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# The effect of the integration of science and mathematics on critical thinking and scientific process skills of the gifted students*

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**Abstract**

In this study, the influences of the activities that are prepared with the integration of science and mathematics on the critical thinking and scientific process skills of gifted middle school 6th grade students are investigated. In the study which is performed through the quantitative research method, single group pre- and post-test experimental design is used. In this respect, this is the first study that analyzes critical thinking and scientific process abilities of gifted people by experimental design, using the integration of science and mathematics, in Turkey. The study is performed with 6th grade students studying at a Science and Art Center in Central Anatolia in 2013-14 academic year. During the study that lasts almost 9 weeks, activities prepared through the integration of science and mathematics are applied to the students. Cornell Critical Thinking Scale Level X and Scientific process skills Test are employed used as pre- and post-test. Data are analyzed via a statistical software. In conclusion, it is explored that the activities which are prepared through the integration of science and mathematics have positive effects on critical thinking and scientific process skills of gifted students and within this scope some advices are presented for performers and researchers.



***Keywords:*** Giftedness, interdisciplinary, the integration of science and mathematics, critical thinking, scientific process skills.

## 1. Introduction

Students with gifts and talents are capable of performing at higher levels compared with others of the same age, experience, and environment. (National Association for Gifted Children [NAGC], 2020). Gifted students pay much more attention to mental processes due to their high intelligence level. Therefore, their cognitive individual awareness is higher than normal students (Narimani & Mousazadeh, 2010).

Researchers have made lots of studies to identify "superior ability" and have discovered some attributes which may be common for gifted people. Gifted people grow up and learn faster than their peers due to their superior cognitive abilities. When the literature is examined, gifted individuals have high abstract thinking ability and imagination, are very enthusiastic and curious to obtain information, need to deal with interesting problems that require originality to think, easily transfer the acquired knowledge, successful in constructing and formulating hypothesis, creative, fast learner, good as a problem solver, with critical thinking skills, capable of producing original ideas and solutions, high observational skills, questioning authority, perseverance, showing a high level of patience when faced with difficulties and discouraging situations, having great motivation to accomplish a job, and loving to take risks (Carroll, 1997; Cutts & Moseley, 2004; Gagné, 2009; Gallagher, 2000; Hersberger & Wheatley, 1980).

Considering all these attributes, it is clear that these students need different education. The possibility that students, who cannot use their abilities due to lack of education occasion they need, lose their abilities in time causes the obligation of alternative curriculums for gifted students' education.

For gifted students at preschool, elementary school, and high school education, one of the actions made in Turkey is the opening of the institutions called Science and Art Center (hereafter, SAC) within Ministry of National Education. SACs present education to gifted students in small groups within their opportunities. An education environment is created for the students qualified for these institutions, to develop their abilities without hindering their formal education. SAC includes activities by which students can develop high-level thinking skills, such as analytical thinking, logical thinking, problem solving, creative thinking, considering their individual differences.

Critical thinking, as a part of high-level thinking skills, is a conceivable reflective thinking focusing on determining what should be believed or done (Ennis, 2011). The existing literature for the gifted education has assessed critical thinking as a desirable purpose for gifted programs (Linn & Shore, 2008; Parks, 2009). Critical thinking is the general concept for a wide range of cognitive skills and intellectual dispositions. Critical thinking is considered to help students to (i) effectively identify, analyze, and evaluate

arguments and truth claims, (ii) discover and overcome personal preconceptions and biases, (iii) formulate and present convincing reasons in support of conclusions and (iv)make reasonable, intelligent decisions about what to believe and what to do (Bassham, Irwin, Nardone & Wallace, 2002).

There is a general consensus that some methods, such as problem-oriented learning, critical thinking methods and activation methods, are especially efficient for improvement of students' performance and attitude towards the subject (Nábělková & Plischke, 2015). Effective gifted education must include opportunities for gifted students to improve creative and critical thinking as well as academic and affective skills (Spoon, Rubenstein, Shively, Stith, Ascolani & Potts, 2020). Researchers state that critical thinking is inherently important for the training of global problem solvers, along with representing the goals of the gifted curriculum, and therefore classroom practices and assessments should be done. (Shively, Stith & Rubenstein, 2018).

In the literature, determining the critical thinking of gifted students (Dilekli, 2017; Kohan-Mass, 2016; White, 2010; Köksal, 2016;), developing critical thinking skills using different disciplines (Shively, Stith & Rubenstein, 2018; Sahragard & Heidari, 2014; McKeone, Caruso, Bettle, Chase, Bryson, Schneider & Rule, 2015) or there are many studies that include applications for educators to support the critical thinking of gifted individuals (Spoon et al., 2020).

