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IMPACT OF DIFFERENTIATED TEACHING IN DISTANCE EDUCATION PRACTICE ON GIFTED AND TALENTED PRIMARY STUDENTS

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Abstract

The main purpose of the present study was to develop and apply a mathematics program that meets the academic and mental needs of gifted and talented primary school students during distance education and to test the effectiveness of the program. The current study involved 120 gifted and talented fourth-grade students, 60 of whom were in the experimental group and 60 in the control group. The distance learning program was prepared based on the parallel curriculum model and the differentiation techniques proposed by the grid model were used. For the collection of data, the Mathematics Achievement Test and the Attitude Scale for Mathematics were given to the students in the experimental and control group as pre-test and post-test. The paired-samples t-test was used to compare the pre-test-post-test scores of students in the experimental and control group. The independent group's t-test was used to compare the post-test scores of the students in the experimental group with the post-test scores of the students in the control group. Also, covariance analysis was used to compare post-test achievement and attitude scores after controlling pre-test scores in the experimental and control groups. The results of this study indicate that a differentiated mathematics program delivered via distance education increased the achievement and attitude toward mathematics in the experimental group. It was also stated that conducting similar studies for different courses and comparing results will contribute to distance education.

Keywords: Distance education, gifted and talented children, primary school students, mathematics teaching, program differentiation.

INTRODUCTION

The concepts of special talent, giftedness, and special intelligence are sometimes used interchangeably and sometimes as two separate concepts of intelligence and talent (Renzulli, 2012). When studies on how the topics should be used correctly are examined, the first use focuses on the concept of giftedness and intelligence is a term used to understand the world, produce solutions to problems encountered, and adapt to life in this context (Levent, 2013).

Thurstone, who examined intelligence as a multidimensional concept, said that each dimension represents a mental ability. According to Thurstone, mental abilities stand side by side like an independent mosaic. An interpretation of these factors used the concepts of Gestalt psychology (Kane & Brand, 2003). Guilford was an ardent advocate of Thurstone's model. He developed Thurstone's model of primary mental abilities and presented his model of the structure of intelligence. In this model, intelligence is defined as a "systematic collection of abilities" or "a function of processing different information in various forms".

According to Clark et al. (2012), the concept of "giftedness" is the product of a dynamic and interactive event that makes a difference in thinking and performance, both quantitatively and qualitatively. The term "gifted" denotes a high level of intelligence and represents highly accelerated and integrated brain function. Such a developed structure is expressed as leadership, academic ability, creativity and productivity in the artistic field. How giftedness will occur is directly related to the genetic structure of the individual and its interaction with the environment.

In research on intelligence, there is more than one definition of intelligence. The concept of intelligence and superiority is no longer limited to the cognitive function of the brain; it should include all brain functions and their effective and integrated use. Superiority emerges as a function of creativity in producing ideas, analytical intelligence in evaluating the quality of thoughts, practical intelligence in persuading people to value these ideas and follow them when putting these ideas into practice, and the view that these decisions and their implementation are for the benefit of society. These traits are not completely inherited, they also interact with the environment during development (Sternberg, Jarvin, & Grigorenko, 2011). Galton, who conducted early studies in the field of intelligence, argued that the benchmark for being more mentally capable is to be able to distinguish more from less. According to Binet and Simon, gifted and talented individuals have improved ability to decide and judge (as cited in Sternberg, 2003). According to Renzulli (2016), one of the first to propose the concept of multidimensional superior intelligence and ability, superior intelligence and ability can be explained by the interaction of three main characteristics: high levels of general and special ability, creativity, and motivation. Gardner (2011) stated that superior intelligence and ability encompass the competencies of producing original products, finding and solving problems. Similarly, superiority is the way of solving complicated problems in the most appropriate, efficient, and cost-effective manner, according to Maker (1993). Although definitions vary, for many people, superior intelligence and ability are directly proportional to academic achievement. Described by Renzulli (2005) as “school superiority” or “academic superiority”, this concept is often seen as the only expansion of superior intelligence and ability.

Education of gifted people is increasingly important due to individual educational needs. Educational programs are organized for an average level of intelligence and ability. The perception of these individuals, whose requests and needs are very different, is clear; they learn faster, but they have disadvantaged situations that accompany all these characteristics. The fact that these individuals need to learn based on their interests and needs, and do not want to learn anything they do not need to, is also an important consideration that should not be overlooked. These individuals, who need to learn according to their interests, face several problems in the educational environments available, and many of them are left out of education, unnoticed because they cannot meet this need.

Although students are at the same grade level in classes, their interests, readiness, learning rates, expectations from school, past learning experiences, cultures, and family structures are quite different. Such differences also affect their learning and the support they will need. Planning without taking these differences into account will slow the progress of talented students with a good level while making it difficult for deficient or slow-learning students to understand (Atalay 2014; Crosnoe et al., 2010; Vygotsky, 2011).

