

Evaluating a Newly Developed Differentiation Approach in Terms of Student Achievement and Teachers' Opinions*

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Abstract

This study aims to evaluate a differentiation approach that was recently developed to teach mathematics to gifted middle school students in terms of its practice by teachers by studying the effect of the approach on achievement among both gifted and non-gifted students. From mixed research methods, the study used an explanatory design. It was conducted with 68 gifted and 144 non-gifted students who were in the 5th, 6th and 7th grades and 5 mathematics teachers. A mathematics achievement test, the Multiple Intelligences Inventory, and a teachers' opinion form were used as the data collection instruments. When the lessons that were designed according to the recently developed differentiation approach were compared with the lessons that were conducted according to the Ministry of National Education curriculum, those lessons designed according to the Purdue model, and those that were conducted within the scope of differentiation that was outlined in the Program for Noticing Individual Skills, the participating students' achievements increased significantly with the use of the recently developed differentiation approach. In addition, the teachers expressed that the activities that were conducted based on the differentiation approach were creative, beneficial, and tailored to the students' levels, and they addressed different intelligences types. The teachers reported that the students were more active; the lessons were more effective; the students improved their academic and social skills; and they had opportunities to understand their students better; understand the importance of project studies; and experience the project management process.

Keywords: Giftedness • Teaching mathematics • Differentiation approach • Purdue model • Teacher opinions • Program for Noticing Individual Skills

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Consciously selected tools, and equipment and consciously organized teaching environments and activities that are presented to gifted students support these children in a healthy way and enable them to use their own capacities at their highest levels (Mesleki Eğitim ve Öğretim Sisteminin Güçlendirilmesi Projesi [MEGEP], 2007). Individual diversity and individual differences create obstacles to teaching and developing learning activities at school, and ignoring individual differences is the basic defect of the education system. This indicates that both education systems and individuals differ in terms of personal features, intelligences, and behaviors, and it is wrong to teach according to one uniform plan (Taller, 2004).

Noting the individual skills of gifted students will ensure that they use their learning capacities to the maximum degree, help them to fulfill their potential, and provide additional teaching opportunities that consider these students' special needs (Tunçdemir, 2004; Tüzünak, 2002). Peterian (1916) says that, "Giftedness is always an opportunity for success, and it makes achievement possible, but it is not the success itself." (as cited in Taller, 2004). In other words, gifted children cannot succeed with only their intelligence; they need to use this intelligence in suitable conditions (Taller, 2004). Zalman Usiskin (2000) was the first person who talked about "improving skills of students to the advanced levels." (as cited in Karp, 2011). Abilities related to giftedness can improve under encouraging conditions, but it is necessary to establish these conditions (Karp, 2011).

Enriching the education services that are provided to gifted children means conducting activities that suit their needs and features in standard classroom programs. To accomplish this, it is necessary to plan differentiated learning experiences in typical classrooms (Ersoy & Avci, 2001 as cited in Karakurt, 2009). Using this differentiation program model, activities are prepared that reflect and take advantage of the skills, interests, and curiosity of gifted children; teaching under this model entails using specially planned educational exercises- individual, group and small group- that address real-life problems. In place of the monotonous and meaningless tasks and activities of more standard classroom programs, the differentiation approach presents intriguing activities that fulfill gifted students' individual needs. It is essential in standard classroom programs to make adaptations that suit the needs and features of gifted students. Enrichment has a structure that involves all children irrespective of their skill levels, unlike other

educational practices. Non-gifted children also benefit from these activities (MEGEP, 2007).

Enrichment can be defined as target audience and their needs, interests and skills; content and objectives of the subject area that will be taught; how pedagogy will be used for teaching content, attainments and both and where teaching will take place in order to implement curriculum (Kaplan, 2009). The multiple intelligences approach is used in establishing new schools, defining individual differences, planning and developing curricula, and evaluating education strategies. It is widely used because it can be implemented with different students, subject areas, and grade levels (VanTassel-Baska & Brown, 2009).

Within the scope of the program for noticing individual skills that is compared with the differentiation approach developed in this study and that is implemented in science and art centers in our country, the students are grouped by their individual skills and capacities along with feedback and observations that are made by supportive teachers. Programs are being prepared that consider individual differences among students and uncover their creativity using academic tools that help students realize their skills. Learning environments are equipped with modern teaching instruments that support creativity. Programs are student centered and inter-disciplinary (Bartın Bilim ve Sanat Merkezi, 2014). The Purdue model, which was compared with the new differentiation approach to assess efficiency, comprises three stages. Stage 1 is used as a basis for teaching basic thinking skills, such as fluency, flexibility, originality, imagination, and asking questions. Stage 2 is used for teaching more complex thinking strategies, such as logical inference, critical thinking, and creative problem solving. Stage 3 comprises independent, individual learning, and project activities to guide children toward creative productivity in adulthood (Feldhusen & Kolloff, 1986).

Some of the different models that have been used worldwide to teach gifted students and provide a basis for the differentiation approach that was developed within the scope of this study are as follows: the Williams model, which teachers use to promote different approaches to integrating affective and cognitive factors in classrooms that comprises students with various skills (New South Wales Department Of Education And Training, 2006). The Maker model combines all strategies that suggest ways to tailor basic curricula to suit the features of gifted students (Sak, 2009). The Kaplan model is a simple thinking tool for developing different curricula (New South Wales Department of Education and Training, 2004). The purpose

of the autonomous learner model is to provide students a better understanding of creativity and the features of creative people (Davis, 2011). The Maker matrix involves five problem types for use with each intelligence domain (Maker et al., 1994 as cited in VarTassel-Baska & Brown, 2009). The problem types are structured to have a series of answers and to allow for a choice of methods for solving the Type III problems among them. Type V problems are well structured; they require students to identify the problem, find ways to solve it, and set out the criteria they used to find that solution.