Critical thinking is one of the most important elements of scientific thinking (Azar, 2010). Students' critical thinking skills could be improved via their scientific process skills (Koray, Bahadır & Geçkin, 2006). Scientific process skills can help students to produce higher mental skills, i.e., critical thinking, making decision and problem solving (Karslı & Şahin, 2009). Scientific process skills (SPS) are considered to be a part of the lifelong learning skills that incorporate critical thinking used by students in solving problems, making them more actively involved, and consciously in extending their abilities. In a nutshell, these two beneficial skills have a relationship with each other. For this reason, we argue that scientific process skills are a relevant tool to manage knowledge about the world around them, acquire new information, and critically process it. If these skills are not accurately advanced, we forecast that students cannot analyse knowledge and the concept they obtained cannot help them in understanding the surrounding world (Irwanto, Saputro, Rohaet & Prodjosantoso, 2019).

As was indicated by Dilekli (2017), , as gifted students have different learning preferences than their peers, an enriched curriculum should be applied in regular classes and this enriched curriculum should contain differentiated activities in learning experiences, to help gifted students manage independent study, develop strategies for cooperative learning and to participate in interdisciplinary activities .

There may be some difficulties because of the education of gifted students and SAC project may be counted as a new field of study in Turkey. In addition to the program prepared to develop the abilities of the students of the institution is quite new, lack of materials and activities suitable to the features of the students, is also damaging the establishing purpose of SAC. So, to satisfy this demand, native and foreign literature are examined; the sources, which will affect students' superior thinking styles positively, are examined. The studies proving that the education made with interdisciplinary approach improve superior thinking abilities (Drake & Burns, 2004; Mathison & Freeman, 1997;); urges the researcher to do interdisciplinary works for the education of gifted people. Study problem is created by analyzing the studies about gifted peoples' superior thinking abilities (Altıntaş, 2009; Bapoğlu, 2010; Dixon, Cassady, Cross & Williams, 2005; İşlekeller, 2008; Kettler, 2012; VanTassel-Baska & Stambaugh, 2006).

Interdisciplinary activities intended for the contents and earnings of disciplines, such as science and technology, mathematics, information technologies and liberal arts which are considered to improve students' superior thinking abilities are performed in this study. As such, it is thought that the study will satisfy the gifted students' demands on this field, will also set a good example for other SACs in the country, will lead to perform at other centers and will become a source and content for SACs. Furthermore, it is considered to contribute to a small number of experimental studies made with gifted students and to set light to the researchers who will work on this field. Besides, the number of the studies examining the skills of critical thinking along with the scientific process skills is limited in Turkey (Akar, 2007). When the extant literature is examined, it can be seen that there is not a study that investigates the relationship between the scientific process skills and critical thinking skills of gifted students.

In summary, the goal of this study is to observe the level of critical thinking skills and scientific process skills which are considered to be related with each other and to examine how the activities performed with the integration of science and mathematics affect students.

*1.1. Sub-problems*

- *Is there a significant difference between students' thinking and scientific process abilities pre- and post-test results?*

- Is there a significant relationship between students' thinking abilities pre- and post-test results and scientific process abilities pre- and post-test results?

- Do the students' scores for critical thinking abilities and scientific process abilities change with regard to gender and parents' educational status?

## 2. Method

This study was conducted quantitatively and "single group pre- and post-test experimental design" was used. In single group pre- and post-test experimental design, the effect of experimental operation was determined by a study performed on a single group. In the design, the significance of the difference between the results of pre- and post-test of a single group was tested (Büyüköztürk, Kılıç-Çakmak, Akgün, Karadeniz & Demirel, 2013).

The study group consisted of six gifted students who were studying in 6th grade at 2013-14 academic year spring semester. The students consisting of 4 girls and 2 boys were attending to a SAC in Central Anatolia. The researchers' easy access to students was based on study group's selection. The research started on March 19, 2014 and ended with post-test practices on May 15, 2014. All of the student participants were attending to the same secondary school, and some of them were also in the same class. Additionally, these students got Mathematics, Science and Technology education from same teachers both in the school and SAC. These cases were also important to provide equivalence among the students.

### *2.1. Data collection tools*

Scientific Process Abilities Test, which was originally developed by Okey, Wise and Burns (1985) and was translated and adapted by Aşkar, Geban and Özkan (1994) and Cornell Critical Thinking Scale Level X, which was developed by Ennis and Millman (1985) and was adapted by Akar (2007), were performed as pre- and post-test. CCTSLX consists of 4 subscales. These subscales were: "Inferring with Inductional Reasoning", "Inferring with Deductional Reasoning", "Questioning the Trustworthiness of Observations and Sources" and "Identfying the Suppositions in the Expressions". CCTSLX was a multiple choice measuring tool with three options, consisting totally 71 items. The reason why the number of items measuring the subscales of the test was more than the number of total items was because different abilities are measured with same questions. CCTSLX could be performed from 4th grade to 14th grade. The studies made for the trustworthiness of measuring tools through the data obtained from various studies showed that trustworthiness rates were between 0.67 and 0.90 and for the material separate, 6 studies made with 4th to 8th grade, the rates were between 0.36 and 0.64.

For the validity studies of CCTSLX, it was observed the correlation between other tests measuring critical thinking abilities and correlation values changing between 0.31 and

0.60 were found via 6 measuring tools measuring similar features (Akar, 2007). These results are interpreted to the validity of the scale.

