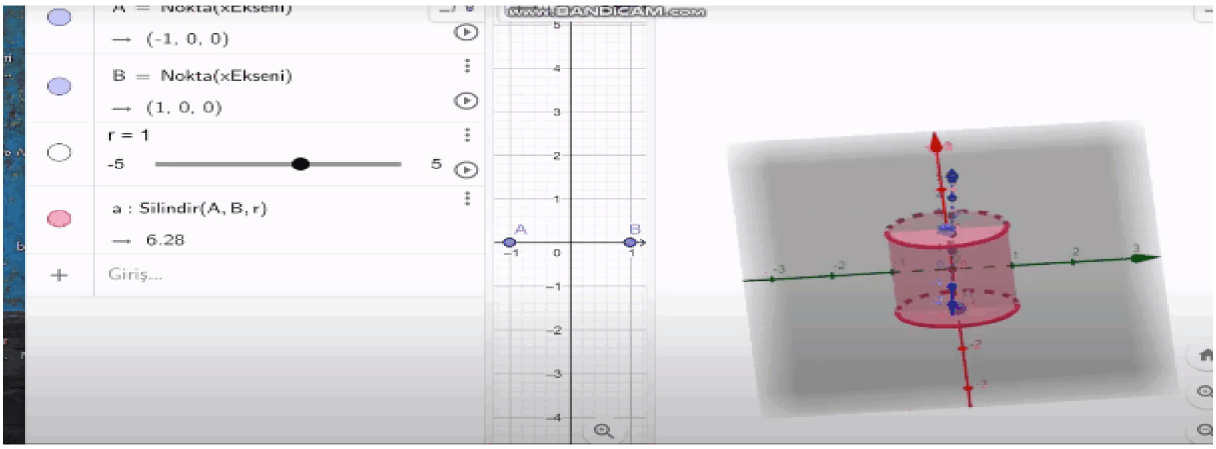


Figure 13. For example code Ö8

Prism and pyramid activity

• "In GeoGebra, use sliders to create "Prism" and "Pyramid" with the same base (n edge) and height (h) in a single window". With the help of the Latex formula, show that the ratio between volumes is 1/3."

In this question, it is aimed to evaluate the drawn prism and pyramid with the same base and height at the same time in volume. Thanks to the radius and height attached to the slider, it is easier to examine the geometric objects created in three dimensions. The analysis of this problem, which is given to teacher candidates as the 7th activity, is given in Table 8.

Table 8.
Analysis of prism/pyramid activity

Geometric objects	Category	f	N	%
Prism/Pyramid	True	47	Ö1, Ö2, Ö3, Ö4, Ö5, Ö6, Ö7, Ö8, Ö9, Ö10, Ö11, Ö12, Ö13, Ö14, Ö15, Ö16, Ö17, Ö21, Ö22, Ö24, Ö25, Ö26, Ö27, Ö28, Ö29, Ö30, Ö31, Ö32, Ö33, Ö34, Ö35, Ö36, Ö37, Ö38, Ö39, Ö40, Ö41, Ö42, Ö43, Ö45, Ö46, Ö47, Ö48, Ö49, Ö50, Ö51, Ö52	90,4
	Falce	4	Ö18, Ö19, Ö20, Ö44	7,7
	Empty	1	Ö23	1,9

