Asian Journal of Contemporary Education
ISSN(e): 2617-1252
DOI: 10.18488/journal.137.2021.51.45.56
Vol. 5, No. 1, 45-56.

URL: www.aessweb.com

VIEWS OF MATHEMATICS TEACHER CANDIDATES ON THE USE OF GEOGEBRA IN PROBABILITY TEACHING

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Article History
Received: 6 May 2021
Revised: 2 June 2021
Accepted: 28 June 2021
Published: 14 July 2021

Keywords
Probability
Dynamic mathematics software
Teacher candidate
Geo Gebra
Math education
8th grade.

ABSTRACT

In this study, it was aimed to reveal the opinions of mathematics teacher candidates about the use of the GeoGebra program, which is dynamic geometry software, in the teaching of probability, which is among the concepts that we generally use in the decision-making process in uncertain situations that we encounter in the teaching process by teachers and students. Within the scope of this purpose, a total of 65 elementary mathematics teacher candidates, who have taken statistics and probability courses at a state university, were given GeoGebra training for 4 weeks and made applications. After the training, a semi-structured opinion questionnaire consisting of 5 questions developed by the researchers was applied to the pre-service teachers. Besides, each participant was interviewed. The study is a case study, and the content analysis method was used in the analysis of the data. It has been determined that it is difficult to write equations in the subject of probability processed through GeoGebra and although it provides result-oriented solutions, it provides good and permanent learning in the context of reaching more sample solutions in a short time, it provides a pleasant, non-monotonous and interesting lesson opportunity by concretizing the subject. Also, it was concluded that dynamic elements provide permanence, but there may be difficulties in applications due to the lack of knowledge of computer use by teachers and students.

Contribution/ Originality: Within the scope of this research, it was determined that the use of GeoGebra, a dynamic software, provides convenience in teaching the subject of probability. It also reveals that it is an effective method for 8th grade students to understand the subject of probability.

1. INTRODUCTION

Probability is among the terms that are frequently used in daily life. Although it has great importance in many decisions of individuals in everyday life, understanding the issue of probability is not as easy for everyone (Hirsch & O'Donnel, 2001; Memnun, 2008). This difference is also valid during the school period, and although most of the students develop different understandings of probability, they are unable to find reasons for events involving probability (Munisamy & Doraisamy, 1998). This situation brings along some problems in the learning process of the subject of probability. Kazak (2010) defined probability as one of the concepts we use during decision-making when faced with situations of unknown outcome in daily life (Kazak, 2010). Although probability has an important place in various sciences (Bulut, 1994) studies have also revealed that most mathematics teachers do not have sufficient knowledge and skills in teaching probability (Tunc, 2006). The subject of probability appears before students in the 8th grade of primary education under the title of "probability of easy events". The subject of

possibility is one of the most difficult subjects for teachers and students (Batanero & Serrano, 1999; Van Dooren, De Bock, Depaepe, Janssens, & Verschaffel, 2003; Yildiz & Baltaci, 2015). Students are mostly able to answer probability questions correctly, but they are insufficient to make explanations to support the correct result. Celik and Güneş (2007); Fischbein and Schnarch (1997) also stated that students used prediction skills, not proven bases, in making sense of probability concepts, and therefore they had difficulties. Although probability is important in teaching mathematics, there are difficulties in teaching probability due to various reasons (Koparan & Kaleli, 2015). Among the reasons for not understanding probability, it was seen that students did not understand questions, tried to memorize formulas, had a negative attitude towards probability, and could not use teaching materials (O'Connell, 1999). Memnun (2008) explained the reasons for not learning the subject of probability in six categories. These categories are students' level of readiness, age, inadequate reasoning skills, negative attitude, and teacher and misconception.

One of the reasons for these difficulties is that individuals who are exposed to situations of probability in daily life do not become aware of these situations and do not notice the traces they leave in their lives. Besides, students' level of readiness and teachers' experience regarding probability are insufficient. Students have difficulties in understanding the abstract probability issues in this process (Gurbuz, 2008). In general, the main problem is that the concepts are abstract in the probability course, which is taught with classical and traditional methods. These concepts need to be embodied to positively affect the students' interest and attitude towards the course. Teachers need to go beyond calculating in the teaching of probability and do activities that will help students make sense of abstract probabilities with the help of real-life situations. The suggestions made in this direction are to raise the awareness of students in probability applications and to use technology to deepen the concepts together with data analysis (Franklin et al., 2007; National Council of Teachers of Mathematics, 2000). Some researchers have suggested the use of computers to understand abstract and difficult concepts in probability teaching and to improve students' skills (Cagan, Erkenci, & Kutluca, 2019; Gurbuz, 2008; Koparan., 2015) and traditional teaching methods are now being replaced by contemporary teaching methods in which students can be more active (Gurbuz, 2008).