Differentiated instruction involves multiple ways used to structure a lesson in which each student has an appropriate level of challenge. Differentiated instruction may include student-centeredness, planned assignments, assessment-based lesson planning, flexible grouping, materials, resources, and supervision (Tomlinson & Hockett, 2008). According to Tannenbaum, differentiation is the modification of a program to meet the different needs of individuals or small groups (Dobron, 2011). Gregory and Chapman (2013) described differentiation as changing the learning process in accordance with individual differences

Differentiated teaching is planned with activities that will advance, support, and improve the cognitive learning levels of gifted individuals, while new studies based on certain theories can also be proposed

according to the results of these studies. Theoretical-based differentiation studies, which are good examples of special educational work, can support the development of gifted individuals and help them receive better quality education. Some of the differentiation models that can be given as examples of theoretical-based differentiation models include differentiation of gains according to Bloom taxonomy (Feldhusen, 1994), curriculum differentiation model (Maker, 1982), curriculum compacting model (Renzulli & Reis, 1985), Kaplan's curriculum differentiation model (Kaplan, 1986), parallel curriculum model (Tomlinson et al., 2002), multi-menu model (Renzulli, 1977), ÜYEP model (Sak, 2009), ÜYÜKEP model (Tortop, 2013; 2015), and the integrated curriculum model (Kutlu Abu & Gökdere, 2020; VanTassel Baska & Wood, 2009).

Differentiation is based on taking into account what each person needs. When differentiating, it is important to plan widely according to the readiness, interest, and learning styles of the students, as the aim is to improve their learning potential. In this way, the study was based on the Kaplan grid model and the parallel curriculum model.

In the grid curriculum model, content must be organized within the framework of a theme. The use of themes is intended to provide an understanding of deductive thought and to support creative thought. Many teachers working with superiors can differentiate their curricula based on this model without being program experts because the grid model is prepared in a frame plan, and the scope and the order do not matter (Van Tassel-Baska & Brown 2007). The Kaplan grid curriculum model, introduced by Kaplan (2009), has continued to be developed since 1973 and is known as a model that draws a framework for differentiation. Complexity and depth should be included within the curriculum, and there is a framework for depth and complexity. Depth refers to progress from concrete to abstract, from information to data, concepts, generalizations, and theories. Complexity is the relationship between concepts. It is the interdisciplinary aspect of the curriculum. It is recommended that the gradually complex subjects be taught to students in an accelerated manner while they are self-learning, as well being focused on concepts and ideas. It is where high-level thinking skills will be developed. According to the curriculum differentiation program to be prepared based on this model, procedures to help the student overcome their existing limits in demonstrating their abilities should be included. Implementation for gifted students is important in terms of representing an appropriate model.

The parallel curriculum model consists of four parallels (sections): the general curriculum, the connections curriculum, the practices curriculum, and the awareness curriculum. Each dimension contains different types of learning achievements. According to Sak (2013), the general curriculum is the first dimension that forms the point of origin of the model. This dimension is where the curriculum has learning gains that improve gifted individuals. The second dimension creates the connections curriculum. Students make connections in this dimension within themselves and across different disciplines. It aims to develop concepts, principles, and skills that are not included in the general curriculum or are not given sufficient weight. The third one is the implementation dimension. It aims to give students behaviors that will allow them to think like experts in that discipline. The fourth dimension of the parallel curriculum model aims to allow students to explore and understand a discipline in depth. They are asked to compare their interests, skills, and abilities with the discipline in which they work. The goal is to enable them to make comparisons to determine which discipline interests them and fits their abilities. According to Tomlinson (2009), the parallel curriculum model is a compelling model for a gifted individual, which enables them to move to an advanced level. It is a curriculum that requires work to develop advanced thinking skills that challenge the student by using four parallel paths simultaneously in the process of selecting and creating content. In the parallel curriculum model, assessments are made for multifaceted measurements of gifted students. It aims to provide students with educational opportunities in different fields at an early age, enabling them to live various experiences and discover and develop their abilities and interests in this way (Doğan & Saraçoğlu, 2019; Tomlinson et al., 2002).

Levy (2008) defined differentiated teaching as an adventure in which the teacher moves the student forward from their current level by determining where the student is, providing flexibility in content,

process, and product. To provide effective mathematics teaching, it is also important to build new knowledge on top of the student's previous knowledge (Van de Walle et al., 2016). In differentiated mathematics teaching, the goal is to maximize student capacity. To increase the development of advanced students, a teaching program is needed where students are told the goal of their studies is to exceed their potential. This is because negative results may occur if the mathematics curriculum is applied to gifted and talented students without differentiation; boredom, regression, and low achievement.

It is necessary to differentiate the mathematics curriculum based on the concepts of acceleration, abstraction/complexity, diversity and creativity, which are the basic principles of curriculum differentiation, and creative thinking in mathematics, which is important in the field of mathematics, thinking styles of mathematical scientists, personality traits and life stories.