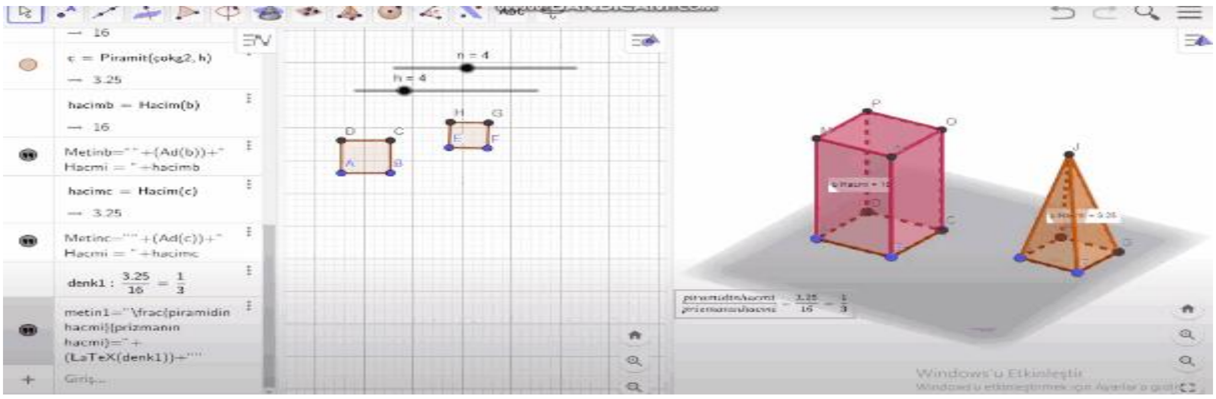


Figure 14. For example code Ö52

When table 8 is examined, it is seen that almost all of the teacher candidates (90.4%) can evaluate the volumetric relationship between prism and pyramid with the help of Geogebra by using sliders. It can be said that the increase in the percentage in the right category compared to the previous activity indicates that a similar problem is more easily done or better understood.

Rectangular prism activity

• "Create a rectangle prism with the help of sliders in GeoGebra. Show the 3D expansion by opening it to the plane."

In this question, teacher candidates were asked to create a prism of rectangles using Geogebra software. The most important point to note is the concepts of height and depth in geometric objects. Thanks to the software that embodies the skill of three-dimensional dreaming, it is aimed to easily see the opening of the geometric object. The analysis of this problem, which is given to teacher candidates as the 8th activity, is given in Table 9.

Table 9.
Analysis of rectangular prism Activity

Geometric objects	Category	f	N	%
Rectangular Prism	True	47	Ö1, Ö2, Ö3, Ö4, Ö5, Ö6, Ö7, Ö8, Ö9, Ö10, Ö11, Ö12, Ö13, Ö14, Ö15, Ö16, Ö17, Ö21, Ö22, Ö24, Ö25, Ö26, Ö27, Ö28, Ö29, Ö30, Ö31, Ö32, Ö33, Ö34, Ö35, Ö36, Ö37, Ö38, Ö39, Ö40, Ö41, Ö42, Ö43, Ö45, Ö46, Ö47, Ö48, Ö49, Ö50, Ö51, Ö52	90,4
	Falce	4	Ö18, Ö19, Ö20, Ö44	7,7
	Empty	1	Ö23	1,9

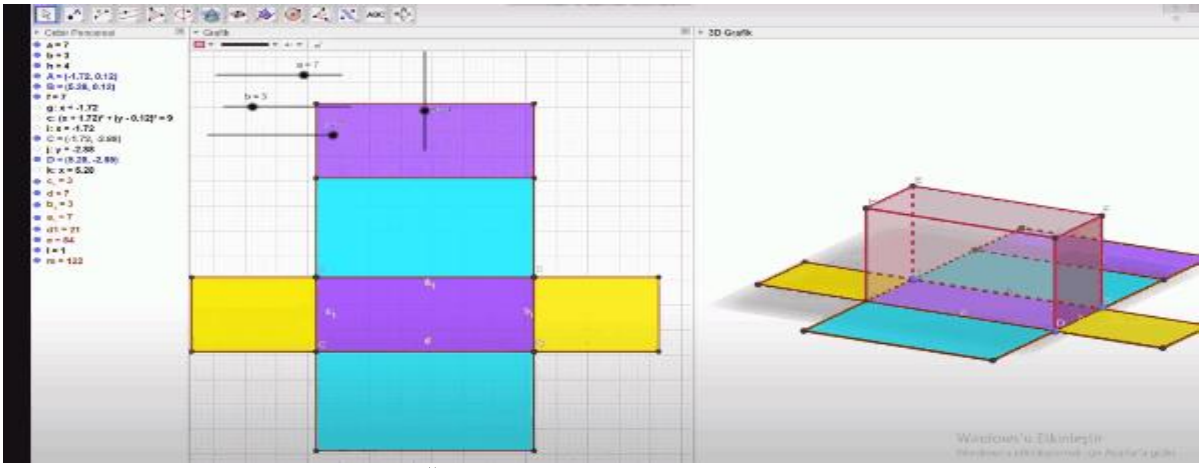


Figure 15. For example code Ö50

When table 9 is examined, we can say that the percentage of geometric drawings and software of teacher candidates with the software has increased. This can be attributed to the consolidation of the software used over time.