Different software should be used in this process where instructional technologies are integrated into learning environments. This softwares have been developed day by day, and in this way, several possible problems from life have become observable easily and quickly. One of this software is the GeoGebra program (Koparan, 2015). GeoGebra is a dynamic mathematical software that was developed in 2001 by Markus Hohenwarter as a master's thesis and allows to use geometry, algebra and analysis at the same time (Hohenwarter & Lavicza, 2007; Preiner, 2008). Geogebra can be defined as a system due to its ability to express mathematical language and visualize it. However, it is also defined as software because it provides dynamic relationships between concepts such as point, line segments, lines and conic sections. One of the features that differentiate GeoGebra is that it can be treated as a system in one aspect and software in the other (Antohe, 2009; Hohenwarter & Jones, 2007). Dikovic (2009) lists the advantages of GeoGebra software as follows;

- Being simple to use, GeoGebra offers menus, commands and help content translated into multiple languages.
- It enables students to learn about their activities, studies and projects through experience and discovery.
- It allows students to customize their work pages.
- GeoGebra is conceived to aid in meaningful mathematical learning. It offers students the opportunity to solve problems in a dynamic environment.
- The teacher's task is not to convey information directly, but to provide students with environments that support their mental structures. In this case, GeoGebra offers good opportunities for collaborative learning.
- GeoGebra also offers teachers the opportunity to use technology in the classroom and bring mathematics to interactive environments.

Because of the advantages of GeoGebra emphasized by Dikovic (2009) and the frequent use of technological tools in today's world, teachers and teacher candidates are expected to include such practices in changing education

and training environments. In various studies conducted in Turkey, math teachers are reported to require computer-based teaching materials that have been developed by the mathematical topics (Birgin, Uzun, & Akar, 2020; Topuz & Birgin, 2020; Zengin, 2018). On the other hand, in a study in which the content analysis of postgraduate theses on GeoGebra was made, they stated that conducting studies on GeoGebra-supported teaching material or learning environment designs would contribute to the literature (Şimsek & Yasar, 2019). Therefore, the purpose of this study is to evaluate the opinions of mathematics teacher candidates about the use of GeoGebra, which is a different method on probability, which is seen as difficult to learn. In this context, the research problem of the study is "What are the opinions of mathematics teacher candidates about probability teaching with GeoGebra, after probability education with GeoGebra and the solution of questions with 8th grade primary school students?".

2. METHOD

2.1. Research Model

This study is a qualitative case study to examine in-depth the data obtained by two different data collection tools related to the research group and to explain the findings obtained in this context (Creswell, 2007). It gives the opportunity to systematically examine the relationships between the obtained data and explain these relationships within the framework of cause and effect (Cohen & Manion, 1994). The opinions of the prospective mathematics teachers about teaching probability with GeoGebra were obtained through the semi-structured interview form and the notes were taken during the GeoGebra preparatory training.

2.2. Choosing the Participant Group

Participants of the study consist of a total of 65 mathematics teacher candidates, 41 male and 24 female who is studying in the Department of Primary Mathematics Teaching at a state university. While participation is voluntary, the participants must attend the GeoGebra training, which will last 4 weeks. In this context, an easily accessible sampling method (Yıldırım & Simşek, 2006) was used as a sample. All of the participants were selected from teacher candidates who passed the statistics-probability course. Participating pre-service teachers were coded as ÖA1, ÖA2,…, ÖA65.

2.3. Data Collection Tools

In the study, a semi-structured interview form prepared by the researcher through literature review and notes taken during the preparatory education were used to determine the opinions of primary school mathematics teacher candidates about teaching probability with GeoGebra. Two experts in mathematics education examined the data collection tool used in the study. Thus, the content validity of the data collection tool was tried to be obtained. However, interviews were made with 5 teacher candidates who did not participate in the study, and the final form of the data collection tool was shaped after the pilot study. On the other hand, the notes taken during the preparatory GeoGebra training were also used to support the data.

2.4. Preparatory Training Practice and Data Collection Process

To start the research, first, the permission of the ethics committee was obtained, and then the GeoGebra preparation training process for probability teaching, which will continue for 4 weeks, has started. The education was carried out for a total of 8 hours, 2 hours per week, remaining from the compulsory lesson time of mathematics teacher candidates. The work plan and its content are presented in Table 1.

Apart from the researcher, a research assistant from the department of mathematics teaching was present during the training to help teacher candidates. After the preparatory training, an interview form was applied to the teacher candidates. Then the preparatory training, the teacher candidates solved questions with GeoGebra for an

8th grade student of their choice. An interview form was applied to prospective teachers after the applications. On the other hand, one-on-one interviews were conducted with the participants. During the interviews, the research assistant, who participated in the preparatory training together with the researcher, was also present, and the participants were informed and recorded. The interviews lasted between 3-5 minutes.

Table-1. Preparatory GeoGebra training work plan for probability teaching.

