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Original Research Article

The Effect of Teaching Geometry Which is Differentiated Based on the Parallel Curriculum for Gifted/Talented Students on Spatial Ability

ABSTRACT: The purpose of this research is to evaluate the effects of teaching geometry which is differentiated based on the parallel curriculum for gifted/talented students on spatial ability. For this purpose; two units as "Polygons" and "Geometric Objects" of 5th grade mathematics book has been taken and formed a new differentiated geometry unit. In this study, pretest and posttest designs of experimental model were used. The study was conducted in Istanbul Science and Art Center, which offers differentiated program to those who are gifted and talented students after school, in the city of İstanbul and participants were 30 students being 15 of them are experimental group and the other 15 are control group. Experimental group students were underwent a differentiated program on "Polygons" and "Geometric Objects" whereas the other group continued their normal program without any differentiation. Spatial Ability Test developed by Talented Youth Center of John Hopkins University was used to collect data. Above mentioned test was presented to both groups of the study. Collected data was analyzed by Mann Whitney-U and Wilcoxon Signed Rank Test which is in the statistics program. It is presented as a result of the study that the program prepared for the gifted and talented students raised their spatial thinking ability.

Key Words: teaching geometry, gifted ındividual, spatial thinking

This research was proceeded from the doctoral thesis of the first author.

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INTRODUCTION

While planning the curriculum, especially for the primary level, the needs of average and close to average students are taken into primary consideration. However, it bears utmost importance to take into consideration the needs of the students who are quicker to learn and analyze the knowledge than their peers. This important to build a program for them not ignoring their needs. Building an education-training program according to one sloe level will be injustice for the others. Today, gifted and talented students, whose needs are ignored, lose their intention in the program and left aside in the education and training process. It should not be ignored that these students, as any other students in need of special education, have the right to be involved in education and training process that appeals to their interests. Many teachers teaching the gifted students state that gifted students are getting bored of an education environment which is full of exercises and repetitions, parrot fashion, teacher centered, and assessed by tests, and which gives no free thinking environment. As to Stemberg and Grigokeronko (2000). Gifted students need information and sources to be independent thinkers, and opportunities to develop their knowledge.

As to Passow (1959) gifted and talented students need to boost their abilities to think critically, configure meanings and senses, see the relationship between previous, current and next learning, and they should be educated within the school's auspice in terms of how to learn and how to discipline their intelligence.

Galileo sets how important geometry is for making the world meaningful as follows: Universe is always open to our eyes; however, it cannot be understood without knowing its language and the letters that language is written. Universe is written in mathematics language; its letters are the triangles, circles, and other geometric objects. Without all of these even a single word of it cannot be understood. Without all of these it is only like going around in a dark labyrinth (Pappas, 2003). As it is clear from Galileo's explanation, he thinks that geometry is an important tool to understand universe and to make use of that tool, it is important to know its basics. To make use of geometry students should discover geometry's basics such as triangle, tetragon, and polygon, they should know the characteristics of those terms, learn their relations with each other and how to classify them. However, all those things in a non-differentiated program are presented as not something to discover but to memorize.

Geometric thinking is a king of mathematical thinking and it has its own concept. It is important to decide what knowledge, ability, and experiences should the students gain in terms of geometry, and to set their geometric thinking levels according to those aspects. Developing geometric thinking on a child is something that depends on process and it has some definite steps. Thus, to develop the geometric thinking ability of a child, this process should be well-planned and organized (Regina, 2000).

Hoffer (1981) divides the basic abilities to be built on a child in terms of geometric thinking into 5 categories:

- Visual skills: Recognition, observation, map reading, symbolization, seeing from different angles.
- Verbal skills: Proper use of terminology, and proper transfer of relations belonging to space and concept.
- Drawing skills: Transferring by drawing, being able to draw two or three dimensional shapes.
- Logical skills: Classification, determining the characteristics of a geometric object or shape, giving different examples, building hypotheses, testing them and proofing.
- Application skills: Applying learned geometric concepts into different situations and daily life.

Geometry is a field that should be offered in the primary school level with utmost importance. The base of geometric thinking on children are started to be built during those years together with pre-school process. As primary school students can understand concrete and finite subjects, geometry topics should be dealt with as possible as in an environment that they are living and observing. Students should not be made to analyze the outcomes as geometric objects and shapes come together or separate (MONE, 2004), because geometry classes depend on children's developing sense of universe. Spatial visualization is the most important part of geometric thinking.

Curriculum, which is an important element of education system, has an active role on gaining and developing thinking abilities, because curriculum determines pattern of education and purposes to be reached. Curriculums which supplies students with applying knowledge together with acquiring it, providing new ideas to be put together with the old ones, adding new futuristic problems to the already current ones, namely supporting students' development by revealing their creativeness, are the ones that will contribute to thinking skills (Atkıncı, 2001). Gifted and talented students need a differentiated curriculum to use their capacities as much as possible, reveal and develop their interests, strong abilities, and skills to be enhanced.

Within the scope of the study, the curriculum was designed which is based on the Parallel Curriculum Model developed in 2002 by Tomlinson, Kaplan, Renzulli, Leppien, Burns, and Purcell, which has an important place in education of gifted and talented students, was used as base and

The Parallel Curriculum Model; it consists of the core curriculum, curriculum of connections, curriculum of practice, and curriculum of identity. It is possible to use all of these curriculums or only one of them (Tomlinson et. al., 2002: 18).