Scientific Process Abilities Test was developed by James R. Okey and his friends. Translation to Turkish and adaptation were made by İlker Özkan, Petek Aşkar and Ömer Geban (2004). It was explored that this test used in the research was more suitable to 8th grade secondary school students in point of cognitive development level. Aydoğdu (2006) rebuilt the scale wherefore his sample in the research consists of 7th grade students and removed some items and performed the test on 336 7th grade students. After the execution, separating index and strength of the materials and trustworthiness coefficient of the test were calculated. After the calculation, the questions in which materials had separating index under 0.30 were removed from the test. Thus, a test containing 25 multiple choices and having 0.81 trustworthiness coefficient was obtained. Considering gifted students' cognitive developments, because they could easily overcome higher education levels, the edited version of the test for 7th grade students was used in this study. Maximum score to get from SPAT was 25. SPSS Statistics 22.0 software package is employed in analyzing the quantitative data obtained from CCTSLX and SPAT.

*2.2. Data collection process*

In the preparation phase of the applied activities, firstly the literature on the education of gifted individuals was scanned, and the sources for developing the higher level cognitive skills of the students were explored. After the exploration, the activities including mathematics, science and technology lessons concerning from 5th to 8th grade students were obtained from the internet. A part of activities consisted of "Pioneering Mars Curriculum and Activity Guide" prepared in cooperation with NASA, The University Of Southern Mississippi and CISSTEM (Center for Integrative Studies in Science, Technology, Engineering, and Mathematics). This part aimed at developing students' scientific problem solving abilities, making experimental designs, making researches by using different disciplines, making analysis, synthesis and evaluation and developing their critical thinking abilities. Furthermore, the activities, whose pilot experiments were made, were utilized in the project titled "Applied Science School for Scientists of the Future" at Gazi University, Faculty of Education between the period 16th-24th June 2014. Usage of both science and mathematics disciplines together, researching, solving problems in accordance with scientific steps, usage of concept knowledge and experimental design implementations together and being intended for development of superior thinking abilities were taken into account while choosing the activities. To confirm the applicability and suitability to gifted students' level of these activities, opinions were got from three academicians who were studying on this field and from two teachers who got graduate education and who were teaching at SAC on their

fields. After making required revisions in the light of suggestions, translations and adaptations of the activities were made by the researcher. The translations were showed to a linguist academician, opinions were got from him/her, and some revisions were made so that students understood the activities better. Finally, the activities were finalized.

The performing stage of the activities consisted of researching, finalizing the activity proper to the instructions, discussing the results and evaluating processes. In the stage, it was taken care to set up an educational environment that aimed to improve students' critical thinking abilities, provided them to solve problems in accordance with scientific steps, had an active attendance by the students and let the students express their ideas and solution suggestions easily. The first activity included the stages of group work, research, and presentation of the research to the class. The students who had a successful result at research, prediction and inference stages of the activity slogged have same sufficiency at group stage. In the second activity, it was expected from the students to create a concept map in the light of the data gained in previous activity. During the activities, students benefited from the processes such as research, description, seeing the relationship among the concepts, choosing the keywords, discussion, criticizing and generalization. At the end of the process, they developed and edited their concept maps by brainstorming with each other. The third activity consisted of a form through which students studied how some technologies were produced for different aims and were used in daily life. Some of the students brought newspaper news and articles from magazines, shared these findings and gave information about the subject to their classmates at the start of the lesson. They finalized the activity with questions and answers by discussing the findings and evaluation stages. At the end of the lesson, every student shared the technology he/she wanted to create, its reasons and possible negative outcomes with the class.

In the fourth activity, materials like car, motion detector and board were used. The experiment was set up with the students and sometimes questions were asked to the research students to make them think deeply about the activity. Questions such as "How would the result be if the experiment was set up differently?", "How would the change effect the speed-time graph of the car on the remade experiment?" and "In similar cases, which precautions should be taken to prevent possible accidents in daily life?" were asked to students to teach them to generalize, to see the relationships between concepts and events, to make inference, to link these to daily life in order to activate their mental processes. The researcher encouraged the students to create different ideas and they arranged existing experimental setup according to their hypotheses, the students tested the hypotheses, got the results and expressed their ideas. Discussion environment was created related to the results that the students obtained from the setups and the lesson was finalized after every student expressed his/her ideas about other students'

hypotheses and setups. Here are some graphics students drew with regard to the experiment in this lesson.

