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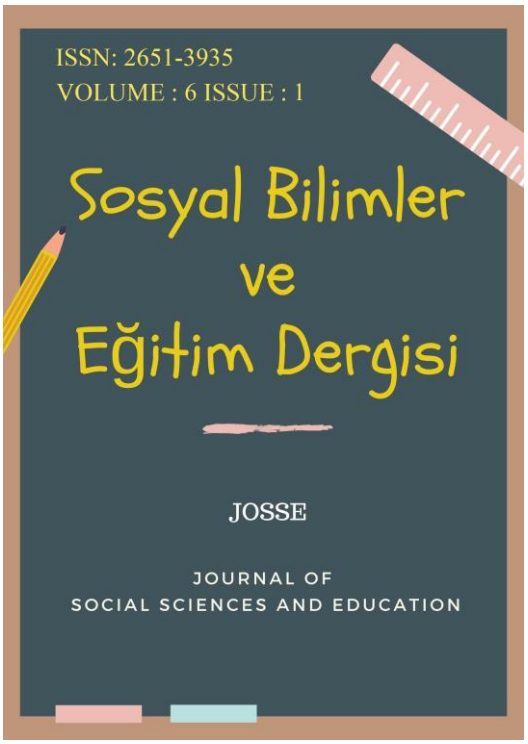

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Comparison of Scientific Creativity Levels of 12th Classroom Students with Various Variables

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Comparison of Scientific Creativity Levels of 12th Classroom Students with Various Variables

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Abstract

One of the important skill areas that should be acquired by students in education is creative thinking skills. In this context, various scales have been developed by different researchers to measure creativity. Hu and Adey also developed a 7-item scale to measure scientific creativity in 2002. This developed scale was adapted into Turkish by Pekmez, Aktamış (2009) and Çeliker, Balım (2012); validity and reliability studies were carried out. The Cronbach alpha measurement reliability coefficient was found to be 0.86 by Çeliker and Balım (2012).The aim of this research is to compare students' scientific creativity according to various variables by using the scientific creativity scale developed by Hu and Adey (2002). The sample of the research consists of 249 students studying in the twelfth grade of high schools in İzmir.The scores obtained were compared using variables such as gender, educational status of the parents, central exam score and percentile in the exam. As a result of the study, there is no significant effect of gender variable on creativity. Moreover, the higher the maternal and paternal education level that is secondary education, undergraduate and higher education, the higher the originality score averages. Then, as the exam score range increases, the originality score average increases. Students in the 5% percentile have high originality score averages. The results of this study shows that mostly, article 5 has statistically significant difference about gender, maternal education level and average exam scores.

Keywords: Fluency, originality, creativity, scientific creativity scale, scientific thinking.

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Introduction

For centuries, creativity has been considered as a gift of God, unique only to extraordinary people, and most often used as creativity in the field of Fine Arts (San, 1979). According to Haladyna (1997), creativity can occur while writing, speaking, composing, theater or painting. In addition, the tools we use, electronic devices, the food we eat, the scientific knowledge we learn are somehow connected with creativity. Examples of creativity can be seen in everything belonging to humanity. Is it necessary to have a high intelligence to come up with all these products?A certain level of intelligence is required for creativity, but a highly creative individual in a field may not be able to base on a high level of intelligence. The very high intelligence stage may not involve creativity of the same height. Both highly intelligent and highly creative individuals are identified but this cannot be generalized (San, 2004). The relationship between creativity and intelligence can be considered a relationship given scientific creativity. According to Getzels and Csikszentmihalyi (1972), intelligence and creativity represent different processes and creative efforts in different fields may require different degrees of intelligence. For example, a creative artist doesn't need a high intelligence, but a Nobel Prize-winning physicist certainly does (Sternberg and O'hara, 1999). Innate abilities may be necessary for creativity, but can be developed in existing potential.(Andreasen, 2009; Honig, 2000). therefore, when it is considered that intelligence can be developed, it can be said that the existing potential creativity can also be developed. In some studies, they argue that it is not correct to establish a relationship between intelligence and creativity (Daniel, 1997; Starko, 1995). An individual does not need to be gifted to be creative, and being gifted is not a prerequisite for the emergence of creativity potential in individuals (Karabey and Yurumezoglu, 2015). On the other hand, some studies show that genetic transfer and environmental effects on the concepts of intelligence-talent-creativity are important in terms of development. (Moore,2009). In this context, it can be said that creativity can be developed with the effect of the environment.