The Whole Curriculum takes its basic definition and aim from the first parallel of called as "the Core Curriculum" of the Parallel Curriculum. In this parallel the nature of discipline is described. The second parallel is the curriculum of connections. It widens the Core Curriculum as letting the students make connections between discipline or disciplines, cultures or places, and different time spans or different constitutions of theirs. The third one is the curriculum of practice which will enable students to understand the realities, concepts, principles, and the methodology of discipline, and make them masters in terms of the fields mentioned. The fourth and the last one is the curriculum of identity. This will help students recognize their own developments, strong aspects, self values, and preferences (Tomlinson et. al., 2002:17).

The Parallel Curriculum makes teachers prepare an effective and compeller education program making them use any parallel on its own or combined with the others. Curriculum prepared for those who have a high potential in learning should be flexible. Thus, the prepared curriculum should be research encouraging instead of being in some definite forms and patterns (Tomlinson et. al., 2002:19). Considering all these mentioned aspects, the purpose of this study is is to evaluate the effects of teaching geometry which is differentiated based on the parallel curriculum for gifted/talented students on spatial ability.

METHOD

Research Model

Experimental method was used for the research. Experimental method is the one in which researcher produces the data to be observed taking the control to determine the cause and effect relations. In this research method, generally aims are described as hypothesis. In this way, judgements for the probable causes of events are tested (Karasar, 2002:87).

"Pretest and Posttest Pattern with Control Group" of this method was used. Two groups as control and experiment were used in the study. Equivalence provided groups were assigned as control and experimental groups randomly. Experimental group, which is continuing in İstanbul Science and Art Center (İstanbul BİLSEM) as gifted and talented students, is applied thematic, spatial thinking and creativeness boosting geometry based on the Parallel Curriculum. However, gifted and talented students in control group continued their education with the method decided by Ministry of Education with no intervals to the teaching and training period. Before the geometry unit started in their schools, research started and finished in İstanbul BİLSEM.

Application started with giving pretests to the both groups. After the last lesson, which was 20 hours in total, both groups were given posttests.

Research Group

Since it is an experimental research, sample determination was not used in establishing research group. İstanbul Science and Art Center (İstanbul BİLSEM) was chosen for the study as it gives education for those who are gifted and talented, which serves well to the aim of the study. Students who are nominated by the formal education institutions undergo a group screening, and then those who show enough performance are taken to the individual inspection WISC-R Test. Their intelligence scores are calculated and the number of students as the ministry allows is enrolled.

Within the scope of research, 5th graders continuing in BİLSEM were chosen. As there were two groups for the study, gender (Table 1), IQ scores (Table 2), the average score of the previous year's math classes (Table 3) and the pretest average grades of the Spatial Ability Test (Table 4) were used together with their intelligence scores to choose and match the groups. Mann Whitney-U Test was used to measure the difference between the groups, and there seemed no significant differences.

Distribution of the participant control and experimental group students according to gender is shown below:

Table 1. Frequency analysis of control and experimental group students according to gender

	Male	**Female**	**Sum of Class**
Experimental	8	7	15
Control	8	7	15
Sum of Genders	16	14	30

Groups resemble each other in terms of gender.

As it is considered that the intelligence scores of the students is a factor that can affect the result of the study, findings of this factor is given below:

Table 2. The results of non-parametric Mann Whitney-U test used for measuring the significancy differences between the ıntelligence scores of groups

WISC-R Results	**N**	**Mean of Sequences**	**The Sum of Sequences**	**U**	**Z**	***p***
Experimental	15	15,17	227,50			
Control	15	15,83	237,50	107,500	-,209	,835
Total	30					

In Table 2, significance of difference between intelligence scores of experimental and control group students according to the WISC-R results is shown. No significant difference was found according to the results of Non-Parametric Mann Whitney-U Test used for determining control and experimental groups (U=107.500, p=.835).

As it is considered that previous years' reported scores of maths of students is a factor that can affect the result of the study, findings of this factor is given below:

Mann Whitney-U Test was used to measure the significancy of differences between spatial ability pretest scores of experimental and control groups, and the results are given in Table 3 below:

Table 3. Independent groups Mann Whitney-U test results between spatial ability pretest scores of experimental and control groups

Spatial Ability Scores	**N**	**Mean of Sequences**	**The Sum of Sequences**	**U**	**Z**	***p***
Experimental	15	15	225			
Control	15	16	240	105,000	-,482	,630
Total	30					

As can be seen in the table above, there is not a statistically significant difference between the spatial ability pretest results of both groups (U=105.000, p=.630). It can be said that the spatial ability level of both groups was nearly the same before the study application.

Data Collection Tools

Generally, in tests about education both mathematical and verbal skills to measure higher-up thinking ability are seen extremely important. However, with this emphasis on mathematical and verbal skills, such skills to be useful for ability measuring in terms of mathematics and natural sciences as spatial ability can be ignored. Besides, the ones failing the average of these tests however having spatial ability and being able enough to succeed in mathematics, science, engineering cannot be recognized. To fill in this space, it is stated by John Hopkins University Center for Talented

Youth that the Spatial Test Battery was developed (Stumpf, 2006).

