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The Effect of STEM-Based Activity Designed for Gifted Students on Students' Scientific Creativity and Cognitive Achievement*

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Abstract

This research aimed to determine the effect of STEM-based activity designed for gifted students on students' scientific creativity and cognitive achievement. Depending on this purpose a simple experimental method, which is one of the quantitative research approaches, was preferred. While the "Scientific Creativity Scale" was used to determine the effect of STEM-based activity designed for gifted students on students' scientific creativity, the "Academic Achievement Test" developed in the field of preferred subject matter was used as part of the research to determine the effect on cognitive achievement. SPSS 25.0 package program was used to analyze quantitative data collected in the form of pre-testing and post-testing. When evaluating the effect of STEM-based activity for gifted students on scientific creativity; the post-test scores obtained by the research group from the scientific creativity scale differed significantly from the pre-test scores. It has been concluded that the nature of STEM-based activity and the steps involved in the engineering design process have an impact on the relevant skill in making a meaningful difference in scientific creativity. When the effect of STEM-based activity developed for gifted students on cognitive achievement is evaluated; it was concluded that the post-test scores obtained from the cognitive achievement test of the research group differed significantly from the pre-test scores. In making a meaningful difference in cognitive achievement, STEM-based activity directs the student to research and question and provides meaningful-lasting learning.

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INTRODUCTION

Societies that are self-sufficient in the economic, technological, and scientific field, or who want to actively carry out the cycle between science (Levent, 2013), product, and materiality in all aspects, strive to educate individuals who can produce solutions to the scientific problems they face, using criteria such as creativity, critical thinking, and problem-solving in the production process, do not ignore the originality factor and try to come up with new designs using scientific knowledge (Cutts & Moseley, 2004). When the profiles of the individuals that societies strive to raise are considered, the importance of gifted individuals with more advanced cognitive abilities than their peers, which includes criteria such as creativity, critical thinking, problem-solving, and originality, becomes apparent to society (Ayverdi, 2018). Therefore, it becomes a necessity to give these individuals opportunities to develop their skills, maximize their cognitive capacity use and meet their educational needs. When the educational studies carried out to support the development of gifted students and meet their educational needs are examined; Training strategies such as grouping, acceleration, enrichment, and mentoring and training models such as the maker model, Purdue model, Renzulli model, Grid model, Gifted Training Program model, Unlimited Capabilities model, and Autonomous Learning model are found. Although it supports the development of gifted individuals, it needs to be updated and adapted depending on the requirements of the age in the 21st century, called the technology age, given the periods and contents of the emergence of the relevant strategies and models. Given the motto of development and change brought about by the 21st century; It would not be wrong to say that approaches created by bringing together various disciplines, responding to technological developments, and providing comprehensive integration are needed within the educational process to be offered to gifted individuals. This situation has made it inevitable for the STEM approach, which brings together the disciplines of science-technology-engineering and mathematics, to have the potential to respond to technological developments and have an important role in gaining skills that are described as 21st-century skills, to enter the education lives of individuals with special abilities.

The STEM approach, which is an approach that brings together science, mathematics, technology, and engineering disciplines (Bybee, 2010), is very important in ensuring the integration of technology and engineering into the educational process in this age, which is described as the information and communication age, in gaining an interdisciplinary perspective of individuals and in making information meaningful (Holdren, Lander, & Varmus, 2010). The perspective gained and the knowledge that becomes meaningful enable individuals to acquire skills in areas such as creative thinking, critical thinking, and problem-solving strategies and create opportunities for them to enrich themselves culturally and intellectually. This opportunity will be reflected in the scientific and academic research carried out, and it is seen that studies on STEM education are carried out in various subject areas and from different perspectives. When the studies carried out on STEM education or STEM approach are examined; cognitive achievement in STEM (Acar, 2018; Becker & Park, 2011; Bircan, 2019; Ceylan, 2014; Dogan, 2019; Eroglu, 2018; Han, 2013; Higde, 2018; Irkicatal, 2016; Koroglu, 2019; McKinnon, 2018; Sarican, 2017; Tabaru, 2017; Tastan-Akdag, 2017; Wai, Lubinski, Benbow, & Steiger, 2010; Yildirim, 2016; Yildirim & Altun, 2015), meaningful learning in STEM (Kocyigit, 2019; Tseng, Chang, Lou, & Chen, 2011), scientific process skills in STEM (Alan, 2017; Alan, 2020; Ayverdi, 2018; Cotabish, Dailey, Robinson, & Hughes, 2013; Dogan, 2019; Sacan, 2018; Tabaru, 2017; Tastan-Akdag, 2017; Yamak, Bulut & Dundar, 2014; Yildirim, 2016), critical thinking skill in STEM (Acar, 2018; Duran & Sendag, 2012; Hacioglu, 2017), student engagement in STEM (Hedrick, Dizen, Collins, Evans, & Grayson, 2010), STEM profession (Higde, 2018; Karakaya, 2017; Kiriktas, 2019; Kizilay, 2018; Koroglu, 2019; Tseng et all., 2011), motivation in STEM (Higde, 2018; Kizilay, 2018), engineering skill in STEM (Ayverdi, 2018), learning perception in STEM (Gulhan, 2016; Koc, 2019; Reisslein, Moreno, & Ozogul, 2010), problem-solving in STEM (Acar, 2018; Alan, 2017; Bicer, Nite, Capraro, Barrosso, Capraro, & Lee, 2017; Ceylan, 2014; Koc, 2019; Sarican, 2017; Tabaru, 2017), attitude in STEM (Bircan, 2019; Dogan, 2019; Gulhan, 2016; Irkicatal, 2016; Ismail, Zain, & Zin, 2019; Kiriktas, 2019; Kocyigit, 2019; Koroglu, 2019; Lou, Shih, Die, & Tseng, 2011; Sacan, 2018; Toma & Greca, 2018; Yamak et all., 2014; Yildirim, 2016; Zhou, Zeng, Xu, Chen, & Xiao, 2019) and creativity in STEM (Ayverdi, 2018; Bicer et all, 2017; Ceylan, 2014; Eroglu, 2018; Gulhan, 2016; Hacioglu, 2017). Additionally, it is seen that the necessity of ensuring the integration of STEM activities into the education and training process (Gul, 2019; Lin, Hsiao, Williams, & Chen, 2020; Okulu, 2019; Shahali, Halim, Rasul, Osman, & Arsad, 2019; Tunc, 2019; Ustu, 2019; Yazar, 2019), the perception of STEM education (Jeong & Kim, 2015; Kiriktas, 2019; Knezek, Christensen, Wood, & Periathiruvadi, 2013; Lee et all, 2012; Marulcu & Sungur, 2012), the views on STEM activities (Karahan, Canbazoglu-Bilici & Unal, 2015), the effect of STEM education on interest (Hsu, Lin, & Yang, 2017) and the intentions of the STEM (Lin & Williams, 2016) are determined. When the literature is examined considering the gifted individuals and the STEM approach; It is seen that the effect of the STEM approach on the knowledge status of gifted individuals towards natural sciences (Robinson, Dailey, Hughes, & Cotabish, 2014), scientific process skills (Ayverdi, 2018), 21st-century skills (Kulegel, 2020), creativity (Ozcelik, 2017), mental models for STEM (Mullet, Kettler, & Sabatini, 2018) and attitude towards the concept of engineering (Koyunlu-Unlu & Dokme, 2017) has been determined.

