Investigation of the Effects of Interdisciplinary Science Activities on 5th Grade Students' Creative Problem Solving and 21st Century Skills

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This research is based upon the master thesis titled "The effects of science activities prepared according to the interdisciplinary teaching approach on the creative problem-solving and 21st century skills of 5th graders" which is authored by Beyza ALPASLAN and supervised by Assoc.Prof.Dr.İlknur GÜVEN

ABSTRACT
In this research, it was aimed to examine the effects of interdisciplinary science activities on 5th grade students' creative problem-solving skills and 21st century skills. The study group consisted of 50 5th grade students, 26 girls and 24 boys, were studying at a public school in Ankara, Çankaya district in the 2018-2019 academic year. The Creative Problem Solving Attribute Inventory and the 21st Century Skills Tests were applied to the students before and after the application. The obtained data were analyzed using a statistical program. The "Dependent Groups t-Test" and "Cohen's d" test, which are parametric tests, were used in the analysis of the Creative Problem Solving Attribute Inventory and the 21st Century Skills Test. In line with the evaluations made, it was concluded that interdisciplinary science activities positively affected students' creative problem solving skills and 21st century skills. Suggestions were made based on the findings.
Keywords: Interdisciplinary Science Activities, Interdisciplinary Teaching, Creative Problem Solving Skills, 21st Century Skills.

INTRODUCTION
When we look from the past to the present, we can say that we live in a rapidly changing and developing world and as a consequence of this, daily problems become more complicated day by day and problems can be global wicked problems. The coronavirus pandemic is such a problem which interconnected health, economic, privacy and social consequences. The problem-solving concept has broadened beyond its pre-21st century roots and solutions, if they exist, are transdisciplinary (Drake & Reid, 2020). With the pandemic, scientists from all around the world, from all disciplines have come together and have been doing studies by integrating their knowledge (World Health Organization, 2020; Lavazza & Farina, 2020). The Covid-19 pandemic is a global problem and not only health workers but economists, psychologists and many other experts of other professionals are working together to find a solution. For example, in this period, Coronavirus Scientific Advisory Board was set up on January 2020 in Turkey consisted expert academicians in microbiology, virology, infection, internal medicine, intensive care and chest diseases (Milliyet, 2020). On the other hand, the sociologoues and many other experts worked together to find a solution to the coronavirus problems by conducting studies with an interdisciplinary approach. As we saw in the last days of 2019, sometimes life problems can be too complicated to solve with only one discipline.

It is an unavoidable requirement to raise children as who can find creative solutions to problems in life. People generally tend to perceive the outside world with a totalitarian approach. Their attempts to find solutions to the problems they encounter or the manner in which they communicate with others are not limited to information and skills typical to certain disciplines. The questions asked in daily life and the answers given to these questions often encapsulate the subject matter of more than one discipline (Yıldırım, 1996). Students need experience in transdisciplinary problem-solving to be equipped with 21st century skills (Drake & Reid, 2020).

According to the Oxford dictionary, the term "discipline" is "*an area of knowledge; a subject that people study or are taught, especially in universities*" and origins are medieval (https://www.oxfordlearnersdictionaries.com). It etymologically means "instruction given to a student" and is related to the Latin term disciplina

(https://www.etymonline.com/word/discipline). A discipline is essentially a "complex structure" that involves; being involved, being shaped by and shaping it, being in and relating to a scientific community (Parker, 2002).

The term interdisciplinary is an approach that consciously applies the methodology of more than one discipline to a central theme, problem, issue or experience (Jacobs, 1989). Mills and Huber (2005) say that the term discipline has a pedagogical identity, and therefore it can be said that an interdisciplinary teaching is enriched by using the language, methods, or laws of one or more other disciplines (Chettiparamb, 2007). In interdisciplinary teaching, based on a certain concept, knowledge and skills from different disciplines are integrated and they are bringed together in a meaningful way (Yıldırım, 1996).

Interdisciplinary teaching is not an artificial combination of some History, some Geography, some Mathematics or Music in one lesson hour. Truly interdisciplinary teaching, however, is the organization of teaching entirely around concepts or problems and the effective integration of knowledge from different fields in the processing of this concept or problem. This is a closely related approach to the way we use knowledge and skill in real life. The success of education also depends on the ability to use knowledge and skills for solving problems or generating ideas. In the disciplinary approach, it is left to the student to combine the knowledge and skills learned in separate courses for the solution of problems, and it is assumed that this combination will occur automatically most of the time. However, the results of the disciplinary education that has been going on for years show that students can use a very small part of the knowledge and skills they learned at school in real life and they have difficulty in applying these knowledge and skills to the problems they encounter (Yıldırım, 1996). The purpose of interdisciplinary teaching is to generate a collection of information that is required in order to fully understand the world we live in and the universe (Nicolescu, 2000; Özkök, 2005). According to Yarker and Park (2012), allowing students to think about a problem without there being limitations of a discipline can help them better see the connections between two disciplines in the content provided. In order to solve complicated real-life problems, interdisciplinary teaching approach needs to be enhanced (Newell, 2013). Interdisciplinary approaches significantly help to create a society that is scientifically literate. The expectation from the students is to critically evaluate and think about real life problems using information that is solely based on science. If the students learn the science with interdisciplinary approaches they can be critical thinkers. Interdisciplinary teaching approach addresses this need and it is effective in increasing many of the high-level thinking skills in students (Özkök, 2005; Yarker and Park, 2012; Gürkan, 2019).