Displacement activity

• "Select any polygon and vector tool, you draw and move it accordingly in GeoGebra."

With this question, it is aimed that the teacher candidate sees more clearly by embodying the subject of displacement in the transformation geometry using the software. The analysis of this problem, which is given to teacher candidates as the 9th activity, is given in Table 10.

Table 10.
Analysis of displacement activity

Transformation Geometry	Category	f	N	%
Displacement	True	46	Ö1, Ö2, Ö3, Ö4, Ö5, Ö6, Ö7, Ö8, Ö9, Ö10, Ö11, Ö12, Ö13, Ö14, Ö15, Ö16, Ö17, Ö21, Ö22, Ö24, Ö25, Ö26, Ö27, Ö28, Ö29, Ö30, Ö31, Ö33, Ö34, Ö35, Ö36, Ö37, Ö38, Ö39, Ö40, Ö41, Ö42, Ö43, Ö45, Ö46, Ö47, Ö48, Ö49, Ö50, Ö51, Ö52	88,5
	Falce	5	Ö18, Ö19, Ö20, Ö32, Ö44	9,6
	Empty	1	Ö23	1,9

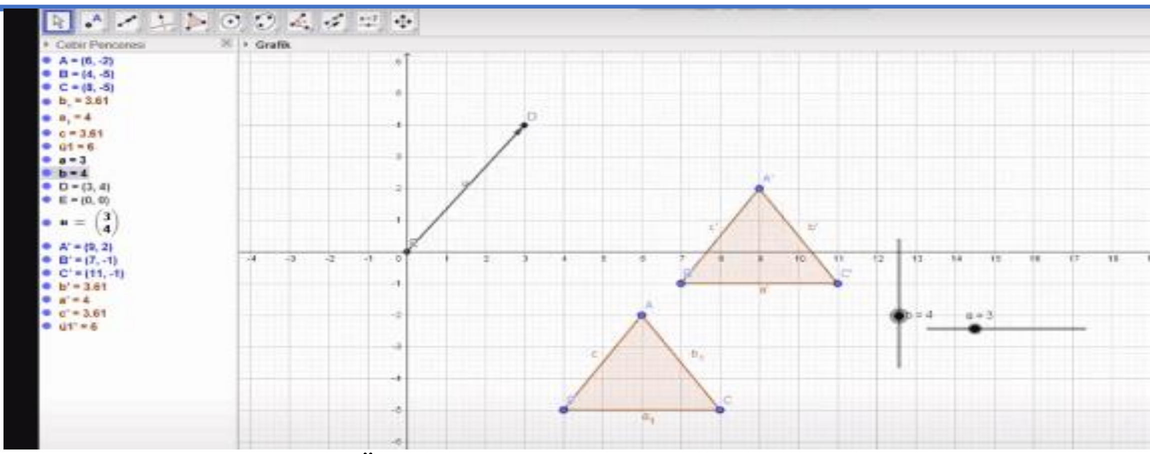


Figure 16. For example code Ö35

Reflection activity

• "In GeoGebra, project a polygon according to this accuracy by determining the correctness of symmetry. Show reflection conditions."

With this question, it is expected that the characteristic features such as the axis of symmetry of the reflection, maintaining the distance to the axis, and realizing what the objects look like as a result of reflection are expected to be configured by the teacher candidate. The analysis of this problem, which is given to teacher candidates as the 10th activity, is given in Table 11.

Table 11.

Analysis of Reflection Activity

Transformation Geometry	Category	f	N	%
Reflection	True	46	Ö1, Ö2, Ö3, Ö4, Ö5, Ö6, Ö7, Ö8, Ö9, Ö10, Ö11, Ö12, Ö13, Ö14, Ö15, Ö16, Ö17, Ö21, Ö22, Ö24, Ö25, Ö26, Ö27, Ö28, Ö29, Ö30, Ö31, Ö33, Ö34, Ö35, Ö36, Ö37, Ö38, Ö39, Ö40, Ö41, Ö42, Ö43, Ö45, Ö46, Ö47, Ö48, Ö49, Ö50, Ö51, Ö52	88,5
	Falce	5	Ö18, Ö19, Ö20, Ö32, Ö44	9,6
	Empty	1	Ö23	1,9