Few and far between were studies in which the skills and competence areas of gifted individuals were considered together, and the effect of STEM was evaluated. However, considering the skill such as critical thinking, creativity, and problem-solving that STEM activities carried out based on the engineering design process try to provide to individuals, it would not be wrong to state the characteristics that distinguish gifted individuals from other individuals. The characteristics that STEM education tries to be learning outcomes coincide with the characteristics of gifted individuals. Concordantly, applications that will support competence and talent development should be carried out. Considering the situation mentioned within the scope of the research, it is aimed to determine the effect of STEM activity on scientific creativity and critical thinking skills within the skills and cognitive achievement within the field of mental activity of gifted students. For this purpose, it was tried to support the development of the competence and ability areas of gifted students who can produce solutions to the scientific problems encountered, and who can use criteria such as scientific creativity, critical thinking, problem-solving, and originality in the process of producing solutions and who strive to put forward new designs by using scientific knowledge. On the other hand, the fact that activities will be carried out based on science-technology-engineering-mathematics understanding will also enable gifted students to grow up as "engineer students". It is thought that this situation can enable the training of individuals who can put forward original ideas, who can make entrepreneurial designs by assimilating the process of producing scientific solutions, and thus contribute to the economic and social status of our country.

STEM-BASED ACTIVITY AND SCIENTFIC CREATIVITY

The concept of scientific creativity, which is conceptually different from the concept of creativity, is influenced by values such as intelligence, knowledge, learning style, personality, and motivation (Hu & Adey, 2002), which are scientifically put into work at each stage from the definition of the problem to the design put forward for its solution (Samuels & Seymour, 2015) and the blending of the individual's knowledge from the scientific dimensions. Ambruso (2003) related the concept of scientific creativity with the scientific ability and scientific process and stated that scientific creativity has an important role in processes such as defining problems, establishing hypotheses, and conducting experiments, just like a scientist. Similarly, Lin, Hu, Adey & Shen (2003) mentioned the relationship between scientific creativity and talent and stated that creativity is based on scientific assumptions in terms of technique and knowledge. Zhang, Liu & Lin (2002) stated that the concept of scientific creativity is found in individuals who think about scientific dogmas and can take initiative and that it is the ability that is actively used in the problem-solving process. Samuels and Seymour (2015), who stated that STEM education has positive effects on scientific creativity and problem solving, stated that the basis of STEM education is to carry out applications through the problem, and in this process, students' curiosity is attracted to the subject area and their scientific creativity is put to work and students can develop strategies in the dimension of solution. Hu and Adey (2002) mentioned that scientific creativity takes place at the intersection dimension of the integrity formed by the combination of science, technology, and other disciplinary, which are considered as separate clusters. In this sense, it is important to consider the dimensions of the interdisciplinary approach called STEM holistically in terms of the use and development of scientific creativity. Doppelt (2009) stated that this situation is achieved through a process consisting of 6 stages for the use and development of scientific creativity in STEM education. In the first stage, it is a case of determining the objectives of the design for the solution of the problem. To reveal the objectives of the design, it is necessary to reveal the problem in detail, determine the limitations, and make sense of the needs. In the second stage, it is a collection of information areas for the solution of the problem. Information for each of the STEM fields needs to be conceptualized and research resources need to be used appropriately to solve the problem. In the third stage, it is necessary to make inferences about the solution to the problem. At this stage, ideas that can be derived for the solution of the problem are put forward rather than the right or wrong idea. Solution proposals that can be produced from ideas are important for the next stage. In the fourth stage, it is a matter of choosing the optimal solution from the solution proposals put forward. The important thing is that the solution is aimed at the solution of the problem and that the advantages and disadvantages are evaluated holistically. In the fifth stage, it is a matter of selecting and creating the appropriate methods and techniques for the chosen solution path. From drawing the solution to creating the prototype, all processes occur in this process. In the last stage, it is necessary to evaluate whether the design is aimed at solving the problem. When all the steps are taken into consideration, it is seen how effective the engineering design process is on scientific creativity and that they have a structure that can be mapped as steps.

STEM-BASED ACTIVITY AND COGNITIVE ACHIEVEMENT

Cognitive achievement is an indicator of the competencies and competencies of individuals in the event, situation, or subject area and is expressed in the literature as academic achievement or success. Cognitive achievement can be based on a learning outcome, a goal, or a purpose, or it can be directed to a subject area. Therefore, the existence of knowledge, skills, and competence areas in cognitive achievement should not be forgotten. In other words, the cognitive achievement is not the answers given to the questions posed to the individual. Cognitive achievement is the recruitment of knowledge, skill areas, and competencies in the questions asked. In this sense, since the individual's success status in the relevant subject area will be quantitatively revealed in the evaluation of cognitive success, the measurement tool created to evaluate cognitive success should have competence in terms of hardware and content. In addition, accumulation, skill, and competence criteria should be taken into consideration in the applications carried out to improve the cognitive success of the individual (Lemelin et al., 2007).

When the literature on whether STEM education affects increasing the cognitive achievement of individuals by developing their knowledge, skill areas, and competencies is examined, the meta-analysis study conducted by Becker and Park (2011) reveals the relationship between STEM and academic achievement summarizes the situation. In the research conducted on the key concepts of STEM and cognitive achievement using various search engines, 28 studies were found. With the effect of the interdisciplinary understanding of STEM education, it has been revealed that meaningful differences occur in students' learning, affect skill development, and gain competence and thus provide the development of cognitive success. In addition, since STEM education provides a rich learning environment to the student, it is stated that it has a positive effect on interest, motivation, and attitude factors as well as cognitive achievement. Concordantly, it would not be wrong to say that the rich conceptuality and holistic features of STEM have a positive effect on cognitive achievement.