Mathematics education is a branch of science that enables the development and application of methods and theories about the learning and teaching of mathematics within the framework of academic studies (Baki, 2018). Objectives of the mathematics course curriculum are to enable the student to use mathematical language effectively, to develop mathematical thinking skills, to develop a positive attitude towards mathematics, and to ensure that they value mathematics. It also aims to develop the student's problem solving, reasoning, research, generation and use of knowledge skills, metacognitive knowledge and skills, and the characteristics of being systematic, careful, patient, and responsible (MoNE, 2018). Since mathematics is a science focused on principles and operations that follow a logical and consistent pattern (Van De Walle, et al., 2016), if the concepts and rules are memorized without permanence in students' minds, they will have difficulties with different problem structures and this will prevent students from achieving the desired success in the mathematics lesson. It is believed that effective mathematics teaching is possible in environments where the teacher is a guide, students have sufficient knowledge, complete technological equipment, engage in active participation and the number of students is low (Öztürk & Güven, 2012). A study of the relevant literature also showed that differentiated teaching practices in mathematics education have a positive effect on the concepts of achievement, attitude, persistence, cognition skills, self-efficacy perception, creativity, and academic self (Akkaş, 2014; Eşiyok, 2017; Karataş, 2013; Sezgin & Baysal, 2019; Taş, 2013; Yabaş, 2008). Traditional mathematics teaching, which focuses on academic achievement, often emphasizes computation, formula memorization, and routine problem-solving skills with practice. The problems that may arise during the implementation of differentiated programs in traditional education are listed as follows: lack of adequate time, teachers requiring a lot of time for evaluation and monitoring tests, individual differences in learning speed, and challenges in doing and assessing additional activities. These problems that inevitably arise in traditional education can be easily addressed in internet-based distance education, which can offer individualized education through distance education management system software. The advantages of distance education are many. The proportion of benefits compared to face-to-face education is high. Distance education is student-centered and it offers equal opportunity, provides educational opportunities for physically handicapped students, and removes geographical and regional barriers. It is ideal for those who cannot benefit from traditional education. It enables employees to continue their education and allows the person to learn at their own pace. It provides the opportunity to access information quickly and easily. It eliminates the additional expenses such as transportation, accommodation, accommodation and nutrition required in face-to-face education. It provides an interactive and dynamic learning process with the instructors. Being independent of time and place, it provides students with 24/7 access to the educational environment from any place with internet access.

Due to combining a differentiated mathematics program with the possibilities of distance education, students can perform activities such as projects, assignments, and research, which makes them active recipients. In this way, students can maximize their learning by accessing resources such as computers, the internet, online data banks, and academic journals to access necessary information other than the information learned in the course. As a method, internet-based distance education means that teachers

organize learning tools, materials, subjects, and teaching techniques according to distance learning opportunities to achieve their teaching goals.

In this context, unlike previous studies conducted in the field, differentiated mathematics teaching was carried out with distance education applications and the impact of the differentiated program on the achievement and attitude of gifted and talented students was investigated.

Purpose of the Study

The basis of the educational process lies in the teaching-learning processes. The compatible use of methods and techniques in these processes allows a person to achieve what is expected from education most efficiently. Distance education differs from traditional education in that it makes extensive use of communication and information technologies, both in terms of its goals and the tools and equipment it employs. For this reason, the techniques and the course materials should be planned and used according to the possibilities provided by the distance education method based on the educational model. In distance education applications, the random use of teaching techniques without being based on an educational model and the emphasis on applications that prioritize technology can prevent internet-based distance education from being effective and efficient. For these reasons, during the implementation of distance education, an educational process should be planned that will facilitate the achievement of the goals of education. In this study, differentiation in mathematics prepared for superiors was based on internet-based distance education applications. The distance learning program was prepared based on the parallel curriculum model and the differentiation techniques proposed by the grid model were used.

In previous studies, differentiated mathematics teaching was carried out and the effect of the differentiated curriculum on the achievement and attitudes of gifted students was examined. In this study, unlike previous ones, differentiated education was carried out with distance education applications and the effectiveness of differentiated education given through distance education was examined. The main objective of the study was to prepare a mathematics program aiming to develop the creative thinking of gifted and talented students in mathematics and to test its effectiveness in distance education. Based on this main objective, the sub-objective of the study was to reveal whether there was a statistically significant difference between the achievement and mean scores for attitude towards mathematics of the group to which the differentiated program was applied and the achievement and mean scores in attitude towards mathematics of the group who did not receive a differentiated program.

Research Problem

What is the impact of differentiated mathematics teaching prepared by considering the characteristics of students in distance education applications on the achievement and attitude of gifted and talented students?

Sub-problems:

For students in the experimental and control group in the distance education process;

1. Is there a statistically significant difference between the academic achievements in the mathematics course?
2. Is there a statistically significant difference between attitudes towards the mathematics courses?

METHOD

Research Model

A pre-test/post-test control group experimental design was used to obtain data for the study. In this design, participants are measured before and after the experimental process related to the dependent variable (Büyüköztürk, 2016; Karasar, 2020). This pattern is a powerful one that allows the researcher to interpret the results in the context of cause and effect when testing the effect of experimental processing on the dependent variable and is often used in behavioral sciences (Büyüköztürk, 2020).

The independent variable in the study is the teaching method applied. Attitude and achievement, which are likely to change depending on this method, are dependent variables.

Research Group

The research was conducted with 120 fourth-grade students who took mathematics courses for the 2019-2020 academic year with the distance education method. All students were identified as gifted by the WISC-R intelligence test. A total of 60 students constituted the experimental group, while 60 students constituted the control group. In the experimental group 27 of the students were female (45%), 33 were male (55%), while in the control group 30 of the students were female (50%) and 30 were male (50%). According to these data, the number of students in the experimental and control groups, as well as their gender distribution, are equivalent.