Based on the literature review the differentiation approach that was developed within the scope of this study aimed to be a project-based, multiple intelligences-based, interdisciplinary approach that used creative thinking and enrichment activities. The following results were obtained. Activities based on project-based learning increase students' achievement (Baş, 2011; Dağ & Durdu, 2011; Değirmenci, 2011; Deniz Çeliker, 2012; Doğay, 2010; Gözüm, Bağcı, Sünbül, Yağız, & Afyon, 2005; Karaçallı, 2011; Kaşarcı, 2013; Özer & Özkan, 2010; Yıldırım, 2011); teach them the steps for preparing projects (Dağ & Durdu, 2011); contribute to learning by doing (Dağ & Durdu, 2011; Gözüm et al., 2005); positively affect cooperative and group work skills (Çetin & Şengezer, 2013; Dağ & Durdu, 2011; Sadioğlu, Onur Sezer, Çağlar Özteke, & İlhan Tuncer, 2012); encourage students to be social (Çetin & Şengezer, 2013; Dağ & Durdu, 2011; Gözüm et al., 2005; Sadioğlu et al., 2012); ensure teacher guidance throughout the project studies (Sadioğlu et al., 2012); improve students' sense of responsibility (Gözüm et al., 2005; Kurak, 2009); help to identify students' interests and skills (Kurak, 2009); make lessons more enjoyable, prevent lessons from being monotonous and teacher-centered, and make students more active (Memişoğlu, 2011); make lessons more understandable (Gözüm et al., 2005; Memişoğlu, 2011); increase students' motivation (Gözüm et al., 2005; Papastergiou, 2005) and self-confidence (Papastergiou, 2005); ensure persistency (Gözüm et al., 2005); and improve their communication skills (Gözüm et al., 2005). Curricula that incorporated these facets in their designs led to increased positive attitudes toward the lessons (Deniz Çeliker, 2012; Kaşarcı, 2013) and to greater lesson retention (Cengizhan, 2007; Karaçallı, 2011).

It was identified that multiple intelligences-based teaching increased students' achievements (Altınsoy, 2011; Altun, 2009; Elmacı, 2010; Gözüm, 2011; Sivrikaya, 2009; Şirin, 2010; Uzunöz & Akbaş, 2011; Yalmanlı & Gözüm, 2013); retention

of the lessons and teaching activities (Gözüm, 2011; Gürbüz, 2011; Yalmanlı & Gözüm, 2013); positive attitudes toward the lessons (Altınsoy, 2011; Şengül & Öz, 2008); and interest in the lessons (Şengül & Öz, 2008). It was determined that practices that were project-based and that used an interdisciplinary approach offered intense, satisfactory learning experiences and were very efficient and that students gained important experience with interdisciplinary studies, project-based teaching, cooperative learning, and peer correction (Şahin, 2007).

It was observed that teaching activities based on creative thinking increased students' academic achievements (Kadayıfçı, 2008; Kök, 2012; Kurtuluş, 2012; Özcan, 2009; Özerbaş, 2011; Scott, Leritz, & Mumford, 2004), their positive attitudes toward lessons (Akçam, 2007; Scott et al., 2004); and their retention scores (Emir, 2001). In addition, encouraging creativity and incorporating it into teaching models increased students' achievements, creativity, and spatial thinking skills (Kök, 2012). It was concluded that skill-based grouping and homogenous groups had positive effects on gifted students' academic achievements (Adodo & Agbayewa, 2011; Hoffer, 1992; Kulik & Kulik, 1982) and attitudes toward topics (Adodo & Agbayewa, 2011; Kulik & Kulik, 1982).

It was identified that teaching based on enrichment activities increased students' achievements (Beecher & Sweeny, 2008; Coyne & Fogarty, 2007; Fakolade & Adeniyi, 2010; Kirkey, 2005; Luehmman, 2009; Olszewski-Kubilius & Lee, 2004; Singh, 2013). It was determined in studies about tailoring curricula that doing so also increased students' achievements (Beecher & Sweeny, 2008; Colson, 2008; Kadum-Bošnjak & Buršic-Križanac, 2012; Kirkey, 2005; Mastropieri et al., 2006; Reis, McCoach, Little, Muller, & Kaniskan, 2011; Simpkins, Mastropieri, & Scruggs, 2009). Furthermore, when the studies based on the Purdue model were analyzed, it was determined that the lessons that used the Purdue 3-staged enrichment model also increased students' achievements (Altıntaş & Özdemir, 2009, 2010; Moon, Feldhusen, & Dillon, 1994; Ünlü, 2008), and it was identified that project-based teaching also increased students' achievements (Altıntaş & Özdemir, 2009, 2010; Baran & Maskan, 2013; Moon et al., 1994; Sert, 2008; Tertemiz, 2012; Ünlü, 2008).

The above literature review revealed that no studies had been conducted focusing on teaching gifted students in public schools in Turkey. In addition, it was found that studies about gifted students were generally project-based. Because there were no

differentiation approaches that aimed to fulfill gifted students' education needs, this absence in the field was considered in this study. The study is important for two reasons. One, it designed a differentiation approach and evaluated it on the basis of how teachers used it to allow gifted students to use their full potential during mathematics lessons and to improve their academic achievements and creativity skills. Second, the study also analyzed the effect of this developed approach on both gifted and non-gifted students. Furthermore, the study is important because it presents the effectiveness of the new differentiation approach by comparing the results of its use with the results of teaching lessons within the frame of a model and a program.

This study aims to evaluate a differentiation approach developed for teaching mathematics to gifted middle school students in terms of teacher usage by observing its effect on the achievements of both gifted and non-gifted students. The study also aims to determine the effect of this approach on students' achievements by comparing it with the lessons that were conducted within the framework of the Ministry of Education curriculum, the Purdue model, and the Program for Noticing Individual Skills. Based on the above explanations, we can express the study's problem statement as follows: "Does the differentiation approach developed for teaching mathematics to gifted middle school students has an effect on the achievements of gifted and non-gifted students?"