METHOD

RESEARCH DESIGN

This study was aimed to determine the effect of STEM activity designed for gifted students on students' scientific creativity and cognitive achievement. Depending on this purpose; (1) Application of pre-tests to determine the scientific creativity and cognitive achievement of gifted students, (2) Conducting the STEM activity process with the teaching material designed for gifted students, (3) Applying post-tests to determine the scientific creativity and cognitive achievement of gifted students at the end of the application process, and (4) Evaluating the effect of STEM activity on scientific creativity and cognitive achievement. In the realization of the relevant steps, the simple experimental method, which is one of the quantitative research approaches, was preferred. In simple experimental method research carried out on only a single research group without a control group, the situation of the group before the application process and the situation after the application process are evaluated by comparing them. Therefore, in the simple experimental method, the responsibilities fulfilled in the application process are evaluated (Trochim, 2001). Within the scope of the research, the expectation of evaluating the effect of the process by comparing the scientific creativity and cognitive achievement situations before the STEM activity with the teaching material designed for gifted students and the situations after the application process appropriated the use of the simple experimental method.

PARTICIPANTS

In the fall semester of the 2019-2020 academic year, it was carried out on a total of 24 students studying in the ITR (Individual Tw Program at the science and art center in the city center of Trabzon. In the conduct of the ITR Program on the students studying: (i) The preferred subject is given to the students at the 6th grade level as an achievement in the science course curriculum, (ii) The absenteeism problems of the students in other groups and the attendance status in the activities to be carried out in steps in the process is an important variable, and (iii) the teachers who are performing their teaching duties at science and art center are expressing that it would be appropriate to choose the ITR Program.

In the selection of the students studying in the ITR Program, all the students in the ITR program who are studying at the science and art center on the days and times determined by the researcher without any criteria are included in the research process. The information of the participants is presented in Table 1.

Table 1. *The Demographics of the Recruited Study Participants*

Participant	*Gender*	*Age*	*Grade Level*	*Participant*	*Gender*	*Age*	*Grade Level*
P1	Female	13	6th-grade level	P13	Male	13	6th-grade level
P2	Female	13	6th-grade level	P14	Male	14	6th-grade level
P3	Female	14	6th-grade level	P15	Male	14	6th-grade level
P4	Female	13	6th-grade level	P16	Male	13	6th-grade level
P5	Female	14	6th-grade level	P17	Male	14	6th-grade level
P6	Female	13	6th-grade level	P18	Male	13	6th-grade level
P7	Female	14	6th-grade level	P19	Male	14	6th-grade level
P8	Female	13	6th-grade level	P20	Male	13	6th-grade level
P9	Female	13	6th-grade level	P21	Male	13	6th-grade level
P10	Female	13	6th-grade level	P22	Male	14	6th-grade level
P11	Female	13	6th-grade level	P23	Male	13	6th-grade level
P12	Female	14	6th-grade level	P24	Male	14	6th-grade level

When examining Table 1, it is seen that the research was carried out with a total of 24 students studying in the ITR Program. The fact that the number of men and women in the student group is equal has been an important parameter for the gender variable to affect the results, although it is a situation that occurred randomly.

DATA COLLECTION TOOLS

While the "Scientific Creativity Scale" was used to determine the effect of the STEM activity designed for gifted students on the scientific creativity variable of the students, the "Academic Achievement Test" developed in the preferred subject area was used in the context of the research to determine the effect on cognitive achievement.

SCIENTIFIC CREATIVITY SCALE

For the scientific creativity dimension, which is one of the variables to be evaluated within the scope of the research, the scale developed by Hu and Adey (2002) and adapted into Turkish, and the study of its use was carried out by Deniş-Çeliker and Balım (2012). This scale consists of 7 open-ended questions and 7 sub-dimensions. The first question is about different uses, the second question is about problem discovery, the third question is about product development, the fourth question is about imagination, the fifth question is about problem-solving, the sixth question is about creative ability, and the seventh question is about product design. In each question, gifted students were expected to answer the problem situation using their scientific creativity. When the content of the questions was examined, the quality of the answer was examined instead of being true or wrong. In the qualification examination process, fluency, flexibility, and originality criteria were taken into consideration.

COGNITIVE ACHIEVEMENT

For the cognitive achievement dimension to be evaluated within the scope of the research, the "Alternative Energy Sources Success Test" developed by Ergin (2010) was used. The achievement test consists of a total of 20 questions, 16 of which are multiple choice and 4 of which are open-ended. In multiple-choice questions, 5 points were given for each correct answer, while in open-ended questions, evaluation was provided over 5 points depending on the theme creation process. In the creation of the content of the questions, the achievements of the curriculum of the science course were taken into consideration and the aim of the curriculum was focused on the acquisitional objectives that the curriculum aimed to provide to the students.

PROCEDURES

For the scientific creativity variable, the measurement tool developed by Hu and Adey (2002) and adapted to Turkish by Denis-Celiker and Balim (2012) was used. In the applications carried out in the form of pre-test – post-test, data collection was provided individually to prevent students from being affected by each other. Students were given approximately 30 minutes to complete the data collection tool, which consisted of a total of 7 questions. It is stated that the accuracy or inaccuracy criterion is not sought in the answers they will give in the measurement tool, and therefore they should answer using their scientific knowledge.

For the cognitive achievement variable, the "Alternative Energy Sources Success Test" developed by Ergin (2010) was used. Students were given 25 minutes in the process of collecting data with the measurement tool, 16 of which consisted of multiple choice and 4 open-ended questions. It is stated that the first 16 questions will be scored as correct or incorrect answers and the last 4 questions will be evaluated depending on their scientific knowledge and mental models. Students were given 25 minutes in the process of collecting data with the measurement tool, 16 of which consisted of multiple choice and 4 open-ended questions. It is stated that the first 16 questions will be scored as correct or incorrect answers and the last 4 questions will be evaluated depending on their scientific knowledge and mental models.

On the other hand, the applications carried out with the students in the ITR Program were carried out by the vertical enrichment strategy and as an educational model, it was determined that the features of the grid model were more suitable for STEM application.

