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The Effects of the Program Including Differentiated STEM Applications Based on the Parallel Curriculum Model on the Critical Thinking Skills, Creativity and Attitudes of Gifted and Talented Students

Aydın Tiryaki[1], Omer Cakiroğlu[2], Yavuz Yaman[3]

[1]Graduate Education Institute, İstanbul University-Cerrahpaşa, Suleymaniye Takvimhane Caddesi, No: 19, 34116, Fatih, İstanbul, Turkey

[2, 3]Hasan Ali Yücel Faculty of Education, İstanbul University-Cerrahpaşa, Fatih, İstanbul, Turkey

Abstract*: In this study, the effect of the program including differentiated STEM applications based on the Parallel Curriculum Model on the gifted and talented students learning the Electricity Unit of 7th grade has been investigated by using quantitative method. Twenty-four gifted and talented students attending the 7th grade of the Istanbul Chamber of Commerce Science and Art Center in 2017-2018 academic year participated into the practice lasting 16 hours in 4 weeks. Cornell Critical Thinking Test, Torrance Creative Thinking Test and TOSRA were used for data collection. The collected data were statistically evaluated by using SPSS 21.00 package program. The program, which includes the differentiated STEM applications according to the parallel curriculum model, has been found to be more effective than the research-based learning model in the development of the attitudes of gifted and talented students towards critical thinking skills, creativity and science.*

Keywords: STEM, Gifted, Critical Thinking, Attitude, Creativity

1. Introduction

In recent years, one of the most interesting and most intensively studied subjects in education has been on gifted and talented students [1], [2]. It is seen in the literature that the studies about this topic generally focus on students' creativity, attitudes towards the teacher and critical thinking skills [3]-[5]. When it comes to comparing with other students, it can be observed that the gifted and talented students have some distinctive features such as being more curious, creative, questioning, researching, critical thinking, working hard, innovative, forward-looking and more mature than their peers [6]-[8]. Therefore, it is inevitable that the education program to be applied to gifted and talented students will be different from the generally-applied education programs [9] In almost every discipline, an intensive effort is observed to develop a differentiated curriculum for those students [10]. One of the mostly preferred field of interest for students defined above is each elements of STEM (**S**cience **T**echnology **E**ngineering **M**athematic) disciplines [11]-[14]. STEM's Science discipline is one of the disciplines in which creativity and critical thinking skills are highly applicable [5], [11], [15], [16]. Since STEM involves the relationship between disciplines, Science discipline also contributes to the creativity, critical thinking and questioning skills of the students [17]. Parallel Curriculum Model is one of the models applied to gifted and talented students in Science education which is one of the STEM disciplines [18]. This model consists of four interrelated structures; Core Curriculum, Links Curriculum, Implementation Curriculum and Identity Curriculum [19]. Although there are different studies on the model of parallel curriculum or on STEM separately, no study has been found in the combined form of the two in the literature. In this study, the effects of differentiated STEM applications on students' critical thinking, attitude and creativity were investigated based on the parallel curriculum model.

1.1 Purpose of the Study

It is aimed at this study to determine how the program including differentiated STEM applications based on the parallel curriculum model affects the attitudes, critical thinking and creativity skills of gifted and talented students studying Electricity Unit in the 7th grade. The research questions are guided as following:

1) Does the program, involving the STEM practices based on the parallel curriculum model, have an impact on the critical thinking skills of gifted and talented 7th grade students?
2) Does the program, involving the STEM practices based on the parallel curriculum model, have an impact on the attitudes of gifted and talented 7th grade students?
3) Does the program, involving the STEM practices based on the parallel curriculum model, have an impact on the creativity of gifted and talented 7th grade students?

2. Methodology

Quantitative research design was used in this study [20].

2.1. Participants

As the participants of the study, 12 students for experimental group and 12 students for control group were randomly selected from the gifted and talented students in the 7th grade of the Istanbul Chamber of Commerce Science and Art Center, in 2017-2018 education year. These students were selected by a special ability test conducted by the government. The students participating in the practice are all 13 years old; two of them are girls and the others are boys. While differentiated STEM program based on Parallel Curriculums Model was applied to the experimental group students, the control group students were taught with a Inquiry Based Learning Model.

2.2. Data Collection

Data were collected quantitatively through three different measuring instruments. The study was carried out in the 7th grade electricity unit for 16 lessons - 4 weeks.

2.2.1. Torrance Creative Thinking Test

orrance Creative Thinking Test, designed by E. Paul Torrance in 1974, was utilized for figuring out the creativity scores of the students. The test consists of two parallel forms: Form A and Form B, and two parts: "verbal" and "modal". In order to define the scores of creativity of the students, "Torrance-Creative Thinking- Modal-Form A" was applied as the pretest in the beginning of the study and the Modal-Verbal Form B of the same test was given as the post-test in the end.