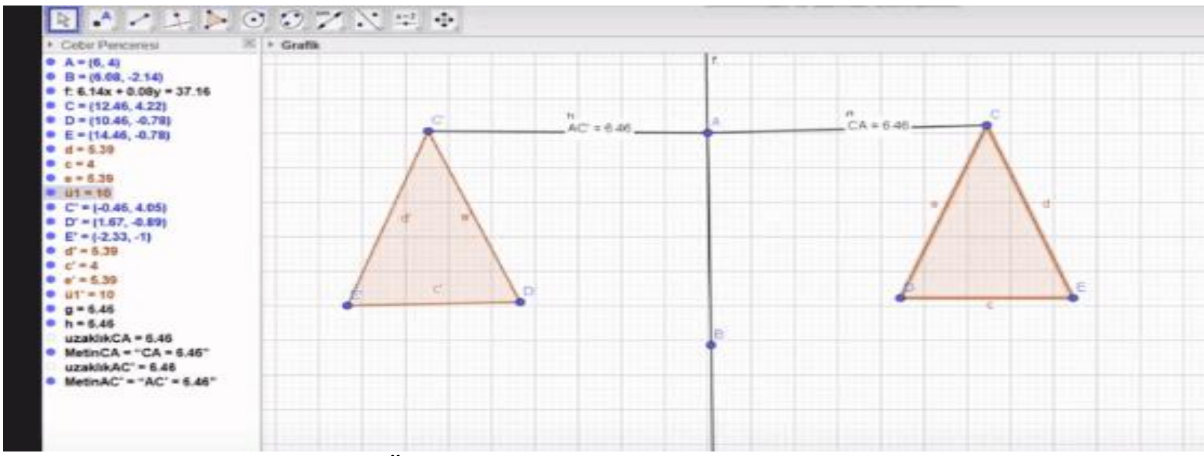


Figure 17. For example code Ö42

In general, when the tables are examined, deltoid in the field of triangular and polygonal learning of teacher candidates is 65.4%; rectangle 67.8%; smooth hexagon 77%; parallels 67.4%; trapez like 61.6%; cylinder/cone 88.5%; 90.4% of the pyramid;

rectangular prism; displacement 88.5%; with 88.5% of the reflection, it is seen that they complete the given activities by using the software correctly. The reason why teacher candidates are more successful in geometric body and transformation geometry can be interpreted as the fact that a software that is learned for the first time is better understood and used over time. The fact that the short paths and toolbars on the interface of GeoGebra, which is better used over time, are mostly related to geometry, and that the graphics window has a dynamic structure, makes this software more preferred in terms of learning and teaching geometry. In parallel, 13 doctoral and 41 master's thesis related to Geogebra, which was published until June 2018 at the YÖK National Thesis Center, are usually examined on success, learning or permanence and focus more on geometry (Şimşek & Yaşar, 2019).

In this section, where the perspectives of the teacher candidates for Geogebra are examined, the topics prepared in line with the questions in the halved opinion form are below.

Triangles, polygons and quadrilaterals of the GeoGebra program; Effect on geometric objects and transformational geometry learning area

Table 12.
Triangles, polygons and quadrilaterals; Effect on geometric objects and transformational geometry learning area

Theme	Category	Code	N	f	%
Impact on Geometry Learning Areas	Positive	Volume-Area relationship	Ö1, Ö19, Ö21, Ö24, Ö38, Ö44	6	6,7
		Visuality-Embody	Ö2, Ö7, Ö8, Ö10, Ö11, Ö13, Ö14, Ö16, Ö19, Ö20, Ö24, Ö27, Ö29, Ö31, Ö32, Ö33, Ö36, Ö37, Ö40, Ö41, Ö42	21	23,3
		Semantics-association	Ö6, Ö7, Ö10, Ö11, Ö12, Ö14, Ö15, Ö16, Ö18, Ö19, Ö20, Ö21, Ö22, Ö24, Ö26, Ö27, Ö28, Ö31, Ö32, Ö34, Ö37, Ö38, Ö43, Ö44, Ö45	25	27,8
		Useful	Ö1, Ö2, Ö4, Ö8, Ö9, Ö13, Ö17, Ö20, Ö21, Ö22, Ö32, Ö33, Ö34, Ö39, Ö41, Ö43	16	17,8
		Permanent	Ö5, Ö12, Ö18, Ö37	4	4,4
		Easy Teaching-Accurate drawing	Ö5, Ö6, Ö11, Ö42, Ö44	5	5,6
		Active use	Ö15, Ö33, Ö36, Ö37, Ö45	5	5,6
	Nötr	I don't know	Ö3, Ö23	2	2,2
	Negative	Useless	Ö30, Ö35, Ö17	3	3,3
Total				90	100