DATA ANALYSIS

In the process of analyzing the quantitative data collected in the form of pre-test and post-test, SPSS 25.0 package program was used. In the analysis process, it was first determined which test method would be used in the analysis of the data obtained from each measurement tool. In this context, normality analysis was used. In the normality analysis, the Kolmogorov-Smirnov test is used if the number of participants is greater than 50 and the Shapiro-Wilk test is used if the number of participants is less than 50 (Razzali & Wah, 2011). Within the scope of the study, since the sample group was 24 people, it was decided to use the Shapiro-Wilk test to determine whether the data were distributed normally. As a result of the Shapiro-Wilk test, it was taken into consideration that if the normality value of the pre-test and post-test result of a single sample group is less than .05, the "Wilcoxon Marked Rows Test", which is one of the nonparametric tests, and if it is greater than .05, the analysis should be carried out with the "Associated Samples t-Test", which is one of the parametric tests. The results of the Shapiro-Wilk test of the difference scores that occurred by considering the difference between the final test scores and the preliminary test scores to evaluate the normal distribution status of the variables to be examined within the scope of the research are presented in Table 2.

Table 2. *Shapiro-Wilk Test Results for the Variables Considered in the Research*

	Shapiro-Wilk			
Variable	*Sub-Dimension*	*Statistics*	*sd*	*Significance*
Scientific Creativity	Different Use	,937	24	,136
	Exploring the Problem	,918	24	,060
	Product Development	,893	24	,010
	Imagination	,845	24	,020
	Solving the Problem	,867	24	,000
	Creative Talent	,681	24	,000
	Product Design	,865	24	,000
	Total	,986	24	,615
Cognitive Achievement	-	,975	24	,798

When examining Table 2, the variables considered within the scope of the research, scientific creativity, and cognitive achievement difference scores; "Associated Samples t-Test" was used in the analysis process of the relevant variables depending on the normality value of the result being greater than .05 in the sub-dimensions of scientific creativity variable and exploration of the problem, while "Wilcoxon Marked Sequences Test" was used in the analysis process of the relevant variables depending on the normality value of the result being less than .05 in the dimensions of product development, imagination, problem-solving, creative ability and product design. In the normality evaluation of the total difference scores of the scientific creativity variable, it was decided to use the "Associated Samples t-Test" in the analysis process of the relevant variable depending on the fact that the relevant result was greater than .05.

Similarly, in the normality evaluation of the cognitive achievement difference scores, which is the other variable considered within the scope of the research, it was decided to use the "Associated Samples t-Test" in the analysis process of the relevant variable depending on the fact that the relevant result was greater than .05. In the analysis procedures carried out, Cohen's D effect size was calculated depending on the fact that the value obtained from the Shapiro-Wilk test was greater than .05 and the value obtained from the associated samples t-test applied depending on this size was significant. In the interpretation made; If the value is less than .15, it is considered to be insignificant, between .15 and .40 it is considered to be at a small level, between .40 and .75 it is moderate, between .75 and 1.10 it is considered to be at a wide level, between 1.10 and 1.45 it is considered to be at a very wide level, and if it is greater than 1.45, it is considered to be effective at a perfect level (Dincer, 2014).

VALIDTY AND RELIABLITY

The validity and reliability analyses of the measurement tools were carried out by applying the scientific creativity scale and cognitive achievement test on another group (n=12) with similar qualifications with the sample group. In the validity factor of the measurement tools, content, predictive, construct and face validities were taken into consideration. Cronbach Alpha technique was used in the reliability analysis of the measurement tools. The value of scientific creativity scale determined by Cronbach Alpha technique was calculated as .80 and the value of cognitive achievement test determined by Cronbach Alpha technique was calculated as .71.

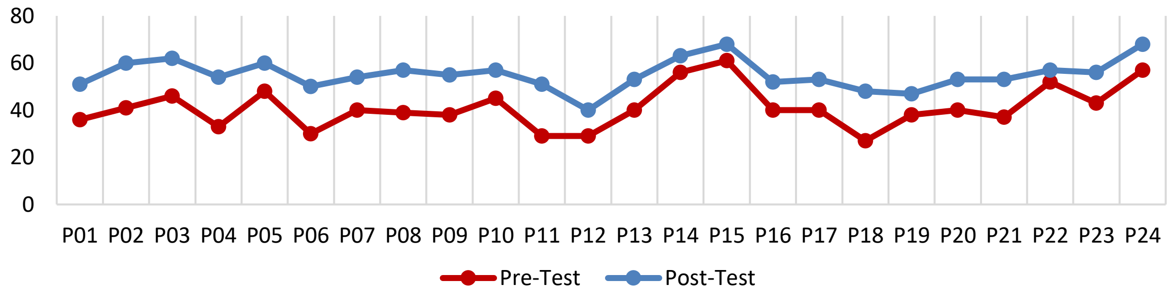
FINDINGS/RESULTS

The effect of the STEM activity designed for gifted students on the scientific creativity variable of the students and the effect on cognitive success are discussed separately and explained below.

THE EFFECT OF STEM-BASED ACTIVITY ON SCIENTIFIC CREATIVITY

To determine the effect of STEM-based activity designed for gifted students on scientific creativity, the data of the total pre-test scores and total post-test scores obtained by the participants from the data collection tool consisting of seven questions are presented in Chart 1.

Chart 1. *Participants' Score Values from The Scientific Creativity Scale*



As explained in Chart 1, it is seen that the total post-test score values obtained by the participants from the scientific creativity scale are higher than the total pre-test score values. The fact that this situation is in favour of the post-test test can be accepted as an indication that the practices carried out produce meaningful results. To evaluate whether the scores obtained by the participant group from the scientific creativity scale produced statistically significant results, the dependent t-test was applied considering the normal distribution of the data, and the results obtained were presented in Table 3.