Creativity is important not only in the field of Fine Arts but also in the scientific sense. Scientific creativity depends on what steps are used to create a new product or develop an existing one; moreover, it depends on how the problem is solved and how the problem is realized (Aktamis and Ergin, 2007). In their study, Charyton and Snelbecker (2007) found that when they compared the average scientific and artistic creativity scores of music and

engineering students, the artistic creativity scores of musicians were higher, but there was no significant difference in scientific creativity

Given the relationship between scientific creativity and knowledge, it is important for creativity to have sufficient knowledge about the subject. In the view of Bailin (1988), if the product is not strongly placed in the past, there may be no creativity because in order for being understood of the product by audience, there has to be some source framework and these sources must be covered by the past. When a person makes some innovations, he or she should make connections with the ones that were made before. Creativity builds new relationships between experience and knowledge. It brings new solutions to problems (San, 2004).

The characteristics of scientific creativity are listed by Hu and Adey (2002) as follows:

* Scientific creativity is a kind of skill.

* Scientific creativity must depend on scientific knowledge and skills.

* Scientific creativity must be a combination of stagnant structure and developmental structure.

* Adult and mature scientists have the same basic mental structure of scientific creativity, but later this is further developed.

* Creativity and analytical intelligence are two different factors of a singular function resulting from mental ability (Kilic and Tezel, 2012).

Creative problem solving involves six steps (finding the confusion, finding the truth, finding the problem, finding the idea, finding the solution, and accepting the finding). It shares similar characteristics with the skills of finding the problem mentioned in this study, formulating hypotheses, and testing hypotheses. They both have the same starting step that finding the problem is the heart of creativity. Secondly, formulating hypotheses is similar to finding the solution because formulating hypotheses is one of the methods for finding solutions. Third, testing hypotheses may be similar to finding acceptance. Because hypotheses are accepted or rejected after testing them in the field of science (Aktamis and Ergin, 2007).

Literature Review and Hypothesis Building

"What is creativity?" When asked, many different definitions can come to mind. Besides being characterized by names such as imagination, foreboding or trick, it is also expressed as being able to add innovation to a phenomenon and bring difference (Ozturk, 2006). Creativity is not just about making things out of nothing. Because a new idea, a new

thought is often either a different form of an old thought or a combination of previously known, previously possessed thoughts. Accordingly, creativity can be defined as making new syntheses from previous thoughts and giving new identities to previous thoughts (Bessis, 1973). According to Senemoglu (1999), creativity involves thinking in different situations in a flexible, fluid, orginal and unusual way. In this sentence, originality means produce unique responses, flexibility means adaptation ability to changing situation and fluency means being sequenced thoughts, expeditiously.

Hu and Adey (2002) demonstrated the 'scientific creativity model ' as a result of evaluating the data obtained from the field literature survey. In the figure, the dimensions of the model of scientific creativity are included.

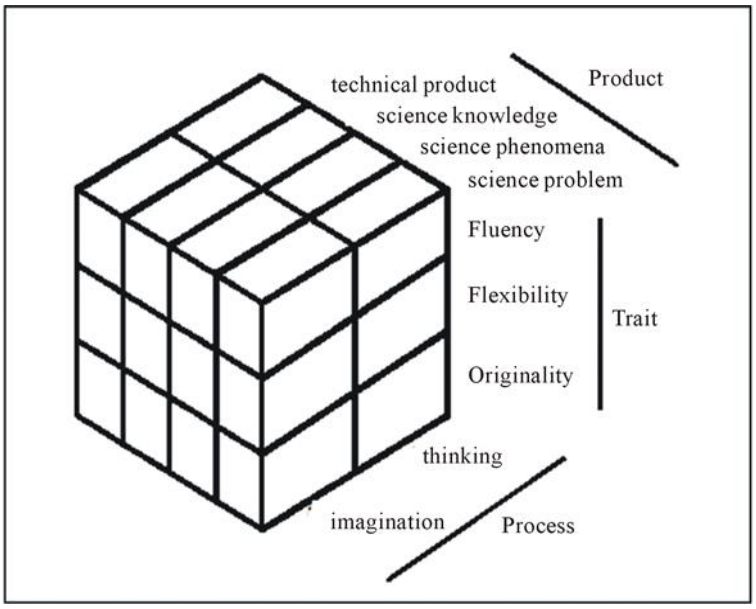

Figure 1. *The Model of Scientific Creativity (Hu and Adey 2002)*

According to this model, scientific creativity is three-dimensional and dynamic. Scientific creativity in this model consists of three dimensions: product, process and trait. The product size consists of technical product, science knowledge, science phenomena and science problem sub-dimensions. The process dimension occurs from sub-dimensions of thinking and imagination, and the trait dimension occurs from sub-dimensions of fluency, flexibility, and originality. This model consists of 24 (2x3x4=24) cells, which form the theoretical basis for the measurement of scientific creativity (Balim and Celiker, 2012).