A secondary problem related to comparing the lessons that were designed based on this differentiation approach with the lessons that were conducted within the framework of the Ministry of Education curriculum and the Program for noticing individual skills is as follows: "Are there significant differences between the pretest and posttest scores of the gifted and non-gifted students in the control and experimental groups?" Another secondary problem related to comparing the differentiation approach lessons with those that were designed according to the Purdue model is as follows: "Is there a significant difference between the pretest and posttest scores of the gifted and non-gifted students in the control and experimental groups?" A final secondary problem related to the opinions of the teachers who participated in this study is as follows: "What are teachers' opinions of the newly developed differentiation approach?"

Method

In this study, a pre/posttest model with a control group was used in accordance with quantitative research methods, and content analysis was used as the qualitative research method. Using this mixed-method (both qualitative and quantitative) approach, an explanatory design was used in the study. In explanatory design, a quantitative method is primarily used, and then, the data are analyzed. Subsequently, qualitative analysis reveals the meanings of the data (Gardner, 2012). Thus, more detailed information will be obtained by supporting the quantitative data achievement test scores that were collected to determine the efficiency of the approach with the qualitative data collected from the teachers' opinion forms.

Universe, Sample, and Study Group

For this study, which was conducted in the fall semester of the academic year 2012-2013, the universe of the potential qualitative study participants was all the gifted and non-gifted students who were in the 5th, 6th, and 7th grades in middle schools in Ataşehir, Maltepe, and Çekmeköy districts in Istanbul. The study sample comprised 68 gifted students and 144 non-gifted students who were in the 5th, 6th, and 7th grades in two public schools and one private middle school in Ataşehir, Maltepe, and Çekmeköy districts in Istanbul (27 gifted 5th grade students, 41 gifted 6th grade students, 60 non-gifted 6th grade students, 84 non-gifted 7th grade students). Furthermore, the study group included 5 middle school mathematics teachers. In this study, convenience sampling was used to determine in which schools the study would be conducted with the help of teachers and administrators who were familiar to the researcher. Familiar teachers and administrators were chosen for practical reasons such as ease of obtaining permission, ease of transportation, careful performing applications and having convenient communication. In addition, purposive sampling was used because the study was conducted with both gifted and non-gifted students to reveal the effects on non-gifted students of the differentiation method that was developed for gifted students. The 5th, 6th, and 7th grades were chosen in part because 8th grade students must prepare for a nationwide examination, and thus, they have busy schedules. In addition, there was no classroom that was composed of gifted 8th grade students in any of the selected study subject schools, and the researcher also preferred the 7th grade to enable comparison

of the current study with the researcher's master's thesis (which compared the newly developed differentiation approach with the Purdue model). This study selected convenience sampling from among the various purposeful sampling types for practical reasons such as being able to select teachers carefully and having convenient communication. The gifted students in the study were determined to be gifted by their schools via intelligence tests, and they attended classes with their gifted peers.

Data Collection Instruments

Mathematics Achievement Test: This study implemented the newly developed differentiation approach with different subjects at the three different grade levels (5th, 6th, and 7th). The achievement pre and posttests were different to avoid practice effect. Both tests comprised entirely different but parallel questions in each implementation. Six implementations were conducted that covered Ratio-Proportion, Tables and Graphics, and The Arithmetic of the Conscious Consumer and 12 achievement tests were prepared. When the new differentiation approach was compared with the Purdue model, the achievement test comprised only questions that tested the objectives of the current grade. However, when the differentiation approach activities were compared with the Ministry of Education (private school and public school) curriculum activities, the achievement tests comprised questions that tested both the current and upper grade objectives about the subject. Unlike in other models, the Purdue model objectives are deeply enriched. Because this situation required a new question category in addition to questions for the current and upper grade objectives, it was not considered within the scope of this study but it was suggested.

Multiple Intelligences Inventory: First, the students' dominant intelligence domains were identified, and the lessons were conducted using a project-based approach by determining the project topics that suited the students' dominant intelligence domains and creativity strategies. The Multiple Intelligences Inventory that was prepared by Saban (2005) was used to determine the students' dominant intelligence domains. The inventory comprised ten sections and eighty items scored on a Likert-type scale. The Multiple Intelligences Inventory Evaluation Profile that was provided by Saban was used to evaluate the inventory scores.

The Opinion Form for Teachers: The teachers' opinion form comprised 8 open-ended questions that were prepared by the researcher and an instructor in accordance with the study objectives. The teachers found it acceptable to state their opinions in written form so that they could express themselves in detail. The data collected from the 5 participating teachers' responses were analyzed. In the data analyses, the researcher coded following the opinions of an expert, and the codes were finalized after a control by the instructor. During this process, a method known as double-coding—by Miles and Huberman (1994)—was employed to test the codes' reliability. In specific, the researcher and an expert mathematics instructor evaluated the teachers' responses and performed the coding. Inter-rater reliability was found to be .91. Because the calculated reliability value was above .70 (Miles & Huberman, 1994), it was determined that there was concordance between the raters in coding the teachers' response data. The codes were then finalized after a final verification the instructor.

Research and Implementation Process

The mathematics lessons in the control and experimental groups were taught by the mathematics teachers at the schools where the study was implemented. Before the implementation, the teachers were informed in meetings about the activities that would be conducted.

The study aimed to conduct the implementation effectively by explaining the activities in detail. Furthermore, it aimed to prepare students for the implementation process in the best way by giving them detailed information about creativity, projects, steps for preparing a project, and the project evaluation process. Before each practice, an achievement test was administered to the students, and the groups with lower average scores were assigned to the experimental group. The others were designated to the control group by considering the classroom achievement test averages. The students' dominant intelligence domains were grouped by administering a multiple intelligences domain inventory in only the experimental group. The students were asked to select project topics from among the alternatives that were presented to them by considering dominant intelligences, the newly developed differentiation approach, creativity strategies, and the subject objectives.

Six teaching practices were implemented within the scope of this study: two featured comparisons between the newly developed differentiation approach and the Purdue model, three compared the differentiation approach lessons with national educational curriculum activities, and one compared the new model with a lesson that was conducted as a part of differentiation studies that took place in a public school. After the implementation, an achievement posttest was administered to all students. In addition, after each practice, an opinion form was given to the experimental group students. Each practice in the study lasted seven weeks.