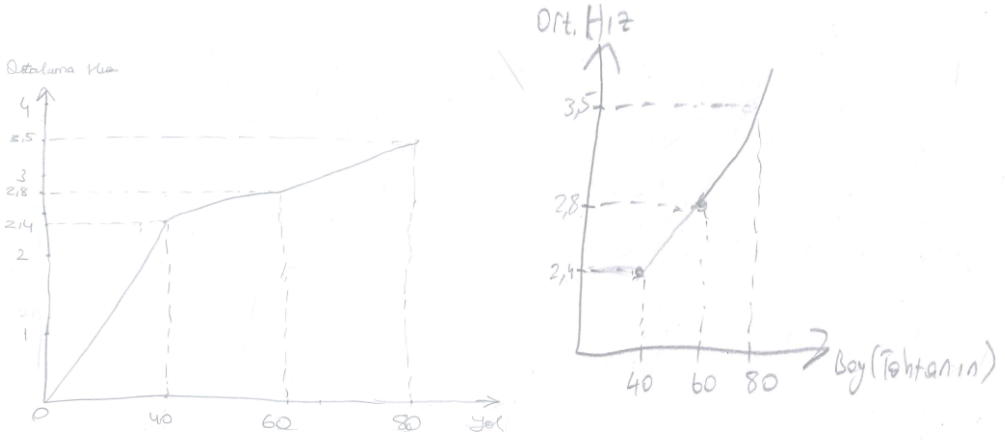


Figure 1. Graphs drawn by the students

In this activity, students expressed data related to a mathematical problem they might face in daily life and drew graphics through the obtained data. In the graph drawing stage, they firstly released the car from a certain point of the ramp and recorded the speed of the car and repeated this operation a few more times and calculated average speed. Then, they repeated the same operation at different points that the board was 40, 60 and 80 centimeters away from the books and found the average speeds at those points and created the graphics through the obtained data. Afterwards, they released the car from different points of the ramp to calculate the flying off distance of the doll put on the car, recorded the distance at detected points and also calculated average distance. While answering these questions, students used mental processes like explanation, interrelating with two variables, generalization, prediction and inference. Additionally, they set up their own hypotheses based on the results and tested these hypotheses in consequence of experiments. After proving their predictions with making comments on the results, they answered the questions asked by their friends.

In the fifth, sixth and seventh lessons, activities that students collected data and made observation on photosynthesis process were performed. After determining unknowns in the light of data obtained from the internet, the students finalized the activity by using processes like comparison, association and cause and effect. For other activity, a lesson was taught in the science laboratory and science teacher of the institution also attended the lesson. The data about photosynthesis process and the experiment were not directly given to the students and open-ended questions were asked to provide them to reach these data through anticipation. Each student showed this process with figures after making the experiment. Within the activity, students showed these processes and hypotheses through drawings. Some of the answers of the students are as follows:

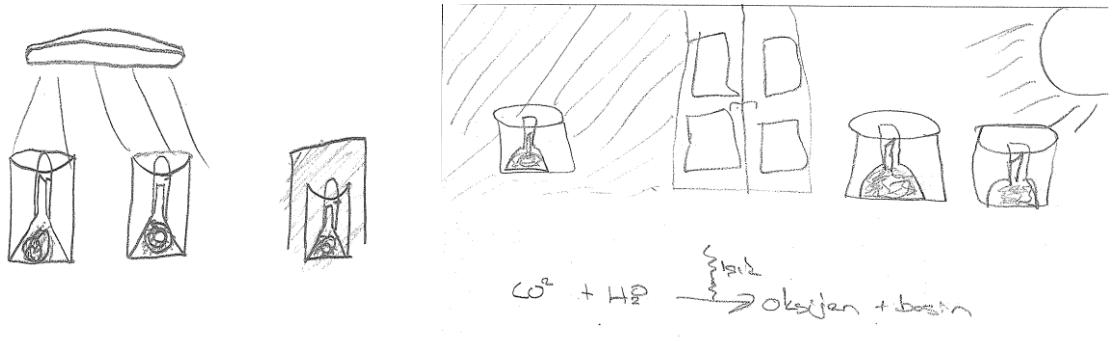

Figure 2. Photosynthesis process

In the next activity, graph reading practice and existing in the content were made and students benefited from the processes like arranging the data, classification and relating.

In the eighth activity, students watched a video about activity content. After answering activity questions, students were asked to write a paragraph about the subject within the frame of cause and effect relationship. Afterwards, students finalized the activity and presented their writings and explanations summarizing the activity to the class.

The content of the ninth activity was prepared intended for students to analyze scientific methods and set up hypotheses. After learning scientific method concepts like dependent and independent variables, determining control and experimental groups and constant, students performed designed experiments and commented obtained data. The tenth activity was prepared to understand the components of an experiment which looked at solving a scientific problem and at making preparation for the experiment in the next activity. During the activity, it was benefited from the processes, such as exploring the components of the activity, possible effect of some changes to the experiment and its results, showing data with graph, seeing the relationship between graphic data and interpretation. It was seen that the students had difficulty in graphing data, using the measures correctly and interpretation. The students created graphs through the researcher's guidance, reminding previous activity's graphs and clues. Afterwards, they analyzed and commented the graphs of each other. After every student arranged his/her graph in light of recommendations and comments, the activity was finalized. Some of the answers of the students about the implementation are as follows:

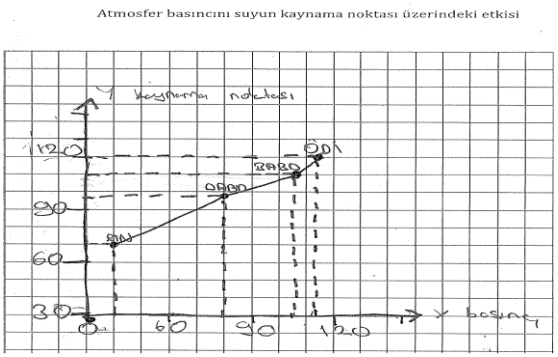


Figure 3. Pressure and boiling point relationship

In the eleventh and twelfth activities, the students designed and performed experiments based on their hypotheses. They repeated the same experiment a few times to observe the effects of changing conditions to the process and the result. Due to the necessity of recording the experiment's results in a few consecutive days, students came to SAC and recorded the data for three days. After recording stage, students met and every student presented his experiment to the class. The process was finalized after brainstorming and setting up cause and effect relationships about the results. Some of the answers of the students about the implementation are as follows:

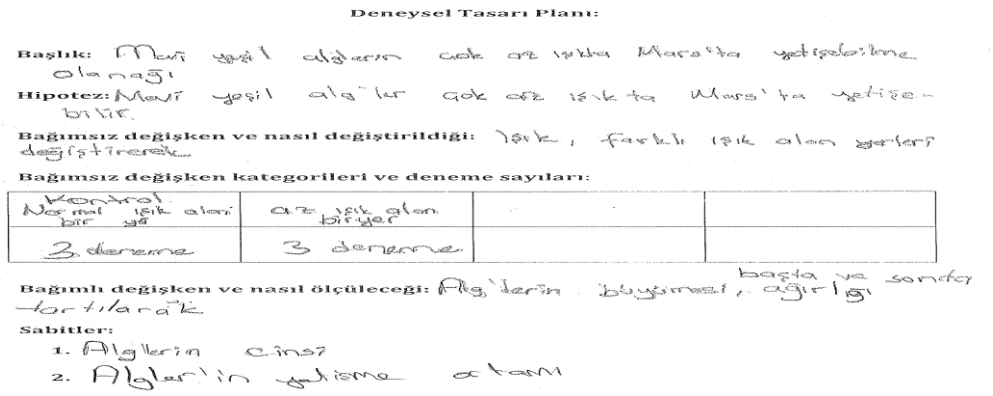


Figure 4. Experimental design plan

## 3. Results

### *3.1. Findings from pre- and post test scores related to students' critical thinking abilities*

Table 1. Descriptive statistics of group CCTSLX pre-test scores

| CCTSLX Pre-test | N | Number of materials | Mean | sd | Min. | Max. |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| Induction | 6 | 23 | 9.83 | 2.13 | 8 | 13 |
| Deduction | 6 | 24 | 12.16 | 3.48 | 10 | 19 |
| Hypothesizing | 6 | 10 | 4.16 | 1.83 | 2 | 7 |
| Observing and Questioning the Trustworthiness of the Source | 6 | 24 | 11.66 | 2.87 | 9 | 17 |
| Total Scores | 6 | 71 | 38.16 | 5.52 | 17 | 47 |

Table 2. Descriptive statistics of group CCTSLX post-test scores

| CCTSLX Post-test | Number of materials | Mean | sd | Min. | Max. |
|---|---|---|---|---|---|
| Induction | 23 | 17.00 | 2.82 | 14 | 22 |
| Deduction | 24 | 16.83 | 2.31 | 15 | 21 |
| Hypothesizing | 10 | 4.83 | 1.16 | 4 | 7 |
| Observing and Questioning the Trustworthiness of the Source | 24 | 14.66 | 2.65 | 10 | 18 |
| Total Score | 71 | 52 | 5.17 | 43 | 58 |

Table 3. Wilcoxon marked ranks test results related to CCTSLX and subscales

| | N | Induction | Deduction | Hypothesizing | Trustworthiness of the source | Post-test and pre-test |
|---|---|---|---|---|---|---|
| Z | 6 | -2.201 | -2.214 | -1.134 | -2.032 | -2.214 |
| p | 6 | 0.028 | 0.027 | 0.257 | 0.042 | 0.027 |

*Based upon negative ranks

*p<0.05 significance level

According to the results of the Wilcoxon Marked Ranks Test made to find out whether a difference between the students' CCTSLX arithmetic average exists or not, a statistically significant difference is discovered between the students' critical thinking scores, between test scores of students before and after the research. ($z = -2.214$; $p<0.05$). When the significance level is taken into account of the subscales ($p<0.05$), the differences between group's pre- and post-test arithmetic averages are found statistically significant in all subscales, except "Hypothesizing".

### *3.2. Findings from pre- and post-test scores related to students' scientific process abilities*

Table 4. Descriptive statistics of group SPAT pre- and post-test scores

| Group | N | Mean | sd | Min. | Max. |
|---|---|---|---|---|---|
| Pre-Test | 6 | 14.33 | 3.07 | 10.00 | 17.00 |
| Post-Test | 6 | 20.66 | 2.33 | 17.00 | 23.00 |

Table 5. Wilcoxon signed-ranks test results related to group's SPAT

| | N | Post-test and pre-test |
|---|---|---|
| Z | 6 | -2.214 |
| Significance level (p) | 6 | 0.027 |

*Based upon negative ranks

*p < 0.05 significance level

When the significance levels are taken into account, according to the results of the Wilcoxon Marked Ranks Test Results, which is made to find out whether a difference between the students' SPAT scores exists or not, a statistically significant difference is discovered between the students' SPAT score averages before and after the research ($z = -2.214$; $p < 0.05$).

