Vol. 18(12), pp. 392-398, December 2023
DOI: 10.5897/ERR2023.4375
Article Number: 4773C0B71495
ISSN: 1990-3839

http://www.academicjournals.org/ERR

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Educational Research and Reviews

Full Length Research Paper

The effect of differentiated instruction on gifted students' critical thinking skills and mathematics problem solving attitudes

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Received 10 October, 2023; Accepted 2 November, 2023

It is known that a significant portion of the world's child population is gifted. Studies on the applications that can be used in the education of these gifted students have been given importance in recent years. In this study, the effect of differentiated instruction method on mathematics problem solving attitude and critical thinking skills of gifted students at primary school level was examined. The research is a pretest-posttest one-group quasi-experimental study. The study group consisted of five elementary school students diagnosed as gifted in Antalya/Turkey. "Mathematics Problem Solving Attitude Scale" and "Critical Thinking Scale" were used as data collection tools. The study continued for eight weeks, three hours a week. Throughout the study, problem solving instruction with differentiated method was carried out by the researcher. Within the scope of the study, quantitative data were analyzed using SPSS statistical package program. There was a significant difference between the pre-test and post-test of the mathematics problem solving attitude and critical thinking scales in the students. According to the results, it was concluded that there was a significant difference in the participants after the application. Therefore, it is possible to mention that individualized and differentiated education should be included in the mathematics problem solving attitude and critical thinking skills of gifted students due to its positive effect.

Key words: Giftedness, critical thinking, differentiated education, problem solving.

INTRODUCTION

Each student has different individual characteristics. These different characteristics show themselves in different ways when individuals reach school age. Because the difference in interest, ability and readiness arising from the difference in individual characteristics shows itself more clearly at school age. According to these characteristics, education

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should be planned in a way that is appropriate for each student and teachers should respect these differences. Making changes in teaching according to the interests of individuals is a tool that increases performance, motivation and success (Torrance, 1995). At this stage, teachers should develop their observation skills well, because a teacher who accepts the existence of these differences should diversify teaching more effectively by reaching as many students as possible (Demir, 2013).

Otherwise, students with individual differences cannot be expected to benefit from uniform instruction at the same level. In order to ensure that each student benefits from instruction at the highest level, we need to diversify instruction as much as possible, considering that students' needs are different and have different characteristics (Beler and Avcı, 2011; Kontaş, 2012).

Differentiated instruction is one of the ways of thinking based on the principle of combining students' general and subject-specific interests with the subject studied by considering their readiness, interests and learning styles and offering them different options and opportunities, and learning in a way that they feel comfortable (Şaldırak, 2012).

Differentiated instruction is a method that largely consists of approaches based on social-constructivist learning theory (Tomlinson and Allen, 2000). In this method, choices can be made for the teacher, learner and subject. For example, it gives the teacher the opportunity to plan for different students, while giving students the right to explore, choose and present. Therefore, it can be said that differentiated instruction is a student-centered method that integrates the instructor, learner and learning subjects (Özer and Yılmaz, 2016). However, in order to benefit from this method at the highest level, the characteristics of the method should be well known and the studies should be organized accordingly.

In differentiated instruction, the aim is always to move the student from his/her current level to a better place. There are three different factors for this to happen. One of these factors is the materials used in the process. The prepared materials should be neither above nor too far below the level of the student. When an educational material is prepared below the level of the student, it cannot be expected to benefit the student. Likewise, a material that is much above the level of the student will not be of any benefit. Therefore, if we want to achieve the highest development in this method, we should pay close attention to the appropriateness of the student level. The second biggest factor of this method is interest. The preparations and studies made for the student's interest are the factor that affects student motivation the most. This will provide a great benefit in making the student successful. The third major factor is the learning profile. Learning profile is a concept that describes how a student learns. This concept consists of variables such as intelligence preferences, learning style, gender and culture (Özer and Yılmaz, 2016). Intelligence preference is the factor that plays the leading role in the preparation of individualized curricula. Preparing an education program suitable for the types of intelligence shaped according to the interests and abilities of individuals prepares the environment for the student to benefit from education at the highest level. The self-realization of gifted individuals by using their potential at the highest level can be achieved through an education appropriate to their abilities (Kaya, 2013). In the education of gifted individuals, separate education, enrichment and acceleration models are generally used (Yıldız, 2010). Differentiated education, on the other hand, is enriching education with a similar expression. In this process, the teacher should focus on the answers to questions such as how to provide instruction (input), how much and what kind of support to provide to the student (level of support), what kind of reactions to expect from the student (response), how much time is needed for learning (duration), and what are the expectations for students' participation in activities (participation) (Levy, 2008).