Weeks	Content	Duration (hours)
1	GeoGebra software overview	2
2	Content creation-applications related to mathematics subjects	2
3	Content creation-applications related to mathematics subjects	2
4	Content creation-applications related to probability teaching	2

2.5. Data Analysis

The data obtained in the study were evaluated by the content analysis method. Accordingly, the data obtained from the participants were coded by 2 independent researchers, taking their similarities and differences into account. Content analysis: It is the detailed and systematic analysis and interpretation of a certain material to determine patterns, themes, and prejudices (Berg & Lune, 2014). Interview forms were analysed in detail, and the most emphasized expressions and important themes by the students were formed. To ensure the reliability of the analysis of qualitative data, the analysis of the two coding researchers were compared with the reliability formula proposed by Miles and Huberman (1994). Accordingly, because of the examinations of the coders, the compliance rate in the coding was calculated as 90%. Also, the themes coded differently were compared with the common views of the researchers. In the interviews made for external validity, the answers of the students were presented with direct quotations. Frequency and percentage tables were used to present the data comprehensively. For the internal validity of the research, triangulation was made with the data obtained from field notes, interviews, and opinion form.

3. RESULTS

3.1. The Views of Preservice Mathematics Teachers about Teaching Probability through Geogebra

Teacher candidates' opinions were consulted about teaching probability through GeoGebra. The data obtained from the pre-service teachers were analysed by creating themes. The themes created were shaped according to the benefits, negative sides and difficulties of the participants in probability teaching with GeoGebra. The opinions of the teacher candidates about the benefits of probability teaching with GeoGebra were presented in Table 2.

When Table 2 was examined, the benefits of probability teaching with GeoGebra, in general, were collected in three categories. These were related to the course content, course process and consideration / interests. The opinions of the teacher candidates about the course content were: "It provides a connection with daily life (f = 2, 3%), makes it easier to grasp the subject (f = 2, 3%), it provides concretization of concepts (f = 31, 47.6%), more it enables to solve many questions (f = 44, 67.6%), enables to calculate probability with very high numbers (f = 32, 49.2%), for the same type of question, it can give many sample results with the help of sliders (f = 17,% 26.15) ".

The statements of ÖA21 and ÖA55 about associating with daily life;

"Since we encounter probability problems in daily life, we can solve many similar example questions with GeoGebra and establish a connection with our lives. In addition, while solving questions to my student, I was able to solve the kind of questions my student might encounter." (ÖA21).

"It is very beneficial to see the examples of probability from our lives and to concretize them with George" (ÖA55).

Regarding concretizing the probability issue with GeoGebra, ÖA3 and ÖA43 used the following expressions.

"It helps to materialize the subject by turning the theoretical possibility into experimental possibility. It was easier to explain the subject." (ÖA3).

"GeoGebra was able to eliminate the abstraction of probability, I was able to better understand and explain the questions. My student really understood much better, I was able to turn it into concrete." (ÖA43)

Table-2. Opinions of mathematics teacher candidates about the benefits of probability teaching with GeoGebra.

Categories	Codes	f	%
Related to the course content	It provides a connection with daily life.	2	3
	It makes the subject easier to grasp.	2	3
	It provides concretization of the concepts.	31	47.6
	Provides more sample solutions.	44	67.6
	It enables to calculate probability with very high numbers.	32	49.2
	With the help of sliders, many examples can give results for the same type of question.	17	26.15
Related to the course process	Visual learning	11	16.9
	Provides interaction between courses	3	4.6
	Diverse and different material	35	53.8
	Increases efficiency	10	15.3
	Great convenience when lecturing	34	52.3
	Provides reinforcement	6	9.2
	Teacher-student communication increases	3	4.6
	Saving on time	9	13.8
	Effective lesson presentation	9	13.8
	Provides distance education	11	17
	Permanent learning	16	24.6
Consideration - interest	Motivating students to the lesson	8	12.3
	Interest in lessons increases	10	15.3
	It makes the lessons fun / enjoyable	16	24.6
	Prevents / reduces students' prejudices to the lesson	16	24.6
	Against the rote system	2	3
Others	Cheap cost of course	2	3
	Equal learning opportunity	4	6
	Increases interaction with technology	42	64.6

Note: Participants may have given more than one answer.

Regarding the course process, prospective teachers' views on probability teaching with GeoGebra; "Provides visual learning (f = 11, 16.9%), provides interaction between lessons (f = 3, 4.6%), provides permanent learning (f = 16, 24.6%), saves time (f = 1, 1.5%), provides rich material opportunity (video, film, visual, etc.) (f = 35, 53.8%), increases efficiency (f = 10, 15.3%), great convenience when lecturing (f = 34, 52.3%), supports the reinforcement of lessons (f = 6, 9.2%), provides teacher-student interaction (f = 3, 4.6%), supports teachers' effective lecture (f = 9 , 13.8%) and provides distance education (f = 11, 17%) ". The pre-service teachers' opinions focused on providing more opportunity to solve examples and decreasing the teaching load of the teacher. In addition, after the preparatory training, pre-service teachers expressed their views on the benefits of saving time (f = 9, 13.8%) in the interviews.