The Spatial Test Battery was started to be developed by collecting various spatial ability tests existing in literature. The study is stated to be conducted in two steps. In the first step different tests used and distributed by different writers and researchers are collected and catalogued in vast batteries as AA, BB, EE, and FF. Later, the second step was conducted as in three types; the structure of the spatial ability, gender differences in the spatial ability, difficulty levels of inferior tests, internal consistency and validity studies, forming inferior tests in this step. The new version of the Spatial Ability Test Battery includes HH, A, and C forms (Stumpf, 2006). C Form of the Spatial Test Battery used in the study has three sub-tests as Surface Development, Block Rotation, and Visual Memory learning. The number items, allocated time, standard deviation, deviation, and Cronbach's alpha coefficients belonging to each sub tests are given in Table 4 (Stumpf, 2006).

Table 4. The spatial test battery psychometric properties

	Number of Items	Allocated Time	Mean	Standard Deviation	Cronbach's Alpha
Surface Development	35	14	25,02	8,08	093
Block Rotation	24	15	14,74	4,75	,81
Visual Memory Learning	20	8/8	12,46	3,85	,74
Total Spatial Ability	79	45	52,22	12,72	,91

In the study, Battal Karaduman's (2012) test version was applied. Linguistic equivalence, reliability, and validity of the Spatial Test Battery C Form studies are described below:

> *Cronbach's Alpha (a) and KR-20 techniques were applied in the reliability study of the Spatial Test Battery Surface detection sub-test for those aging between 10-14 constituting sample. According to these techniques, 0.60 value is sufficient level and above coefficients are good levels. Cronbach's Alpha reliability coefficient is calculated as (0.80) and KR-20 coefficient is calculated as (0.80). Cronbach's Alpha reliability coefficient is calculated as (0.76) and KR-20 coefficient is calculated as (0.76) in the study of the Spatial Test Battery Rotating Objects subtest reliability. Cronbach's Alpha reliability coefficient is calculated as (0.69) and KR-20 coefficient is calculated as (0.69) in the study of the Spatial Test Battery Visual Memory learning subtest reliability. For Total Spatial Test Battery, Cronbach's Alpha reliability coefficient is calculated as (0.85) and KR-20 reliability is calculated as (0.85). According to these results, reliability level can said to be enough (Battal Karaduman, 2012: 131).*

Procedure

Experimental application took place in the second half of 2010-2011 education-training term and lasted for 10 weeks. Both experimental and control groups started and finished the procedure at the same time.

The Spatial Ability Test was applied to both groups as a pretest. Activities were prepared by the researcher from the "Polygons and Geometric Objects" category of learning geometry field. Besides, from time to time, 5th grade geometry activities prepared by mathematics, mathematics education, and gifted students education masters and teachers from Connecticut University, Northern Kentucky University, and Boston University based on the standards of NCTM (National Council of Teachers of Mathematics) (2000) and NAGG (National Association for Gifted Children). Besides, studies of Mind Games Team of World Puzzle Federation Turkey were used.

The time span and necessary tools for conducting the activities were determined. It was given importance to use the materials especially the ones that gained importance with the new primary curriculum such as dotted paper, geometry board, and pattern blocks.

Before starting the activities, the researcher gave information about the Parallel Curriculum and thematic approach. Besides, at the beginning of each class, the researcher gave information about the topic and how to convey the study.

Students were given instructions to perform the activities. They were directed to make generalizations and find out the rules on their own. To do this, students were asked questions from time to time to lead them think deeper. Information was not presented explicitly, but students were required to find it out implicitly. Devreli and Orbay (2003) suggested that in teaching geometry all physical and intellectual activities should be given to the students as they found out the things for the first time on their own. This idea was given importance in preparing the activities.

After each activity was performed by the students and sometimes by the groups, results were discussed in the class. All the results were analyzed one by one and similarities and differences were aimed to be presented. Students were given importance to use geometric terminology while presenting their findings. After the discussions, there was a cooperation to conclude on terms and generalizations. As gifted students have higher-up level thinking abilities, such activities as to trigger that aspect of theirs in the level of analysis and evaluations suitable to the Parallel Curriculum for gifted students were prepared. Activities were prepared within the "order" theme to develop students' creative and spatial abilities, make knowledge meaningful and related, and reach the higher-up intellectual skills.

Brainstorming technique was used on how "order" can make place in our lives as geometric objects gain definitive and conceptual meanings as an activity about the remembering level according to the first paralel- The Core Curriculum of The Parallel Curriculum (TPC). A whole class discussion was performed on how "geometric order" can be and one of its best examples, golden ratio, is mentioned. Students were shown mind maps compatible to their understanding level and they were asked to form a mind maps and present it in the class thinking on the order of their lives and the properties of quadrilaterals. While preparing mind maps, the importance of considering the relations of the situations was emphasized.

In the application level, students were asked to constitute systems according to the properties of quadrilaterals that they analyzed and discovered. System constituting activity was prepared by the researcher contributing to using and assessing creativeness and judgements. Besides, a net of a cube was given and they were asked to draw the other 10. Later, they were asked to place the numbers on the dice according to its rules, and then they were required to present their work in the class in pairs.

In the analyzing level, difficulty level of the tasks were increased and the students were asked to find out some relations. While doing this, card games and mechanical mind games were made use of. For example, they were asked to think on the disks and rods while they put those disks over the rods according to a rule and they asked to make generalizations.

To relate the discriminating skill with the topic, the properties of the objects were analyzed and to gain the ability of understanding which properties should be considered and what is needed to make discrimination, various tool properties of surface coating areas as honeycomb, tile and hardwood surfaces were used

According to the Curriculum of Connections, which is the second parallel of TPC, a presentation was delivered as to taking attention to the various applications of geometry like the golden ratio used in different disciplines. Instead of giving a list on the properties of geometric objects, students were required to come up with those properties on their own.