Teaching Material (The Subject-based Differentiation Approach for Teaching Mathematics to Gifted Students)

In terms of developing a curriculum based on a differentiation approach, in a topic that was selected from the national education curriculum, some changes were made in content, process, product, and learning environment. These four aspects were defined as follows: *Content* = enriched objectives + theme (the content of the subject as stated in the national education curriculum), *Process* = determining the students' multiple intelligences domains + teachers' strategies + basic skills + research skills + productive skills, *Product* = products, *Learning Environment* = creative thinking + multiple-intelligences + different disciplines + project-based.

Because elaborated objectives were important for determining the topics, they were paired with themes in the content dimension. Because determining students' multiple intelligences would affect teachers' strategies and students' projects, it was addressed in the process dimension. Objectives for the current grade level were given in the theme part. Determining students multiple intelligences, "elaborated objectives, and teachers' strategies" were added in the differentiation approach that was developed to supplement the theme, basic skills, research skills, productive skills, and products that were part of the Kaplan model lesson plan.

The students' multiple intelligences were determined by administering to them the Multiple Intelligences Inventory for Students. In addition, the data obtained from this inventory were used to determine the students' project topics, select the teachers' teaching strategies, and determine the relevant factors for motivating students (addressing their interests and skills). During the objective enrichment phase,

upper-grade objectives were selected for enrichment. For teaching strategies, the strategies discussed in the second dimension of the Williams model were considered. However, some of these strategies were omitted, and new ones were added. The all strategies were as follows: intriguing questions, property listings, analogies, visualization, interdisciplinary approach, incorporating uncertainty, intuitive expression, case evaluations, organized random research, research skills, creative reading skills, creative listening skills, discrimination, topic relationships, the historical perspective, examples of changes, contradictions, creative writing skills, and the creative process.

During the design of the differentiation model, the Williams, Maker, Kaplan, autonomous learner, and Maker matrix models and Gardner's multiple intelligences were used. Among the five problem types stated within the scope of the Maker matrix model, Type III and Type V problems were especially emphasized. Project topics were presented to students by determining the topic outlines. Students were responsible for all stages including project problem, method, and presentation. Therefore, the projects used Maker matrix Type V problems. Some projects also used examples of Type III problems that allowed for different solutions and different answers.

In the newly developed differentiation approach, students were faced with different, exciting project topics that suited their skills and interests and addressed extra objectives. In other words, both vertical and horizontal enrichment were implemented in specific, both the objective and the activity dimensions were enriched. Within the scope of the designed differentiation approach, the study examined how the strategies in the Williams model fit with which Maker model process changes. The purpose here was to determine the process changes that would be made in the curriculum via the strategies that would be used according to the subject. The students developed some products through strategies, and these were evaluated by their teachers and peers through listening. The students who presented were subject to peer and teacher evaluation, and the information process was considered especially when preparing scoring rubrics for the projects. Students were given feedback from the researchers, who watched video recordings of their presentations, and based on researcher observations, they were asked to reorganize their projects.

During the process phase of the designed model, the point that required research skills, particularly for project preparation —the information process—

among the skills that are included in the scope of research skills in the Kaplan model process phase was called the project preparation stage (student instructions) after editing by the researcher and the lecturer. Students were asked to prepare projects by considering these stages. An evaluation form that had been prepared based on the information skills portion of the information process was used to evaluate projects. Students were informed about the effect of each stage on their overall project evaluations. Thus, it became easier to determine which stages required more concentration from the students.

With the help of the activities based on this study's differentiation approach, the students developed self-confidence and positive risk-taking behaviors through situations such as choosing among project topics that addressed their dominant intelligence domains; choosing the proper presentation methods facing and addressing critiques and criticizing friends as a part of peer assessment; promoting their opinions and projects to others in response to the critiques; planning projects; preparing work plans and working according to these plans; distributing tasks; taking responsibility; being responsible for both their own and their friends' learning; cooperating; presenting their work; and receiving positive feedback for their efforts.

Data Analyses

Quantitative Analyses: Statistical analyses were performed after the achievement pre/posttest scores were collected for both the gifted and non-gifted students. All analyses set 95% as the confidence interval, and $p < .05$ was accepted as statistically significant. The item remaining, item discrimination, and item total indices were calculated by conducting item analysis of the achievement test scores after the pilot practice and accepting the significance level as .05. Ultimately, the final test versions were selected, and test reliability ranged between .700 and .858.

To determine the control and experimental groups, the overall test scores obtained were considered without looking at the current or enriched objective scores obtained from the achievement pretest. When the differentiation approach was compared with the Purdue model, only the overall test scores from the achievement pre and posttests were considered. This was because the tests only contained questions about current subject objectives. In the comparison of differentiation approach activities, related Ministry of Education curriculum activities and activities

under the rubric of a program for noticing individual skills, both current and enriched objective scores and overall scores (current objective score+ enriched objective score), were calculated because the tests contained questions about both current and enriched grade objectives. In this study, which was conducted in two public schools and a private school, all the non-gifted students who participated were from two different classrooms in a public school, and all the gifted students who participated were from the other public school and the private school. Classroom sizes were small because both the control and the experimental groups comprised gifted students who had been selected from throughout Istanbul in an implementation being conducted in public schools. In each implementation, the same teacher was assigned to the control and experimental groups, and five teachers were assigned to six implementations.

Non-parametric tests were used in less-populated classrooms (fewer than 30 students) (Baydur, 2012; Kalaycı, 2009) for the data analysis. In studies in which the classrooms were crowded, (more than 30 students), descriptive statistics were examined to analyze the normality of the data, and the Shapiro-Wilk normality test was used because there were fewer than 50 students. In addition, parametric tests were used to analyze the scores that fulfilled the conditions of normality, and non-parametric tests were used to analyze the scores that did not.

