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EXAMINING THE ATTITUDE CHANGE OF PRE-SERVICE ELEMENTARY SCHOOL TEACHERS TOWARDS A COURSE OF MATHEMATICS EDUCATION WITHIN THE FRAMEWORK OF THEORY OF DIDACTICAL SITUATIONS

Research Article

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EXAMINING THE ATTITUDE CHANGE OF PRE-SERVICE ELEMENTARY SCHOOL TEACHERS TOWARDS A COURSE OF MATHEMATICS EDUCATION WITHIN THE FRAMEWORK OF THEORY OF DIDACTICAL SITUATIONS¹

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Abstract

This study investigated whether the training program given within the framework of the Theory of Didactical Situations (TDS) within a mathematics education course could change the pre-service elementary teachers' attitudes towards a mathematics education course in an 11-week teaching process. In the study, the mixed method was used. The participants were 86 pre-service elementary teachers (52 female and 34 male). In the study, the quantitative research data were collected using the Attitude Scale for Mathematics Education Courses (ASMEC), and the qualitative data were collected using semi-structured interviews. For the analysis of the quantitative data, paired samples t-test was applied, and for the analysis of the qualitative data, content analysis was conducted. The results revealed that the training program given in line with TDS created a statistically significant difference between the pre-test and post-test scores of the pre-service elementary school teachers with respect to their attitudes towards courses of mathematics education ($t(85)=-2.22$, $p=.029$) and that there was no statistically significant difference in terms of gender, though ($t(84)=-.987$, $p=.327$ and $t(84)=1.108$, $p=.258$). It was found that the training program given in accordance with TDS had a positive influence on changing and developing the attitudes of the pre-service elementary teachers towards mathematics education courses.

Keywords: Attitude change, Gender, Mathematics courses, Theory of Didactical Situations, Pre-service teachers.

1. Introduction

Students' attitudes towards mathematics at schools have considerable influence on their approaches to problems (Bloom, 1977; Ministry of National Education [MoNE], 2018). In this respect, most initial studies on attitudes towards mathematics focused on the relationship between attitudes and any other variable (for example, achievement) (Goldin et al., 2016). Goldin et al. (2016) point out that recent studies on attitudes towards mathematics have avoided such vicious circles and that studies conducted to examine the attitudes of students unsuccessful in problem solving towards mathematics have provided researchers with new insights. It is an undeniable fact that attitudes towards mathematics are developed to a great extent in school years (Bloom, 1977) and that teachers have a key role in the development of these attitudes. This situation has led the focus onto the training of teachers who will teach

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mathematics at all levels at schools. Therefore, studies on teacher training now focus more on how to make changes in pre-service teachers' attitudes towards mathematics (Anderson & Piazza, 1996; Bailey, 2014; Charalambous et al., 2009; Philippou & Christou, 1998). All these studies demonstrate that well-designed teaching environments could lead to changes in pre-service teachers' attitudes towards mathematics.

It is reported that pre-service teachers' mathematics-related experiences they gain during their elementary school and high school years shape their attitudes towards mathematics (Hourigan et al., 2016). Ball (1990), who draws attention to this situation, states that pre-service teachers' past experiences in their elementary school and high school years are not enough to understand mathematics teaching and that it is thus necessary to focus more on their past experiences to create changes in their attitudes towards mathematics. The present study examined the changes in the pre-service elementary teachers' attitudes towards mathematics in the process of teaching mathematics in a teaching environment designed in line with the constructivist approach, which was different from the way of teaching mathematics they faced in their elementary and high school years. In order to clarify this purpose, it is first necessary to mention what the attitude is, what the attitude towards mathematics is and how the attitude towards mathematics appears. Following this, the related literature on how attitudes can be changed will be reviewed.

1.1. Review of the Literature on Attitudes towards Mathematics

The term attitude, which is a considerably complex psychological variable, is used for emotional states, behavioral tendencies, beliefs, views and perceived social distances (Hunter et al., 1984). Thus, it is obvious that attitude includes cognitive, emotional and behavioural components (Maio, Haddock and Verplanken, 2019). This makes it necessary to examine attitude in different study fields from different perspectives.

Researchers define attitude in many different ways, yet there are two prominent definitions of attitude. According to one of these two definitions of attitude, it refers to emotional reactions involving positive and negative feelings in the state of equilibrium (McLeod, 1992). According to the second definition of attitude, it refers to the behaviors of acting, feeling or thinking, which reflect the individual's tendencies or thoughts (Philipp, 2007). Examining a number of definitions of attitude, Leder (1987) explains the fundamental properties of attitude as follows: 1. Being learned in time, 2. Being prepared in advance for appropriate or inappropriate action and 3. Having consistency in responses. Similarly, McLeod (1992) reports that attitudes develop in line with experiences in time; that they are consistent; and that strong changes in students' attitudes could thus have long-term influence. However, this does not mean that an attitude towards a subject or an object will never change. For instance, those who teach a discipline develop a certain degree of attitude during their education lives towards the subjects they will have to teach in future. One of these disciplines is the mathematics education.

It is seen that there is no compromise on the definition of the term attitude in mathematics education and that a wide variety of definitions of attitude have been provided. Some mathematics educators define attitude towards mathematics as a positive or negative emotional tendency towards mathematics courses at school (Haladyna et al., 1983), while others regard it as the emotional reaction to mathematics and beliefs and behaviours regarding mathematics (Hart, 1989). All these definitions demonstrate that individuals' attitudes towards mathematics are mostly in the form of inner reactions, and this makes it necessary to investigate the internal mechanisms of individuals (within the process) which they use when exposed to mathematical actions. This will allow revealing how attitudes towards mathematics could be changed.

In relation to how attitudes towards mathematics appears, McLeod (1989) claims that attitudes towards mathematics refer to automatized constantly-repeated emotional reaction and to the transfer of a current attitude to a new but related situation. In this respect, the starting point of the present study is the hope that pre-service teachers' attitudes towards mathematics could be developed with the help of the two situations above which cause attitudes to occur.