According to the Curriculum of Practice, which is the third parallel of TPC, students were asked in groups to design a geometric city with certain rules within the order theme both to make them gain analysis ability by determining the relations between geometric objects and to boost their creativeness.

Given the evaluation criteria or from time to time producing their own criteria, students evaluate their own work and the ones of others.

Students were made to perform flooring with pattern blocks, and do works with tangram pieces to develop their creative thinking and spatial skills. Students were asked to write a story and instead of writing the names of some objects, animals, and humans in the story, they were first asked to prepare those things in tangram pieces and stick them in the story where they needed to give names. In all this process, it was given importance for students to work in an open ended fields as concept, process, and product.

According to the Curriculum of Identity, which is the last parallel of TPC, identity activity was prepared for students to lead them think on their aims and the opportunities given to them, inspect themselves with mathematics, and implementing geometry in their own lives to understand it deeply. In this concept, they were asked in groups to examine the lives of scientists studied geometry and act it out on a stage using puppets that they designed and scripted.

The Spatial Ability Test was applied again as a last time to experimental and control groups.

Data Analysis

In the data analysis process, Mann Whitney-U Test as a non-parametric one and Wilcoxon Signed Rank Test were used.

FINDINGS

The results of Non-parametric Mann Whitney-U Test which is used to test whether there is a significant difference between experimetal and control group's Spatial Ability pretest (block rotation, surface development and visual memory training) scores are given in Table 5.

Table 5. The results of Mann Whitney-U Test which is used to test whether there is a significant difference between the groups' Spatial Ability pretest scores

		N	R.M.	R.S.	U	z	*p*
Block Rotation	**Experimental**	15	13,37	200,50	80,500	-1,334	,182
	Control	15	17,63	264,50			
	Total	30					
Surface Development	**Experimental**	15	16,43	246,50	98,500	-,582	,561
	Control	15	14,57	218,50			
	Total	30					
	Experimental	15	15,13	227,00	107,000	-,230	,818
Visual Memory Learning	**Control**	15	15,87	238,00			
	Total	30					
Total	**Experimental**	15	14,60	219,00	99,000	-,560	,575
	Control	15	16,40	246,00			
	Total	30					

As it can be seen in Table 5, according to the results of Mann Whitney-U Test, there is not a significant difference between experimental and control group's Spatial Ability pretest (block rotation, surface development and visual memory training) scores (U=80.500, p>0.05) (U=98.500, p>0.05), (U=107.000, p>0.05), (U=99.000, p>0.05).

The results of Wilcoxon Signed Rank Test which is used to test whether there is a significant difference between pretest and posttest scores of experimental group's Spatial Ability (block rotation, surface development and visual memory training) scores are given in Table 7.

Tablo 6. The results of Wilcoxon Signed Rank Test, which is used to test whether there is a significant difference between pretest and posttest scores of experimental group's Spatial Ability scores

Score	Rows	N	R.M.	R.S.	z	*p*
Block Rotation - pretest	**Negative Rows**	0	,00	,00		
	Positive Rows	14	7,50	105,00	-3,314	0,001
Block Rotation - posttest	**Equal**	1				
Surface Development - pretest	**Negative Rows**	0	,00	,00		
	Positive Rows	15	8,00	120,00	-3,411	0,001
Surface Development - posttest	**Equal**	0				
Visual Memory Learning - pretest	**Negative Rows**	0	,00	,00		
	Positive Rows	12	6,50	78,00	-3,064	,002
Visual Memory Learning - posttest	**Equal**	3				
Total - pretest	**Negative Rows**	0	,00	,00		
	Positive Rows	15	8,00	120,00	-3,413	,001
Total - posttest	**Equal**	0				

As can be seen in Table 6, as a result of Wilcoxon Signed Rank Test used to test whether there is a significant difference between the experimental group's pretest and posttest scores of block rotation, there is a statistically significant difference between rows mean favouring posttest with a degree of .01, (z=-3.314, p<0.01). It can be observed that object rotation posttest scores of experimental group students are significantly higher.

As a result of Wilcoxon Signed Rank Test used to test whether there is a significant difference between the pretest and posttest scores of surface development, there is a statistically significant difference between rows mean favouring posttest with a degree of .01, (z=-3.411, p<0.01). It can be observed that surface development posttest scores of experimental group students are significantly higher.

As a result of Wilcoxon Signed Rank Test used to test whether there is a significant difference between the pretest and posttest scores of visual memory learning, there is a statistically significant difference between rows mean favouring posttest with a degree of .01, (z=-3.064, p<0.01). It can be observed that visual memory learning posttest scores of experimental group students are significantly higher.

As a result of Wilcoxon Signed Rank Test used to test whether there is a significant difference between the total pretest and posttest scores of the spatial ability, there is a statistically significant difference between rows mean favouring posttest with a degree of .01, (z=-3.413, p<0.01). It can be observed that the spatial ability total posttest scores of experimental group students are significantly higher.

The results of Wilcoxon Signed Rank Test which is used to test whether there is a significant difference between pretest and posttest scores of control group's Spatial Ability (block rotation, surface development and visual memory training) scores are given in Table 7.