Articles of Scientific Creativity Scale and place of the articles on The Model of Scientific Creativity:

Article 1: Please write down the different ways in which you can use a glass scientifically. For example, experimental tube construction.

The place of article in the model of scientific creativity: (science knowledge) X (fluency, flexibility, originality) X (thinking) (1x3x3=9) covers 9 cells.

Article 2: If you could travel on a spaceship and travel to a different planet, what scientific questions would you like to explore? Please write as many questions as you can about this planet, considering the questions you're wondering. For example, are there any living creatures on the planet?

The place of article in the model of scientific creativity: (science problem) X (fluency, flexibility, originality) X (thinking and imagination) (1x3x2=6) covers 6 cells.

Article 3: What would you do if you could make an ordinary bike more interesting, more useful and more beautiful? Please write that down. For example, I would make the wheels phosphorescent so they could be seen in the dark

The place of article in the model of scientific creativity: (technical product) X (fluency, flexibility, originality) X (thinking and imagination) (1x2x3=6) covers 6 cells.

Article 4: What would happen on Earth if there was no gravitational force? For example, people would be flying through the air.

The place of article in the model of scientific creativity: (science phenomena) X (fluency, flexibility, originality) X (imagination) (1x3x1=3) 3 covers cells

Article 5: How many different methods can you divide a square into four equal parts? Draw it down and show it.

The place of article in the model of scientific creativity: (science problem) X (flexibility, originality) X (thinking and imagination) (1x2x2=4) covers 4 cells.

Article 6: How do you test which is better if you were given two types of napkins? To do this, please write down all the methods you can think of, the tools you will use, and how to follow a simple way with a simple explanation.

The place of article in the model of scientific creativity: (science phenomena) X (flexibility, originality) X (thinking and imagination) (1x2x2=4) covers 4 cells.

Article 7: Please design an apple picking machine. Draw a picture of the machine you are designing and specify the name of each part and what kind of function it has.

The place of article in the model of scientific creativity: (technical product) X (flexibility, originality) X (thinking and imagination) (1x2x2=4) covers 4 cells (Celiker and Balim, 2012).

The hypothesize sentences are sorted as follows:

H1: *Gender variables affect students' scientific creativity.*

H2: *Students' central score ranges influence their scientific creativity.*

H3: *Students' maternal education level affects their scientific creativity*.

H4: *Students' paternal education level affects their scientific creativity.*

H5: *The percentage share of students affects their scientific creativity.*

Method

Model

The sample of the research consists of 249 students studying in the twelfth grade of high schools in İzmir. It is thought that the students in the last year of compulsory education will have the highest abstract thinking skills. In addition, it was thought that the comparison of the scores of the students who took the central exam in the same year could be interpreted more accurately.

The students applied “Scientific Creativity Scale” which is developed by Hu and Adey adapted to Turkish by Pekmez, Aktamis (2009) and Celiker, Balim (2012); validity and reliability studies were made by Celiker and Balim (2012). Articles of Scientific Creativity Scale which are composed of seven articles was used for only the traits of “fluency” and “originality” in the Model of Scientific Creativity. Acording to Pekmez and Aktamis (2009) the correlations between scores vary from 0.89 to 1.00 with a median of 0.94. The results suggest that the scoring procedure is adequately objective. In addition ,To obtain a measure of face validity of the test, 5 people of science education researchers (n= 12) and science teachers (n=3) were asked questions . they were in scale has been translated to Turkish language by four science teachers for language validity, the similarities were checked and it was found out that there exists a 90% agreement by Pekmez and Aktamis (2009).Morever, The test was administered by Çeliker and Balım (2012) on a total of 389 students. Item-total correlations ranged from 0.37 to 0.74 scales. In addition, the Cronbach's alpha coefficient of the scale was calculated as 0.86. According to this model, scientific creativity is three-dimensional. This

In the model, scientific creativity consists of three dimensions: product, process and feature.