Another important issue is that attitude towards mathematics has a relationship with how mathematics is taught. In this respect, the most important cause of anxiety is reported to be the case of teaching under the guidance of an authoritarian teacher (Altun, 2013). Ball (1990; 1996) states that pre-service elementary teachers are accustomed to using teacher-centered approaches based on memorization and other related procedures rather than using their own independent thoughts. In our country, it could be stated that student-centered approaches are not common in practice though these approaches are theoretically suggested. This situation has arisen the question of how different methods of teaching influence the affective domain regarding mathematics. In one experimental study, Alsup (2004) reported that there was a decrease in the pre-service elementary teachers' levels of anxiety about mathematics when they were taught mathematics using constructive methods instead of traditional methods. Therefore, teachers are suggested to make use of more advanced methods of teaching mathematics (MEB, 2018). When compared to the traditional methods, student-centered approaches to solving problems provide a better class atmosphere in the teaching process (Gok & Erdogan, 2017). Therefore, it is thought that a positive change could occur in pre-service teachers' attitudes towards mathematics when mathematics is taught with the help of new student-centered teaching approaches (for example, teaching mathematics via games).

This change, which could be regarded as the last step of the teacher training process of pre-service teachers, is considered to be a negative situation when compared to elementary school and high school students. The reason is that individuals' attitudes towards mathematics will become rooted (Hembree, 1990; Ma & Kishor, 1997). On the other hand, Beswick (2006) points out that causing permanent changes in pre-service teachers' beliefs and attitudes is difficult but possible with the help of appropriate designs. As a support to this, Anderson and Piazza (1996) state that teaching mathematics to pre-service teachers by changing the curriculum in line with the constructivist learning approach has positive influence on their attitudes towards mathematics. In one small-scale cohort study carried out with pre-service teachers taking the repeat course of mathematics, Bailey (2014) found that an open-ended mathematical investigation resulted in positive reflections upon the pre-service teachers' knowledge, beliefs, and attitudes regarding mathematics. Liljedahl (2005) demonstrated that experience in AHA! had positive influence on the pre-service teachers' affective domains (beliefs and attitudes). Charalambous et al. (2009) reported that a mathematics preparatory program based on the history of mathematics had positive effects on the pre-service teachers' beliefs and attitudes in certain aspects. In another similar study conducted by Philippou and Christou (1998), it was seen that use of contents based on the history of mathematics within the scope of the curriculum of mathematics developed the pre-service teachers' attitudes especially with respect to their levels of satisfaction with mathematics as well as with respect to the benefits of mathematics. Peker and Ulu (2018) stated that teaching mathematics with the help of traditional approaches did not influence teachers' attitudes while constructive approaches had the potential to have influence. Hodges and Kim (2013) revealed that the university students' attitudes towards mathematics significantly developed in an environment designed to increase their motivations. Based on the results of all these studies, it could be stated that it is possible to make changes in pre-service teachers' attitudes towards mathematics when various appropriate designs are used to teach mathematics no matter how resistant pre-service teachers' attitudes are to mathematics.

1.2. The Curricula and Attitudes towards Mathematics in Turkey

The concept of attitude within the scope of the curriculum of mathematics in Turkey is generally examined together with self-efficacy and anxiety about mathematics within the framework of affective characteristics (MoNE, 2009). The affective elements related to mathematics (attitude, self-efficacy and anxiety) are mentioned in detail in the curriculum. It is pointed out that in the teaching process, teachers should determine the affective characteristics of students in several ways (observation, questionnaire, diaries and so on) and take related precautions. In order to increase students' levels of motivation in mathematics courses, things that should be done in a teaching process to help students develop positive attitudes include: a) focusing on conceptual learning, b) selecting appropriate out-of-class tasks, c) effective use of the feeling of achievement, d) use of game-based learning and e) encouraging cooperative learning (MoNE, 2009).

It is seen that the changes done in the curricula in 2013 and 2018 did not cover attitudes towards mathematics at all because of the efforts to simplify the mathematics curriculum. In the 2018 mathematics curriculum, it is pointed out that attitude has the potential to change in the process and that it is a variable to be revised constantly. Several issues should be covered in the mathematics curriculum and taken into account for students to develop positive attitudes towards mathematics.

The influence of developing positive attitudes towards mathematics on learners' achievements in mathematics cannot be ignored. For this reason, mathematical games related to the course contents should be included where appropriate in the curriculum (MoNE, 2018).

It is seen in the curriculum that the primary attention is paid to the relationship between attitude and achievement. A number of researchers revealed a strong connection between attitudes towards mathematics and achievement in mathematics (Akdemir, 2006; Grootenboer & Marshman 2016; Yenilmez 2007). Secondly, it is emphasized that positive changes in attitude should be ensured with the help of mathematical games. Fenyvesi et al. (2014) claim that games can be used in teaching mathematics in an effective way to develop attitudes towards mathematics. Based on the assumption that all individuals enjoy playing games, it could be stated that they have positive attitudes towards games. As mentioned by McLeod (1992), it is believed that integration of mathematical information into a game will help individuals direct their game-related attitudes to learn mathematics, which will then lead to changes in their attitudes towards mathematics.

Another dimension of the present study is the affective relationship between gender and mathematics. In relation to this, there are many studies in literature (Leder, 1992; Markovits & Forgasz, 2017). Initial studies reported a higher tendency of viewing mathematics as an activity more for men (E.g. Leder, 1992). A more recent study suggested that pre-service teachers' attitudes towards mathematics did not change depending on gender (Çakıroğlu and Işıkbal, 2009). In the present study, determining how pre-service teachers with different genders are influenced by the process of teaching mathematics as appropriate to the constructive approach was considered to be important.

Depending on this assumption, the present study examined how pre-service teachers' attitudes towards mathematics change when the above-mentioned potential of games is used in teaching mathematical concepts within the scope of the course of Mathematics Teaching I. In this respect, in the study, the Theory of Didactical Situations was taken as reference to the active use of games in mathematics education.

1.3. The Theory of Didactical Situations

The Theory of Didactical Situations (TDS), which was put forward by Brousseau (1997), could be said to be a game-based learning approach whose roots depend on the constructivist approach (Arslan et al., 2011; Artigue, 1994; Laborde, 2007).

Brousseau (1997) explained the basic components of TDS within the context of a game called *the race to 20*. Accordingly, games have an important place in the theory. The games designed within the framework of the theory are not ordinary games but those which involve both winning and losing and which thus require optimum strategies to win (Erdogan & Ozdemir Erdogan, 2013). Learning occurs as a result of students' engagement in a milieu (for example, a game) which is considered to be a combination of epistemological constraints. In this definition, a milieu is an instructional tool which involves epistemological conditions to reveal the target information (Ligozat & Schubauer, 2010).