Table 7. The results of Wilcoxon Signed Rank Test, which is used to test whether there is a significant difference between pretest and posttest scores of control group's Spatial Ability scores

Score	Rows	N	R.M.	R.S.	z	*p*
Block Rotation - pretest	**Negative Rows**	8	8,38	67,00		
	Positive Rows	6	6,33	38,00	-,914	,361
Block Rotation - posttest	**Equal**	1				
Surface Development - pretest	**Negative Rows**	5	5,60	28,00		
	Positive Rows	9	8,56	77,00	-1,545	,122
Surface Development - posttest	**Equal**	1				
Visual Memory Learning - pretest	**Negative Rows**	6	7,00	42,00		
	Positive Rows	6	6,00	36,00	-,238	,812
Visual Memory Learning - posttest	**Equal**	3				
Total - pretest	**Negative Rows**	6	7,00	42,00		
	Positive Rows	8	6,00	36,00	-,440	,660
Total - posttest	**Equal**	1				

As can be seen in Table 7, as a result of Wilcoxon Signed Rank Test used to test whether there is a significant difference between the spatial ability pretest and posttest scores of block rotation, there is not a statistically significant difference between the rows mean (z=-.914, p>0.05).

As a result of Wilcoxon Signed Rank Test used to test whether there is a significant difference between the pretest and posttest scores of surface development, there is not a statistically significant difference between rows mean of control group students (z=-1.545, p>0.05).

As a result of Wilcoxon Signed Rank Test used to test whether there is a significant difference between the pretest and posttest scores of visual memory learning, there is not a statistically significant difference between rows mean of control group students (z=-.238, p>0.05).

As a result of Wilcoxon Signed Rank Test used to test whether there is a significant difference between the total pretest and posttest scores of the spatial ability, there is not a statistically significant difference between rows mean of control group students (z=-.440, p>0.05).

The results of Mann Whitney-U Test which is used to test whether there is a significant difference between experimetal and control group's Spatial Ability posttest (block rotation, surface development and visual memory training) scores are given in Table 8.

Tablo 8. The results of Mann Whitney-U Test which is used to test whether there is a significant difference between the groups' Spatial Ability posttest scores

		N	R.M.	R.S.	U	z	*p*
Block Rotation	**Experimental**	15	19,37	290,50	54,500	-2,412	,016
	Control	15	11,63	174,50			
	Total	30					
Surface Development	**Experimental**	15	18,80	282,00	63,000	-2,059	,040
	Control	15	12,20	183,00			
	Total	30					
	Experimental	15	20,30	304,50	40,500	-2,999	,003
Visual Memory Learning	**Control**	15	10,70	160,50			
	Total	30					
Total	**Experimental**	15	20,33	305,00	40,000	-3,009	,003
	Control	15	10,67	160,00			
	Total	30					

As can be seen in Table 8, as a result of Mann Whitney-U Test used to test whether there is a significant difference between the experimental and control group's spatial ability posttest scores of block rotation based on the experimental/control group variation, there is a statistically significant difference between groups favouring experimental group with a degree of .05 ($U=54.500$, $p<0.05$). It can be observed that block rotation posttest scores of experimental group students are significantly higher than posttest scores of control group.

As a result of Mann Whitney-U Test used to test whether there is a significant difference between the experimental and control group's spatial ability posttest scores of surface development based on the experimental/control group variation, there is a statistically significant difference between groups favouring experimental group with a degree of .05, ($U=63.000$, $p<0.05$). It can be observed that surface detection posttest scores of experimental group students are significantly higher than posttest scores of control group.

As a result of Mann Whitney-U Test used to test whether there is a significant difference between the experimental and control group's spatial ability posttest scores of visual memory learning based on the experimental/control group variation, there is a statistically significant difference between groups favouring experimental group with a degree of .05, ($U=40.500$, $p<0.01$). It can be observed that visual memory learning posttest scores of experimental group students are significantly higher than posttest scores of control group.

As a result of Mann Whitney-U Test used to test whether there is a significant difference between the experimental and control group's spatial ability total posttest scores based on the experimental/control group variation, there is a statistically significant difference between groups favouring experimental group with a degree of .05.. It can be observed that spatial ability total posttest scores of experimental group students are significantly higher than posttest scores of control group.

DISCUSSION AND CONCLUSION

The spatial ability pretest results of experimental group based on the parallel curriculum model and control group with no application of differentiation are examined. Collected data show that there is no significant difference between the spatial ability pretest scores of experimental and control groups. This finding supports the expected prediction in terms of the spatial ability pretest results and it can be said that the spatial ability scores of both groups were equal to each other before the application process. The reason of this can be that students are given the same concept of topics and they are not offered any activity about the spatial ability.

The scores of experimental group were analyzed as pretest and posttest, and total and sub dimension. Collected data shows that in terms of spatial ability (block rotation, surface development, visual memory learning) there is a statistically significant difference between pretest and posttest scores favouring posttest with a degree of .01.

If we are to look at sub dimensions respectively; in various studies block rotation is described in different ways such as intellectual rotation, spatial comprehension, intellectual transformation, manipulation of objects by mind, ability of rotating two or three dimensional objects in mind and being able to recognize them in various rotations, ability of rotating objects in mind effectively (Strong & Smith, 2002, trans. Stumpf, 2006; Olkun & Altun, 2003; Clements, 1998; McGee, 1979; Linn & Petersen, 1985, trans. McClurg et al., 1997).