When the opinions of the teacher candidates about the consideration - interest category were examined, it was seen that the topic of probability becomes more enjoyable with the use of GeoGebra and the increase in interest in the lesson and the subject of probability. In addition, teacher candidates expressed their views related to teaching probability with GeoGebra as "Increases students 'motivation to the lesson and motivations (f = 8, 12.3%), increases students' interest in the lesson (f = 10, 15.3%), ensures that lessons are fun / enjoyable (f = 16, 24.6%), It prevents /

reduces students' prejudices to the subject of probability (f = 16, 24.6%), it can be useful against the rote system (f = 2, 3%).

The teacher candidates expressed their opinions outside of these three categories. These are "it can create less costly lesson environment, provide equal opportunity and increase interaction with technology". The teacher candidates stated that it would be very beneficial to teach probability with GeoGebra since it will increase interaction with technology (f = 42, 64.6%). Regarding "It is very easy to explain probability with GeoGebra" and "interaction with technology", ÖA39 used the following statement.

"Secondary school students, in particular, do not understand probability questions. The teacher must tell by drawing or animating. When the probability is explained with Geogebra, many questions can be solved, and the question is presented by concretizing. Besides, it would be very good to be familiar with the computer for both students and teachers."

The opinions of mathematics teacher candidates about the negative sides of probability teaching with GeoGebra are presented in Table 3.

Table-3. Opinions of mathematics teacher candidates about negative sides of probability teaching with Geogebra.

Categories	Codes	f	%
Negativities regarding probability	Giving a direct result on probability	4	6
	The solution can be difficult to understand	7	11
	Applications can be confusing	3	4.6
	Difficulty writing multi-digit equations	19	29.2
Technical downsides	There may be a power outage during the lesson	6	9.2
	There may be internet interruptions during the lesson	1	1.5
	Failure to add required material or install the program	5	7.6
Teacher - related negativities	The teacher may be insufficient to use the GeoGebra program	24	37
	Classroom management can be difficult	31	47.7
	Teachers may lack experience in using computers	9	14
	Teacher may not have time to plan	2	3.7
Student - related negativities	Students' lack of knowledge about the GeoGebra	6	9.2
	May cause distraction in the student	4	6
	The student may not know how to use a computer	23	35.3
	The computer can be used out of purpose	19	29.2
	May prevent permanent learning	4	6
	The student can become a passive listener	12	18.4
	Can make students forget their writing habits	3	4.6
	Note-taking habits of students may decrease	5	7.6
Other	Not expressing opinion	10	15.3

Note: Participants may have given more than one answer.

When Table 3 was examined, it was seen that the opinions of the pre-service teachers about the possible negativities about teaching probability with GeoGebra were grouped under four headings. These were problems related to probability, negativities that may be technical, problems originating from the teacher and negativities caused by the students. Participants' opinions about possible technical negativities about teaching probability with GeoGebra was as "there may be a power outage during the lesson (f = 6, 9.2%), that there may be an internet connection problem in the course (f = 1, 1.5%), the required material is not added or the program is not installed" (f = 5, 7.6%). For this reason, the participants stated that especially the teachers may have problems as there will be disruptions in their course plans.

In the interviews, among the problems that may be encountered in probability teaching through GeoGebra, the negativities caused by the teacher constitute the other category. The teacher candidates, especially, teachers do not know how to use the GeoGebra program (f = 24, 37%), teachers' deficiency in using computers (f = 9, 14%), there may be a waste of time during the lessons (f = 2, 3.7%) Classroom management may be difficult during GeoGebra application (f = 31, 47.7%). In this context, the statements of teacher candidates;

"Unfortunately, even currently, many teachers do not even know how to send mail. In other words, it may be troublesome for teachers and students who do not know how to use computers to use the GeoGebra program." (ÖA34)

"A lot of time passes while the teacher is dealing with the computer in computer-taught lessons, and the lesson can be inefficient at that time". (ÖA12).

At the end of the interviews, four codes were created for negative situations related to probability in teaching the subject of probability with GeoGebra. Although their frequency was low, the first of these was that the GeoGebra program gives a direct result in probability questions. (f = 4, 6%). Secondly, the solution may be difficult to understand (f = 7, 11%) and thirdly, applications may be mixed (f = 3, 4.6%), and finally teachers candidates have difficulty writing a multi-step problem equation (f = 19, 29.2%).

According to the findings obtained from the opinions of the teacher candidates, among the probable negative sides of probability teaching through GeoGebra, there was also a category of negativities caused by the student. These were the students' lack of knowledge about GeoGebra (f = 6, 9.2%), it may cause distraction in the student (f = 4, 6%), the student may not know how to use a computer (f = 23, 35.3%), and the computer may be misused (f = 19, 29.2%), it can prevent permanence in learning, (f = 43, 4.6%), the student can become a passive listener (f = 3, 4.6%), it can dull the writing skills of students (f = 3, 4.6%), students' note-taking habits may decrease (f = 3, 4.6%). Particularly, the teacher candidates stated that computers should be viewed as a game tool and used for reasons other than their purpose as follows.

"When students get a computer, the first thing that comes to mind is games, they immediately download games and listen to music". (ÖA9)

"I witnessed the teachers listening to music on the smartboard in the schools we went for internship." (ÖA11)

The findings obtained from the participant teacher candidates under the theme of situations that mathematics teacher candidates have difficulties while solving questions to 8th grade students with GeoGebra on probability are presented in Table 4.