According to TDS, students can learn all the mathematical concepts when exposed to appropriate situations (Warfield, 2014). Here, Warfield (2014) defines the situation as conditions in which students need to use or learn a mathematical concept. In this respect, another important concept in the theory is the concept of the situation. According to the theory, instructional designs which will allow students to create their own knowledge are important (Erdogan & Ozdemir Erdogan, 2013). Such situations refer to didactical situations in the theory. According to didactical situations, the teacher manages to conceal the target outcome from students (for example, presenting the outcome by embedding it in the game), and students can study independently of the teacher's interventions in the teaching process (Warfield, 2014). In such situations, for the purpose of preserving the didactical structure of the environment, Brousseau (1997) defines some of the phases in the learning environment as follows:

Devolution phase: This is the phase in which students undertake the responsibility of the game to achieve meaningful learning without depending on the teacher's feedback (Ligozat & Schubauer, 2010).

Action phase: In this phase, students interact with the milieu and implicitly develop several strategies (Warfield, 2014).

Formulation phase: This is the phase in which students explicitly express the implicit ideas (for example, hypotheses) they have developed in the action phase (Warfield, 2014).

Validation phase: In this phase, students tell other individuals the validity of their ideas they have developed in the formulation phase. Here, the motto is to convince others they talk to.

Institutionalization phase: The teacher revises, shapes and (if necessary) classifies the ideas that the students have developed in the phases of action, formulation and validation, which could be applied in a sequential or overlapping manner, and transfers these ideas into a mathematical dimension (or explains these ideas in a way other people can understand) (Warfield, 2014).

When all these phases are taken into account, it could be stated that the teacher's role in the phases of action, formulation, and validation is just to organize discussions within groups and between groups and to establish interaction between students and the parameters of the environment (Erdogan, 2016). In this way, the teacher's role in reaching the target information is minimized, and students are provided with an environment in which they can develop their knowledge thanks to the feedback they receive in the environment. Consequently, didactical situations can be used effectively as a dynamic approach when a solution is found to a problematic situation, when students try to reach the target information and when student-centered approaches involving the use of games are designed.

In literature, one of the purposes of studies on attitudes towards mathematics could be said to transform negative attitudes into positive ones (Di Martino & Zan, 2015). What makes the present study differ from other related studies in literature was that this study aimed to investigate how mathematics education given to pre-service teachers with the help of the parameters of innovative learning approaches influenced their attitudes towards mathematics. In this respect, this study could be said to provide a different dimension for studies on attitudes towards mathematics.

In an effective teaching process, students reach the information directly on their own. It is obvious that didactical situations provide an appropriate environment for students to reach the information themselves. In such environments, students can learn the selected problem or situation by entertaining, doing and living without any boredom (Erdogan et al., 2014). Considering the influence of the attitudes of the teacher who will design these environments on students' attitudes (Duru et al., 2005; McLeod, 1992) as well as considering the relationship between their achievements in mathematics and the positive attitudes they will develop regarding mathematics (Caraway, 1985; Cheung, 1988; Lucas, 1998; Savas et al., 2010), it could be stated that the positive attitudes to be developed in relation to mathematics by pre-service elementary teachers, who will become teachers in future, have a close relationship with mathematics teaching. Consequently, based on the thought that pre-service teachers' attitudes and beliefs regarding mathematics can be changed during their teacher training process (Dogan, 1999), didactical environments could be designed in relation to the course of mathematics education for pre-service elementary teachers. Within the framework of this basic conclusion, the present study aimed to examine the influence of the course of Mathematics Teaching I executed in an didactical learning environment on pre-service elementary teachers' attitudes towards mathematics education. Also, the study tried to reveal the potential of TDS to change pre-service elementary teachers' attitudes towards courses regarding mathematics education.

2. Method

2.1. Research Purpose and Design

This study examined whether the training program given in accordance with the Theory of Didactical Situations (TDS) within the scope of a mathematics education course could create changes in the pre-service elementary teachers' attitudes towards a mathematics education course in an 11-week teaching process. In the study, the mixed method was adopted, and besides quantitative data, qualitative data were collected to elaborate and support the quantitative data. The flow of research process was as follows: the pre-test, the training program, post-test and interviews. In addition, the study did not include a control group. In this respect, the study was carried out using a pre-test-post-test weak experimental design with a single group (Buyukozturk et al., 2012).

2.2. Research Purpose and Design

In the study, in the 1st week prior to the application process and in the 9th week following the application process, the Attitude Scale for Mathematics Education Courses (ASMEC), which was developed by Karakas Turker and Turanli (2008) and whose reliability was calculated as 0.928, was applied to the pre-service elementary teachers to determine the influence of an didactical teaching environment on the participants' attitudes towards mathematics education courses. In the application process, the activities prepared for the course of Mathematics Teaching I within the framework of TDS were carried out in two class hours a week in a period of seven weeks making 14 class hours in total. In the first two weeks, the concepts and phrases related to TDS were discussed. In the following weeks, the activities

designed in line with TDS in the studies conducted by Erdogan et al. (2014), Brousseau (2002), Gok and Erdogan (2017), Gok et al. (2017a, 2017b) and Inan et al. (2017) were carried out in turn. Table 1 presents the 11-week syllabus applied within the scope of the present study.

Table 1. *Syllabus*

Week	Content
1	Applying ASMEC to the pre-service elementary teachers as the pretest.
2 and 3	Introducing the basic concepts and phases of TDS.
4	Explaining how the activities will be conducted, and applying the activity developed by Erdogan et al. (2014).
5	Applying the activity of <i>Race to 20</i> designed by Brousseau (2002).
6	Applying the activity of <i>Caesar and Captivities</i> designed by Gok and Erdogan (2017).
7	Applying the games of <i>Race with Numbers</i> and <i>Bacteria Colony</i> designed by Gok et al. (2017a, 2017b).
8	Applying the game of <i>Online Ticket</i> designed by Inan et al. (2017).
9	Applying ASMEC to the pre-service elementary teachers as the posttest.
10 and 11	Holding semi-structured interviews with eight pre-service elementary teachers selected using the purposeful sampling method.