In every application the same teachers led the classes in the control and experimental groups. Because the students could have memorized the questions, the achievement pre and posttests comprised different but parallel questions. The newly developed differentiation approach was applied to students in different grades and for different subjects. The differentiation approach was also compared with a different program and a model. Varying the applications was intended to reveal the effectiveness of the differentiation approach

Qualitative Analysis: A teachers' opinion form was also used in this study. The data collected from these forms were coded, and the code frequencies are presented in tables. The qualitative aspect of the study investigated the qualities of credibility, transferability, consistency, and sustainability. Qualitative research concepts such as internal and external validity and internal and external reliability correspond to persuasiveness, transmissibility, consistency, and conformity (Yıldırım & Şimşek, 2011). To demonstrate the persuasiveness of the findings from the opinion forms, researcher diversity was employed, and experts' opinions were

considered in the data analysis. In addition, expert examination was employed by taking experts' opinions using qualitative research methods. To demonstrate the transmissibility of the findings from the opinion forms and to document that participants reflected their own opinions, direct quotations were taken from the participants' responses. To ensure the consistency of the findings from the opinion forms, inter-coder reliability was calculated using the formula stated by Miles and Huberman (1994), and the consistency was found to be .91. In this case, because the calculated consistency was above 70%, it was determined that there was consensus between raters in coding the interview data. Conformity was ensured by testing for inter-rater reliability.

Findings

Findings and Interpretations Regarding Mathematics Achievement Tests

The Analysis of Public School I (6th Grade: Tables and Graphics): This section presents the findings from comparing the lessons that were designed using the newly developed differentiation approach and those that were designed according to the program for noticing individual skills.

Before the implementation, an achievement test was administered to determine the control and experimental groups, and it was established that there were no significant differences between the groups according to the Mann-Whitney U test ($U = 14.00, p = .85 > .05$). Thus, the group with the smaller mean rank was selected as the experimental group (5.83), and the group with the larger rank served as the controls (6.20).

Looking at Table 1, although there were no significant differences between the current objective scores of the gifted students in the control and experimental groups before implementation ($U = 12.50, p = .64 > .05$), after implementation, there was a significant difference between current objective scores that favored the experimental group ($U = .00, p = .00 < .05$). Furthermore, there were no significant differences between the enriched objective scores of the gifted students in the control and experimental groups before implementation ($U = 14.50, p = .92 > .05$); however, after implementation, there was a significant difference that favored the experimental group ($U = .00, p = .00 < .05$). There were also no significant differences between the overall objective scores of the gifted students in the control and experimental groups before implementation ($U = 14.00, p = .85 > .05$); however, after implementation, there was a significant difference that favored the experimental groups ($U = .00, p = .00 < .05$). When we consider these results, it is seen that post-implementation, both current and enriched objective scores and overall scores of students increased in the experimental groups but not among the controls.

The Analysis of Private School Achievement Test Scores (Fifth Grade: Tables and Graphics): This section presents the findings from the lessons that were designed according to the new differentiation approach compared with the lessons that followed the Ministry of National Education curriculum.

Before the implementation, an achievement test was administered to identify the control and experimental groups, and it was determined that there were no significant differences between the groups according

Table 1
Mann-Whitney U Test Comparison Regarding the Achievement Test Scores of Gifted Students in the Control and Experimental Groups Before and After Implementation (Overall-Current-Enriched Objectives)

Score	Group	N	Mean Rank	Mean Sum	U
Pre-Overall	Control	5	6.20	31.00	14.00
	Experimental	6	5.83	35.00	
Post-Overall	Control	5	3.00	15.00	0.00
	Experimental	6	8.50	51.00	
Pre-Current	Control	5	6.50	32.50	12.50
	Experimental	6	5.58	33.50	
Post-Current	Control	5	3.00	15.00	0.00
	Experimental	6	8.50	51.00	
Pre-Enriched	Control	5	6.10	30.50	14.50
	Experimental	6	5.92	35.50	
Post-Enriched	Control	5	3.00	15.00	0.00
	Experimental	6	8.50	51.00	

Table 2
Mann-Whitney U Test Comparison of the Achievement Test Scores of the Gifted Students in the Control and Experimental Groups Before and After Implementation (Overall-Current-Enriched Objectives)

Score	Group	N	Mean Rank	Mean Sum	U
Pre-Overall	Control	14	15.57	160.00	69.00
	Experimental	13	12.31	218.00	
Post-Overall	Control	14	7.89	110.50	5.50
	Experimental	13	20.58	267.50	
Pre-Current	Control	14	19.43	272.00	15.00
	Experimental	13	8.15	106.00	
Post-Current	Control	14	7.50	105.00	0.00
	Experimental	13	21.00	273.00	
Pre-Enriched	Control	14	15.07	211.00	76.00
	Experimental	13	12.85	167.00	
Post-Enriched	Control	14	10.25	143.50	38.50
	Experimental	13	18.04	234.50	

to the Mann-Whitney U test ($U = 69.00, p = .28 > .05$). As such, the group with the smaller mean rank was selected as the experimental (12.31) group, and the other group was the control group (mean rank: 15.57).

As seen in Table 2, there were no significant differences between the enriched ($U = 76.00, p = .45 > .05$) objective and overall ($U = 69.00, p = .28 > .05$) scores of the gifted students in the control and experimental groups before the implementation. There was a significant difference before implementation between the groups' current scores ($U = 15.00, p = .00 < .05$) in favor of the control group. However, after implementation, there was a significant difference between the students' overall ($U = 5.50, p = .00 < .05$), current ($U = .00, p = .00 < .05$), and enriched ($U = 38.50, p = .01 < .05$) objective achievement test scores that favored the experimental group.

The Analysis of Private School Achievement Test Scores (Fifth Grade: Ratio and Proportion): This section presents the findings from comparing the lessons that were designed according to the new differentiation approach with those that were designed according to the Purdue model.

Before the implementation, an achievement test was administered to identify the control and experimental groups, and it was determined that there were no significant differences between the groups according to the Mann-Whitney U test ($U = 87.50, p = .86 > .05$). As such, the group with a smaller mean rank was selected as the experimental (13.73) group, and the other was the control group (mean rank: 14.25).