In Gül's (2014) study titled 'Differentiated Instruction and Adaptations', she included the steps that should be followed in order for differentiated education to be successful and various adaptations that can be made in content, process and product dimensions. Taş and Sırmacı (2018) examined 'The Effect of Differentiated Instruction on Students' Metacognitive Skills and Academic Achievement in Mathematics' and interpreted it as a finding support that the method is an effective variable on academic achievement. When the studies conducted in the field are examined, it is observed that differentiated instruction has positive effects on individuals in many different characteristics.

This study aims to design differentiated problem-solving teaching activities for gifted and talented students at primary school level and to investigate the effects of these activities on students' mathematics problem solving attitudes and critical thinking skills. Since the education of gifted and talented students is still new in our country, many problems are encountered in this process (Çepni et al., 2002). One of the biggest of these problems is that teaching mathematics to gifted students is very flat and inadequate. The scarcity of studies in this field and the difficult accessibility of activities make it difficult for teachers with gifted students. This study is important in terms of guiding teachers with gifted students, providing examples of applications, and providing an idea about the problems and solutions that may arise in the process. In the study, it is necessary to determine the student's intelligence type well and evaluate the process well.

Practices other than the type of intelligence that the student is predisposed to reduce the quality of education and negatively affect the teacher-student relationship. Within the scope of this study, mathematics problem solving attitudes and critical thinking skills of gifted students

Table 1. The research design.

Group	Pre-test	Process	Post-test experimental group
Gifted students	x	8-week differentiated instruction training	x

Table 2. Demographic characteristics of the students participating in the study.

Grade	Girl	Male
Grade 1	1	-
Grade 2	-	2
Grade 3	1	1
Total	2	3

at primary school level were examined in differentiated problem-solving instruction and the following questions were tried to be answered.

1. Is there a significant difference between the pre-test and post-test scores of the mathematics problem solving attitude of the gifted student to whom the differentiated instruction method was applied?
2. Is there a significant difference between the critical thinking pre-test and post-test scores of gifted students to whom differentiated instruction method was applied?

METHOD

The research model, the study group (participant characteristics), the data collection tools used in the research, the data collection process and how the data were analyzed were explained.

Research model

This study was conducted to observe the effect of differentiated instruction applied to gifted students at primary school level on students' mathematics problem solving attitudes and critical thinking skills, a one-group pretest-posttest quasi-experimental design was used. One- group pretest-posttest quasi-experimental design is a type of design in which the effect of the experimental procedure is examined by applying tests before and after the experimental procedure (Büyüköztürk, 2015). Table 1 shows the research design.

Study group

The study was conducted with five students diagnosed as gifted and attending primary school in Antalya, Turkey in 2022 to 2023. These five students were randomly selected among students diagnosed as gifted by the guidance and research center in Turkey. All necessary permissions were obtained to include the students in the study. The parents of the students had undergraduate education. All of the students are studying at the 'Science and Art Center', an official institution in Turkey that provides education for gifted students. In addition, all of the students stated before the study that they liked mathematics very much and that they enjoyed learning and solving problems. The distribution of students according to their grade and gender is shown in Table 2.