In the research process, the pre-service elementary teachers were divided into two groups, and the activities presented in Table 1 were carried out in order. In the study, as the learning environment which would influence the pre-service elementary teachers' attitudes towards mathematics education courses, the five phases defined by Brousseau (1997) for a-didactical learning environments (Devolution: I, Action: II, Formulation: III, Validation: IV, Institutionalization: V) were taken into account. It was seen that the applications used in the study were designed in accordance with constructive learning environments and that the application process encouraged students' participation and drew their attention. Thanks to this, the pre-service teachers were expected to demonstrate a more interested attitude towards the mathematics education course. In each of these applications, the pre-service teachers were given a problem case embedded in a game. The pre-service teachers were expected to reach a mathematical concept by coping with the conditions in the game in the process. For example, the long division was examined in the game of *race to 20*, and the prime factorization of a number was examined in the game of *bacteria colony*. In these games, the purpose was to teach the pre-service teachers how to design the game and to organize the environment in which mathematical concepts could be taught via games in class rather than just reaching these concepts. Table 2 presents the behaviors of the lecturer and of the pre-service elementary teachers in the application process of the activities.

Table 2. *Lecturer and student behaviours*

Phase	Student	Lecturer
I	-Understanding the rules of the game	-Preparing the environment -Determining the materials -Introducing the game and explaining its rules
II	-Being willing to play the game -Being active in discussions within the group	-Organizing the dynamic structure of the environment -Encouraging the game context
III	-Producing hypotheses -Examining the opponent group's hypotheses -Putting forward a model	-Encouraging within-group discussion -Having the hypotheses presented in class -Having everyone understand the hypotheses
IV	-Justifying the group's hypotheses -Trying to refute the opponent groups' hypotheses -Making explanations and providing evidence -Taking an active part in class discussions	-Encouraging discussions regarding the hypotheses -Providing the groups with the opportunity to justify or refute the hypotheses -Organizing the in-class discussions
V	-Understanding the target information in the game -Making predictions regarding the use of the target information in real life	-Re-explaining the target information in the game context, -Providing different strategies necessary to win the game -Giving mathematical meaning to the target information produced within the context of the game

As can be understood from Table 2, when the phases in TDS regarding the application of the activities are examined, it is seen that a learning environment appropriate to the constructivist approach was established. Table 2 presents in detail the behaviors of the lecturer and of the pre-service teachers in all these phases. Here, there is a transition from the phase of devolution to that of institutionalization. This approach is of vital importance for the sake of the development of knowledge. In this process, there are prominent changes in the roles and responsibilities of the lecturer and of the pre-service teachers in different phases of the activity. This situation is important for the dynamic structure of the environment, for obtaining new information through the phases within the context of the game and for reaching the target information. In this respect, in the first and last phases of the activity, the lecturer undertakes an active role and acts as a guide or organizer in the other phases for the proper application of the activity. As for the pre-service teachers, they have a receptive but questioning role in the first and last phases of the activity, while in the other phases, they take an active position in which they discover and structure the information, do mathematics and use scientific processes.

2.3. Sample and Data Collection

The study group included 86 pre-service teachers (52 female and 34 male) attending the Department of Elementary School Teaching at a state university in Turkey in the Fall Term of the academic year of 2017-2018. The participants were determined using the criterion sampling

method within the scope of purposeful sampling (Buyukozturk et al., 2012). The criteria included being registered to the mathematics education course and taking the education given within the scope of the study. The participants in the study were those who had theoretical knowledge about constructive learning environments thanks to their undergraduate education but who had not examined this practically in any course at all. In this respect, the pre-service teachers experienced mathematics education for the first time in their lives in environments designed in accordance with constructive approaches.

In the study, first, the quantitative data were collected and analyzed. Later, the qualitative data were collected via the interviews held with eight pre-service elementary teachers who were selected randomly based on the analysis of the quantitative data (four with low levels of attitudes and four with high levels of attitudes).

For the purpose of collecting the quantitative data in the study, the Attitude Scale for Mathematics Education Courses (ASMEC) developed by Karakas Turker and Turanli (2008) was applied to the pre-service elementary teachers before and after the application process. The reliability of the scale was calculated as 0.928, and it was a five-point Likert-type scale rated as “I totally disagree”, “I disagree”, “I am neutral”, “I agree” and “I totally agree”. The scale was made up of 18 items (12 with positive statements and 6 with negative statements (Karakas Turker & Turanli, 2008), and it was applied to all the 86 pre-service elementary teachers before and after the application process. In the study, the Cronbach alpha coefficient for the reliability of the research data was calculated as 0.707. This result shows that the data collected in the study were reliable (Salvucci et al., 1997; Kiliç, 2016).

Following the application process, for the purpose of supporting the quantitative data, interviews lasting 10 to 15 minutes were held with eight of the pre-service elementary teachers. In order to avoid any loss of data, the interviews were audio-recorded. The interviews were held to validate the results and to determine the related causes of these results and as well as to reveal the individuals' feelings, thoughts, beliefs and viewpoints regarding the research subject being investigated (Cohen & Manion, 1998; Yildirim & Simsek, 2013). In the study, the semi-structured interview method was used because it allows the researcher to change the order of the questions and explain the questions in detail (Cepni, 2010). The interview questions were prepared in line with the main research problem by asking two field experts for their views. The questions can be seen in Appendix 1. The interview questions were related to the undergraduate courses that the pre-service elementary teachers liked and disliked (specifically the course of mathematics teaching), why they liked or disliked these courses, how the teaching process should be improved regarding the courses they disliked, their background knowledge regarding the constructivist learning environments prior to the application process, the changes in their knowledge about the constructivist learning environments following the application process, the positive and negative effects of the activities carried out within the scope of TDS on liking, learning and teaching the course of Mathematics Teaching 1, and the changes caused by these activities in the pre-service teachers' interests in mathematics education courses.

2.4. Data Analysis

For the analysis of the quantitative data collected via the attitude scale, the package software of SPSS 18.0 was used. In order to reveal whether the education given to the pre-service elementary teachers had influence on their attitudes towards the course of mathematics education, paired samples t-test was applied.