Table-4. The situations that mathematics teacher candidates have difficulty applying GeoGebra on probability.

Categories	Codes	f	%
Difficult issues regarding probability	The equation in probability is harder than other topics	2	3
	Applications can be confusing in multi-step problems	4	6.15
	Applications can be confusing	4	6.15
	Difficult to understand as the fraction of probabilities	1	1.5
	Change question button is daunting	2	3
	It's hard to give the gains	5	7.6
Technical	Failure to add required material or install the program	5	7.6
	Difficulty writing the code in the input section while making a list	3	4.6
	Difficult to tie the question to the exile	19	29.2
	Those who have trouble writing functions	12	18.4

Note: Participants may have given more than one answer.

When Table 4 was examined, it is stated that after the applications made with the mathematics teacher candidates, they had difficulties under two categories while processing the subject of probability through GeoGebra. First of these, in the category of difficulties related to the probability course; It is more difficult to write equations on probability than other subjects (f = 2, 3%), the applications may be mixed (f = 4, 6.15%), it is difficult to understand as the fraction number of probabilities (f = 1, 1.5%), the change question button is tricky (f = 2, 13%), it is difficult to give the gains (f = 5, 7.6%).

The second category that the teacher candidates had difficulties was determined as technical subjects. These; not adding the required material or not installing the program (f = 5, 7.6%), having difficulties in writing the code in the input part while making a list (f = 3, 4.6%), having difficulty in locking the question to the ban (f = 19, 29.2%), It was determined that those who had difficulties in writing functions (f = 5, 18.4%). Regarding this

category, it was observed that the students had difficulties in adapting the GeoGebra program in terms of probability in the applications of the pre-service teachers.

After learning the subject of probability with the GeoGebra program, the opinions of pre-service mathematics teachers about what kind of differences occur in their teachings about probability were presented in Table 5.

Table-5. Differences between mathematics teacher candidates' previous learning after teaching probability with GeoGebra.

Subjects	f	%
Seeing where things are coming from	7	10.7
Finding a faster solution	51	78.4
Solving the situation visually	18	27.6
To be practical	17	26.15
Those who think the subject is enjoyable	2	3
Seeing all possibilities	21	32.3
Seeing the difference between experimental probability and theoretical probability	32	49.2
Better grasp of GeoGebra	13	20
Changing perspective on probability	7	10.7
Accessing more examples for the same question type	31	47.6
To be able to differentiate dependent and independent events more easily	2	3
See the question in concrete form	18	27.6
Seeing diversity in terms of expression technique	21	32.3
Much easier to tell than direct expression	39	60

Note: Participants may have given more than one answer.

After the applications made with the mathematics teacher candidates, the prospective teachers were asked to make a comparison with their previous teachings on probability after processing the subject of probability with GeoGebra. The findings obtained were categorised as practical to see where the events came from (f = 7, 10.7%), to reach a faster solution (f = 51, 78.4%), to solve the situation by seeing (f = 18, 27.6%) (f = 21, 32.3%), those who think the subject is enjoyable (f = 2, 3%), seeing all possibilities (f = 21, 32.3%), seeing the difference between experimental probability and theoretical probability (f = 32, 49.2%), having a better understanding of GeoGebra (f = 13, 20%), changing probability perspective (f = 7, 10.7%), reaching more examples for the same question type (f = 31, 47.6%) , being able to distinguish between dependent and independent events more easily (f = 2, 3%), seeing the question in its concrete form (f = 18, 27.6%), seeing diversity in terms of expression technique (f = 21, 32.3%), much easier to tell than direct expression (f = 9, 13.8%). In this context, some of the teacher candidates stated the following;

"I think the most important difference of geogebra was to be able to explain very practically and solve questions. It saves a lot of time and allows many questions to be solved." (ÖA54).

"In the questions I solved with Geogebra, I understood the dependent and independent events more clearly. It was very easy to explain to the student, I did not need to draw." (ÖA13).

In Table 6, other topics where GeoGebra can be used are presented according to the opinions of the teacher candidates.

When Table 6 was examined, the teacher candidates stated that they could use the GeoGebra program mostly in geometry. It was determined that the teacher candidates gave answers as geometry subjects (f = 54, 83.7%), functions (f = 23, 35.3%), analytical geometry (f = 18, 27.6%), fractions (f = 17, 26.15%)), derivative (f = 2, 3%), analysis course subjects (f = 9, 13.8%), transformation geometry (f = 27, 41.5%), problems (f = 7, 10.7%) , patterns (f = 7, 10.7%), graphic drawing (f = 31, 47.6%), all subjects (f = 8, 12.3%). The teacher candidates had no idea about teaching probability with GeoGebra before the applications. After the preparatory training, most of the teacher candidates stated that they would actively benefit from GeoGebra for every subject. They stated that they found it very useful both in terms of increasing the variety of questions and in terms of seeing the applications of other mathematical subjects.