The product dimension consists of technical product, scientific knowledge, scientific fact and scientific problem sub-dimensions.In addition to the process dimension, thinking and imagining sub-dimensions, the feature dimension also constitutes the sub-dimensions of fluency, flexibility and originality. This model, which constitutes the theoretical infrastructure for measuring scientific creativity, consists of 24 (2x3x4=24) cells(Balim and Celiker, 2012).

Data obtained by entering the SPSS 17 package program, the averages of the students' scores for each question and the averages of points for each variable were calculated separately. Data obtained by using T-test and Anova scientific creativity scale by comparing the mean scores of originality and fluency with various variables ($p<0.05$ level), we investigated whether there was any significant difference.

When calculating the originality score of the first four articles of the scale, all correct answers include 2 points for 5%, 5-10% for 1 point, and 0 points for other responses. In the evaluation of article 5, students entering 5% scored 3 points, students entering 5-10% scored 2 points, other responses are 1 point. In the evaluation of article 6, students entering 5% scored 4 points, those students entering 5-10% scored 2 points, and other responses are 0 points. Article 7 is worth between 1-5 points according to originality. Fluency score is found by calculation given by students regardless of quality. Flexibility is obtained by calculating the number of each area or approach used in the answer (Celiker and Balim, 2012). The answers which were given by students were scored as follows,

Article 1: Lenses and glasses, which were the most common answers given by the students, were scored 0 points. Answers with high frequency such as magnifying glass, telescope microscope, 1 point, and answers with low frequency such as burette, tape measure, electroscope were scored 2 points.

Article 2: “Is there life on the planet?” The answer was given at a very high frequency with a score of 0. “How is the atmosphere?”, “Is there water?” such answers were still high frequency and were evaluated with a score of 1. From answers such as “What's the diameter of the planet? Do they have sex? Do they have religious beliefs?” were given 2 score by obtaining low frequency.

Article 3: The answers such as “I would light up” and “It could fly” were given with high frequency and were evaluated over 1 score. “I would have made a bike that could produce oxygen”, “I would have made a bike that could be used by the visually impaired” answers were rated over a score of 2 as it was given at low frequency.

Article 4: Answers such as “Everything would fly”, “There would be no life” were rated at 0 points. Again, high frequency answers such as “Transportation would be difficult”, “There would be no traffic” were rated at 1 point. Answers given by few people such as “Time would be different”, “Fire would not be lit” were rated at 2 points.

Article 5: The answers about the division of the Square as shown in the figure were given by a large number of students and they were evaluated with a score of 0.

Article 6: “I look at the water absorption power. It is not qualified if it disperse in water quickly.” These answers like were used by a  large number of subjects so rated with the score of 0. Answers like “I would test it by touch, look at its softness” were given 2 points. Moreover, low frequency responses such as “I would look at the tear of it by stretching and putting ice on it”, “I would look at the light transmission” were rated with the score of 4.

Article 7: Scoring of article 7 and scoring of the other articles based on fluency and flexibility, comparing originality scores with others can be prepared as another project. The results can be described by comparison.

Findings

The data collected by scale from the students participating in the study are included in the following tables. Table 1 shows that the T– test results of the originality and fluency score averages do not differ statistically significantly according to the gender variable ($p>0.05$).

Table 1. T– *Test Results by Gender Variable of Originality and Fluency Scores*

	Sex	**N**	**$\bar{x}$**	**S**	**sd**	**T**	**p**
Originality	Female	145	23.28	14.29	245	0.34	.739
	Male	102	22.67	12.49			
Fluency	Female	146	16.40	8.96	247	-0.01	.792
	Male	103	16.41	7.079			

Table 2 displays that by looking at the originality score average according to maternal education level, average score of students with primary level maternal education is 22.5, the average score of students with secondary level maternal education is 20.88, and average score of students with undergraduate or higher level maternal education is 27.02. Moreover, based

on maternal education level, fluency scores are 16.59 for primary education graduates, 15.01 for secondary education and 18.05 for students with undergraduate and higher maternal education.

Table 2. *Descriptive Statistics of Originality and Fluency Scores Based on Maternal Education Level Variable*

Type of Score	**Maternal Education**	**N**	**$\bar{x}$**	**SS**
Originality	Primary	105	22.50	12.57
	Secondary	83	20.88	11.45
	Undergraduate degree and higher	59	27.02	16.96
Fluency	Primary	106	16.59	9.26
	Secondary	84	15.01	6.73
	Undergraduate degree and higher	59	18.05	7.96

When the Anova results of originality and fluency scores were analyzed according to the maternal education level variable, there is no significant difference in fluency score averages ($F = 2.44$; $p>0.05$). Anova results showed a significant difference in maternal education level ($F = 3.76$; $p<0.05$). This significant difference was realized between students with secondary level maternal education and students with undergraduate or higher level maternal education.