Data collection tools

The higher the internal and external validity of a scientific research, the more important and valuable the research becomes (Baştürk, 2009). "Mathematics Problem Solving Attitude Scale" and "Critical Thinking Scale" were used as data collection tools in the study. Information about these measurement tools is explained.

Mathematics problem solving attitude scale

This data collection tool was developed by Çanakçı (2008). The purpose of developing the tool was to develop a reliable and valid 'problem solving attitude scale' for 2nd grade elementary school students and to explain the relationship between the problem-solving attitude determined by using this scale and the student's mathematics achievement (Çanakçı, 2008). Reliability and validity studies of the scale were conducted. The total variance of the scale was determined as 42.693%. Pearson correlation coefficient calculated using the test-retest technique is 0.89. Cronbach Alpha internal consistency coefficients are 0.848. Çanakçı (2008) determined the sub-problems of the scale under three main headings: 'Sub-Problems Related to Mathematics Problem Solving Attitude Scale, Sub-Problems Related to Mathematics Achievement, and Sub-Problems Related to Mathematics Problem Solving Attitude'. While the scale consisted of 77 items during the development phase, it is a 5-point Likert-type scale consisting of 19 items in its final form and has two stages. In the first stage, it measures students' 'Enjoyment Dimension' consisting of 10 items and in the second stage; it measures the 'Teaching Dimension' consisting of 9 items. In addition, Çanakçı (2008) developed a 'Personal Information Questionnaire' for the researcher to determine some demographic and personal information of the students. In the Personal Information Questionnaire, there are questions about parents' education level, gender, and mathematics report card grade. The scale is graded as 'strongly agree (5), agree (4), undecided (3), disagree (2), strongly disagree (1)'.

Table 3. Experimental process.

Week	Date	School	Operation
Week 1	March 7/8, 2023	Science and Arts Center	Personal ınformation form Mathematics problem solving attitude scale pre-test critical thinking scale pre-test
Week 2	March 14/15, 2023	Science and Arts Center	Addition problem solving with differentiated education
Week 3	March 21/22, 2023	Science and Arts Center	Subtraction problem solving with differentiated education
Week 4	March 28/29, 2023	Science and Arts Center	Multiplication problem solving with differentiated education
Week 5	April4/5, 2023	Science and Arts Center	Division problem solving with differentiated education
Week 6	April11/12, 2023	Science and Arts Center	Liquid measurement problem solving with differentiated education
Week 7	April18/19, 2023	Science and Arts Center	Length measurement problem solving with differentiated education
Week 8	April25/26, 2023	Science and Arts Center	Mathematics problem solving attitude scale posttest Critical thinking scale posttest

Critical thinking scale

The critical thinking scale consisting of 17 items developed by Görücü (2014) was used to collect data in the study. The dimensions of the 5-point Likert-type scale (completely agree, partially agree, undecided, disagree, strongly disagree) are communication, truth-seeking, prejudice and self-confidence. In the scoring of the scale, scoring was carried out starting from the option "totally agree" to the option "strongly disagree". In negative statements, the items were scored in the opposite direction. The reliability coefficient of the scale calculated in the study is 0.69.

Data collection process

The program was implemented for 3 h a week for 8 weeks. The study was generally conducted on Tuesdays for the first-class hour and on Wednesdays for the third- and fourth-class hours. The studies were carried out in a quiet environment in the study class of the affiliated institution. The students in the school were from families with high and middle socio-economic status. During the study period, frequent meetings were held with the families of the students, and care was taken to ensure that the process progressed in cooperation between the family and the teacher.

Different topics were determined for each week and the study was carried out simultaneously with the mathematics annual plan prepared by the Ministry of National Education. The stages of the study, which was implemented for 24 h in total in an 8-week period, are given in the Table 3. The experiment process for each week given in Table 3 is as follows:

Week 1: In the first week, pre-tests were administered to the participants and the plan of the implementation phases was prepared in line with the annual plan.

Week 2: In this week, the plan prepared was started to be applied to the participants. In the application, which started with addition problems, students were asked to solve 30 questions in total in a one-week period. The stage sizes of the questions were gradually increased and different solution methods were presented to the students.