Table-6. Other mathematics topics that mathematics teacher candidates may use Geogebra.

Topics	f	%
Geometry	54	83.7
Functions	23	35.3
Analytical geometry	18	27.6
In fractions	17	26.15
Derivative	2	3
Analysis	21	32.3
Transformation geometry	27	41.5
Problems	13	20
Patterns	7	10.7
Graphic drawing	31	47.6
In all topics	8	12.3

Note: Participants may have given more than one answer.

4. DISCUSSION

When the findings regarding the benefits of probability teaching with GeoGebra were examined, mathematics teacher candidates stated that they found it useful to study the subject of probability through the GeoGebra program, because of that students understand much more comfortably while solving probability questions, the interaction with technology would increase, the concepts would become concrete, it would provide rich material opportunities, and it offered the opportunity to solve more sample questions in a short time, especially by trying the same problem for many different values. Considering that learning with multi-question solving and trial and error is more permanent, the importance of prediction and trial and error for mathematics education is increasingly becoming striking (Sahin, 2007; Segovia & Castro, 2009; Yıldız, Baltacı, Kurak, & Güven, 2012).

The mathematics teacher candidates stated that the preparatory training made for teaching probability with GeoGebra were beneficial and practical on behalf of teachers and teacher candidates. It is thought that the training given from theoretical to practice would be beneficial in developing teacher candidates. Considering in particular probability teaching, one of the factors affecting the learning of probability concepts is students' negative attitudes (Memnun, 2008). It is thought that these prejudices will be broken in the context of the opinions that the lessons are fun in teaching with Geogebra. The fact that the concepts in mathematics courses are abstract makes mathematics different from other courses (Inci & Uras, 2019; Zengin, Kağızmanlı, Tatar, & Isenler, 2013). Although it is not frequent in studies on the concretization of mathematical concepts, these points were highlighted in the opinions of prospective teacher candidates about the positive aspects of teaching probability with GeoGebra (Seker & Erdoğan, 2017; Topuz & Birgin, 2020). For example, the importance of GeoGebra becomes apparent when studies on software that concern preservice mathematics teachers are examined. The main reason for this is that abstract mathematical equations and problems are concretized and visualized with GeoGebra (Zengin et al., 2013). It was observed that the opinions of mathematics teacher candidates about other positive aspects of probability teaching with GeoGebra focused on the content of the course, the effectiveness of the courses and the students' interest in the lessons. In traditional learning environments, students stated that they could not have the opportunity to predict, reason, intuitively think, motivate, experiment, see what was obtained from the experiment and extract formulas for probability questions, however, these possibilities were largely provided by GeoGebra. At the same time, although GeoGebra is not important for other courses, it makes mathematics lessons effective (Baki, 2015; Zengin et al., 2013).

On the other hand, the opinions of the participating teacher candidates as the probable downsides of probability teaching with GeoGebra; technical negativities, negativities originating from teachers and students. First, considering the negativities caused by the teacher, the fact that the participant teacher candidates stated that they

have deficiencies in GeoGebra software indicates the need for special education in the field of mathematics (Yıldız, Sarıtepeci, & Seferoğlu, 2013). Also, they emphasized that it may be difficult for the teacher to dominate the classroom during the application and there may be a waste of time. On the other hand, GeoGebra enables students to comprehend the subject in a shorter time, and the teacher does not waste time by writing on the board and drawing shapes and enables them to use the dynamic environment time more efficiently (Usun, 2004). In this respect, it may be stated that GeoGebra supported teaching does not cause time loss, unlike traditional teaching, it can be more effective and save time for the long process.

Although the GeoGebra applications on probability were limited, it was observed that the participant teacher candidates constituted very creative examples, gained experience, and expressed their opinions about them. These discourses have emerged as a superficial reflection of the possible benefits of using GeoGebra. Topal and Akgun (2015) study is parallel in this regard. It would be more beneficial to include practical rather than theoretical practices in preparatory training. Thus, teachers and teacher candidates would gain experience in such technology applications and feel sufficient in using the GeoGebra program.

After the preparatory training, it was observed that the participant teacher candidates were able to make more in-depth evaluations regarding the subject of probability. Among them, they stated that technology can be easily adapted to daily life by using the GeoGebra program on probability and may be useful for the development of problem-solving skills. These findings are in parallel with the findings of Özen and Yavuzsoy-Köse (2013) study. The development of these skills is among the basic skills of the secondary education program that is aimed to be developed in students (MEB, 2013). At the same time, the participants stated that the use of such technologies would increase the interaction between lessons and have a positive effect on reducing misconceptions. Baki and Güveli (2008) mentioned in his study that similar benefits may be observed in the effective use of such technologies, especially in mathematics lessons.

A remarkable number of pre-service teachers stated that teaching geometry subjects with GeoGebra would be very efficient. Saha, Ayub, and Tarmizi (2010); Seker and Erdoğan (2017); Topuz and Birgin (2020) similarly investigated the effect of the GeoGebra program on student achievement in teaching geometry and found significant differences in student achievement.