Table 3
Mann-Whitney U Test Comparison of the Achievement Test Scores of the Gifted Students in the Control and Experimental Groups Before and After Implementation

Score	Group	N	Mean Rank	Mean Sum	U
Pre-Achievement	Control	14	14.25	199.50	87.50
	Experimental	13	13.73	178.50	
Post-Achievement	Control	14	7.54	105.50	0.50
	Experimental	13	20.96	272.50	

As seen in Table 3, there were no significant differences in the pre-achievement test scores ($U = 87.50, p = .86 > .05$) of the gifted students in the control and experimental groups before implementation. However, after implementation, there were significant differences in post-achievement scores ($U = 0.50, p = .00 < .05$) in favor of the experimental group. In specific the achievement test scores in the experimental group increased after the implementation.

According to a Wilcoxon signed-rank test comparison regarding the achievement test scores

of the students in the control and experimental groups before and after implementation, there were significant differences between the gifted students' achievement scores in both the control ($z = -2.21, p = .02 < .05$) and experimental ($z = -3.18, p = .00 < .05$) groups before and after implementation. In specific, achievement scores were higher in both the control and experimental groups after implementation.

The Analysis of Private School Achievement Test Scores (Sixth Grade: Tables and Graphics): This section presents the findings from comparing the lessons that were designed according to the new differentiation approach and those that were based on the Ministry of National Education curriculum.

Before the implementation, an achievement test was administered to identify the control and experimental groups, but it was determined that there were no significant differences between the groups based on the Mann-Whitney U test ($U = 102.00, p = .66 > .05$). As such, the group with the smaller mean rank was selected as the experimental group (14.80), and the other was the control group (mean rank: 16.20).

Table 4
Mann-Whitney U Test Comparison of the Achievement Test Scores of the Gifted Students in the Control and Experimental Groups Before and After Implementation (Overall-Current-Enriched Objectives)

Score	Group	N	Mean Rank	Mean Sum	U
Pre-Overall	Control	15	14.80	222.00	102.00
	Experimental	15	16.20	243.00	
Post-Overall	Control	15	8.00	120.00	0.00
	Experimental	15	23.00	345.00	
Pre-Current	Control	15	14.20	213.00	93.00
	Experimental	15	16.80	252.00	
Post-Current	Control	15	10.77	161.50	41.50
	Experimental	15	20.23	303.50	
Pre-Enriched	Control	15	16.80	252.00	93.00
	Experimental	15	14.20	213.00	
Post-Enriched	Control	15	8.00	120.00	0.00
	Experimental	15	23.00	345.00	

Table 4 shows that there were no significant differences between the pre-overall ($U = 102.00, p = .66 > .05$), pre-current ($U = 93.00, p = .41 > .05$), and pre-enriched ($U = 93.00, p = .40 > .05$) scores of the gifted students in the control and experimental groups. However, there were significant differences between the post-overall ($U = .00, p = .00 < .05$), post-current ($U = 41.50, p = .03 < .05$), and post-enriched ($U = .00, p = .00 < .05$) scores of the gifted students in the control and experimental groups.

The Analysis of Public School 2 Achievement Test Scores (Sixth Grade: Tables and Graphics): This section presents the findings based on comparing the lessons that were designed according to the new differentiation approach and those that were conducted according to the Ministry of National Education curriculum.

Before the implementation, an achievement test was administered to identify the control and experimental groups, and it was determined that there were no significant differences between groups according to independent group *t*-test results, $p = .40 > .05$. As such, the group with a smaller mean rank was selected as the experimental group (27.21), and the other was the control group (mean rank: 28.68).

Table 5
Mann-Whitney U Test Comparison of Achievement Test Scores of the Non-gifted Students in the Control and Experimental Groups

Score	Group	N	Mean Rank	Mean Sum	U
Pre-Current	Control	32	30.09	963.00	435.00
	Experimental	28	30.96	867.00	
Post-Current	Control	32	16.53	529.00	1.00
	Experimental	28	46.46	1301.00	
Pre-enriched	Control	32	33.88	1084.00	340.00
	Experimental	28	26.64	746.00	
Post-enriched	Control	32	16.52	528.50	0.50
	Experimental	28	46.48	1301.50	

Table 5 shows that there were no significant differences between the non-gifted students' pre-current ($U = 435.00, p = .84 > .05$) and pre-enriched ($U = 340.00, p = .10 > .05$) scores in the control and experimental groups. However, after implementation, there was a significant difference between the non-gifted students' current ($U = 1.00, p = .00 < .05$) and enriched ($U = .50, p = .01 < .05$) scores in the control and experimental groups that favored the experimental group.

Table 6
Independent Group T-test Comparison of the Non-gifted Students' Achievement Test Scores in the Control and Experimental Groups

Score	Group	N	Average	sd	df	t
Pre-Overall	Control	32	28.68	5.57	58	0.84
	Experimental	28	27.21	7.86		
Post-overall	Control	32	27.00	7.24	58	23.26
	Experimental	28	67.53	6.09		

As shown in Table 6, there were no significant differences between the pre-overall, $p = .40 > .05$) scores of the control and experimental groups. However, there were significant differences between the post-overall, $p = .00 < .05$) scores of

the control and experimental groups in favor of the experimental group.

The Analysis of Public School2 Achievement Test Scores (Seventh Grade: Conscious Consumer Arithmetic): This section presents the findings from comparing the lessons based on the new differentiation approach with the lessons that were designed according to the Purdue model.

Before the implementation, an achievement test was administered to identify the control and experimental groups, but the Mann-Whitney U test found that there were no significant differences between the groups ($U = 837.00, p = .68 > .05$). In this case, unlike with the other applications, the class with the larger mean rank (43.57) was determined as the experimental group, and the other class (mean rank: 41.43) was determined as the control group in accordance with the class teachers' opinions. The class that did not have sufficient background in preparing projects was determined as the experimental group based on the teacher's opinion.