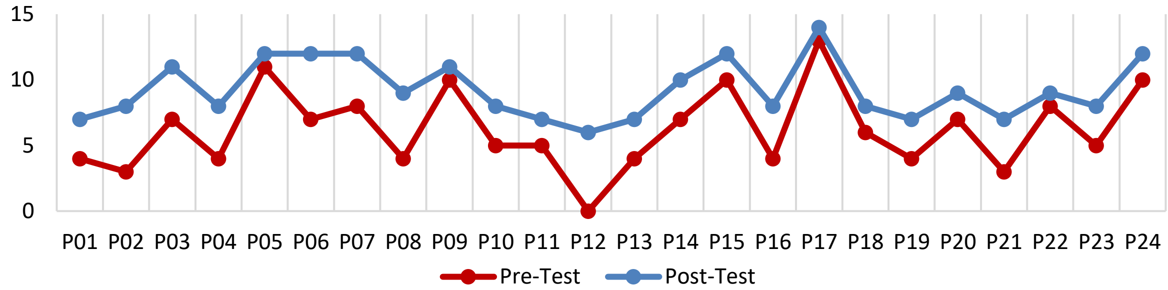
Table 3. *Results of Dependent T-Test Regarding Students' Scientific Creativity Scores*

Scientific Creativity	*n*	$\bar{X}$	*ss*	*sd*	*t*	*p*
Pre-Test	24	41,04	8,92	23	14,82	.00
Post-Test	24	55,08	6,37			

When examining Table 3, it is revealed that there is a significant difference in the scientific creativity of the participants after the implementation of the STEM-based activity designed for gifted students, t(23)=14,82, p<.05. On the other hand, Cohen's D effect size was calculated and found to be 3.03 to determine the difference in significance between the participants' pre-test and post-test scores. It can be stated that the difference is due to excellent STEM-based activity.

The first sub-dimension of the scientific creativity scale is different use. The data of the pre-test scores and post-test scores obtained by the participants depending on their answers to the first question of the measurement tool are presented in Chart 2.

Chart 2. *Participants' Score Values from The Different Use Sub-Dimension*



As explained in Chart 2, it is seen that the post-test score values obtained by the participants from the different usage sub-dimensions are higher than the pre-test score values. The fact that this situation is in favor of the post-test can be accepted as an indication that the practices carried out produce meaningful results. To evaluate whether the scores obtained by the participant group from different use sub-dimension of the scientific creativity scale produced statistically significant results, the dependent t-test was applied considering the normal distribution of the data, and the results obtained were presented in Table 4.

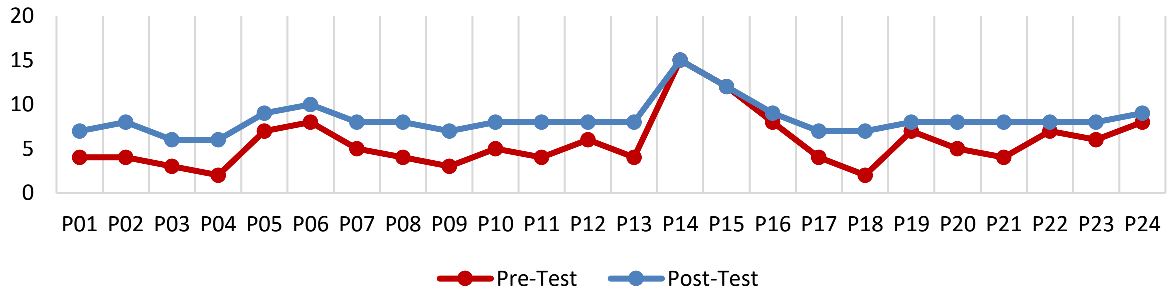
Table 4. *Results of Dependent T-Test Regarding Students' Different Use Scores*

Different Use	*n*	$\bar{X}$	*ss*	*sd*	*t*	*p*
Pre-Test	24	6,20	3,05	23	10,42	.00
Post-Test	24	8,58	2,28			

When examining Table 4, it is revealed that there is a significant difference in the different use of the participants after the application of STEM activity to the group, t(23)= 10,42, p<.05. On the other hand, Cohen's D effect size was calculated and found to be 2.13 to determine the difference in significance between the participants' pre-test and post-test scores. It can be stated that the difference is due to excellent STEM-based activity.

The second sub-dimension of the scientific creativity scale is exploring the problem. The data of the pre-test scores and post-test scores obtained by the participants depending on their answers to the second question of the measurement tool are presented in Chart 3.

Chart 3. *Participants' Score Values from The Exploring the Problem Sub-Dimension*



As explained in Chart 3, it is seen that the post-test score values obtained from exploring the problem sub-dimension of all other participants, except for the score values of the participant with the code P15, are higher than the pre-test score values. To evaluate whether the scores obtained by the participant group from exploring the problem sub-dimension of the scientific creativity scale produced statistically significant results, the dependent t-test was applied considering the normal distribution of the data, and the results obtained were presented in Table 5.

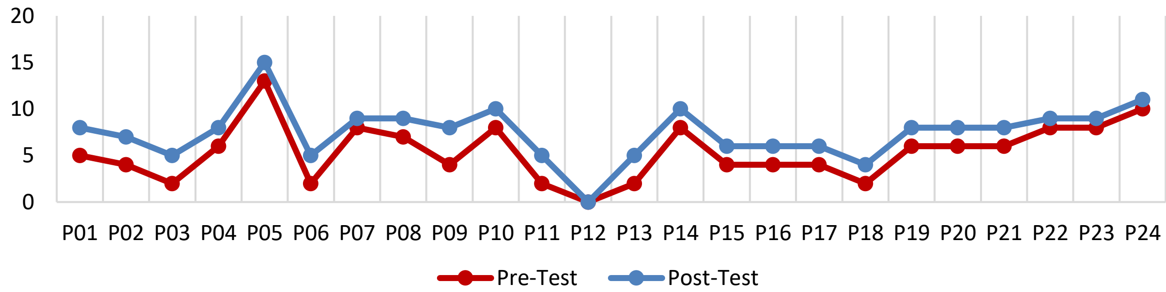
Table 5. *Results of Dependent T-Test Regarding Students' Exploring the Problem*

Exploring the Problem	*n*	$\bar{X}$	*ss*	*sd*	*t*	*p*
Pre-Test	24	5,70	3,02	23	9,13	.00
Post-Test	24	8,33	1,88			

When examining Table 5, it is revealed that there is a significant difference in exploring the problem of the participants after the application of STEM activity to the group, t(23)= 10,42, p<.05. On the other hand, Cohen's D effect size was calculated and found to be 1.86 to determine the difference in significance between the participants' pre-test and post-test scores. It can be stated that the difference is due to excellent STEM-based activity.

The third sub-dimension of the scientific creativity scale is product development. The data of the pre-test scores and post-test scores obtained by the participants depending on their answers to the third question of the measurement tool are presented in Chart 4.