During the research, the units about natural numbers and fractions were differentiated considering the principles of differentiation, differentiation models, creativity models, and Bloom's revised taxonomy (Anderson & Krathwohl, 2001) for the experimental group. All subjects in the unit of natural numbers and fractions are included in the theme of system, conservation, equivalence, and evaluation. The application of the research lasted a total of 35-course hours (7 weeks). First, natural numbers unit was taught. This unit lasted 15-course hours (3 weeks). After that, the fractions unit was taught for 20-course hours (4 weeks).

Teaching and learning activities were carried out with lesson plans prepared to ensure the gains of the units and the effective participation of the students. At this stage, elements of the distance education management system were also used. A virtualized version of the real class environment was used by ensuring communication and interaction (see Appendix A Teaching and learning activities for visual samples). The course content was presented to students, questions were asked, feedback and notifications were provided. It was possible to evaluate the students individually by obtaining data about the extent to which the students followed the course and which questions were answered correctly or incorrectly.

A daily lesson plan was prepared for each unit, and the course being taught through distance education was considered when preparing these lesson plans (see Appendix B for sample lesson plan). In the experimental group, activities, involving high-level thinking skills were prepared in accordance with distance education, and creative thinking strategies were featured. Creativity and differentiation models were investigated, the theoretical foundations of the applied program were established and expert approval was obtained. Mathematics teaching was completed using a distance education program and course materials prepared based on the parallel curriculum model used in the study and differentiation techniques proposed by the grid model.

In the control group, no intervention was made to the educational process. The teacher requested students take notes during the lesson and asked them questions. At the end of the lesson, the teacher completed the lesson in classical form, by summarizing and repeating the subject.

Before starting the natural numbers unit, the experimental group was informed about the grid and parallel curriculum models, which were used as the basis for the research, and the program used for differentiation of mathematics subjects. These models and materials were described to students. In addition, since the characteristics of mathematics and mathematicians constitute one of the main dimensions of the differentiated curriculum, students were also informed about these issues. During the application, worksheets suitable for differentiated instruction, problem menus consisting of real-life problems, activities that enable students to determine their own hypotheses and propose their own hypotheses were prepared.

Although differentiated units are based on a comprehensive theme and mathematics, they also include different disciplines. The chosen theme was change. The activities were designed to reinforce the features of mathematics, thinking strategies and styles of mathematicians, as well as the use of creative thinking skills. Mathematics teaching was carried out by synthesizing creativity, high-level thinking

skills and differentiation models. One of the models utilized in the differentiation dimension of the prepared program was the grid curriculum model developed by Kaplan. In the grid model, it is argued that it is beneficial to consider the subjects within a theme including all disciplines. For this reason, the theme of the program was determined as "change". In the grid model, the content, process and product are differentiated under the selected theme.

In the differentiated program, in accordance with the theoretical basis of the grid model, “big ideas” and “generalizations” were added to the content, allowing interdisciplinary issues and interdisciplinary connections to be established. Within the scope of content differentiation of the model, “key questions” were prepared for the relevant parts of these generalizations.

Each lesson started with these key questions. At the end of the course, generalizations were given as a summary. The process differentiation part of the model covers using different thinking skills while teaching the lesson. All of the process skills topics mentioned in the grid model were used in the differentiation program (basic skills, creative thinking skills, problem-solving skills, critical thinking skills). The product differentiation part of the model allows the acquired knowledge and skills to be expressed in various ways. The differentiated program allows for diversity in terms of communication as it attaches importance to both written and verbal communication.

Data Collection Tools

In the study, an achievement test with multiple-choice questions was used to assess differences in academic achievement between the experimental and control groups before and after the experimental practice, and an attitude scale consisting of Likert-type items was used. Permission for this study was obtained from the local ethics committee (protocol number: E-35853172-300-00001536076).

Achievement Test

In distance education, the achievement test used to determine the impact of differentiated teaching on students' achievements was developed by the researchers. Relevant literature screening was conducted for the development of the achievement test, and information about the creating test items was taken into account (Doganay & Karip, 2006; Linn, 2006; Tekin, 2004). The achievement test was used to measure the achievement status before and after the experimental practice. Applications of the test used the educational management system. The highest score that can be obtained from the achievement test consisting of 20 questions is 100 points. Item separation indices for the items in the test vary from .31 to .84, while item difficulty indices vary from .34 to .86. The mean difficulty of the test was calculated as .58, which indicates that the test has moderate difficulty. The Cronbach Alpha coefficient of the test was determined as .74. Büyüköztürk (2020) stated that the reliability coefficient calculated for a test of .70 and higher is sufficient for reliability. The reliability of test scores is within acceptable limits.

Attitude Scale

The Short Form of Attitude Scale for Mathematics, developed by Lim and Chapman (2013) and adapted to Turkish by Hacıömeroğlu (2017), was used in the research. The scale obtained in the adaptation study conducted by Hacıömeroğlu (2017) consists of 19 items and three sub-dimensions. The reliability coefficient calculated for the entire scale was .84. Five ranges were taken as the basis for the evaluation of the scale. These are strongly disagree, agree, undecided, disagree, and fully agree, respectively. The scale includes three sub-dimensions: happiness, motivation, and self-confidence. In the happiness sub-dimension, 'how much students enjoy learning maths' is measured. In the motivation sub-dimension, 'students' interest in mathematics and their desire to study advanced mathematics' is measured. In the self-confidence sub-dimension, students' "confidence and self-concept related to mathematics performance" and "their beliefs about the benefits, importance, and value of mathematics in life" are measured.