Since the visuality required to study probability problems in traditional learning environments cannot be provided, alternative learning environments are needed. In this context, the different features of dynamic statistics software would create learning environments suitable for teachers and students.

Funding: This study received no specific financial support.
Competing Interests: The author declares that there are no conflicts of interests regarding the publication of this paper.

REFERENCES

Antohe, V. (2009). Limits of educational soft" geogebra" in a critical constructive review. *Annals Computer Science Series*, 7(1), 47-54.

Baki, A. (2015). *Mathematics education from theory to practice* (6th ed.). Ankara: Letter Publication.

Baki, A., & Güveli, E. (2008). Evaluation of a web based Mathematics teaching material on the subject of functions. *Computers & Education*, *51*(2), 854-863. Available at: https://doi.org/10.1016/j.compedu.2007.09.003.

Batanero, C., & Serrano, L. (1999). The meaning of randomness for secondary school students. *Journal for Research in Mathematics Education*, *30*(5), 558-567. Available at: https://doi.org/10.2307/749774.

Berg, B. L., & Lune, H. (2014). *Qualitative research methods for the social sciences. Pearson custom library* (8th ed.). Harlow, Essex, England: Pearson Education.

Birgin, O., Uzun, K., & Akar, S. G. M. (2020). Investigation of Turkish mathematics teachers' proficiency perceptions in using information and communication technologies in teaching. *Education and Information Technologies*, *25*(1), 487-507.

Available at: https://doi.org/10.1007/s10639-019-09977-1.

Bulut, S. (1994). *The effects of different teaching methods gender on probability and attitudes toward probability.* Unpublished PhD Thesis. Middle East Technical University, Ankara.

Cagan, N., Erkenci, M., & Kutluca, T. (2019). *Using a computer aided concept map in probability teaching: CMAP.* Paper presented at the 5th Eurasian Conference on Language and Social Sciences, Belek.

Celik, D., & Güneş, G. (2007). Investigation of understanding and misconceptions of 7th, 8th and 9th grade students about probability. *Journal of National Education, 35*(173), 361-375.

Cohen, L., & Manion, L. (1994). *Research methods in education.* London: Routledge.

Creswell, J. (2007). *Qualitative inquiry & research design: Choosing among five approaches* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Dikovic, L. (2009). Implementing dynamic mathematics resources with GeoGebra at the college level. *International Journal of Emerging Technologies in Learning (iJET), 4*(3), 51-54. Available at: https://doi.org/10.3991/ijet.v4i3.784.

Fischbein, E., & Schnarch, D. (1997). Brief report: The evolution with age of probabilistic, intuitively based misconceptions. *Journal for Research in Mathematics Education, 28*(1), 96-105. Available at: https://doi.org/10.5951/jresematheduc.28.1.0096.

Franklin, C., Kader, G., Mewborn, D., Moreno, J., Peck, R., Perry, M., & Scheaffer, R. (2007). *Guidelines for assessment and instruction in statistics education (GAISE) report.* Alexandria, USA: American Statistical Association.

Gurbuz, R. (2008). A computer aided material that can be used in teaching probability. *Mehmet Akif Ersoy University Journal of the Faculty of Education, 8*(15), 41-52.

Hirsch, L. S., & O'Donnel, A. M. (2001). Representativeness in statistical reasoning: Identifying and assessing misconceptions. *Journal of Statistics Education, 9*(2), 1-22. Available at: https://doi.org/10.1080/10691898.2001.11910655.

Hohenwarter, M., & Jones, K. (2007). Ways of linking geometry and Algebra, the case of Geogebra. *Proceedings of the British Society for Research into Learning Mathematics, 27*(3), 126-131.

Hohenwarter, M., & Lavicza, Z. (2007). Mathematics teacher development with ICT: Towards an International GeoGebra Institute. *Proceedings of the British Society for Research into Learning Mathematics, 27*(3), 49-54.

Inci, K. C., & Uras, M. (2019). Views of elementary mathematics education department academic staff on the use of materials in mathematics teaching. *Current Research in Education, 5*(1), 23-33.

Kazak, S. (2010). Students' misconceptions about probability and learning difficulties. M.F. Özmantar, E.Bingölbali and H. Akkoç (Ed.), Mathematical misconceptions and solution suggestions (pp. 121-147). Ankara: Pegem Academy.

Koparan, T., & Kaleli, Y. G. (2015). The effect of simulation-based learning on prospective teachers "Inference skills in teaching probability. *Universal Journal of Educational Research, 3*(11), 775-786. Available at: https://doi.org/10.13189/ujer.2015.031101.

Koparan, T. (2015). Difficulties in learning and teaching statistics: Teacher views. *International Journal of Mathematical Education in Science and Technology, 46*(1), 94-104. Available at: https://doi.org/10.1080/0020739X.2014.941425.

MEB. (2013). *Primary education institutions (Primary and Secondary Schools) science course (3, 4, 5, 6, 7 and 8th Grades) curriculum.* Ankara: MEB Publishing House.