One-way analysis of variance test gives information about the compared means whether there is a significant difference, but does not give information about the size of the difference.

Therefore, it is important to know the effect size. The effect size is called eta-square (η^2). It is found by dividing the intergroup variance by the total variance(Can,2014,s.157). It can take values between 0 and 1. A value of 0.01 can be interpreted as a small effect size, a value of 0.06 as a medium and a value of 0.14 as a large effect size(Green and Salkind,2005,s.157).

The η^2 value between the groups was 0.03. Approximately 3% of the variance of fluency scores depends on maternal education level. The results are exhibited in Table 3.

Table 3. *Anova Results of Originality and Fluency Scores Based on Maternal Education Level Variable*

Type of Score	Source of Variance	Sum of Squares	sd	Average of Squares	F	p	Significant Difference
Originality	Intergroup	1351.72	2	675.86	3.76	.025	Secondary - Undergraduate and higher
	Ingroups	43856.03	244	179.74			
	Total	45207.74	246				
Fluency	Intergroup	326.28	2	163.13	2.44	.089	
	Ingroups	16439.57	246	66.83			
	Total	16765.84	248				

Table 4 shows that by looking at the originality score average according to paternal education level, average score of students with primary level paternal education is 23.13, the average score of students with secondary level paternal education is 20.77 and average score of students with undergraduate or higher level paternal education is 25.85. In addition, fluency scores are 16.61 for students with primary level paternal education, 15.47 for students with secondary level paternal education and 17.42 for students with undergraduate and higher level paternal education.

Table 4. *Descriptive Statistics of Originality and Fluency Scores According to Father Education Level Variable*

Type of Score	Paternal Education	N	$\bar{x}$	SS
Originality	Primary	69	23.13	13.73
	Secondary	100	20.77	11.03
	Undergraduate degree and higher	78	25.85	15.80
Fluency	Primary	70	16.61	10.49
	Secondary	101	15.47	6.83
	Undergraduate	78	17.42	7.50

degree and higher

When the Anova results of originality and fluency scores were analyzed according to the paternal education level variable, there is no significant difference in fluency score averages (F=1.28; p>0.05). Table 5 indicates the result. Anova results show a significant difference in paternal education level (F=3.12; p<0.05). This significant difference realized between students with secondary level paternal education and students with undergraduate and higher level paternal education. The value of η^2 between the groups is 0.025. Approximately 2.5% of the variance of fluency scores depends on paternal education level.

Table 5. *Anova Results of Originality and Fluency Scores According to Paternal Education Level Variable*

Type of Score	**Source of Variance**	**Sum of Squares**	**Sd**	**Average of Squares**	**F**	**p**	**Significant Difference**
Originality	Intergroup	1130.05	2	565.025	3.12	.046	Secondary - Undergraduate and higher
	Ingroups	44077.69	244	180.646			
	Total	45207.74	246				
Fluency	Intergroup	173.09	2	86.543	1.28	.279	
	Ingroups	16592.75	246	67.450			
	Total	16765.84	248				

Table 6 indicates that the average of originality points of the students who have an average score of (200-300) according to the exam score range is 17.24. For the other average exam scores that are (301-350), (351-400), (401-450) and (451-500), the average of originality points of the students are 21.66, 21.05, 24.74 and 26.90 respectively.

According to the exam scores, the average of fluency points of the students who have an average score of (200-300) is 13.76. For the other average exam scores that are (301-350), (351-400), (401-450) and (451-500), the average of fluency points of the students are 16.85, 15.43, 17.08 and 217.70 respectively.

Table 6. *Descriptive Statistics of Originality and Fluency Scores According to Exam Score Range Level Variable*

Points Range	Exam Score	N	$\bar{x}$	SS
Originality	200-300	33	17.24	10.16
	301-350	41	21.66	10.52
	351-400	58	21.05	13.50
	401-450	38	24.74	10.00
	451-500	77	26.90	16.51
Fluency	200-300	34	13.76	8.15
	301-350	41	16.85	10.88
	351-400	58	15.43	7.197
	401-450	38	17.08	6.88
	451-500	78	17.70	7.80

In Table 7, based on exam score ranges variable, Anova result of fluency scores do not show a significant difference ($F=1.68$; $p>0.05$). However, there is a significant difference about originality scores ($F=3.80$; $p<0.05$). This result is perceived in the exam score ranges of (200-300) and (451-500). The η^2 value between the groups is 0.059. About 5% of the variance of fluency scores depend on the level of students 'central exam score range.