2.2.2. CORNELL Critical Thinking Test

To be able to score the critical thinking skills of the students "CORNELL Critical Thinking Test- Level X", developed by Ennis and Milman in 1985, was used in the research. The original reliability coefficient of the test is .69 and its version adapted to Turkish has .71 reliability coefficients [21].

2.2.3. TOSRA

The TOSRA (Test of Science-Related Attitudes) scale developed to measure students' attitudes towards science has 70 items and 7 sub-dimensions each of which has 10 different items. The scale is 5-point Likert type (1: Strongly Disagree, 2: Disagree, 3: Undecided, 4: Agree and 5: Strongly Agree). Four of the 7 sub-dimensions were used in the study. These sub-dimensions are Adopting Scientific Attitude, Enjoying Science Lessons, Science as a Leisure Time Interest, and Science as Career Preference. Each sub-dimension consists of 10 items. Cronbach's Alpha value for overall reliability is .82 for the original [22] and Turkish version [23] of the TOSRA test involving 4 sub-dimensions and 40 items in total.

2.3. Data Analysis

The analysis of the quantitatively gathered data was done by SPSS 21.00 statistical program.

3. Findings

The statistical values about students' critical thinking skills, creativity, attitudes before the application and Raven SPM plus Test are given in Table 1 below.

Table 1: Pretest Scores of both Groups Raven SPM plus, CORNELL Critical Thinking Test, TOSRA and Torrance Creative Thinking Tests Results of Mann Whitney-U Test

Tests	Groups	N	Sort Sum	U	Z	P
Raven SPM Plus Test	Experimental	12	158,00			
	Control	12	142,00			
	Total	24		64,00	-.462	.644
Cornell Critical Thinking Test	Experimental	12	162,50			
	Control	12	137,50			
	Total	24		59,50	-.724	.469
Torrance Creative Thinking Test	Experimental	12	151,00			
	Control	12	149,00			
	Total	24		71,00	-,058	.954
TOSRA	Experimental	12	174,50			
	Control	12	125,50			
	Total	24		47,50	-1,417	.157

The values related to the pretest scores of Experimental and Control Groups for Raven SPM Plus (U=64,00, Z= -.462, p: .644), CORNELL Critical Thinking Test (U=59,50, z=-.724, p: .469), Torrance Creative Thinking Test (U=71.00, z=-.058, p: .954) and TOSRA (U=47,50, z=-1.417, p: .157) are given in Table 1.

Table 2: Pretest– Posttest scores and Wilcoxon Test Values for the Control Group according to CORNELL Critical Thinking Test, Torrance Creative Thinking Test, and TOSRA

Tests	Pretest- Posttest	N	Sort Sum	Z	P
Cornell Critical Thinking Test	Negative Rank	2	4,50		
	Positive Rank	10	73,50	-2,719	.007
	Equal	0			
Torrance Creative Thinking Test	Negative Rank	4	17.50		
	Positive Rank	8	60.50	-1.687	.092
	Equal	0			
TOSRA	Negative Rank	0	.00		
	Positive Rank	12	78,00	-3,064	.002
	Equal	0			

The findings about the pretest-posttest averages of the Control group for CORNELL Critical Thinking Test (Z=-2,719, p: .007), Torrance Creative Thinking Test (Z=-1,687, p: .092) and TOSRA (Z=-3,064, p: .002) can be seen in Table 2.

Table 3: Pretest– Posttest scores and Wilcoxon Test Values for the Experimental Group According to CORNELL Critical Thinking Test, Torrance Creative Thinking Test, and TOSRA

Tests	*Pretest- Posttest*	*N*	*Sort Sum*	*Z*	*P*
Cornell Critical Thinking Test	Negative Rank	0	.00		
	Positive Rank	12	78,00		
	Equal	0		-3,065	.002
Torrance Creative Thinking Test	Negative Rank	2	3.50		
	Positive Rank	10	74.50		
	Equal	0		-2,780	.005
TOSRA	Negative Rank	0	.00		

	Positive Rank	12	78,00	-3,064	.002
	Equal	0			

The data about pretest-posttest averages of the experimental group for CORNELL Critical Thinking Test (Z=-3,065, p: .002), Torrance Creative Thinking Test (Z=-2,780 p: .005) and TOSRA (Z=-3,064, p: .002) are given in Table 3.