Week 3: This week, subtraction problems were practiced. Again, a total of 27 questions were solved in 3 class hours. The students again avoided doing operations and tried to do it mentally as much as possible. In a total of 6 of the 27 questions, they made small mistakes and reached the wrong result.

Week 4: In the 4th week of the implementation, multiplication problems were started. Participants started to perform operations and tried to reach the solution step by step in progressive questions. A total of 36 questions were solved in this week. The participants made mistakes in 4 of these questions because they tried to reach the solution in a short way.

Week 5: In the 5th week of the implementation, division questions were started. Participants were asked to solve a total of 32 questions on this subject. The students made mistakes in 2 of these questions and corrected their mistakes themselves when asked to look at the question again. Students were asked to solve single-stage questions and questions with more than one stage.

Week 6: This week, participants were asked to solve liquid measurement problems. The students started to discover their own solutions and took care to re-solve the questions with different solutions.

Week 7: In week 7, the last week of the implementation week, the participants were asked to solve length measurement questions.

Week 8: In this week, the implementation was completed and the post-tests were administered to the students.

Data analysis

The data obtained in the study were analyzed using the SPSS 21 package program. When appropriate conditions are met, parametric tests give more reliable results than nonparametric tests. However, in this study, it was deemed more appropriate to use non-parametric tests due to the normality test results and $n < 30$. In analyzing the data for the one-group pretest-posttest design, the related means t-test is generally applied, but in order to determine whether the pretest and posttest scores obtained in this study show significant differences according to the method applied, the Wilcoxon signed- rank test was used because the number of samples was not sufficient for parametric tests. Analyses were performed with the SPSS package program and the significance level was taken as $p<0.05$. Test results were analyzed, reported and then interpreted.

FINDINGS

In this part of the study, the effectiveness of the interventions on mathematics problem solving attitude and critical thinking skills were evaluated.

Table 4. Findings related to the pre-test and post-test scores of the mathematics problem solving attitude scale of the study group.

Pre-test/final test	N	Rank mean	Row total	z	p
Negative sequence	0[a]	11.95	0.00		
Positive sequence	5[b]	19.77	474.50	-2.66	0.009
Equal	0[c]	-	-		

*p<0.05.

Table 5. Findings related to the study group critical thinking scale pre-test and post-test scores.

Pre-test/final test	N	Rank mean	Row total	z	p
Negative sequence	0[a]	0.00	0		
Positive sequence	5[b]	21.50	825.00	-5.516	0.000
Equal	0[c]	-	-		

Evaluation of mathematics problem solving attitude

The second sub-problem of the study was determined as *"*Is there a significant difference between the pre-test and post-test scores of the mathematics problem solving attitude of gifted students to whom differentiated instruction method was applied?*".* In order to examine the problem situation, the "Mathematics Problem Solving Attitude Scale" was applied to the participants before and after the application and the difference was analyzed with Wilcoxon Signed Rank Test. The analysis of the participants' pre-test and post-test scores is given in Table 4.

According to Table 4, the results of the analysis show that there is a significant difference between the pre-test and post-test scores of the students on the Mathematics Problem Solving Attitude Scale (z = -2.66, p <0.05). When the rank means and sums of the difference scores are considered, it is seen that the observed difference is in favor of the positive ranks, that is, the post-test score. In other words, it was determined that the posttest scores of the students on the Mathematics Problem Solving Attitude Scale were significantly higher than the pre-test scores.

Assessment of critical thinking skills

The second sub-problem of the study was determined as: *"*Is there a significant difference between the critical thinking pre-test and post-test scores of the gifted student to whom the differentiated instruction method was applied*?* "Critical Thinking Scale" was applied to the participant before and after the application. Wilcoxon signed ranks test was applied to see the difference between pre-test and post-test scores and the results are given in Table 4. "Critical Thinking Scale" was applied to the participant before and after the application. The differences between the pre-test and post-test are evaluated in the Table 5.