Applications of the attitude scale used the education management system. Students were contacted by e-mail or phone and given information about the scale. In addition, they were also reminded of the importance that their responses should reflect their true views about the items.

The application of the achievement test and attitude scale was made using the user names and passwords of the students in the experimental and control group via the distance education management system. For tests administered online to be performed reliably, some requirements must be met. These requirements include ensuring that those who take the test are not in a disadvantageous position in the computer environment compared to paper-pen tests, they can fully use the facilities in the computer environment, and the control of the test taker is at the highest level during the application. Meeting these requirements depends on whether the computer skills of the applied group are sufficient, as well as the suitability of the software used. People should be able to freely navigate between app screens, go back and review their responses, and change them if necessary. The user should be able to see the elapsed time, which question they are answering, and how many questions are left. In this way, practitioners can use the facilities they have in paper and pen tests (Şencan, 2005). These points were considered in the applications of the tests.

Analysis of Data

Following reliability calculations for the prepared multiple-choice test, the achievement test and the mathematics attitude scale were applied separately to the experimental and control group students as pre-test and post-test. Before the analysis of the data, a general evaluation was made and the presence of missing values was checked. After this evaluation, the assumptions of normality, such as skewness and kurtosis, were examined. Since the skewness and kurtosis coefficients were within the range of ±3 limits, the data was determined to have normal distribution and parametric tests were used (Büyüköztürk et al., 2020).

To analyze the pre and post-test achievement and attitude scores of students in the control and experimental groups, the t-test for paired samples was used. The t-test for independent samples was used to compare the achievement and attitude test pre-test and post-test scores of students in the experimental group with the pre-test and post-test scores of the control group. Also, covariance analysis was used to compare post-test achievement and attitude scores after controlling pre-test scores in the experimental and control groups. If the difference between groups or variables was statistically significant during the analysis, Cohen's d effect size was calculated for the t-test. Cohen's d values for effect size of small, medium, and large are classified as .20 (small), .50 (medium), and .80 (large), respectively. (Cohen, 1988; Rosnow & Rosenthal, 1991).

RESULTS

In this study, the impact of higher-level thinking skills and curriculum differentiation strategies, mainly creative thinking, on the achievement and attitude levels of gifted and talented students was analyzed for a mathematics course and was statistically significant in developing behaviors targeted by the mathematics course.

First, the groups were compared according to their achievement scores before the implementation to see if the experimental and control groups were equivalent. As a result of the t-test for independent groups conducted to determine whether the group averages differed according to the pre-test variable for achievement, the difference between the group averages was not found to be statistically significant [$t_{(118)}$=1.787, p>.05]. The pre-test mean scores for achievement of the groups indicate that the groups match each other.

Table 1. Comparison of experimental and control groups according to pre-test achievement and attitude scores

	Control Group			Experimental Group					
	Mean	Std.Dev.	n	Mean	Std.Dev.	n	t	df	Sig.
Achievement (Pre-test)	84.93	9.242	60	87.63	7.183	60	1.787	118	.077
Attitude (Pre-test)	82.28	10.145	60	85.18	9.296	60	1.632	118	.105

*p<.05

To determine the effective readiness levels of the groups, the scores obtained by the students from the pre-test for the attitude scale for the mathematics course were compared. As a result of an independent group t-test conducted to determine whether the groups differed according to the pre-test attitude scores variable, the difference between the mean scores for the groups was not found to be statistically significant [$t_{(118)}$=1.632, p>.05]. This indicates that there was no statistically significant difference between the attitudes of experimental and control group students towards mathematics courses and that the groups are equivalent to each other in terms of effective readiness levels.

First sub-problem: what is the impact of differentiated mathematics teaching in distance education applications on academic achievement in gifted and talented students?

The t-test for paired samples was used to compare the pre-test and post-test achievement scores of students in the experimental and control groups to research this sub-problem.

Table 2. T-test results showing the impact of differentiated mathematics teaching on the academic achievement of the experimental and control groups

	Pre-test		Post-test						
	Mean	Std.Dev.	Mean	Std.Dev.	n	t	df	Sig.	d
Achievement (Control G.)	84.93	9.242	81.55	10.351	60	2.316	59	.024	.344
Achievement (Experimental G.)	87.63	7.18	97.58	2.77	60	10.329	59	.000*	1.80

*p<.05

As seen in Table 2, as a result of the t-test for paired samples conducted to test whether there was a statistically significant difference between the pre-test mean score for the achievement test in the control group ($\bar{X}_{pretest}$=84.93) with the post-test mean score ($\bar{X}_{posttest}$ =81.55), the difference between the means was not found to be statistically significant [$t_{(59)}$=2.316, p<.05]. The effect size calculated from the test result shows that this difference was very small. Based on this data, traditional teaching applied in the control group did not have much effect on the academic achievement levels of the control group students.

As can be seen in the table, the academic achievement level of students in the experimental group were pre-test mean score $\bar{X}_{pretest}$= 87.63 and post-test mean score $\bar{X}_{posttest}$= 97.58. As a result of the t-test for paired samples conducted to test whether there was a statistically significant difference between the mean pre-test and post-test scores, the difference between the group means was found to be statistically significant [$t_{(59)}$=-10.329, p<.05, d=1.80]. The effect size calculated from the test result shows that this difference was quite large. Based on this data, the differentiated teaching applied in the experimental group significantly increased the success of the experimental group students.