Studies support the idea that it is necessary to offer children concrete objects to develop their spatial and geometric thinking abilities. It is important for kids to play with many objects in their hands to learn geometric items (trans. Yolcu, 2008). With this perspective, tangram was used both to make students learn the names, characteristics of geometric objects, and to develop their higher-up thinking skills together with spatial ability and creative thinking. Instead of giving the tangram pieces as a whole, given 7 pieces of tangram, there happened a study to make the tangram by folding paper pieces. To do this, first of all students were required to manipulate those tangram pieces in their minds and then put them on a piece of paper with two dimensional characteristic. Meanwhile, while using the tangram pieces, the names of shapes were used and their characteristics were emphasized. Later, a story was made to be written by the students using the tangram pieces. It was observed that students had some difficulty in building tangrams by folding paper, however, later in the story writing step they enjoyed it. Some students added some other specialities to their tangrams such as foot, eyes, glasses etc, and this got the attention of other students leading them to do the similar things as well.

For the purpose of contributing to the spatial ability of students, pattern blocks were used as well as tangram. Here, students were asked to manipulate the objects in their minds and develop a bordure for a wallpaper company. Besides, some activities were performed such as asking them to lay down the pre-prepared puzzles to get the most scores.

Similar activities were also conducted by using pen and paper. Shown the honeycomb example, they were asked to prepare similar flooring and clothing activities. During this process, such questions as "How can we cover a layer without any space between the coverages?" were asked.

Similarly some other objects were used during the process such as Soma Cubes which consists of 7 pieces and students were asked to build a cube by gathering the pieces; materials lined in two colours on a rubber with 27 units of cubes, and students were asked to prepare a cube of 3x3x3 paying attention to their spaces between the pieces and the sequencing of the colours; pentomino and tetromino for the purpose of surface coating; Katamino game in which students were asked to coat a getting bigger and smaller surface with geometric objects; and Equilibrio game in which students were asked to put the geometric objects in a coordinated and balanced way complying with the sample given.

In conclusion, such use of concrete materials in experimental group made students enjoy the work that they are doing and show utmost attention, which made the learning process fun, learn the geometric objects better, and rotate the objects in their minds. This situation affected the posttest results in a significant way.

Surface development is described as the way of forming three dimensional objects such as boxes or cones by folding or rotating a two dimensional object (like a piece of paper or cane), or the way of dissolving a three dimensional object to a two dimensional one (Stumpf, 2006).

Besides asking students to form tangrams by folding paper pieces, they were also required to draw the nets of a cube and form a dice. As the opposing surfaces should have been 7 in total, students were required to pay attention and calculate the surface detection. It was observed in the activities that folding paper and drawing an object in its nets and gather it together to form another one led the surface development posttest score be significantly higher.

Visual memory learning is the abilities of meaning, drawing or describing an object or a number of objects after a limited time. In the visual memory learning test used within the study one piece of all shapes were coloured in black, and it necessitated to recognize a stimulus among the similar ones (Stumpf, 2006).

To use the power of visual memory as an advantage, it is important to put more elements that stimulates the visual memory learning. So, drawing the learned information, making graphics, caricaturing the events, using colours, and underlining the important points with highlighters are the factors that boost the level of permanent space of knowledge in memory (Duyar, 2001:29).

The level of remembering the words is related to how meaningful they are for us. To be able to learn a word, it is necessary for a word to relate to something other that we have learnt (Duyar, 2001:34-35).

It is boring, difficult, and easy to forget for a student to keep in memory what a geometric object is and what the listed characteristics of theirs are. For this purpose, to make the students easier to remember the characteristics of geometric objects, such studies as 3 dimensional model developing, caricatures or drawings telling the relations of geometric objects, logo designs, origami were conducted. All those mentioned elements developed the visual memory learning and made visual memory learning posttest scores significantly higher.

In conclusion, findings of this study show that the spatial ability total scores of experimental groups students is significantly higher than pretest scores with a degree of .01, favouring the posttest. The spatial ability is important for many mathematics topics, especially for geometry. However, current mathematics teaching curriculum does not include the topic of developing the spatial abilities.

The importance of spatial ability in many mathematical process such as forming simple geometric objects and forming more sophisticated ones out of simple objects, developing abilities of space and numbers, and learning the relations between the figures and numbers. So, activities to boost the creative thinking abilities of experimental group students were planned in the study. Also, using 3 dimensional concrete objects, pattern blocks, flooring and tangrams, making paper or model designs suitable for "order" theme of geometry or other disciplines (like caricature, drawings, origami, model, logo etc.) led the experimental group students spatial ability posttest scores significantly higher.

Pretest and posttest scores of control group who were not applied differentiated curriculum were analyzed. Findings show that there is not a significant difference between control group spatial ability pretest and posttest results in total and sub dimensional aspects. According to MONE (2005), in the new curriculum of mathematics, geometry topics are not left to the end of the year but they are spreaded to the whole year, showing that the importance given to geometry teaching is getting higher. Besides, activities have become more visual and the time allocated to geometry has been increased. In the first 5 years of new curriculum, geometric objects are introduced and named as whole and depending on visual characteristics. When we look at this perspective, it is possible to boost the spatial abilities of students without making any differentiation but it is important to realize and know what problems students face in mathematic classes while learning geometry.