When the results in Table 5 are examined, it can be said that the critical thinking skills of gifted students improved significantly in the differentiated learning environment (z = -5.516, $p < 0.05$). When the rank averages and sums of the difference scores are considered, it is understood that this difference is in favor of the positive ranks, that is, the post-test scores. The data obtained show that there is a significant difference in favor of the effectiveness of the study.

DISCUSSION

In this study, which was conducted to examine the effect of differentiated instruction on the mathematics problem solving attitude and critical thinking skills of gifted individuals; both mathematics problem solving attitude and critical thinking skills of students were examined. The fact that there was a significant difference between the pre-test and post-test of mathematics problem solving attitude and critical thinking scales proved that differentiated instruction practices resulted in a positive contribution.

The presence of gifted students is a situation that we have started to encounter frequently in educational environments and educators are not quite sure what to do. Teachers have the primary responsibility for the education of these students. Teachers have a very important role in the process of individual diagnosis and diagnosis of these students, in the education to be prepared according to their individual needs, in the monitoring and evaluation of the process. However, according to the American National Association for Gifted Children (2009), teachers responsible for the education of gifted children do not

receive any training on giftedness and have difficulty in conducting specialized studies.

Research shows that gifted children show different mental, social, physical and personality characteristics than their peers (Akarsu, 2001; Feldhusen, 2005; Yakmacı-Güzel, 2002). Therefore, this small but unique group of gifted children in order to better understand the group that shows great differences with gifted students, knowing their different characteristics from their non-gifted peers can provide a better understanding of them (Önal, 2020). The educational environment offered by teachers who are trained to know these differences and who organize the educational environment according to these students should be far from the traditional educational environment. It is inevitable to achieve success with teachers who offer a fun and not boring classroom environment. Otherwise, it is possible that the label of giftedness may lead to social exclusion (loneliness), unrealistic self-confidence, perfectionism and anxiety about failure (Öpengin, 2012). Due to the differences of these students, various educational studies have been conducted throughout history to address the differences of these individuals (Dönmez, 2004). One of these educational studies is differentiated instructional practices.

The student-centered approach of differentiated instructional practices helps students build a path that brings them closer to success by activating their intrinsic (Deci and Ryan, 1985) and achievement motivators such as interest, curiosity and desire (Danzi et al., 2008). It has been found that students exhibit high levels of interest, curiosity and enthusiasm in differentiated instruction compared to traditional instructional models (Martin and Pickett, 2013).

According to the results of this study, the application of differentiated instruction to gifted students in primary school has a positive effect on both the mathematics problem solving attitude and the critical thinking tendency of the individual. When the literature is reviewed, there are studies in which differentiated instruction method contributes positively to the education of gifted students. Thomson (2010) based on interviews with gifted students and their teachers, states that the differentiated instructional environment with online courses enables students to control their learning speed, learning processes, and self-control, as well as having features that meet the needs of gifted students. Altıntaş and Özdemir (2014), in their control group pretest-posttest experimental model study with twenty-seven gifted students, stated that technology-based differentiated instruction method contributed positively to the academic achievement of these students. Umar and Reis (2014) mentioned that differentiated instruction using blended learning method increased the academic achievement of gifted and talented students. These studies in the literature are consistent with the current study, and they have mentioned the positive contribution of differentiated instructional environment to the education of gifted students.

Recommendations

In the light of these findings, a teacher with a gifted student should first identify the student's area of interest and differentiate his/her instruction as much as possible. Teachers should cooperate with institutions that provide special education for these students, such as the Science and Art Center where the student receives education, and should increase the course hours as much as possible to develop critical thinking tendencies. In order to improve the student's attitude towards solving mathematical problems, questions of different dimensions should be solved and a fun mathematics teaching environment that is far from traditionalism should be provided. Students should be encouraged to discover new ways of solving problems and studies should be conducted for this skill.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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