Chart 4. *Participants' Score Values from The Product Development Sub-Dimension*



As explained in Chart 4, it is seen that the post-test score values obtained from the product development sub-dimension of all other participants, except for the score values of the participant with the code P12, are higher than the pre-test score values. To evaluate whether the scores obtained by the participant group from the product development sub-dimension of the scientific creativity scale produced statistically significant results, the Wilcoxon signed-ranks test was applied considering the non-normal distribution of the data, and the results obtained were presented in Table 6.

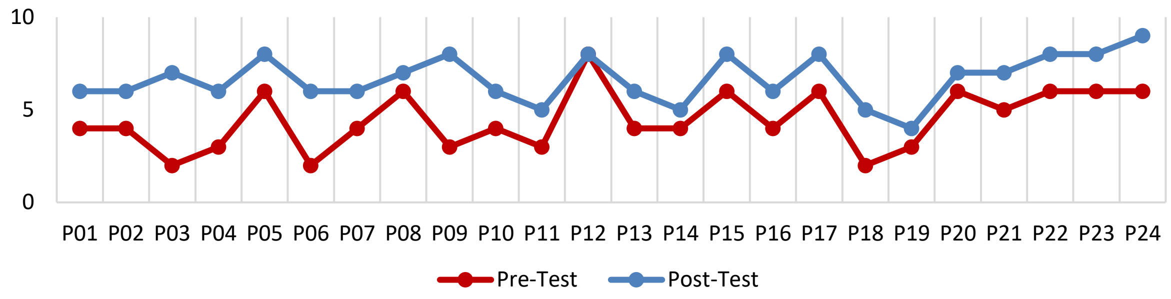
Table 6. *Results of Wilcoxon Signed-Ranks Test Regarding Students' Product Development*

Product Development	*n*	*Mean Rank*	*Sum of Ranks*	*z*	*p*
Negative Ranks	0	,00	,00		
Positive Ranks	23	12,00	276,00	-4,28	.00
Ties	1				

When examining Table 6, it is revealed that there is a significant difference in the product development of the participants after the STEM-based activity designed for gifted students is applied to the group (z=4,28, p<.05). When the pre-test and post-test scores of the participants for the product development sub-dimension were evaluated, it was determined that the significant difference that occurred was in favor of positive ranks, that is, the post-test scores.

The fourth sub-dimension of the scientific creativity scale is imagination. The data of the pre-test scores and post-test scores obtained by the participants depending on their answers to the fourth question of the measurement tool are presented in Chart 5.

Chart 5. *Participants' Score Values from The Imagination Sub-Dimension*



As explained in Chart 5, it is seen that the post-test score values obtained from the imagination sub-dimension of all other participants, except for the score values of the participant with the code P12, are higher than the pre-test score values. To evaluate whether the scores obtained by the participant group from the imagination sub-dimension of the scientific creativity scale produced statistically significant results, the Wilcoxon signed-ranks test was applied considering the non-normal distribution of the data, and the results obtained were presented in Table 7.

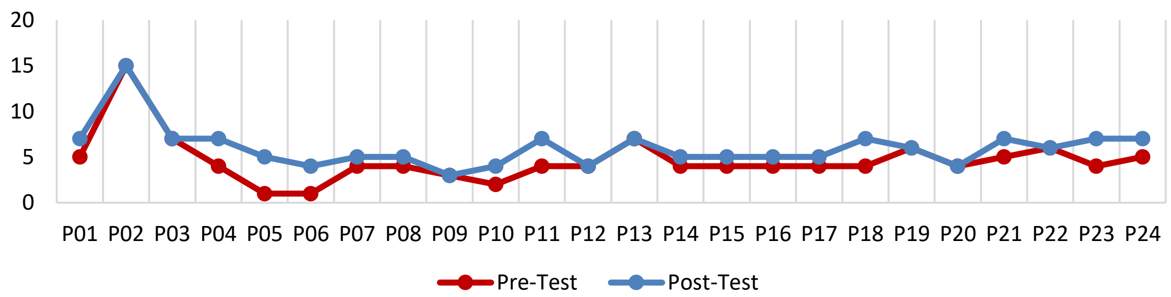
Table 7. *Results of Wilcoxon Signed-Ranks Test Regarding Students' Imagination*

Imagination	*n*	*Mean Rank*	*Sum of Ranks*	*z*	*p*
Negative Ranks	0	,00	,00		
Positive Ranks	23	12,00	276,00	-4,29	.00
Ties	1				

When examining Table 7, it is revealed that there is a significant difference in the imagination of the participants after the STEM-based activity designed for gifted students is applied to the group (z=4,29, p<.05). When the pre-test and post-test scores of the participants for the imagination sub-dimension were evaluated, it was determined that the significant difference that occurred was in favor of positive ranks, that is, the post-test scores.

The fifth sub-dimension of the scientific creativity scale is solving the problem. The data of the pre-test scores and post-test scores obtained by the participants depending on their answers to the fifth question of the measurement tool are presented in Chart 6.

Chart 6. *Participants' Score Values from The Solving the Problem Sub-Dimension*



As explained in Chart 6, it is seen that the post-test score values obtained from solving the problem sub-dimension of all other participants, except for the score values of the participants with the codes P02, P03, P09, P12, P13, P19, P20, and P22, are higher than the pre-test score values. To evaluate whether the scores obtained by the participant group from solving the problem sub-dimension of the scientific creativity scale produced statistically significant results, the Wilcoxon signed-ranks test was applied considering the non-normal distribution of the data, and the results obtained were presented in Table 8.

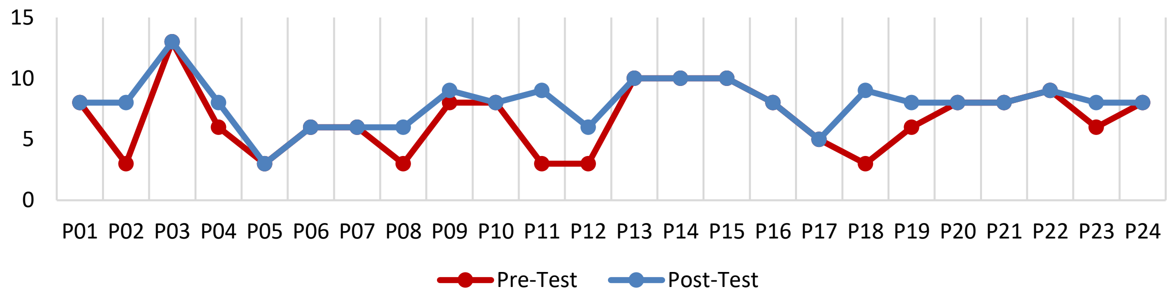
Table 8. *Results of Wilcoxon Signed-Ranks Test Regarding Students' Solving the Problem*

Solving the Problem	*n*	*Mean Rank*	*Sum of Ranks*	*z*	*p*
Negative Ranks	0	,00	,00		
Positive Ranks	16	8,50	136,00	-3,55	.00
Ties	8				

When examining Table 8, it is revealed that there is a significant difference in solving the problem of the participants after the STEM-based activity designed for gifted students is applied to the group ($z=3,55$, $p<.05$). When the pre-test and post-test scores of the participants for solving the problem sub-dimension were evaluated, it was determined that the significant difference that occurred was in favor of positive ranks, that is, the post-test scores.