Table 7
Independent Group t-Test Comparison in the Achievement Scores of the Non-Gifted Students in the Control and Experimental Groups

Score	Group	N	Average	sd	df	t
Post-Achievement	Control	42	25.33	8.24	82	17.82
	Experimental	42	55.78	7.38		

Table 7 shows, a significant difference between the post-achievement, $p = .00 < .05$) scores of the control and experimental groups in favor of the experimental group.

Table 8
Wilcoxon Signed-Rank Test Comparison of the Achievement Scores of the Non-Gifted Students in the Control Group

Group	Score	Posttest-Pretest	N	Mean Rank	Mean Sum	z
Control	Post-achievement/ Pre-Achievement	Negative Rank	8	12.94	103.50	3.88
		Positive Rank	30	21.25	637.50	
		Equal	4			

As seen in Table 8, there was a significant difference in favor of the posttest between the achievement test scores ($z = 3.88, p = .00 < .05$) of the non-gifted students that were obtained before and after implementation in the control group according to the Wilcoxon signed-rank test comparison. According to these results, there was an increase in the achievements of the control group students.

Table 9
Teachers' Responses to the Question "How did you find the activities used in this study?"

	Creative		Successful		Useful		Suitable to the Students' Levels		Addressed Different Intelligence Domains	
	f	%	f	%	f	%	f	%	f	%
Question 1	4	80	5	100	5	100	5	100	5	100

Teachers' Opinion Form

The study was conducted with different teachers at different schools: one teacher from public school1, two teachers from the private school, and two teachers from public school 2, for a total of five teachers. To measure the teachers' opinions about the study, a teachers' opinion form was developed. The questionnaire had eight open-ended questions and was administered to the teachers after the implementation. Teachers completed the form by hand, and the other two sent them as e-mail attachments.

In Table 9, we observe that the teachers who participated in this study thought that the study activities were creative, successful, useful, and suitable to the students' different levels and that they addressed the students' different intelligence domains.

Table 10
Teachers' Responses by Code to the Question: "What do you think about using similar activities with other mathematics subjects?"

	They can be used		They cannot be used	
	f	%	f	%
Question 2	5	100	-	-

Table 10 shows that the teachers agreed that the activities of this study could be used with other subjects in mathematics. However, one teacher believed that conducting the same activities with all mathematics subjects could waste time. It was suggested that conducting these activities in all schools would lead to difficulties in terms of background and readiness levels (teacher, student, administrator, parents), but we believe that these difficulties could be overcome with good planning. In addition, the teachers thought that these activities would increase achievement in subjects that require more active student participation, especially in subjects in which students have sufficient preliminary information that they can use. In addition, it was thought that these activities could bring great richness to mathematics lessons, which have few materials.

Table 12
Teachers' Responses by Code to the Question: "Can you compare your previous lessons with this study's activities?"

	Improved Social and Academic Skills		Increased Motivation		Efficient		Active Students		Use in Daily Life		Tiring		Short-term Project	
	f	%	f	%	f	%	f	%	f	%	f	%	f	%
Question 4	5	100	4	80	4	80	3	60	3	60	1	20	1	20

Table 11
Teachers' Responses by Code to the Question: "What are the advantages and disadvantages of the activities used in this study?"

	Codes	f	%
		Question 3	Increased Motivation
Advantage	Teaching Social Skills	5	100
	Providing the Opportunity to Implement and Observe Academic Skills	5	100
	A Chance for Permanent Learning	3	60
	Reinforcing Objectives	3	60
Disadvantage	Group Work	1	20
	Time	1	20
	Crowded Classroom	1	20

Table 11 shows that the teachers perceived a number of advantages to this study's activities: teaching social skills (making presentations, expressing oneself, etc.); providing the opportunity to implement and observe academic skills (conducting research, designing, editing, etc.); engage in the subjects and lessons; and ensuring permanent learning and reinforcing objectives. In addition, the teachers stated that group work (because of parents), time, and crowded classrooms could create some disadvantages.

Table 12 reflects that the teachers had observed that their students were more active. As the teachers guided the project studies, the students shared more information with them and, with the help of the lessons, became more efficient. The teachers also observed that the students' interests and motivation had increased, making the lessons more enjoyable. In other words, the students' motivation for their lessons, their academic and social skills (self-confidence, increased readiness, knowledge of different presentation methods, etc.), and their daily use of the mathematical concepts they were learning (providing the opportunity to learn what subject was being taught and why) all increased. Furthermore, the teachers noted that the long-term projects were used

in other lessons but that the short-term projects were used within the scope of this lesson. One teacher also found this study to be slightly more tiring than the other lessons.

Table 13
Teachers' Responses by Code to the Question: "Have you learned what to do as a project coordinator within the scope of this study?"

	Yes		No	
	f	%	f	%
Question 5	5	100	-	-

In Table 13, we see that all the participating teachers informed about how to serve as project coordinators within the scope of this study.

Table 14
Teachers' Responses by Code to the Question: "What do you think about the suitability of the given project topic for the curriculum and the students' levels?"

	Suitable		Not Suitable	
	f	%	f	%
Question 6	5	100	-	-

Table 14 shows that the teachers found the project topics to be suitable to their curricula and to the students' levels. However, one teacher stated that even though they worked in small numbers, some students had difficulties.

Table 15
Teachers' Responses by Code to the Request: "If you had any difficulties within the scope of this study, please state them."

	Group Work		Preparation for the Presentation		Time		The Size of the Classroom	
	f	%	f	%	f	%	f	%
Question 7	1	20	1	20	1	20	1	20

According to Table 15, the teachers had some difficulties with the following issues: group work, preparing for presentations and time and classroom size. However, they reported that students successfully completed the given tasks. One teacher thought that he/she could not spare the time for the project preparation phase. One teacher classified classroom size as a difficulty. However, he/she eventually stated that the study was efficient.

Table 16
Teachers' Responses by Code to the Question: "What were the benefits of this study for you?"