In the study, the qualitative data collected via the semi-structured interviews were analyzed using the content analysis method. These data were first transferred to the computer by

listening to them repeatedly. Following this, for the analysis of these data, the pre-service teachers' responses to each question were coded in accordance with certain rules (for example, determining the similar responses), and the related themes were obtained by gathering the codes under appropriate themes (Buyukozturk et al., 2012). The participants' responses were presented as frequency values in relation to the theme in the tables given in the section of findings. In this respect, the themes regarding the use of mathematical games in the teaching process of the mathematics education course were given as positive themes (+) and negative themes (-). For better clarification, extracts were given in relation to some of the participants' responses. In addition, for the analysis of the data, two field experts coded the data independently. Following this, a reliability study was conducted regarding the codings. In order to determine the reliability of the codings, the formula of Agreement/(Agreement +Disagreement) x 100 suggested by Miles and Huberman (1994) was used. If the value calculated with this formula is 70% or higher, then the codings are considered to be reliable. In the present study, the codings were done for each question separately, and the calculated values were found to range between 75% and 95%. The clues regarding how the themes were obtained were supported with direct quotations in the section of findings. In order to reach consensus, the researchers discussed the codes that they disagreed on. For the analysis of the qualitative data, the pre-service elementary teachers were coded as S1, S2, ..., S8.

3. Results

This part first presents the findings obtained via the analysis of the quantitative data and those obtained via the analysis of the qualitative data.

3.1. Findings Obtained via the Attitude Scale

In order to determine whether the training program given within the framework of didactical situations caused any significant difference between the pre-service elementary teachers' attitudes towards the course of mathematics education in terms of their pretest and posttest results, paired samples t-test for independent groups was applied. The results can be seen in Table 3.

Table 3. *T-test results regarding the ASMEC scores*

	N	X	ss	sd	t	p
Pretest	86	71.69	7.97	85	-2.22	.029
Posttest	86	73.50	7.96			

According to Table 3, the mathematics education course given in the didactical learning environment caused a statistically significant difference between the pretest and posttest results regarding the pre-service elementary teachers' attitudes towards the courses of mathematics education ($t(85)=-2.22$, $p=.029$). This result could be said to be due to the fact that the didactical situation, one of basic components of TDS, provides environments for mathematics teaching within the framework of the constructivist learning approach.

For the purpose of revealing whether there was a significant difference between the pre-service elementary teachers' attitude scores regarding the courses of mathematics education with respect to their gender, paired samples t-test was applied, and the results can be seen in Table 4.

Table 4. *T-test results for the ASMEC scores with respect to gender*

		N	X	ss	sd	t	p
Pretest	Male	34	72.73	8.45	84	.987	.327
	Female	52	71.00	7.65			
Posttest	Male	34	74.71	7.77	84	1.108	.258
	Female	52	72.71	8.05			

As can be seen in Table 4, the mathematics education given in line with the didactical situations did not reveal any statistically significant difference between the pretest and posttest scores of the pre-service elementary teachers regarding their attitudes towards the courses of mathematics education with respect to their gender ($t(84)=.987$, $p=.327$ and $t(84)=1.108$, $p=.258$). In Turkey, the course of Mathematics Teaching I is given to 3rd grade students attending the Department of Elementary School Teaching at universities. The fact that there was no significant difference between the pre-service elementary teachers' attitudes towards the courses of mathematics education with respect to the variable of gender (male and female) might have been because they had gone through similar educational processes.

3.2. Findings Obtained via the Interviews

The results of the content analysis of the data obtained via the semi-structured interviews will be presented in three parts. The first part is related to the factors influential on the pre-service elementary teachers' attitudes towards the courses of mathematics education. The second part will present the influence of the training program designed in line with the constructivist approach on the pre-service elementary teachers' viewpoints about the course of mathematics education. As for the last part, it will present information about the pre-service elementary teachers' use of TDS in their future professional lives.

3.2.1. Attitude towards the course of mathematics education

This part presents the findings obtained in relation to the pre-service elementary teachers' attitudes towards courses of mathematics education determined via their views and the findings regarding the factors influential on their attitudes towards these courses. In the study, the pre-service elementary teachers were asked to state the courses they liked and disliked. Table 5 shows the pre-service teachers' views about the course of mathematics education.

Table 5. *Attitude towards the course of mathematics education*

Attitude	Pre-service teachers	f
Positive	S1, S4, S7, S8	4
Negative	S2, S3, S5, S6	4

Table 5 demonstrates that half of the pre-service elementary teachers had positive attitudes towards the course of mathematics education and that the other half had negative attitudes. This result was found consistent with the quantitative data. The reason is that the number of the pre-service teachers with high levels of attitudes towards the courses of mathematics education and the number of those with low levels of attitudes was the same before the interviews. Below are the views of some of the pre-service elementary teachers about the undergraduate course of Mathematics Teaching I.

A : Which courses among the undergraduate courses do you like and enjoy?

S4 : Mathematics.

A : Why do you like it?

S4 : I don't know. I like to deal with it when I see it.

A : Do you like courses of mathematics education?

S5 : No... because... it is quite difficult.

One of the pre-service teachers, S4, reported that s/he liked mathematics and related courses without giving any reason. Accordingly, it could be stated that S4 liked courses of mathematics education. On the other hand, another pre-service teacher, S5, found mathematics difficult and thus stated that s/he thus did not like mathematics or other specific courses related to mathematics education. Although this question was directed to the pre-service teachers within the framework of the course of Mathematics Teaching I, they responded to the question considering mathematics. Based on this, it could be stated that the pre-service teachers tended to demonstrate a common attitude towards mathematics and other related courses. The fact that the pre-service teachers' attitudes towards the courses of mathematics education were in association with mathematics could be said to reflect their emotional tendencies they had developed via their past experiences in mathematics.

Table 6 presents the causes of the pre-service elementary teachers' attitudes towards the course of Mathematics Teaching I. In Table 6, the positive views about the factors influential on the pre-service elementary teachers' attitudes are shown with the sign (+), the negative views with (-) and those both positive and negative were shown with (+,-).