The sixth sub-dimension of the scientific creativity scale is creative talent. The data of the pre-test scores and post-test scores obtained by the participants depending on their answers to the sixth question of the measurement tool are presented in Chart 7.

Chart 7. *Participants' Score Values from The Creative Talent Sub-Dimension*



As explained in Chart 7, it is seen that the post-test score values obtained from the creative talent sub-dimension of all other participants, except for the score values of the participants with the codes P01, P03, P05, P06, P07, P10, P13, P14, P15, P16, P17, P20, P21, P22, and P24, are higher than the pre-test score values. To evaluate whether the scores obtained by the participant group from the creative talent sub-dimension of the scientific creativity scale produced statistically significant results, the Wilcoxon signed-ranks test was applied considering the non-normal distribution of the data, and the results obtained were presented in Table 9.

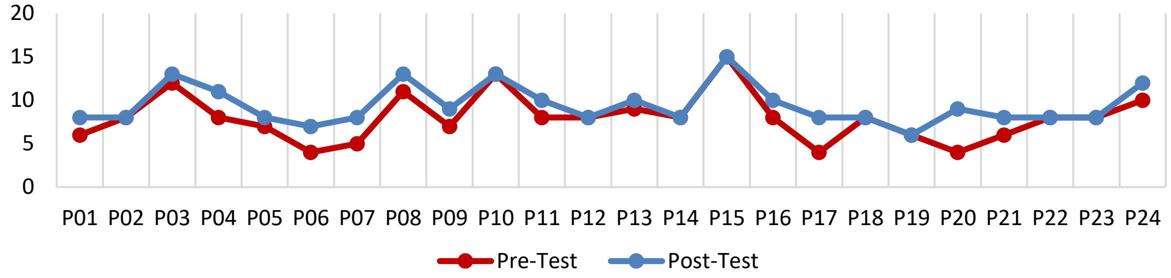
Table 9. *Results of Wilcoxon Signed-Ranks Test Regarding Students' Creative Talent*

Creative Talent	*n*	*Mean Rank*	*Sum of Ranks*	*z*	*p*
Negative Ranks	0	,00	,00		
Positive Ranks	9	5,00	45,00	-2,68	.00
Ties	15				

When examining Table 9, it is revealed that there is a significant difference in the creative talent of the participants after the STEM-based activity designed for gifted students is applied to the group ($z=2,68$, $p<.05$). When the pre-test and post-test scores of the participants for creative talent sub-dimension were evaluated, it was determined that the significant difference that occurred was in favor of positive ranks, that is, the post-test scores.

The seventh sub-dimension of the scientific creativity scale is product design. The data of the pre-test scores and post-test scores obtained by the participants depending on their answers to the seventh question of the measurement tool are presented in Chart 8.

Chart 8. *Participants' Score Values from The Product Design Sub-Dimension*



As explained in Chart 8, it is seen that the post-test score values obtained from the product design sub-dimension of all other participants, except for the score values of the participants with the codes P02, P10, P12, P14, P15, P18, P19, P22, and P23, are higher than the pre-test score values. To evaluate whether the scores obtained by the participant group from the product design sub-dimension of the scientific creativity scale produced statistically significant results, the Wilcoxon signed-ranks test was applied considering the non-normal distribution of the data, and the results obtained were presented in Table 10.

Table 10. *Results of Wilcoxon Signed-Ranks Test Regarding Students' Product Design*

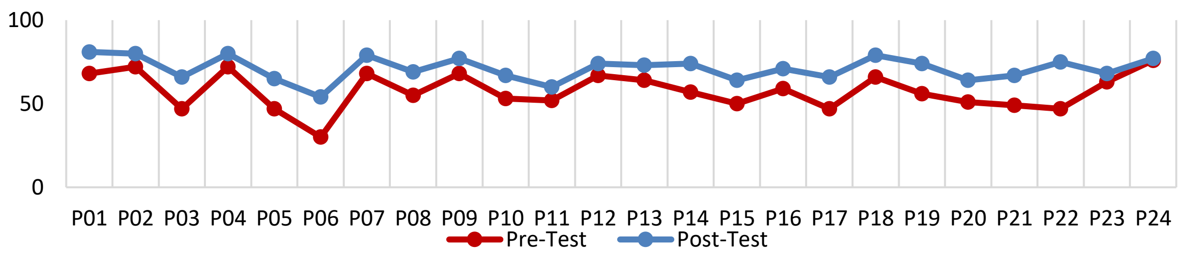
Product Design	*n*	*Mean Rank*	*Sum of Ranks*	*z*	*p*
Negative Ranks	0	,00	,00		
Positive Ranks	15	8,00	120,00	-3,45	.00
Ties	9				

When examining Table 10, it is revealed that there is a significant difference in the product design of the participants after the STEM-based activity designed for gifted students is applied to the group (z=3,45, p<.05). When the pre-test and post-test scores of the participants for product design sub-dimension were evaluated, it was determined that the significant difference that occurred was in favor of positive ranks, that is, the post-test scores.

THE EFFECT OF STEM-BASED ACTIVITY ON COGNITIVE ACHIEVEMENT

To determine the effect of STEM-based activity designed for gifted students on cognitive achievement, the data of the total pre-test scores and total post-test scores obtained by the participants from the data collection tool consisting of twenty questions are presented in Chart 9.

Chart 9. *Participants' Score Values from The Cognitive Achievement*



As explained in Chart 9, it is seen that the total post-test score values obtained by the participants from the cognitive achievement test are higher than the total pre-test score values. The fact that this situation is in favor of the post-test test can be accepted as an indication that the practices carried out produce meaningful results. To evaluate whether the scores obtained by the participant group from the cognitive achievement test produced statistically significant results, the dependent t-test was applied considering the normal distribution of the data, and the results obtained were presented in Table 11.