### *3.3. The relationship between the students' scientific process abilities pre- and post-test scores and critical thinking abilities pre- and post-test scores*

Table 6. Spearman's rank differences correlation related to group SPAT pre- and post-test scores and CCTSLX Pre- and post-test scores

| | | CCTSLX pre-test | CCTSLX post-test |
|---|---|---|---|
| SPAT Pre-Test | Correlation Coefficient | -0.029 | - |
| | Significance | 0.957 | |
| | N | 6 | |
| SPAT Post-Test | Correlation Coefficient | - | 0.559 |
| | Significance | | 0.249 |
| | N | | 6 |

*p < 0.05 significance level

Spearman's Rank Differences Correlation calculation is made to determine the relationship between the group's SPAT pre- and post-test scores and CCTSLX pre- and post-test scores. Accordingly, the correlation coefficient, coming out from scientific process skills test and critical thinking pre-test, is found 0.029. The direction of the correlation is negative. When the correlation measures and gaps indicated by Büyüköztürk et al. (2013) are taken into account, we can say the relationship between CCTSLX pre-test and SPAT pre-test is on negative direction and low. When it comes to the significance level, it is seen that this relationship does not create a significant difference (p>0.05). According to the relationship between the students' SPAT and CCTSLX scores after the implementation, it is determined that this relationship is on positive direction and medium level with the value found 0.059. When we look at the significance level, this relationship also does not make a significant difference with regard to the findings (p>0.05).

### *3.4. The situation of the score average of the students' critical thinking abilities and scientific process abilities with regard to gender factor*

Table 7. Mann-Whitney U test results regarding group SPAT post-test scores with regard to gender factor

| Groups | N | Rank average | Rank total | U | P |
|---|---|---|---|---|---|
| Girls | 4 | 4.13 | 16.50 | 1.5 | 0.233 |
| Boys | 2 | 2.25 | 4.50 | | |

Due to low data amount in the group, it is tested whether a difference exists between two groups' averages using a not parametric comparison test called Mann-Whitney U, (Can, 2013). Accordingly, it is found a significant difference is not detected between the girls' and the boys' scores, in terms of scientific process abilities.

Table 8. Mann-Whitney U test results regarding group CCTSLX post-test scores with regard to gender factor

| | Grup | N | Rank average | Rank total | U | P |
|---|---|---|---|---|---|---|
| Induction | Girls | 4 | 4 | 16 | 2 | 0.355 |
| | Boys | 2 | 2.5 | 5 | | |
| Deduction | Girls | 4 | 4 | 16 | 2 | 0.340 |
| | Boys | 2 | 2.5 | 5 | | |
| Hypothesizing | Girls | 4 | 4.25 | 17 | 1 | 0.134 |
| | Boys | 2 | 2 | 4 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Observing | Girls | 4 | 4.13 | 16.5 | 1.5 | 0.240 |
| | Boys | 2 | 2.25 | 4.5 | | |
| Questioning the trustworthiness of the source | Girls | 4 | 4.13 | 16.5 | 1.5 | 0.240 |
| | Boys | 2 | 2.25 | 4.5 | | |
| Total score | Girls | 4 | 4.25 | 17 | 1 | 0.165 |
| | Boys | 2 | 2 | 4 | | |

After the Mann- Whitney U test which is performed to determine whether a significant difference between girls' and boys' critical thinking level scores in post-test implementation exists or not, it is seen that the difference is not statistically significant ($U=1$, $p > 0.05$).

### *3.5. The situation of the score averages of the students' critical thinking abilities and scientific process abilities with regard to parents' educational status*

Table 9. Kruskal-Wallis test results regarding group CCTSLX post-test scores with regard to mother's educational status

| Groups | N | Rank average | sd | $\chi^2$ | p |
|---|---|---|---|---|---|
| Primary school | 2 | 2.5 | 3 | 3.571 | 0.312 |
| Secondary school | 1 | 6 | | | |
| High school | 2 | 2.5 | | | |
| University | 1 | 5 | | | |

After the analysis, it is seen that students' critical thinking scores do not significantly differ with regard to mother's educational status factor. [$\chi 2\ (3) = 3.57$, $p > 0.05$].

Table 10. Kruskal-Wallis test results regarding group SPAT post-test scores with regard to mother's educational status

| Groups | N | Rank average | sd | $\chi^2$ | p |
|---|---|---|---|---|---|
| Primary school | 2 | 4.5 | 3 | 4.242 | 0.236 |
| Secondary school | 1 | 5.5 | | | |
| High school | 2 | 1.5 | | | |
| University | 1 | 3.5 | | | |

According to the results of Kruskal-Wallis test made regarding mother's educational status, it is seen that students' scientific process skills scores do not significantly differ with regard to mother's educational status factor. [$\chi 2$ (3) =4.24, p> 0.05].