In Karaman's (2000) study of what difficulties the students of geometry learning process face, he consulted 25 geometry teachers in terms of what the teacher come across in teaching geometry in terms of the problems that their students face. So, teachers suggested that students; "cannot recognize the characteristics of two and three dimensional objects", "have difficulty in copying the shapes on the board to their notebooks", "cannot use the objects effectively and cannot picture their different appearances from different directions", and "prefer numbers rather than abstract level geometry". The main reason of this can be not implementing visuality in the classes and not using concrete materials and objects leaving visuality as a theory in the books.

Besides, since monotype general curriculum is prepared for the average student attitudes in terms of teaching geometry, the needs of gifted and talented students ignored, and higher-up thinking abilities as creative thinking and spatial ability are not developed, it might be that there was not a significant difference between control group spatial ability pretest and posttest scores in non-differentiated curriculum. This shows that in general education institutions where there is no differentiated curriculum, gifted and talented students are left aside to be expected being successful without giving them chance to make use of their abilities fully.

When the spatial ability total posttest scores of experimental and control group students were analyzed, there is a significant difference between the groups with a degree of 0.01, favouring the experimental group.

In the experimental group, where creative thinking and the parallel curriculum were taken as basis, for students to gain spatial abilities such tools used as 3 dimensional models, caricatures or drawings telling the relations between geometric shapes, logo designs, origami as a different way of geometry, soma cube, tangram, pattern blocks, tetromino, pentomino, katomino, Equilibrio. This may led experimental group spatial ability posttest total scores be significantly favoured.

The findings of the study is compatible with the following studies carried out to show that differentiated geometry teaching affects the spatial ability level of students: Shawal (1999); Melancon (1994); Battista & Clements (1989), trans. Kaykan (2005); Gutierrez (1992); Baki & Güven (2007);

Yolcu (2008); Yıldız (2009); Arıcı (2009); Olkun (1999), trans. Yolcu (2008); Boyraz (2008).

Besides, the following studies on the effect of spatial ability based art education based on the level of spatial ability: Kárpáti (1997); Haanstra (1996); Winner (1993); Moody (1991).

SUGGESTIONS

When we look from a perspective of students' gaining, research findings tell us that gifted and talented students are ready to be gained in advanced levels, they can preserve information in their memory for a longer period of time than those with an average memory, they can transfer what they learn to other situations more easily, and when they are given the correct education system they can quickly progress in higher-up learning levels.

Even though the Board of Education has given up the former 2005 classic and traditional approach to teaching mathematics to primary 1-5 years, as there are no activities to trigger higher-up thinking abilities in mathematics such as creative and spatial thinking skills, gifted and talented students are expected to be successful without given the chance to use their full capacity. As a result, students become uninterested to the curriculum and the level of gained knowledge falls behind their actual capacity. As a result of this, interests of students can direct itself to other fields and it may lead them to be excluded from education and learning process. Even a single child excluded from education and learning span means that it is a lost for the child itself, for the country and for humanity.

The main purpose of education reforms to be made should be realizing the characteristics of gifted and talented students, supporting these characteristics and leading them to proceed, and making them productive individuals that produces solutions to the problems. To reach these purposes, education regulations of gifted and talented students must include importance given to ideas, meanings, perspectives, and relations; building understanding and comprehension skills, giving opportunities to be creative, developing healthy curiousness.

Considering these steps, it will be beneficial to make a geometry curriculum in our country not ignoring but considering the needs of gifted and talented students. The concept of equality of opportunity in education should include all the children as well as those who are described as gifted and talented individuals. Regulations must be used to lead every student reach to the utmost point of his/her own potential.

REFERENCES

Arıcı, S. (2012). *The effect of origami-based ınstruction on spatial visualization, geometry achievement and geometric reasoning of tenth-grade students*. Yayınlanmamış Yüksek Lisans Tezi. Boğaziçi Üniversitesi.

Atkıncı, H. (2001). *İlköğretim birinci kademe eğitim programlarının yaratıcı düşünmenin gelişmesine etkileri.* Yayınlanmamış Yüksek Lisans Tezi. Çanakkale Onsekiz Mart Üniversitesi.

Baki, A. ve Güven, B. (2007). Dinamik Geometri Yazılımı Cabri 3D'nin Öğretmen Adaylarının Uzamsal Yetenekleri Üzerine Etkisi. The Proceedings of 7th International Educational Technology Conference, 3-5 May 2007, Near East University-North Cyprus 116-120.

Batdal Karaduman, G. (2012). *İlköğretim 5. sınıf üstün yetenekli öğrenciler için farklılaştırılmış geometri öğretiminin yaratıcı düşünme, uzamsal yetenek düzeyi ve erişiye etkisi.* Yayınlanmamış Doktora Tezi. İstanbul Üniversitesi, Sosyal Bilimler Enstitüsü.

Büyüköztürk, Ş., Çakmak, E. Kılıç, A., Özcan, E., Karadeniz, Ş. ve Demirel, F. (2011). Bilimsel Araştırma Yöntemleri, Pegem Akademi Yayınları, Ankara.

Battista, M.T. ve Clements, D.H. (1998). Finding the Number of Cubes in Rectangular Cube Buildings. *Teaching Children Mathematics,* 4(5), 258-264.

Clements, D.H. (1998). *Geometric and Spatial Thinking in Young Children*. Mathematics for the Young Children. State Unversity of New York at Buffalo, Part 2.

Duyar, M.S. (2001). Accelerated Word Memory Power. Mega Bellek Öğrenimi Eğitim Hizmetleri Limited Şirketi, Ankara.