When table 12 is examined, there are inferences that 94.5% of teacher candidates have positive perception, 2.2% are unable to fully experience the software at any time, and 3.3% have sufficient knowledge, that Geogebra does not contribute to them about the concepts they already know, but that it is useful software for new learners of geometry and its subjects. The following are the excerpt sentences for the opinions and opinions of the teacher candidates.

It is a program that provides an opportunity to better understand a *course based on visuality such as geometry, to question the reason for the formulas of volume and space, and to embody abstract concepts. It allowed us to understand geometry and other areas of learning. Therefore, it was very useful (Ö19).*

It has helped us to understand geometric objects better when drawing and to notice the relationship between them when drawing side by side. It has helped us to see more clearly the differences between making sense of objects. I also think it is quite permanent (Ö37).

Drawing shapes step by step using the toolbar in the software and proving formulas is more practical, fun and useful on paper (Ö20).

Every math teacher should know about this program. Teaching and learning mathematics with Geogebra is easy and quite easy thanks to the correct drawings (Ö6).

Whether it's geometric opening, 3D graphics, being able to put shapes where we want them, playing on them in the shapes we want, and learning to do so is very valuable in terms of experience (Ö45).

Of course it is useful. But I think it might be more useful for someone who's just met these concepts. He didn't add anything to me because we knew these concepts very closely and we saw them for years (Ö17).

I have not experienced this application easily. I didn't get enough productivity because my friends and I used a commuter computer. Therefore, I do not know (Ö23).

Negative opinions about the Geogebra program

Table 13.
Negative opinions about the GeoGebra program

Theme	Category	Code	N	f	%
Negative opinions	No negative feedback	None	Ö1, Ö2, Ö4, Ö5, Ö7, Ö8, Ö10, Ö11, Ö12, Ö13, Ö14, Ö15, Ö16, Ö18, Ö19, Ö20, Ö21, Ö24, Ö25, Ö26, Ö27, Ö28, Ö29, Ö30, Ö31, Ö32, Ö33, Ö34, Ö35, Ö36, Ö37, Ö38, Ö40, Ö41, Ö43	35	77,8
	Negative feedback	Phone compatibility	Ö3, Ö6, Ö9, Ö22	4	8,9
		Technological skill	Ö17, Ö23	2	4,4
		Complex	Ö44	1	2,2
		Opening to plane	Ö39, Ö42, Ö45	3	6,7
Total				45	100

When table 13 is examined, it is seen that 77.8% of teacher candidates do not have any negative opinions or suggestions regarding Geogebra software. However, 22.2% were inadequate in their adaptation to the phone app of the Geogebra program (8.9%); requires high-level technological knowledge (4.4%); software is somewhat complicated in terms of learning (2.2%); inferences that some geometric drawings cannot be opened to the plane (6.7%) have been determined. The following are excerpt sentences for the opinions and opinions of teacher candidates in the negative category.

My negative view of this software is that there are some problems when downloaded to the phone because the software is a computer program (Ö3).

I definitely think that it is a program that should be used at every stage of teaching geometry. However, details about the program should be explained in detail with a long process.Software *compliance was a little difficult for us due to a lack of technological knowledge (Ö17).*

A very nice and useful program that should be used by every teacher, especially in the examination of 3-length objects, but I consider the inability to open the cylinder and cone to the plane as a deficiency (Ö39).

The application interface can be simpler (Ö44).