	Knowing Student		Understanding the Importance of the Project		Project Management	
	f	%	f	%	f	%
Question 8	5	100	3	60	3	60

Table 16 shows that teachers perceived the opportunities to get to know their students (to see how students used information they already had, to observe which project preparation stages proved difficult for students, to observe how students used their skills to take an activity and convert it into a product, etc.); to understand the importance of the project studies; and to experience the process of project management with the help of the activities that were conducted in this study.

Discussion

The Results Based on Quantitative Analysis

When this developed differentiation approach was compared with the differentiation within the scope of the Ministry of Education curriculum and the Program for noticing individual skills, it was concluded that this study's differentiation approach increased students' achievements. Compared with the Purdue model, this study's approach led to increased (and statistically significant) achievements in both the control and the experimental groups. The Purdue model was developed for the gifted students, and there are studies that show that Purdue model activities also increase gifted students' achievements. For this, it is normal to reach such a result.

All the implementations were parallel with the following studies in terms of their results that project-based activities increased student achievements: Baş (2011), Dağ and Durdu (2011), Değirmenci (2011); Deniz Çeliker (2012), Doğay (2010), Gözüm et al. (2005), Karaçalı (2011), Kaşarcı (2013), Özer and Özkan (2010), and Yıldırım (2011); that grouping according to skills into homogenous groups increased gifted students' academic achievements: Adodo and Agbayewa (2011), Hoffer (1992), Kulik and Kulik (1982); that teaching based on multiple intelligences increased students' academic achievements: Altınsoy (2011), Altun (2009), Elmacı (2010), Gözüm (2011), Sivrikaya (2009), Şirin (2010), Uzunöz and Akbaş (2011), Yalmanlı and Gözüm (2013); that teaching applications based on creative thinking increased students' academic achievements: Kadayıfçı (2008), Kök (2012), Kurtuluş (2012), Özcan (2009), Özerbaş (2011), Scott et al. (2004); that teaching based on enriched activities increased students' achievements: Beecher and Sweeny (2008), Coyne and Fogarty (2007), Fakolade and Adeniyi (2010), Kirkey (2005), Luehmann (2009), Olszewski-Kubilius and Lee (2004), Singh (2013); and that

curriculum differentiation increased students' achievements: Beecher and Sweeny (2008), Colson (2008), Kadum-Bošnjak and Buršic-Križanac (2010), Kirkey (2005), Mastropieri et al. (2006), Reis et al. (2011), Simpkins et al. (2009). In addition, the fact that the Purdue model increases achievement shows parallel results with the studies by Altıntaş and Özdemir (2009; 2010), Baran and Maskan (2013), Moon et al. (1994), Sert (2008), Tertemiz (2012), and Ünlü (2008).

The Results Based on Qualitative Analysis

The teachers who participated in this study agreed that the study activities were creative, successful, useful, and suitable to the students' levels and that they addressed different intelligence types. The teachers agreed that this study's activities could be used with other mathematics subjects, and they observed a number of advantages to this study's system. The teachers expressed that the students were more engaged in this study. The lessons were more efficient. The students were motivated to participate in the lessons. They improved their social and academic skills and learned how to use mathematics subjects in daily life. In addition, the teachers noted that other lessons used long-term project studies but that within the scope of this lesson, they used short-term projects. All the teachers stated that they felt informed about what to do as project coordinators.

The teachers in this study thought that the project topics were well suited to the curriculum and to the students' levels. Although the teachers did express some difficulties with issues such as group work, preparing for presentations, making time for their students, and time and classroom size, they reported that they had successfully accomplished the given tasks. The difficulties in terms of time and class size were not experienced within the scope of this study. Because the teachers were participating in a study such as this one for the first time, it was normal that they would think in this manner. It is thought that these teachers will gain more experience as they repeat these activities throughout the school year so that they will eventually be able to reduce their time commitments to the minimum at each step. The teachers reported that this study's activities had given them, the opportunity to get to know their students, understand the importance of project

studies, and experience the process of project management. Teachers who know their students and identify their skills and capacities can prepare suitable learning environments for the students. It is believed that this study's activities will combine with its effects to increase the quality of teaching, the students' interest in the lessons, and the learners' achievements.

The results for the teachers' opinions show parallels with Adodo and Agbayewa (2011), Altınoy (2011), Altun (2009), Baş (2011), Beecher and Sweeny (2008), Colson (2008), Coyne and Fogarty (2007), Çetin and Şengezer (2013), Dağ and Durdu (2011), Değirmenci (2011), Deniz Çeliker (2012), Doğay (2010), Elmacı (2010), Fakolade and Adeniyi (2010), Gözümlü et al. (2005), Gözümlü (2011), Gürbüz (2011), Hoffer (1992), Kadayıfçı (2008), Kadum-Bošnjak and Buršic-Križanac (2010), Karaçallı (2011), Kaşaracı (2013), Keskin (2011), Kirkey (2005), Kök (2012), Kulik and Kulik (1982), Kurak (2009), Kurtuluş (2012), Luehmann (2009), Mastropieri et al. (2006), Memişoğlu (2011), Olszewski-Kubilius and Lee (2004), Özcan (2009), Özer and Özkan (2010), Özerbaş (2011), Papastergiou (2005), Reis et al. (2011), Sadioğlu et al. (2012), Scott et al. (2004), Simpkins et al. (2009), Singh (2013), Sivrikaya (2009), Şahin (2007), Şengül and Öz (2008), Şirin (2010), Uzunöz and Akbaş (2011), Yalmanacı and Gözümlü (2013), and Yıldırım (2011).

Suggestions

It is suggested that this newly developed differentiation approach be used in different grade levels with other mathematics subjects and in different lessons to redesign project topics by considering different process changes and different creativity strategies. Furthermore, it is suggested that this approach's learning activities be used to collect data from identified pilot schools throughout the country. In addition, it is suggested that all teachers throughout the country be informed about how to guide the project preparation process and that students be informed about how to prepare projects. The achievement tests that are currently used to compare other approaches with the Purdue model only use current grade objectives. Instead, it is suggested that because of the differentiation approach that was developed for this study and the Purdue model, achievement tests should include questions about upper grade and more profound objectives.

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