Gutierrez A. (1992) Exploring the Links Between Van Hiele Levels and 3-Dimensional Geometry. *Structural Topology,* 31-47.

Haanstra, F. (1996). Effects of Art Education on Visual-Spatial Ability and Aesthetic Perception: A Quantitative. *Studies in Art Education*, 37, 4, 197-209.

Hoffer, A. (1981). Geometry is More Than Proof. *Mathematics Teacher*, 74, 11-18.

Karaman, T. (2000*). The relationship between gender, spatial visualization, spatialorientation, flexibility of closure abilities and the performances related to plane geometry subject of the sixth grade students.* Boğaziçi Üniversitesi, Yayımlanmamış Yüksek Lisans Tezi.

Karasar, N. (2002). Bilimsel Araştırma Yöntemi. Ankara: Nobel Yayınları.

Kárpáti, A. (1997). Detection and Development of Visual Talent. Journal of Aesthetic Education, Vol. 31, No. 4, Special Issue: *Giftedness and Talent in the Arts,* 79-93.

Kayhan, E.B. (2005). *Investigation of high school students' spatial ability.* Yayınlanmıs Yuksek Lisans Tezi. Orta Oğretim Fen ve Matematik Alanları Eğitimi, ODTU.

McClurg, P., Lee, J., Shavalier M. & Jacobsen, K. (1997). Exploring Children's Spatial Visual Thinking in an Hypergami Environment, 2-4.

McGee, M.G. (1979). Human Spatial Abilities: Psychometric Studies and Environmental, Genetic, Hormonal and Neurological Influences. *Psychological Bulletin*, 86,5, pp. 889-918.

MONE (Ministry of National Education) MEB, (2004). *İlköğretim Matematik Dersi Öğretim Programı*. Ankara: Devlet Kitapları Müdürlüğü.

MONE (Ministry of National Education) MEB, (2005). *İlköğretim Matematik Dersi 1-5. Sınıflar Öğretim Programı*. Ankara: Devlet Kitapları Müdürlüğü.

Melancon, J. (1994). Developing Visualization and Spatial Skills, Loyola University, http://www.nade.net/documents/SCP94/SCP94.12.pdf

Moody, L.J. (1991). Copying, Naturalistic Drawing and Spatial Aptitude. Visual Arts Research, Vol. 17, No. 2(34), 33-42.

Olkun, S. ve Altun, A. (2003). İlköğretim Öğrencilerinin Bilgisayar Deneyimleri ile Uzamsal Düşünme ve Geometri Başarıları Arasındaki İlişki. TOJET - *The Turkish Online Journal Of Educatıonal Technology,* 2(4), 1-7.

Pappas, T. (2003). *Yaşayan Matematik. (Çev. Silier Y.).* Ankara: Doruk Yayınları.

Passow, H. (1959). The Comprehensive High School and Gidted Youth. (Ed. French, J.L.). *Educating the Gifted, A Book of Readings*. (187-199). USA: Henry Holt and Company, Inc.

Regina, M.M. (2000). Enhancing Geometric Reasoning. Look Smart Find Articles, Online, Summer.

Shawal, M.A. (1999). *An Investigation of the Relationship Between Spatial Ability and Mathematics Learning for Yemeni Students.* UMI ProQuest Digital Dissertations, http://wwwlib.umi.com/dissertations/fullcit/9923693

Sternberg, R.J. ve Grigorenko, E.L. (2000). *Teaching for Successful Intelligence.* USA: Skylight Training and Publishing Inc.

Strong, S., & Smith, R. (2002). Spatial Visualization: Fundamentals and Trends In Engineering Graphics. *Journal of Industrial Technology,* 18, 1.

Stumpf, H. (2006). *STB: Spatial Test Battery Manuel. Center for Talented Youth*, USA: John Hopkins University.

Tomlinson, C.A., Kaplan, S.N., Renzulli, J.S., Leppien, J., Burns, D. ve Purcell, J. (2002): *The Parallel Curriculum: A Design to Develop High Potential and Challenge High Ability Learners*. USA: Corwin Pres, INC.

Winner, E. (1993). Exceptional Artistic Development: The Role of Visual Thinking. *Journal of Aesthetic Education,* 27, 4, Special Issue: Essays in Honor of Rudolf Arnheim, 31-44.

Yıldız, B. (2009). *Üç-Boyutlu Sanal Ortam ve Somut Materyal Kullanımının Uzamsal Görselleştirme Ve Zihinsel Döndürme Becerilerine Etkileri.* Yayınlanmamış Yüksek Lisans Tezi. Hacettepe Üniversitesi, Fen Bilimleri Enstitüsü.

Yolcu, B. (2008). *Altıncı Sınıf Öğrencilerinin Uzamsal Yeteneklerini Somut Modeller ve Bilgisayar Uygulamaları ile Geliştirme Çalışmaları.* Yayınlanmamış Yüksek Lisans Tezi. Eskişehir Osmangazi Üniversitesi, Fen Bilimleri Enstitüsü.

Yolcu, B. (2008). *Altıncı Sınıf Öğrencilerinin Uzamsal Yeteneklerini Somut Modeller ve Bilgisayar Uygulamaları ile Geliştirme Çalışmaları.* Yayınlanmamış Yüksek Lisans Tezi. Eskişehir Osmangazi Üniversitesi, Fen Bilimleri Enstitüsü.