Geogebra's choice of use in professional life

Table 14.
Geogebra's choice of use in the teaching profession

Theme	Category	Code	N	f	%
Life profession use in	I use	Smooth and error-clear drawing	Ö1, Ö13, Ö44	3	6,5
		Easy narration by embodying	Ö2, Ö3, Ö6, Ö8, Ö10, Ö13, Ö14, Ö18, Ö19, Ö20, Ö26, Ö27, Ö29, Ö30, Ö34, Ö35, Ö36, Ö39, Ö42	19	41,3
		Interesting	Ö5, Ö32, Ö33, Ö43	4	8,7
		Dynamic learning by associating	Ö7, Ö16, Ö21, Ö22, Ö24, Ö38	6	13,1
		Permanent and fun	Ö9, Ö12, Ö28, Ö37, Ö40, Ö41, Ö45	7	15,2
		Active learning by discovery	Ö11, Ö15	2	4,3
		Time saving	Ö25	1	2,2
	Not use	Lesson time limitation	Ö4	1	2,2
		Opportunity inequalities	Ö17, Ö23	2	4,3
	Vary from… to…	School facilities	Ö31	1	2,2
Total				46	100

I would consider using my exams to prepare them, especially in order to draw correctly and properly (Ö1).

Yes, I think it will facilitate mathematical concepts in lectures, visualization and material (Ö27).

I definitely use it, it's an interesting and effective method (Ö5).

Yes, I do. I would like the students to truly understand the information I am describing and to realize a dynamic learning by associating geometry with everyday life (Ö7).

Yes, of course. It's a very permanent and fun software (Ö9).

Yes, it allows us to save time in the course (Ö25).

I use it, it provides active learning by exploring as students see in more detail what comes from where (Ö15).

However, when Table 13 is examined, it is seen that some of the teacher candidates (6.5%) do not want to use Geogebra in their professional lives or state that it will vary depending on the situation (2.2%). Excerpt sentences for these categories are given below.

It is currently difficult to implement in the MEB education system. Considering the limited course time and the inability of programs to function properly on some computers, I do not intend to use it (Ö4).

As I have seen from my environment, most students have technological deficiencies and do not have the same opportunities. In this case, I try to find a teaching method that everyone can access (Ö23).

I think the situation will change depending on the schools. Many schools don't even have a smart board (Ö31).

Discussion

Geogebra facilitates learning (Shadaan & Leong, 2013) when it comes to using Geogebra software, interest (Caligaris et al., 2017; Celen, 2020) and increased material ability, mathematical communication skills and mathematical reasoning skills (Bakar et al., 2015).It also improves problem solving skills (Septian et al., 2020), increases teacher-student interaction during class (Zulnaidi et al., 2020), accelerates the learning process with visuality (Caligaris et al., 2017), is easy to use and equipped with rich content (Saputra & Fahrizal, 2019; Yorganci, 2018) and provides effective learning (Muslim & Haris, 2017; Septian et al., 2020). New versions of GeoGebra are very effective at creating three-dimensional interactive applications, attracting sliders and objects to different locations, visualizing basic concepts with interactive applications (Caligaris et al., 2017). In addition, GeoGebra software helps teacher candidates to be more confident in the math course process, reducing the anxiety of teaching mathematics. Thus, mathematics, which seems abstract, difficult to understand and explain, is moved to a more visual and concrete learning environment. Students who learned geometry using Geogebra tended to understand the subject more than those who did not (Alkhateeb & Al-Duwairi 2019; Bakar et al., 2015; Japa et al., 2017; Jelatu, 2018; Seloraji & Eu, 2017; Sudihartinih & Wahyudin, 2019). In addition, Geogebra improves student proficiency and perception in geometry learning (Ridha & Pramiarsih, 2020), which can strengthen students' comprehension levels (Condori et al., 2020; Kusumah et al., 2020) is a software.

Therefore, it can be said that GeoGebra not only improves understanding of geometry, but also provides motivation and a positive attitude about geometry to understand geometric concepts (Carter & Ferrucci, 2009; Saha et al., 2010; Shadaan & Eu, 2013; Zengin et al., 2012). He agreed with Shadaan and Leong (2013) that Dogan and İçel (2011) positively influenced students' learning and achievements, and that the use of technology was a motivational tool that could increase students' confidence and improve learning processes, and that technology was a useful tool in removing the need for students to memorize. Studies stating that teaching with Geogebra is an effective teaching method in which it further increases academic success (Ayyıldız, 2020; Balci-Şeker, Erdogan, 2017; Kan, 2014; Kaya, 2017; Mercan, 2012; Selcik & Bilgici, 2011; Uzun, 2014; Demirbilek & Özkale (2014) found that Geogebra did not make a statistically significant difference in terms of academic achievement, but that its students positively attitudes towards mathematics and GeoGebra software (Aktümen et al., 2011; Güven, 2012; Uzun, 2014).