Table 7. *Anova Results According to Test Score Range Variable of Originality and Fluency Scores*

Type of Score	Source of Variance	Sum of Squares	sd	Average of Squares	F	p	Significant Difference
Originality	Intergroup	2671.08	4	667.77	3.80	.005	(200-300)-(451-500)
	Ingroups	42536.6628	242	175.77			
	Total	45207.7418	246				
Fluency	Intergroup	449.3958	4	112.35	1.68	.155	
	Ingroups	16316.44	244	66.87			
	Total	16765.84	248				

Table 8 shows that the T– test results of the originality score averages differ statistically significantly according to the percentile variable (t(242)=2.47, p<50.05).

T– test results of fluency score averages show no statistically significant difference compared to percentile variable (t(244)= 1.65, p.> 0.05). η^2 which is calculated for the originality score is 0.083. We can say that approximately 8% of the variance observed in the scale depends on the percentile.

Table 8. *T– Test Results of Originality and Fluency Scores Based On Percentile Variable*

	Sex	**N**	$\bar{x}$	**S**	**sd**	**t**	**p**
Originality	5% percentile	89	24.30	10.86	242	2.47	.014
	After 5%	155	20.83	10.38			
Fluency	5% percentile	90	16.83	5.987	244	1.65	.101
	After 5%	156	15.40	6.87			

Discussion and Result

The aim of this study is to to determine variables which are gender, maternal education level, paternal educational level, central exam score ranges and percentile of students that may affect students's scientific creativity. As a result of the study, there is no significant effect of gender variable on creativity. Moreover, the higher the maternal and paternal education level that is secondary education, undergraduate and higher education, the higher the originality score averages. Then, as the exam score range increases, the originality score average increases. Students in the 5% percentile have high originality score averages. Considering that the students in the 5% group generally prefer project schools, it will be important to compare the creativity of this group with the other group. In addition, the comparison of central exam scores and creativity score averages will also create data for field writing. It can be said that as the success of the students increases, the originality dimension of their creativity increases. The results of this study shows that mostly, article 5 has statistically significant difference about gender, maternal education level and average exam scores. Other articles do not have such a difference. In item 5, "How many different methods can you divide a square into four equal parts?" A question has been asked. It can be said that

this question is a question that requires prior knowledge of geometry. When this lack of knowledge is closed, the difference between the average scores may also decrease. From another point of view, it can be said that as the level of maternal education increases, students' exam success increases. Considering that there is a positive correlation between geometry knowledge and exam scores, it can be assumed that the high average score of the 5th item is normal. Aydın and Ayverdi (2012) determined in their study that there is a positive and significant relationship between general creativity, scientific creativity, and end-of-term academic achievement scores of science and technology courses. Aktamis and Ergin (2007) determined in their study that there is a relationship between scientific creativity and scientific process skills. Mercan (2022) examined the relationship between the creativity of secondary school students and their ability to be gifted in mathematics, she found a significant relationship between their ability to be gifted in mathematics and their creativity. Scientific creativity and scientific thinking processes show parallelism. It can be considered normal that students who are successful in their courses have high scientific creativity average scores. However, considering that the success in the courses will increase with correct practices, it can be said that this score gap will be closed.According to Umit Davasligil, creativity is not as a rare ability that belongs to a minority, but as a cognitive skill that can be developed and nurtured by all humans (Aslan, 2001). In this context, creativity can be developed with the right practices in education. Moreover education is the main topic to support creativity. However, traditional education is far from society, technology and innovation. Questions that demand stereotypes, ready-made information and expected answers neutralise the creativity of the students. In addition, only people who can do numerical calculations are successful in university exams, individuals who can be successful in many areas are not able to study on the departments they want. Thus, the education system should be able to respond to the needs of both the society and the age by being affected by these changes while educating individuals to ensure social development (Turkoglu, 2004, 29). Moreover, creativity should be enabled in the contemporary education system. Free and critical thinking are requirements of contemporary educational understanding (Ozturk, 2004). If educational environments and measurement methods are organized to improve students ' creativity, more successful individuals will be trained in creating new ways to problems.

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