Table 6. *Factors influential on attitudes towards the course*

Factors	Pre-service teachers	f
Influence of the teacher	S1(+), S2(-), S3(-), S4(+,-), S7(-)	5
Intelligence type	S1(-), S2(+,-), S3(-,+), S8(+)	4
Method of teaching	S2(+), S3(-), S7(+), S8(-)	4
Achievement	S3(-), S5(+,-), S7(-), S8(+)	4
Past experience	S3(-), S4(+), S7(+), S8(+)	4
Activity	S6(+)	1
Lack of learning	S4(-)	1
Personal development	S3(+)	1

The pre-service elementary teachers pointed out that the teacher was the most influential factor on attitudes towards a course. In addition, the intelligence type of individuals, their achievement in courses, their past experiences and the method of teaching were among other important factors. Some of the pre-service teachers' views reflecting the codes in Table 6 are as follows:

S3 : To tell the truth, considering my past education life, I wasn't good at mathematics in my secondary school years. And this still affects me, ... I mean I'm not good at it ... thus, it doesn't interest me as much as other courses.

S4 : To me, it is because of my childhood. For example, my elementary school teacher tried hard to make me love this math ...

S5 : I like these courses (non-mathematical courses) because ... it looks easier to pass these courses, but math is a bit more difficult.

As can be seen in these dialogues, the cause of the negative attitudes towards courses of mathematics education was reported by S3 to include intelligence type and past experiences. Another pre-service teacher, S4, stated that s/he developed a positive attitude towards mathematics thanks to his/her teacher (teacher effect) at elementary school level (past experience). On the other hand, S5 associated his/her attitudes towards a course with his/her achievement or failure in that course.

In the study, the pre-service teachers were asked to state what kinds of changes could be done in relation to the teaching method within the scope of a course to develop positive attitudes towards that course. The pre-service teachers' responses to this question are presented in Table 7.

Table 7. *Suggestions for changing attitudes towards a course*

Suggestion	Pre-service teachers	f
New approaches	S2, S3, S5, S6, S8	5
Relating to real life	S1	1
Good teacher	S4	1
Course materials (textbooks)	S7	1

According to Table 7, most of the pre-service teachers reported that the use of new teaching methods rather than traditional methods of teaching could lead to changes in attitudes towards these courses. Some of the dialogues reflecting the suggestions in Table 7 are as follows:

S2 : They directly provide academic information and force students to memorize that information. For example, gamification ... but if they design games, I believe it will be more effective.

S3 : Different things could be done ... I am not against presentations but ... (against constant use of the same teaching methods)

S4 : A good teacher could have made me love the course.

As can be seen in these dialogues, S2 and S3 thought it was necessary to use modern approaches to teaching to cause changes in attitudes towards a course, while S4 claimed that it was the teacher to influence attitudes towards a course.

3.2.2. The potential of the training program given in accordance with TDS to influence attitudes towards courses of mathematics education

This part presents information about the pre-service elementary teachers' knowledge regarding the constructivist approach before the education given in line with TDS, about their knowledge after the training program and about how the training program changed their attitudes towards the course of mathematics education. Table 8 presents information about the pre-service elementary teachers' knowledge about the constructivist approach.

Table 8. *The pre-service teachers' knowledge about the constructivist approach*

Components	Pre-service teachers	f
Active participation	S4, S5, S7, S8	4
Method-based	S1, S4, S7	3
Student-centered	S2, S3, S5	3

As can be seen in Table 8, the pre-service elementary teachers had too limited knowledge about the constructivist approach, and some of them had not even heard about it (for example, S6). Some of the dialogues reflecting the pre-service teachers' knowledge about the constructivist approach are as follows:

S6 : I don't know anything about it.

S7 : Well, we learned the 5E method in the course of Environmental Education ... I think the system at that time before I came to this university, was not the constructive one (high school years).

S2 : As far as I know thanks to our courses related to teaching, it is not a teacher-centered approach but a student-centered approach ... this was all I know about the constructivist approach.

S3 : Actually, I didn't have much knowledge about it ...

S5 : The student tries to learn on his or her own by being active, doing and living, and the teacher guides the student This was what I knew about it.

The dialogues above demonstrate that before the education given in accordance with TDS, some of the pre-service teachers did not have any knowledge about the constructivist approach and that some of them were knowledgeable about this approach thanks to the courses related to teaching within the context of methodology (the 5E method). In addition, some of the pre-service teachers reported that they did not take any education in their past school years (elementary, secondary and high school years) in accordance with the constructivist system. They stated that they heard about this system for the first time at university. Although the constructivist approach was first adopted with the changes done in curricula in Turkey in 2005, this approach cannot be said to be put into practice properly. This was also obvious in the related views of the pre-service teachers.

In the study, the pre-service elementary teachers were asked to evaluate the education given in accordance with TDS, and their views can be seen in Table 9.

Table 9. *Evaluation of the activities designed based on TDS*

Components	Pre-service teachers	f
Positive	S1, S2, S3, S4, S5, S6, S7, S8	8
Negative	-	0

As can be seen in Table 9, all the pre-service teachers were satisfied with the activities designed within the framework of TDS. Below are some of the pre-service teachers' views showing their satisfaction with the education given in accordance with TDS:

S3 : Yes, of course, I like it. People always like different things.

S4 : It allowed me to view what we have learned so far from a broader perspective ...

S6 : In the past, I didn't know such games could be designed. And I didn't know that mathematical problems could be embedded in games. Now, I know such games, and they are really good.

All the pre-service teachers mentioned different reasons for their positive views about the activities designed in accordance with TDS. In this respect, some of the pre-service teachers pointed to the teaching approach from a different perspective, while some of them reported that they were amazed at the presentation of the problem embedded in a game.

Although all the pre-service teachers reported generally positive views about the activities applied, it was seen that they had different views about the advantages and disadvantages of these activities. Table 10 presents the advantages and disadvantages of the activities designed in line with TDS. In Table 10, the positive views are represented with the sign (+) and the negative views with the sign (-).