İlhan and Aslaner (2017) stated that dynamic geometry software in geometry teaching courses positively increased the perception of visual mathematics literacy in teacher candidates. The reason for this increase was attributed to the awareness of the students about visual or mathematical perception of their activities during the course process. However, in parallel with the findings of the study, Celen (2020) found that individuals with low technology literacy had difficulty using the computer and running Geogebra. This software, which is really useful, easy to use and easily accessible for both students and teachers, must first have sufficient knowledge and skills about the software (Tamam & Dasari, 2021). It was demonstrated by Peker (2009) that the anxiety of teaching mathematics for highly confident teacher candidates decreased. Furner and Marinas (2014) concluded that GeoGebra software positively supports the learning and teaching process, reducing math anxiety. Zengin, (2017) GeoGebra software has been found to increase the confidence of teacher candidates. It is known that the anxiety of teaching mathematics for highly confident teacher candidates decreases (Barçın, 2019; Peker, 2009). However, Ayyıldız (2020) and Barçın (2019) stated that although the trainings given with dynamic software reduced students' concerns about the course, there was no statistically significant difference between attitude, algebraic performance and academic motivation levels for the mathematics course.

Tatar, Akkaya and Kagizmanlı (2011) found that dynamic geometry software will make positive contributions to student learning and that teacher candidates want to use similar programs in their professional lives. In their study, Spector and Haciomeroglu (2011) found that GeoGebra software enables mathematical ideas to be examined by creating dynamic constructions with multiple representations. In addition, it was determined that the teacher candidates thought that dynamic learning environments would contribute positively to students' learning of mathematics and wanted to use dynamic software in their teaching lives (Tatar et al., 2011). It has been determined that teacher candidates think that dynamic learning environments will contribute positively to students' learning of mathematics and want to use dynamic software in their teaching lives (Tatar et al., 2011). Research shows that dynamic mathematical environments can provide a rich learning environment that supports social interaction, critical thinking skills and comprehensive learning experiences (Shadaan & Leong 2013; Lim et al., 2013). According to Sarıtaş (2013), the technology used offers student-centered learning environments that activate the student. In this way, it can be said that teaching technologies are used more effectively by attracting students' attention, attention to the course, developing a positive attitude towards mathematics. In the research results of Baltacı, Yildiz and Kösa (2015), it was found that it is easier for teacher candidates to use software when learning concepts and that they feel more active in this learning environment.

The visualization and discovery provided by GeoGebra software in mathematics teaching provides teachers and students with a more engaging and collaborative learning environment (Shadaan & Leong, 2013). It can be said that the anxiety of teacher candidates to teach mathematics decreased thanks to the fact that GeoGebra software contributes positively to the attitude towards mathematics with its visualization potential and plays an auxiliary role in reflecting mathematical association in the classroom (Gomez-Chacon, 2011).In addition, it has been shown that it contributes to the embodiment of the subject, is used comfortably in learning environments and benefits students and teachers (Zengin et al., 2012). It can be said that Dikovic's (2009) Geogebra software can visualize the mathematical process and has a positive effect on students in the teaching of analysis course subjects. Kutluca and Zengin (2011) stated that Geogebra is used with pleasure and desire by math teacher candidates, that this software with visual depth increases permanence (Selçik & Bilgici, 2011) and that the relationships between mathematical concepts are more easily noticed.

Geogebra teaching is fun, permanent and can be said to increase interest in mathematics (Kutluca & Zengin, 2011; Özdemir, 2011). It has also been observed that the tutorials like the visual, practical, active, technological tools of this software and speed up learning, and they want to use this software in other courses (Tüzer-Ünsal & Akay, 2020).