Table 11. *Results of Dependent T-Test Regarding Students' Cognitive Achievement Scores*

Cognitive Achievement	*n*	$\bar{X}$	*ss*	*sd*	*t*	*p*
Pre-Test	24	57,66	10,94	23	10,64	**.00**
Post-Test	24	71,00	7,06			

When examining Table 11, it is revealed that there is a significant difference in the cognitive achievement of the participants after the implementation of the STEM-based activity designed for gifted students, $t(23)=10,64$, $p<.05$. On the other hand, Cohen's D effect size was calculated and found to be 2.17 to determine the difference in significance between the participants' pre-test and post-test scores. It can be stated that the difference is due to **excellent** STEM-based activity.

DISCUSSION, CONCLUSION AND IMPLICATIONS

When the effect of STEM-based activity designed for gifted students on scientific creativity is evaluated; It is seen that the post-test scores obtained by the research group from the scientific creativity scale differ significantly from the pre-test scores both holistically and in all sub-dimensions of scientific creativity (different use, exploring the problem, product development, imagination, solving the problem, creative talent, product design). It is thought that the nature of STEM-based activity and the steps in the engineering design process affect the emergence of this situation. Considering that the concept of scientific creativity is influenced by values such as intelligence, knowledge, learning style, personality, and motivation (Hu & Adey, 2002), which is scientifically employed at every stage from the definition of the problem to the design put forward for its solution (Samuels & Seymour, 2015) and that the accumulation of knowledge of the individual is blended from the scientific dimensions; It is obvious to expect that the STEM-based activity process, which consists of various steps and is carried out to solve the scientific problem, will affect scientific creativity. According to Doppelt (2009), in the STEM-based activity process consisting of six steps, scientific creativity is used in determining the design objectives for the solution of the problem, in collecting the information areas for the solution of the problem, in making the inferences for the solution of the problem, in choosing and creating methods and techniques appropriate to the solution and in the solution of the problem of the design. When the literature on the effect of STEM-based activity on scientific creativity is examined; Samuels and Seymour (2015) emphasized that solution strategies can be developed by using their scientific creativity by ensuring that STEM education is carried out on a problem basis and that students' curiosity is attracted. Similarly, in the research conducted by Hu and Adey (2002), they mentioned that scientific creativity takes place at the intersection dimension of the integrity formed by the combination of science, technology, and other disciplinary fields. The research conducted by Ayverdi (2018) aimed to determine the effect of STEM-based activity for gifted students on scientific creativity, scientific process, and engineering skills. As a result of the research, it was emphasized that STEM-based activity for gifted students contributed to the scientific creativity and skill development of students. As can be seen from the literature reviews conducted, STEM-based activity positively affects scientific creativity. It was expected to have a positive effect within the scope of the research and once again revealed the effect of STEM-based activity on scientific creativity. Based on the data obtained from both the literature and this research, it would not be wrong to say that STEM-based activity makes a significant difference in the scientific creativity of gifted students.

When the effect of STEM-based activity designed for gifted students on cognitive achievement is evaluated; It is seen that the post-test scores obtained from the cognitive achievement test of the research group differ significantly from the pre-test scores. It is thought that STEM-based activity has the effect of directing the student to research inquiry and providing meaningful-permanent learning in the emergence of this situation. Considering that the concept of cognitive achievement is based on a goal or a purpose and that includes accumulation, skill, and competency criteria (Lemelin et al., 2007), it is expected that the STEM-based activity process, which consists of various steps and performs various tasks towards a goal, will affect cognitive achievement. When the literature on whether STEM education affects increasing the cognitive achievement of individuals by developing their knowledge, skill areas, and competencies is examined, Ceylan (2014) examined the effect of STEM-based activity on students' success, creativity and problem solving, and found that the cognitive achievement levels of students in the experimental group who received education depending on STEM-based activity were higher than those of students in the control group has been revealed to be high. In the research conducted by McKinnon (2018) aimed to examine the effect of STEM education on the success of their students, it was revealed that the reading and mathematics achievement results of students in some schools where STEM education was given differed significantly from those of students in schools without STEM education. As a result of the research, it was emphasized that project-based STEM teaching has a positive effect on student success. Becker and Park (2011), who wanted to evaluate the researches with meta-analysis technique, investigated the relationship between STEM and academic achievement. As a result of the research, it was revealed that with the effect of the interdisciplinary understanding of STEM education in the researches conducted on STEM and cognitive achievement, meaningful differences occurred on the learning of the students, affected the skill development and gained competence and thus enabled the development of cognitive achievement. Concordantly, it has been shown that the conceptuality and holistic features of STEM have a positive effect on cognitive achievement. As can be seen from the literature reviews conducted, STEM-based activity has a positive effect on cognitive achievement. The positive effect of the research was expected and once again revealed the effect of STEM-based activity on cognitive achievement. Based on the data obtained from both the literature and this research, it would not be wrong to say that STEM-based activity makes a significant difference in the cognitive achievement of gifted students.

IMPLICATIONS

- STEM-based activities effect scientific creativity because STEM-based activities are carried out in the form of consecutive steps and there are competencies such as thinking differently, being creative, solving problems, and creating products in the content of these steps. Therefore, it is recommended to carry out STEM-based activities to develop the scientific creativity of gifted students. On the other hand, it is recommended that researchers who want to conduct research to examine the effect of STEM-based activities on the skills of gifted students should not ignore the scientific creativity factor. Concordantly, the predictive effect of scientific creativity of gifted students on other skills can be investigated.
- Considering the effect of STEM-based activities on cognitive achievement, it is recommended to use STEM-based activities in the subject areas aimed at increasing cognitive achievement. On the other hand, activities can be carried out by choosing subjects suitable for the nature of STEM-based activities instead of the subject chosen as the subject within the scope of the research.
- It is recommended to carry out studies that evaluate the effect of STEM-based activities designed for gifted students on areas such as critical thinking, problem solving, analytical thinking and scientific process skills that students have.

AUTHOR CONTRIBUTIONS

- First author have made substantial organizing the research process and have given final approval of the version to be published.
-The second author have made substantial proofreading process, substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data and have been involved in drafting the manuscript or revising it critically for important intellectual content.

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