Table 3. Corrected post-test means for achievement scores in the experimental and control groups

Group	N	Mean	Corrected Mean
Control Group	60	81.55	81.886
Experimental Group	60	97.58	97.248

As can be seen in Table 3, the post-test mean score of the students in the experimental group for academic achievement was $\bar{X}_{experimental}$=97.58, and the post-test mean score of the students in the control group for academic achievement was $\bar{X}_{control}$=81.55. When controlled according to the pre-test mean score, the corrected mean for the post-test scores for academic achievement of students in the experimental group was $\bar{X}_{experimental}$=97.248, and the corrected post-test mean score of students in the control group for academic achievement was $\bar{X}_{control}$=81.886.

Table 4. Covariance analysis results for post-test achievement scores after controlling for pre-test scores in the experimental and control groups

Source of Variance	Sum of Squares	df	Mean Squares	F	p	(η2)
Pre-test	499.802	1	499.802	9.318	.030	.074
Group	6893.210	1	6893.210	128.514	.000*	.523
Error	6275.631	117	53.638			
Total (Corrected)	14487.467	119				

*p<.05

As a result of covariance analysis, there was a statistically significant difference between the post-test academic achievement scores of the students in the experimental group and the control group ($F_{(1-117)}$=128.514, p<.05, η2=.523). When the corrected means of the groups are examined, the difference was in favor of the experimental group. The effect size calculated from the test result showed that this difference was quite large. Based on this data, the differentiated teaching method applied in the experimental group was more effective in improving the academic achievement of students than the traditional teaching applied in the control group.

Second sub-problem: what is the impact of differentiated mathematics teaching in distance education applications on attitudes towards mathematics in gifted and talented students?

The t-test for paired samples was used to compare the pre-test and post-test attitude scores of students in the experimental and control groups to look for the answer to this sub-problem.

Table 5. T-test results showing the impact of Differentiated Mathematics Teaching on the Attitude Scores of the Experiment and Control Group

	Pre-test		Post-test						
	Mean	Std.Dev.	Mean	Std.Dev.	n	t	df	Sig.	d
Attitude (Control G.)	82.28	10.145	82.42	9.582	60	.340	59	.735	-
Attitude (Experimental G.)	85.18	9.296	91.37	4.614	60	4.921	59	.000*	.83

*p<.05

As seen in Table 5, as a result of the t-test for paired samples conducted to test whether there was a statistically significant difference between the attitude pre-test mean scores of the students in the control group ($\bar{X}_{pretest}$=82.28) with the post-test mean scores ($\bar{X}_{posttest}$=82.42), the difference between the means was not found to be statistically significant [$t_{(59)}$=.340, p>.05].

The mean pre-test attitude score of the students in the experimental group was $\bar{X}_{pretest}$= 85.18, and the post-test mean score was $\bar{X}_{posttest}$= 91.37. As a result of the t-test for paired samples conducted to test whether there was a statistically significant difference between the pre-test and post-test mean scores for attitude, the difference between the group means was found to be statistically significant [$t_{(59)}$=4.921, p<.05, d=.83]. The effect size calculated from the test result shows that this is quite a big difference. Based on these data, the differentiated teaching applied in the experimental group significantly improved the attitude of the experimental group students. When the effect sizes of both groups are compared, this difference was significantly greater than the difference in the control group.

Table 6. Corrected post-test mean attitude scores for experimental and control groups

Group	N	Mean	Corrected Mean
Control Group	60	82.42	83.177
Experimental Group	60	91.37	90.607

As can be seen in Table 6, the post-test mean score of the students in the experimental group for attitude was $\bar{X}_{exp.}$=91.37, and the post-test mean score of the students in the control group for attitude was $\bar{X}_{control}$=82.42. When corrected according to the pre-test mean score, the corrected mean post-test score for attitude of the students in the experimental group was $\bar{X}_{exp.}$=90.607, and the corrected post-test mean score for attitude of the students in the control group was $\bar{X}_{control}$=83.177.

Table 7. Covariance analysis results for post-test attitude mean score when controlled according to pretest score in the experimental and control groups

Source of Variance	Sum of Squares	df	Mean Squares	F	p	(η2)
Pre-test	3068.584	1	3068.584	99.620	.000*	.460
Group	1619.609	1	1619.609	52.580	.000*	.310
Error	3603.933	117	30.803			
Total (Corrected)	9075.592	119				

*p<.05

As a result of covariance analysis, there was a statistically significant difference between the post-test attitude scores of the students in the experimental group and control group ($F_{(1-117)}$=52.580, p<.05, η2=.310). When the corrected means of the groups were examined, the difference was in favor of the experimental group. The effect size calculated from the test result shows that this difference was quite large. Based on these data, the differentiated teaching method applied in the experimental group is more effective in improving the attitude of students than the traditional teaching applied in the control group.

DISCUSSION and CONCLUSION

The present study aimed to test the effectiveness of a mathematics program to develop creating thinking skills of gifted and talented students in mathematics during distance education. The presence of statistically significant differences between the mean achievement and attitude towards mathematics scores of the group undergoing the differentiated unit program in the mathematics course and the group with traditional education was analyzed.