Table 10. *Advantages and disadvantages of the activities*

Components	Pre-service teachers	f
Game context	S1(+,-), S2(+), S3(+), S5(+), S6(+), S7(+), S8(+)	7
Class size	S2(-), S4(-), S5(-), S6(-), S7(-), S8(-)	6
Class grade	S1(-), S2(-), S4(-), S6(-), S8(-)	5
Active participation	S3(+), S5(+), S6(+), S7(+), S8(-,+)	5
Entertainment	S2(+), S4(+), S5(+), S7(+)	4
Reasoning	S1(+), S4(+), S7(+), S8(+)	4
Technology	S2(-), S5(-), S6(-), S8(-)	4
Reinforcement	S1(+), S5(+), S7(+), S8(+)	4
Time	S1(-), S2(-), S8(-)	3
Frequency of usage	S1(-), S5(+), S7(-)	3
Concretization	S1(-), S2(+), S4(+)	3
Communication	S3(+), S8(+)	2
Informative	S4(+)	1
Achievement	S5(+)	1
Seating plan	S8(-)	1
Struggling	S4(+)	1
Encouragement	S3(+)	1
Intelligence development	S1(+)	1
Individualization	S1(+)	1
Different solutions	S1(+)	1

Doing activities	S2(+)	1
Material	S2(+)	1
Group work	S8(+)	1
Adaptation	S1(+)	1

According to Table 10, the advantages of the activities designed in line with TDS were reported by the pre-service teachers to include using the game context, being entertaining, requiring reasoning and ensuring active participation. On the other hand, according to the pre-service teachers, the disadvantages included discipline problem in crowded classrooms, games designed over students' levels and technological deficiencies. The dialogues below reflect some of these components:

S2 : It is now more entertaining ... teaching mathematics via games is really important ... with the help of these activities, I have learned how to concretize the teaching process. I have also learned to consider the child's level ... I mean you cannot teach a lesson by imposing it, but with the help of gamification, you can let your students do different activities. I mean you can develop new materials. It doesn't have any negative aspects, but if the teacher fails to consider the students' levels, ... then it results in a waste of time. In the case of too crowded classrooms, I think it will be a bit more problematic ... for example, if you are a teacher at a small village school, you may not have an interactive whiteboard in class.

S3 : The teacher is expected to involve the students in the learning process. The students will learn on their own regardless of whether they learn correct or wrong things. This is what we have learned via these games ... the students were active participants in class ... I think it allowed communicating with the students. Also, I believe it was also encouraging for them.

It was seen that the pre-service elementary teachers had positive perceptions regarding the activities carried out within the scope of TDS. In addition, it was found that the environments created in this context included most of the parameters of the constructivist approach.

Another striking issue was that rather than using the activities designed in line with TDS for the purpose of teaching any concept, most of the pre-service teachers wanted to use these activities to internationalize and reinforce the didactical situations after the teaching process. This is not an intended situation though it seems to be positive when the dynamics of the theory are taken into account. Therefore, this could be an unexpected result obtained in the present study. The reason is that TDS is generally based on the assumption that students can learn the target concept thanks to the designed environment when students do not have enough readiness in relation to a concept to be taught. In the study, while designing the activities, they were developed by taking especially this assumption into consideration.

All in all, the question of how the education given in accordance with TDS influenced the pre-service elementary teachers' attitudes towards the course of mathematics education is of great importance. The dialogues below reflect the pre-service teachers' views about this question.

S1 : My ideas changed just in that way (in a positive way)... my motto is how I can reinforce my students' knowledge and which activities I can use for that purpose. To me, it is quite a different method.

S2 : But, after the lessons, ...

A : Anything changed?

S2 : Yes, things changed ... now, I am interested more. I liked it.

S3 : Yes, my ideas changed. As I said before, it interests me because I always think about how I can teach something. I believe I will do good things.

S4 : It increased my interest, and this is good.

S5 : Well, I can say ... students play games related to these situation theories. For example, I liked the last lesson more.

S6 : You want to solve the problem by playing the game I mean you become more willing to do it.

S7 : It increased my interest. For example, I like math and try hard to learn it. Thus, I liked it because it was better.

S8 : Children are quite enthusiastic about playing games. Thus, they learn subconsciously. To me, it's good for that reason.

A : How did it affect your interest?

S8 : To me, it was positive, and it is really good to be able to apply all these.

It was seen that the activities designed in line with TDS had a positive influence on all the pre-service elementary teachers' interests in the courses of mathematics education. Considering the fact that half of these pre-service teachers had negative attitudes especially towards the courses of mathematics education, the education designed within the framework of TDS could be said to have a great influence on changing their attitudes towards the courses of mathematics education. The fact that the pre-service teachers had positive attitudes towards the courses of mathematics education could be said to be important for their professional development processes in the future when they become teachers.

3.2.3. An Indicator of the Attitude Change Regarding Mathematics Education Courses

This part of the study presents the findings regarding what kind of a teaching approach the pre-service teachers would adopt when they became teachers in the future and whether they wanted to use TDS in their activity designs. In the study, all the pre-service teachers reported that they would design activities in accordance with TDS and use them in future. In relation to this, some of the pre-service teachers' views were as follows:

S1 : I can use it but not in all courses.

S2 : I would like to use it. For a child at that age, everything means playing a game ... and, for this, the best theory is TDS.

S3 : Of course, I will use it. For example, I am taking a course which I requires me teach at schools. And I learn many practical things there just as I do in my department. Honestly, ...I would like to use it in all courses.

S4 : I will certainly use it.

S8 : Yes, I want to use it. There is a flow, which is very good. Also, ... in this method, the teacher has the role of a guide, and the fact that students do all the things on their own is really good for them.

According to these views of the pre-service teachers, they were willing to use TDS in their future professional lives, and they all had different reasons for using it. Lastly, they all reported different limitations to the use of TDS in their future classes.

4. Discussion and Conclusion

The results obtained in the study revealed that the course of Mathematics Teaching I given within the framework of TDS could have positive influence on the pre-service elementary teachers' attitudes towards the courses of mathematics education.

This difference was thought to result from the fact that an adidactical environment, one of the basic components of TDS, is based on the constructivist approach (Artigue, 1994; Laborde, 2007); that it involves a series of phases in teaching mathematical concepts (devolution, action, formulation, validation, and institutionalization); that the students and the teacher have clear-cut roles in these phases; and that the problem is presented in such environments within the context of a game which includes winning and losing (Erdogan & Ozdemir Erdogan, 2013).