Table 11. Kruskal-Wallis test results regarding group CCTSLX post-test scores with regard to father's educational status

| Groups | N | Rank average | sd | $\chi^2$ | p |
|---|---|---|---|---|---|
| Primary school | 1 | 6 | 3 | 2.571 | 0.463 |
| Secondary school | 2 | 3.5 | | | |
| High school | 2 | 2.5 | | | |
| University | 1 | 2 | | | |

According to the results of Kruskal-Wallis test made regarding father's educational status, it is seen that students' scientific process skills scores do not significantly differ with regard to father's educational status factor. [$\chi 2$ (3) =2.57, p> 0.05].

Table 12. Kruskal-Wallis test results regarding group SPAT post-test scores with regard to father's educational status

| Groups | N | Rank average | sd | $\chi^2$ | p |
|---|---|---|---|---|---|
| Primary school | 1 | 5.5 | 3 | 1.932 | 0.587 |
| Secondary school | 2 | 3.25 | | | |
| High school | 2 | 3.5 | | | |
| University | 1 | 2 | | | |

According to the results of Kruskal-Wallis test made regarding father's educational status, it is seen that students' scientific process ability scores not significantly differ according to father's educational status factor. [$\chi 2$ (3) =1.93, p> 0.05].

## 4. Discussion

In this study, the effect of the performed activities on critical thinking abilities level of the gifted students were tried to be explored by performing " Cornell Critical Thinking Test Level X ". With the analysis of data, between the pre- and post-test scores of the students who studied at 6th grade, a significant difference, in favor of the post-test, was discovered. While CCTSLX pre-test average scores of the students were 38.16, as a result of the performed activities, the post-test average score was found 52.00 out of 71 points. When the average scores of the gifted students who participated in the research were

compared with the findings of the studies that were made with the same students and used the same calculation tool (Kettler, 2012; Altıntaş, 2009; Sayı, 2013; İşlekeller, 2008; Bapoğlu, 2010), it is higher with regard to the other studies. Kettler (2012) made his studies with 4th grade students and the students got 44.91 points from the CCTSLX. In the study of Altıntaş (2009), 7th grade students firstly got 33.14 points and in the result of the activities that the researcher performed, this score rised up to 37.35. Additionally, the researcher detected that the activities he developed by using the three-staged Purdue model for the gifted students made a significant difference in the students' critical thinking test scores. When we consider this aspect, the findings of the study support the result of the first sub-problem of this research. Sayı (2013) firstly determined the average scores of the 5th grade students as 13.00 in the critical thinking test. Then, he identified this increasing average as 15.71. İşlekeller (2008) found the students', who are at 5th grade level in which Turkish education that bases critical thinking abilities applied, critical thinking scores as 32.08 and in the post-test this score is 36.08. When the significance of the difference between these two results was statistically tested, a significant difference was observed in terms of the critical thinking ability score averages. The findings of this study support the result of the first sub-problem of the research. In the studies, the critical thinking test score averages of the gifted students differed from each other. The sample formed of different students and the difference of grade levels might be shown among the reasons of different scores.

Within the frame of the activities performed as part of the research, the students showed critical thinking person behaviors, such as asking questions, questioning and researching the knowledge, analyzing the problems, making logical inferences, realizing the contradictions, creating their own ideas and explaining, discussing, and defending them, being able to evaluate both their own ideas and their friends' ideas, doing experiments and observations, expressing their observations in writing and drawing graphs. We can say that this situation contributes to improve the students' critical thinking abilities. It is thought that this significant difference occurs through the effect of the behaviors that the students showed during the study.

With the examination of the obtained data through the study, between SPAT pre-test and post-test scores of the group including 6th grade gifted students, a significant difference in favor of the post-test was detected. Çalıkoğlu (2014) also used the same measurement tool in the research he made with 4th grade gifted students. The researcher, in his study that he investigated the effect of the differentiated science education on the scientific process abilities of the students, specified that there was a significant difference in favor of the post-test between the SPAT pre-test and post-test scores of the students in the experiment group.

Vitti and Tores (2006) expressed that scientific process abilities are also applied in the situations in which critical thinking is essential and they are the abilities that we created in our minds while dividing our logical thoughts into the steps. In the activities performed in the research, the applications which will improve both critical thinking abilities and scientific process abilities of the students were performed. It was considered that this significant difference in favor of the post-test is derived from the students to complete the activities by using the basic and unified scientific process abilities like handling the problem situations in the performed activities proper to the scientific research steps, observing, measuring, prediction, inference, experimenting, identifying and controlling the variables, Hypothesizing, using the data, drawing graph and interpreting the data and all these positively contribute to the evolution of the scientific process abilities of the students.