As a result of the study, there was a statistically significant difference between the pre-test and post-test achievement test scores for students in the experimental group, while there was no statistically significant difference between the pre-test and post-test achievement test scores for students in the control group. Furthermore, there was a statistically significant difference between the achievement post-test scores for the students in the control and experimental groups. According to these findings, it was concluded that differentiated teaching during distance education increased the achievement of gifted and talented students. Previous studies also support this finding.

There are numerous models developed about how to differentiate the curriculum for gifted and talented students. However, the number of studies that test the practical effectiveness of many models, including the parallel curriculum model and grid model used in the present study, is quite limited. The study by Karaduman (2012), which analyzed the impact of differentiated geometry teaching based on the parallel curriculum model for gifted and talented student on creative thinking and academic success, is one of the few studies. The present study concluded that the scores for experimental group students studying the geometry units differentiated with the parallel curriculum model on the achievement test developed by the researcher, Van Hiele Geometric Thinking test and Creative Thinking-Image Creation test were statistically significantly higher than the gifted and talented control group students experiencing traditional teaching.

Although no research was found on the direct application of the grid model, one of the curriculum differentiation models, a study about the effectiveness of differentiated mathematical units was conducted by Kilcan (2005) based on the interdisciplinary thematic approach proposed by the model. The "interdisciplinary-thematic approach" is the process of integrating many different subject areas

with a comprehensive and general theme that is predetermined, associating them with each other. The main idea of the chosen theme can be a general concept that connects different areas of knowledge or a question that covers the whole.

Kansu (2021) developed a differentiation approach for the visual arts education of gifted and talented individuals. The measurement tool used to measure the effectiveness of this differentiation approach was the Torrance Creativity test. When the results of the analysis of the verbal A test and verbal B test scores on the Torrance creativity test were examined, the fluency, flexibility and originality scores increased significantly in line with the scores obtained in the 3 subtests used. Considering the scores before the application of the differentiation approach, there were significant differences between the pre-test and post-test scores. The differentiation approach used in the visual arts education of gifted and talented students explained 85% of the variation in the verbal creativity scores of the students. This situation reveals the effectiveness of the differentiation approach developed for visual arts education of gifted and talented students.

Altıntaş (2014) compared the academic success of students within the scope of the development of a new differentiation approach for gifted students and its application in mathematics teaching. There was a significant increase in the success scores of the students in the experimental group, where the courses designed with the developed differentiation approach were compared with the control group. This situation also shows that enriched, creative thinking-based, dominant intelligence-based activities and curriculum differentiation studies increase the academic success of students. In addition, the content, process, product and learning environment changes made on the basis of creativity strategies increased the academic success of the students.

Kilcan (2005) differentiated the subject of measurements in mathematics by using art, in a way that connected information belonging to different disciplines and created a common pattern to respond to what they experienced through art. In this study, which examined the impact of the interdisciplinary-thematic approach on students' achievement in the 6th grade of primary school, the thematic teaching method was more effective in achieving the goals and behaviors of the unit than teaching with the traditional method. In addition, thematic teaching practice significantly increased the achievement of students in the experimental group. The most important conclusion of the study by Maxey (2013), which examined the extent to which differentiated teaching affected primary school students' mathematical achievement, was that high-level students had a statistically significantly greater increase in achievement scores than low-and middle-level students. However, there were no statistically significant differences in grade-wide achievement test scores in the experimental and control groups. As the most important conclusion of the study by Yabaş (2008), which was conducted to determine the impact of the differentiated teaching approach on students' academic achievements, metacognitive skills, and self-efficacy perceptions, the achievement test, metacognitive skills, and self-efficacy perception scale scores of the class experiencing the differentiated teaching approach were higher than the scores of the class administered the traditional teaching method. Karataş (2013) found in their studies that a learning environment organized for the application of the differentiated teaching approach had an impact on mathematics achievement, creativity, attitude, and academic self-concept of gifted and talented students. The learning environment organized for the differentiated teaching approach significantly improved students' achievement levels, creativity, attitude towards mathematics course and academic self-concept.

The application of differentiated teaching in the traditional education process is considered to increase the achievement level of students. Similarly, it can be said that differentiated teaching applied in distance education also increases the achievement level of students. A study conducted by Scrima (2009) also reached conclusions supporting these findings. The two groups, both traditional and online, achieved similar levels of success. In Scrima's (2009) study, the impact of internet-based education and traditional education on students' achievement levels in a similar way supports the finding that the achievement level observed in the control group of this study increased. According to the results of a similar study conducted by Wu and others (2012), which used differentiated teaching in

traditional education, the achievement of students in the experimental group was significantly higher than those in the control group.

The most important conclusion of the study by Şaldırdak (2012), which was conducted to determine the impact of differentiated teaching practices on students' mathematical achievement and student opinions, was that the differentiated teaching approach positively affected students' achievement. The most important conclusion of the study by Taş and Sırmacı (2013), which was conducted to determine the impact of the differentiated teaching design on students' metacognitive skills and academic mathematical achievement, was that a statistically significant difference was found in favor of the experimental group in academic achievement with the application of the differentiated teaching approach. However, there was no statistically significant difference in the metacognitive skill test scores.