Saglam (2014) claims that the affective characteristics of teachers regarding mathematics had an influence on their ways of teaching mathematics. On the other hand, in the present study, it was found that giving the courses of mathematics education to the pre-service elementary teachers based on the student-centered approach in an adidactical environment caused positive changes in their affective perceptions regarding mathematics. In other words, teaching mathematics courses using new approaches caused the pre-service elementary teachers to develop positive attitudes to the courses of mathematics education. As a support to the results obtained in the study, Tsao, (2018) pointed out that mathematics courses given based on the constructive approach developed pre-service teachers' attitudes towards geometry. In another study conducted in a different discipline, Dündar (2018) reported that use of constructive learning environments in teaching the course of Social Sciences developed pre-service teachers' attitudes towards teaching the course of Social Sciences. Based on these studies, it could be stated that pre-service teachers develop positive thoughts about the related discipline as student-centered teaching experiences contribute to pre-service teachers' development and meet their expectations to a certain extent (Osmanoğlu and Oguzhan Dincer, 2018). Also, in one other study in which professional information modules were used, even though a positive change was found in pre-service teachers' attitudes towards mathematics, this change was not at a desirable level when compared to the control group (Fisher et al, 2017). It takes a long time to develop a positive attitude towards any discipline, yet this could be achieved when innovative approaches and well-organized environments are used.

In the present study, it was seen that the pre-service teachers' attitudes towards mathematics education courses did not differ in terms of gender when they were taught mathematics in line with innovative approaches. As a support to this finding, Tabuk (2018) reported that there was no difference in the pre-service teachers' attitudes towards mathematics teaching with respect to gender. Similarly, in related literature, there are many studies which revealed that pre-service teachers' attitudes towards mathematics or geometry did not differ depending on their gender (Çakıroğlu and Işıksal, 2009; Usman, Yew and Saleh, 2019). On the other hand, there are still other studies demonstrating that attitudes towards mathematics differ based on gender (Bhowmik and Banerjee (Roy), 2016). The findings that attitudes towards mathematics change depending on gender are based on two reasons. The first one is related to the biological difference between men and women, and the second one concerns social and environmental factors (Markovits and Forgasz, 2017). In our country, especially in higher education, female students are not disadvantaged in terms of taking education when compared to male students (OECD, 2018). Therefore, the fact that attitudes towards mathematics education courses do not differ with respect to gender could be associated with the fact that pre-service teachers are exposed to the same education process; that they have similar experiences and that they are not subjected to any social or environmental restriction.

In Turkey, the constructivist approach to teaching became prominent in the curriculum of mathematics in 2005 (MoNE, 2005). In addition, the subsequent changes done in the curriculum (MoNE, 2013, 2018) could be said to keep the elements of the constructivist approach in the revised curriculum. The pre-service elementary teachers, who were the participants in the present study, took their high school education at a time when these curricula were in practice. However, it was seen that none of the pre-service elementary teachers mentioned constructivist approaches in relation to the courses they had taken before their university education, and it could even be stated that they were subjected to the traditional teaching methods in their high school years. Also, it was seen that except for a few courses, the pre-service teachers were provided with theoretical information about the constructivist approach during their university education and that they thus had limited knowledge about this approach. On the other hand, it could be stated that designing all teacher training courses (sometimes even different lesson units of a single course) within the framework of constructivist parameters is a field requiring specialization and that such a design is likely to include various sub-dimensions for different courses. In this respect, because concepts in mathematics are abstract as well as because the cumulative property of concepts is of great importance for teaching these concepts (just as it is true for the building blocks of a construction), creating environments in line with the constructivist parameters for mathematics teaching involves certain difficulties. Based on the assumption that activities carried out under the individual's own control lead to longer permanency, it could be stated that conducting more studies with the combination of theory and practice without ignoring these difficulties involved in the teacher training process will help future teachers develop positive attitudes towards the courses of mathematics education (mathematics courses in general). On the other hand, if the theoretical information given at universities is not supported with well-designed practical applications, it is seemingly inevitable to be in a vicious cycle in which the theoretical information does not support the practice. Therefore, as the primary suggestion to be put forward here, it could be stated that not only teaching mathematical concepts via games at all class grades starting from the teacher training process but also creating a flexible class environment for individuals to take an active part in these games could be influential on changing the attitudes towards mathematics. Also, providing individuals with the opportunity to build their mathematical knowledge in such a teaching environment and encouraging educators with the knowledge of providing these opportunities to become active in the teaching process could help change the attitudes towards mathematics.

Another dimension regarding the development of positive attitudes towards mathematics and related courses is the thought that these attitudes can be developed at early ages and that they become rooted in time (Bloom, 1977; Goodykoontz, 2008). In the present study, as mentioned by some of the pre-service teachers, attitudes towards mathematics begin to appear starting from elementary school years and are developed in the process. It is thought that positive changes to be caused in the attitudes of pre-service teachers towards a mathematics course could first help them gain a good perspective regarding mathematics and then allow them to cause positive changes in their students' attitudes towards mathematics. The present study shows that this is possible and provides clues to certain steps to be taken accordingly.

This study discussed how to make use of TDS by investigating whether it was possible to create changes in the participants' attitudes towards courses of mathematics education within the scope of the course of Mathematics Teaching I within the framework of TDS in a limited period of time. In the study, it was seen that teaching mathematics in an environment designed in line with TDS increased all the pre-service teachers' interests in the course. However, it could be considered to be an unexpected result that the pre-service teachers regarded TDS as a tool to be used for the reinforcement and development of positive attitudes after teaching the

concepts via traditional methods of teaching rather than regarding it as a primary approach to teaching these concepts. The reason for this result could be the fact that the pre-service elementary teachers were mostly subjected to the traditional methods of teaching in their high school years and that they might have thus preferred the traditional teaching approach to be their main teaching approach.

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Appendix 1. Interview Questions

1. Which of your undergraduate courses did you enjoy in most? Is there Mathematics among these courses?
 - Why do you like these courses?
2. Which of the courses do you dislike most?
 - Why do you dislike these courses?
 - What kind of changes/arrangements to done in relation to these courses would you make you enjoy?
3. What did you know about the constructivist teaching environments before the TDS activities? Explain, please.
4. Is there any change in your knowledge about the constructivist teaching environments after the TDS activities? Explain, please.
 - What did you enjoy in the teaching environments designed in accordance with TDS?
 - What did you hate in the teaching environments designed in accordance with TDS?
5. Is there any change in your interest in courses of mathematics teaching before and after the TDS application?
 - If so, what has changed?
 - What do you think the factors causing the change(s) are?
6. What kind of a teaching approach do you plan to adopt in your future class when you become a teacher?
 - Will you use constructivist approaches?
 - Will you use the theory of didactical situations in your class applications? Why?