Table 4: Posttest Scores of both Groups CORNELL Critical Thinking Test, TOSRA and Torrance Creative Thinking Tests Results of Mann Whitney-U Test

Tests	Groups	N	Sort Sum	U	Z	p
Cornell Critical Thinking Test	Experimental	12	200,00	22,00	-2,889	.004
	Control	12	100,00			
	Total	24				
Torrance Creative Thinking Test	Experimental	12	207,00	15,00	-3,297	.001
	Control	12	93,00			
	Total	24				
TOSRA	Experimental	12	219,00	3,00	-3,986	.000
	Control	12	81,00			
	Total	24				

The statistical values about the posttest scores of both groups for CORNELL Critical Thinking Test (U=22,00, Z= -2.889, p: .004), Torrance Creative Thinking Test (U=15,00, Z= -3.297, p: .001) and TOSRA (U=3,00, Z= -3,986, p: .000) are illustrated in Table 4.

4. Discussion

It is seen in the conducted studies that STEM applications are more effective than other learning models in the education of gifted and talented student; in addition, it is understood that STEM education has a positive effect on education of the non-gifted students, as well [15], [24], [25].

According to the results of the Mann Whitney U test, used for Pre-test Raven test, Cornell Critical Thinking Test, Torrance Creative Thinking Test, and TOSRA in Experimental and Control Groups, no significant difference is observed between both groups (Table 1).

When the data about the pretest and posttest scores; and the Cornell Critical Thinking test and TOSRA scores of the students in the Control Group were statistically evaluated by the Wilcoxon test, a significant difference was found in favor of the posttest. On the other hand, there was no significant difference in students' responses in Torrance Creative Thinking test (Table 2).

When the data about the pretest and posttest scores; and the Cornell Critical Thinking Test, Torrance Creative Thinking Test and TOSRA scores of the students in the Experimental Group were statistically evaluated by the Wilcoxon test, a significant difference was found in favor of the posttest (Table 3).

When the scores of the intergroup posttest of Cornell Critical Thinking Test are statistically analyzed through using Mann Whitney U test, it can be seen in Table 4 that Sort Sum of the Experimental Group is 200,00 while it is 100,00 for the Control Group; which pose a significant difference in favor of the posttest of the experimental group. Similar results were also found in previous studies [3], [5], [26]-[28].

When the scores of the intergroup posttest of Torrance Creative Thinking Test are statistically analyzed by Mann Whitney U test, it can be understood from Table 4 that Sort Sum of the Experimental Group is 207,00 while it is 93,00 for the Control Group; which shows a difference in favor of the posttest of the experimental group. According to these results, it is realized that the differentiated STEM programs provide double positive increase in the learning experience of the experimental group students. That inference is suitable with the other studies on this topic in the scientific literature [28]-[32],

When the TOSRA post-test scores of the Experimental and Control Groups were analyzed by using Whitney U Test, the Sort Sum of the Experimental group is 219,00 while it is 81,00 for the control group. Accordingly, a difference of two and a half times in favor of the experimental group is observed in Table 4. Similar results can be seen in different studies in the literature [30], [33]-[35],

5. Conclusion

When the results of the experimental and control group posttests were evaluated; a difference rate of 2 in the Cornell critical thinking test; 2.23 in The Torrance creative thinking test and 2.70 in TOSRA in favor of the experimental group was revealed; as a result of which it is found that the differentiated STEM program developed by the researcher can contribute to the attitudes, creativity and critical thinking skills of the gifted and talented students. The STEM program, developed in the study and differentiated according to the parallel curriculum model, has resulted positively in all three tests. The highest difference was obtained from TOSRA which is 2.70 times.

6. Recommendations

- The program including differentiated STEM applications based on the parallel curriculum model can be applied to the gifted and talented students in different grades of primary and secondary education. The results of those applications can be compared.
- Based on this study, the effects of the program, including differentiated STEM applications based on the parallel curriculum model, on some other variables such as scientific process skills and science literacy can be investigated.
- In this study, the program which includes differentiated STEM applications according to the Parallel curriculum model is compared with the inquiry based learning model. This teaching approach can be compared with different teaching approaches.

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Author Profile

Aydın Tiryaki graduated from the BEd in Science Teaching of İstanbul University in 2011. Four years ago he started his PhD in Science Education at Istanbul University. He has been working in a special Robotic education course since 2015.

Prof. Dr. O. Cakiroglu has been studying in Istanbul University since 2001. Previously, he studied at Marmara and Yildiz Technical University. He taught different physics courses. Areas of interest; superconductors, material science, semiconductors, STEM and science education. In 2003, he worked at Florida State University, National High Magnetic Field Lab (NHMFL), USA and in 2012 at IOWA University.

Assistant Professor **Yavuz Yaman** completed his master's degree in Science Education in the United States. He completed his PhD degree in Department of Gifted education at Istanbul University. He has been working in İstanbul University since 2006. Areas of interest; robotic applications in special education, STEM Education, continues to study on science education, gifted and their education.