Another study examining the impact of differentiated teaching design on academic achievement was conducted by Springer et al (2007). As part of the research, a computer-aided mathematics program was developed and implemented that supported students to learn at their own pace. As a result of the study, the experimental group's post-test mathematics achievement scores were statistically significantly higher than the control group. Based on this, the experimental group taught with a differentiated curriculum was more successful than the control group taught with traditional instruction.

After the study, the pre-test and post-test scores on the attitude scale of students in the experimental group showed a statistically significant and large difference, while the pre-test and post-test scores on the attitude scale of students in the control group showed a statistically significant but smaller difference. It was concluded that while there was a greater positive change in the attitude of the students in the experimental group towards the mathematics course, the attitude of the students in the control group did not change much. In the present study, the post-test attitude scores of the students in the experimental group and the control group were compared and the attitude towards mathematics course was higher in the experimental group gifted and talented students to whom a differentiated teaching method was applied in distance education practices.

In a study by Aydın (2011), which examined the impact of active learning on the attitude toward mathematics, academic achievement, and creative thinking levels, a statistically significant difference was found after the experimental practice between the level of creative thinking, overall academic achievement, and attitude towards the mathematics of the experimental and control group students. These groups had the equal levels of creative thinking, overall academic achievement and attitude towards mathematics before the experimental practice. Since the statistically significant difference obtained was in favor of the experimental group, it was interpreted that the active learning method improved students' level of creative thinking, overall academic achievement, and attitude towards the mathematics course more than traditional teaching methods. Based on these results, differentiated learning methods are effective in improving students' creative thinking, overall academic achievement, and attitude levels. The most important result in the study by Ekinci & Bal (2019) conducted to determine the impact of differentiated teaching method on students' achievement and attitude towards mathematics course was that there were no statistically significant differences in achievement scores in favor of the experimental group, while there were no statistically significant differences in attitude scores. Students stated that the lessons were fun and that their learning was permanent.

Differentiated instruction is an approach developed for the teacher to diversify instruction according to student characteristics. Teachers design a teaching plan that can meet the individual needs of students in the classroom (Avcı & Yüksel, 2016). Based on the findings of our research, differentiated mathematics teaching develops in accordance with the needs of students.

As a result of the research, both the achievement test and attitude scale scores differed statistically significantly in favor of the experimental group, and the full learning model applied with the education management system and course software increased achievement in distance education. For these

reasons, this model can be used in courses that are suitable for use of a full learning model among distance learning courses. In addition, due to the positive impact of the practice with the full learning model on student attitudes in distance education, studies can be carried out aiming to provide awareness of the full learning model for students who will receive distance education.

The distance learning model based on differentiated teaching in mathematics course teaching increased students' academic achievement and positively affected their attitude to the course. Therefore, research can be performed using other learning-teaching approaches and methods such as project-based teaching, programmatic teaching, learning through research, modular teaching, and cascading teaching in distance education.

Limitations

This study has some limitations, for instance it is limited only to the mathematics lesson and the natural numbers and fractions units. It is also limited to course materials prepared based on the parallel curriculum model and differentiation techniques proposed by the grid model.

Suggestions for practitioners

Mathematical communication, which is an important component of research and differentiated curriculum, can be handled separately, verbally and in writing, and the effects of these two separate dimensions on mathematics achievement, comprehension and attitude can be examined. In addition, differentiated education was applied in the study by a mathematics teacher who is an expert in the education of gifted students. Investigations can examine how the same differentiated study is implemented by a classroom teacher.

The findings obtained in the study indicate that practitioners should use differentiated instructional design more. For this, teachers should be informed about the usage areas, principles, techniques, positive and limited aspects of differentiated teaching in pre-service and in-service training. In order to support teachers' use of differentiated instructional design, it may be important to include lesson plans using these designs in teacher workbooks. Larger samples can be studied to arrive at more precise generalizations.

Since the developed unit program only covers the natural numbers and fractions units within the scope of the 4th grade mathematics course, it is insufficient in terms of meeting the differentiation needs of gifted and talented students in mathematics education. Therefore, similar studies can be done for different levels of education and in different subject areas.

Since the developed unit program is limited to the province of Istanbul, there is a need for this study to be applied in other regions of Turkey and to be tested on different sample groups.

Suggestions for researchers

There is a common misconception that success in mathematics is possible only with special talent or skill. The effect of effort and systematic work using techniques specific to a certain field is not considered important in mathematics achievement. This is why it's important to show students that it is possible to learn math, make sense of math, and even solve math problems in creative and original ways. In this context, it is thought that similar studies should be disseminated for all students, including gifted and talented ones. It is important to expand the use of open-ended tests, in which students feel more comfortable and more productive, as emphasized in studies, rather than single-answer test items, especially for higher-order thinking skills. It is necessary to increase the number of studies examining the effects of differentiated units on academic achievement, general creativity, disciplinary creativity, and attitude towards mathematics, as in the current study. Both the short-term and long-term effects of such differentiated teaching should be examined and the curriculum should be constantly renewed in line with these data. In summary, developing effective and high-level programs suitable for the level of students should take priority in the list of things to be done to meet the needs of gifted and talented students. For this, the first thing is to differentiate the existing units in accordance with the potential and interests of the students.

Ethics and Conflict of Interest

This research was approved by permission of Hacettepe University Ethics Board dated 12.04.2021-E-35853172-300-00001536076. The authors have no conflicts of interest to declare.

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