The second sub-problem of the research was determined as "Is there a significant relation between the critical thinking ability pre-test - post-test scores and scientific process skills pre-test - post-test scores of the students?". With the examination of the obtained data, it was seen that there was not a significant relationship between critical thinking ability pre-test - post-test scores and scientific process skills pre-test - post-test scores of the group. The students who think critically use the scientific abilities like detecting the valid and invalid generalizations used in the scientific processes, analyze and evaluate the opinions, establish interdisciplinary relations, make reasonable comments, identify and evaluate the hypotheses (Demirel, 2004). Thereby, the usage of the similar scientific abilities in both thinking abilities, creates a positively significant relation expectation. In the study, when we considered the correlational relationship of both the pre-test and the post-test scores of the students, there was not a significant difference. However, when the post-test scores were examined, it was seen that the grade of the relation was positive and in medium level. When all the resources that the researcher had access to in Turkey and abroad were scanned, it was observed that the studies revealing the relationship between the scientific process skills of gifted students and critical thinking skills were also limited. However, if we consider the studies focusing on the different sample groups, we can see that Akar (2007 worked with the classroom teachers. Accordingly, he found that the relationship between critical thinking abilities and scientific process abilities of the students was weak and explained that there was a significant relationship which was not in an expected level. Koray, Köksal, Özdemir & Presley (2007), in the study in which they examined the relationship of the creative and critical thinking based laboratory exercises with the scientific process abilities of the teacher candidates, explored a positive and significant level difference.

The third sub-problem of the study was determined as "Do the critical thinking abilities and scientific process abilities score averages of the students differ with regard to the gender and the educational status of the parents?" With the examination of the obtained

data, it was seen that both the critical thinking abilities and the scientific process abilities of the group did not significantly differ with regard to the gender. The effect of the gender on scientific process abilities were examined in many different studies and different results were found. Dixon et al. (2005), in their study in which critical thinking abilities of 99 gifted students are compared on the texts that they wrote by hand and computer, specified that the female students got higher scores compared to male students. VanTassel-Baska and Stambaugh (2006) expressed that the gender effect on the scores of the gifted students in critical thinking and comprehension subjects was in an ignorable level. Kettler (2012), in his study in which he compared the critical thinking abilities of the gifted and ordinary students, explored that the relationship between gender difference and critical thinking ability was not significant. Bapoğlu (2010), in the study in which he similarly studies critical thinking levels of the gifted and ordinary students, expressed that the female students get higher scores in hypothesis subject than the male students, and except of hypothesis, the gender was not a significant difference.

With the examination of data related with the educational status of the parents, it was seen that both the critical thinking abilities and the scientific process abilities of the group did not make a significant difference with regard to the educational status of the parents. Bapoğlu (2010) explored the critical thinking levels of the gifted students with CCTSLX and, in the result of the analysis he made with regard to the variant mother's educational status, expressed that the scores of the students whose mothers graduated from a university or had a higher degree made a significant difference compared to the scores of the students whose mothers graduated from a high school. The difference between the ones whose mothers graduated from high school and the ones whose mothers had a lower educational level was accepted as a significant difference. Additionally, while it was signed that the differences were in favor of the children of the highly educated mothers, it was noticed that only the children of the mothers who graduated from college got higher scores compared to the children of the mothers who graduated from a university or had a higher level. In the same study, when the score average differences, with regard to the educational status of the fathers, were examined, in all scales, except of hypothesis subscale, it was seen that the scores of the students differed. When the aspect of the difference was examined, it was identified that the students whose fathers graduated from a university or had a higher level got higher scores compared to the students whose fathers graduated from an elementary school or a high school. With the increase of the educational status level of the parents, behalf of the student's studying conditions, technological possibilities, the increase of the sources of information and continuation of the education life consciously, it was thought to be an important variable. Hortaçsu (1995) specified that a highly educated father could be a teacher and provide guidance to his child in his lessons. In this study, even if it was determined that the educational status of the parents did not have a significant effect on the differentiation in

average scores of scientific process abilities and critical thinking abilities of the students, some researches in literature explored that the increase at the level of the educational status of the parents had positive contributions on the students' academic success and thinking abilities.

## 5. Conclusions

- Studies towards the effect of these activities to the superior thinking abilities such as creative thinking, reflective thinking, analytical thinking, problem solving, analyzing, synthesis, evaluation and decision making may be made.

- Same study may be performed with gifted students at different grades and an extended study group and its effects may be examined.

- The effect of the activities on the students may be studied with stronger experimental designs through the implementation of the study to different experimental designs.

- Through performing the same study with normal students and then comparing them to gifted students, similarities and differences between them may be explored and the reasons of the difference may be examined.

- Downing and Gifford (1996) reveal that the teacher candidates who have higher scientific process abilities are more active at the class and they ask higher level questions and point out the necessity that form teachers should also become sample in the researches. Therefore, SAC teachers may give in service education to develop their own scientific process abilities and provide the students with creating and performing similar activities to improve their superior cognitive abilities.

- Activities which can improve superior cognitive abilities should be developed with regard to the gains at all lessons, especially at Mathematics, and they should be added to the program.

- On the purpose of detecting the time-dependent effects of superior cognitive abilities' level and development and understanding the effects better, a longitudinal study may be performed with including primary school, secondary school, high school, and university.

- It is thought that this study is important in the way of being a source for SAC teachers. But the performers of this study are researchers, not branch teachers. After repeating the activity with the execution of branch teachers, it may be explored

whether any changes occur or not, and the cases stemming from the teachers may be observed.

- At the end of the study, students may be led to do a project, and/or they may be encouraged to design similar activities by taking their interests into consideration.

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