Memnun, D. S. (2008). Difficulties encountered in learning probability concepts, reasons for not learning these concepts and suggestions for solutions. *Journal of İnönü University Faculty of Education, 9*(15), 89-101.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook.* Thousand Oaks, CA: Sage Publications.

Munisamy, S., & Doraisamy, L. (1998). Levels of understanding of probability concepts among secondary school pupils. *International Journal of Mathematical Education in Science and Technology, 29*(1), 39-45. Available at: https://doi.org/10.1080/0020739980290104.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* Reston, USA: NCTM.

O'Connell, A. A. (1999). Understanding the nature of errors in probability problem-solving. *Educational Research and Evaluation, 5*(1), 1-21. Available at: https://doi.org/10.1076/edre.5.1.1.3887.

Özen, D., & Yavuzsoy-Köse, N. (2013). Investigating pre-service mathematics teachers' geometric problem solving process in dynamic geometry environment. *Turkish Online Journal of Qualitative Inquiry*, *4*(3), 61-74.

Preiner, J. (2008). *Introducing dynamic mathematics software to mathematics teachers: The case of GeoGebra*. Unpublished Doctoral Dissertation. University of Salzburg, Austria.

Saha, R. A., Ayub, A. F. M., & Tarmizi, R. A. (2010). The effects of GeoGebra on mathematics achievement: Enlightening coordinate geometry learning. *Procedia-Social and Behavioral Sciences*, *8*, 686-693. Available at: https://doi.org/10.1016/j.sbspro.2010.12.095.

Sahin, A. A. (2007). *Determining the problem solving strategies of 13-14 age group students*. Master's Thesis). Balikesir University, Balikesir.

Segovia, I., & Castro, E. (2009). Computational and measurement estimation: Curriculum foundations and research carried out at the University of Granada, Mathematics Didactics Department. *Electronic Journal of Research in Educational Psychology*, *7*(1), 499-574.

Seker, B. H., & Erdoğan, A. (2017). The effect of geometry teaching with GeoGebra software on geometry course success and geometry self-efficacy. *OPUS International Journal of Society Studies*, *7*(12), 82-97. Available at: https://doi.org/10.26466/opus.313072.

Şimsek, N., & Yasar, A. (2019). Thematic and methodological trends of graduate theses on GeoGebra: A content analysis. *Turkish Journal of Computer and Mathematics Education*, *10*(2), 290-313. Available at: https://doi.org/10.16949/turkbilmat.450566.

Topal, M., & Akgun, O. E. (2015). Investigation of self-efficacy perceptions of pre-service teachers studying in education faculty for educational purposes: Sakarya university example. *Kastamonu Journal of Education*, *23*(1), 343-364.

Topuz, F., & Birgin, O. (2020). Student views on the learning environment and the geogebra-supported teaching material developed on the seventh grade "circle and circle" topic. *Journal of Computer and Education Research*, *8*(5), 1-27. Available at: https://doi.org/10.18009/jcer.638142.

Tunc, E. (2006). *Evaluation of the level of gaining knowledge and skills about probability to 8th grade students of private primary schools and public schools*. Master's Thesis. Balikesir University, Balikesir.

Usun, S. (2004). Instructional technologies in the world and Turkey (A comparative review). *AACE Journal*, *12*(3), 249-279.

Van Dooren, W., De Bock, D., Depaepe, F., Janssens, D., & Verschaffel, L. (2003). The illusion of linearity: Expanding the evidence towards probabilistic reasoning. *Educational Studies in Mathematics*, *53*(2), 113-138.

Yıldırım, A., & Simşek, H. (2006). *Qualitative research methods in the social sciences*. Ankara: Seçkin Publications.

Yildiz, A., & Baltaci, S. (2015). Investigation of primary school mathematics teacher candidates' knowledge of problem posing activities and probability. *Ahi Evran University Journal of Kirsehir Education Faculty*, *16*(1), 201-213.

Yıldız, A., Baltacı, S., Kurak, Y., & Güven, B. (2012). Examining the use of problem solving strategies by gifted and non-gifted 8th grade students. *Uludag University Journal of Education Faculty*, *25*(1), 123-143.

Yıldız, H., Sarıtepeci, M., & Seferoğlu, S. S. (2013). Examining the contribution of in-service training activities organized within the scope of FATIH project to the professional development of teachers in terms of ISTE teacher standards. *Hacettepe University Faculty of Education Journal, Special Issue*(1), 375-392.

Zengin, Y. (2018). Incorporating the dynamic mathematics software GeoGebra into a history of mathematics course. *International Journal of Mathematical Education in Science and Technology*, *49*(7), 1083-1098. Available at: https://doi.org/10.1080/0020739X.2018.1431850.

Zengin, Y., Kağızmanlı, T. B., Tatar, E., & Isenler, T. (2013). The use of dynamic mathematics software in computer assisted mathematics teaching course/The use of dynamic mathematics software in computer assisted mathematics instruction course. *Journal of Mustafa Kemal University Institute of Social Sciences*, *10*(23), 167-180.