It is known that teacher candidates increase their skills such as searching for different solutions, exploring geometric features, generalizing and reasoning, inference and making assumptions (Bansilal, 2015; Chigona et al. 2014; Filiz, 2009; Shadaan & Leong, 2013; Ünay & Özmen, 2006). It also encourages teacher candidates to make assumptions thanks to their many features and tools, encouraging them to make proof (Ceylan, 2012). In parallel, The Güven (2002) stated that after meeting the dynamic geometry software of the teacher candidates, their thoughts changed and they began to see geometry as a whole of relationships that needed to be investigated. GeoGebra software provides students with rich experiences and research and exploration environments (Tüzer-Ünsal & Akay, 2020). In this respect, the correct understanding of mathematical and relational variables and immutables (Akkaya et al., 2011; Güven, 2012), encouraging critical thinking and thinking, student communication, geometric reasoning of ideas, robust reasoning (Shadaan & Leong 2013; Unay & Özmen, 2006) and high-level reasoning skills (Goos et al., 2003).

In his research Weinhandl, Lavicza, Hohenwarter and Schallert, (2020), they noted that Geogebra can be used for feedback, design-based creation, and reverse education for students. Studies showing that teaching with Geogebra is effective (Bakar et al., 2015; Bhagat & Chun-Yen, 2015; Bayaga et al., 2020; Mingirwa, 2016). Bansilal (2015) reports that the use of technology by prospective teachers changes the environment in math teaching and learning, facilitates learning and teaching tasks, and provides opportunities for diversity in math teaching and learning that can increase students' conceptual understanding. In addition, Wang (2008) stated that technology-assisted collaborative learning has a positive effect on students' performance. Dogan and İçel (2011) define GeoGebra as user-friendly with its easy-to-use interface, multilingual menus, commands and help. This interface encourages students to experience mathematics through multiple presentations, experiment with mathematical concepts, use guided discoveries, and personalize their own configurations and communications. Proponents of GeoGebra state that students can easily modify variables using dynamic sliders, parameters, or simply by dragging free objects around the plane (Hohenwarter et al., 2009; Shadaan & Leong 2013). This can help students understand the concepts of independence, addiction, variables and immutables (Akkaya et al., 2011; Hohenwarter et al., 2009). By moving the shapes created by the drag feature of GeoGebra software, the immutable properties and mathematical properties of the object can be discovered (Furner & Marinas, 2007; Kan, 2014; Santos-Trigo & Cristóbal-Escalante, 2008). For example, thanks to GeoGebra-supported applications, vectors created in vectors can be moved to observe the effect of changes in geometric representations on algebraic states (Kan, 2014).

Aktümen et al., (2011) Geogebra program having a Turkish menu will help easy learning; however, he stated that there is not enough time for the implementation of such programs and that there are teacher shortages for the learning of the program. Due to its abstract nature, they assumed that the use of GeoGebra would be most appropriate and useful in understanding concepts in geometry teaching, and that subject competence was important for access to this software, which is a rich variety of computational tools for modeling and simulations.

In addition, Karaaslan and his colleagues (2012) stated that the activities prepared for mathematics and geometry related subjects were suitable for the achievements in the curriculum, but that the course could be processed effectively by the sufficient physical conditions of the school, the teacher's knowledge of the software.

Conclusion

In the study, Geogebra and the teacher candidates realized the memorized knowledge they had already learned. It has been observed that teacher candidates who realize why and how geometric objects should be drawn want to use this program in their professional lives. It has become clear that Geogebra, which provides an increase in interest, motivation and knowledge, should be introduced more to teacher candidates and that the courses that are suitable for the scope should be processed through this software.

Recommendations

In this section, some recommendations are presented in line with the results obtained in the research.

- GeoGebra software must be taught to students before using GeoGebra dynamic software.
- The student's perspective can be expanded by having different activities related to the program.
- GeoGebra software can be actively used by students and teachers on interactive boards in schools.
- GeoGebra software can be introduced to students with mobile phone application. In this way, the inequality of opportunity of students whose socio-economic level is not sufficient can be minimized.
- GeoGebra and similar software programs can be supported through MEB textbooks and activities in additional auxiliary sources.
- The application process of academic researches on GeoGebra, which includes sensory characteristics such as attitude and perception, can be extended.
- Teacher opinions for Geogebra can be examined.

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