In the 21st century, science and technology are developing very rapidly. The changes that occur also shape the structure of societies, the economy and education. Therefore, concepts related to both economy and education such as 21st Century skills, Industry 4.0 and PISA are frequently on the agenda of countries. The integration and application of disciplines along with these concepts are widely discussed in the world of education. The most important approach that emerged with the integration of disciplines is STEM (Science, Technology, Engineering and Math) (Akgündüz, 2019). STEM, which is one of the present day's interdisciplinary approaches, has a lot of research and workshop applications in the field. However, it would not be correct to think of the interdisciplinary approach as only STEM. Actually, STEM is an approach which unifies many other disciplines in addition to the ones it already includes. STEM is an interdisciplinary approach which encapsulates many disciplines such as art, (STEM+A), writing (STEM+W), reading (STEM+R) and entrepreneurship (STEM+E) (Yarker ve Park, 2012).

Creative problem solving helps a person solve problems and creatively manage the changes s/he encounters. It can be used to deal with daily problems as well as long-term challenging situations (Treffinger, Isaksen & Dorval, 2003). In Wallachs' definition of the creative process, there are stages of preparation, incubation, illumination, and validation. These processes were later clarified in the model known as Osborn-Parnes's Creative Problem Solving Model. The Creative Problem Solving Model created with these processes consists of five stages: finding facts, explaining problems, finding ideas, producing solutions and finding acceptance These stages emphasize the need to generate ideas by using creative thinking while solving problems (Treffinger & Isaksen, 2005; Nakano &Wechsler, 2018). Creative Problem Solving (CPS Version6.1™) is the latest version of Treffinger, Isaksen and Dorval's (2003) framework for solving problems and managing change. CPS Version 6.1™ includes the four main components and eight specific stages as: 1. Understanding the Challenge; Constructing Opportunities, Exploring Data, Framing Problems, 2. Generating Ideas: Generating Ideas 3. Preparing for Action: Developing Solutions, Building Acceptance. 4. Planning Your Approach: Appraising Tasks, Designing Process (Treffinger, Isaksen & Dorval, 2003; Treffinger, Isaksen, 2013).

With the interdisciplinary teaching approach, students see and discover the connections among disciplines and so they gain creative problem solving and critical thinking skills (Özkök, 2005; Pannells, 2010; Ivanitskaya, Clark, Montgomery and Primeau, 2002). Creative problem solving skills can be given to students with interdisciplinary teaching approach (Özkök, 2005). In her study about the examination of secondary school teachers' opinions about

interdisciplinary teaching Gürkan (2019) stated that teachers think they support student creativity and production with interdisciplinary education. It is thought that novel solutions can be generated in fields such as science, engineering, marketing and management with individuals who have gained creative problem solving skills (Barak, 2012). Creative problem solving unifies creativity, critical thinking and problem solving which are 21st century skills (Özkök, 2004). Individuals with 21st century skills can generate quick and effective solutions to the problems they encounter in daily life, have strong communicational skills, are critical, creative and are expected to be able to keep up with today's technology. Interdisciplanary teaching approach is effective in getting students to gain 21st century skills (Norhaqihah ve Kamisah, 2017; Özkök, 2004). 21st century skills are the abilities that a student must have in order to prepare him/her for the future.

Many qualities such as creativity, innovation, critical thinking, and problem solving, which have become a necessity for the individual to be prepared for life and adapt to the age, are gathered under 21st century skills (Çokcoşkun, 2019). The individuals who have critical thinking skills, creative, able to produce fast and effective solutions to complex problems, have strong communication skills and have the ability to keep up with today's technology can be thought as having 21st century skillls. The 21st century skills are recognized as crucial skills for students, and interdisciplinary curriculum is recognized as an effective model to teach/learn these skills (Özkök, 2004; Drake & Reid, 2020). Integrated curriculums that embraced interdisciplinary approach are designed to meet 21st century needs (Osman, Hiong & Vebrianto, 2013). In literature, it is seen that many studies have been done about interdisciplinary teaching approach (Demirel & Coşkun, 2010; Drake & Reid, 2020; Chettiparamb, 2007). Interdisciplinary teaching increase the motivation of the students (Barış, 2016; Bolat, 2016; Gürkan, 2016; Gero, 2017), develope their high-level skills (Özkök, 2005; Bolat, 2016; Karabey,2010; Başar, 2018; Paf, 2019; Özçelik, 2015; Osman, Hiong & Vebrianto, 2013) and increase their academic achievements (Özçelik,2015; Gürkan, 2016; Bolat, 2016).

The aim of the study was to examine the effects of the interdisciplinary science activities, those were prepared for students to be actively involved, on the creative problem-solving skills and 21st century skills of 5th grade students. The interdisciplinary activities are associated with the all 5th grade science curriculum achievements. For this purpose, in the study the research question was defined as: "What are the effects of the science activities prepared with the interdisciplinary teaching approach on 5th grade students' creative problem solving and 21st century skills?"

In line with this research question the sub-problems of the study were defined as follow:

1. Is there any effect of the science activities prepared with the interdisciplinary teaching approach on 5th grade students' creative problem-solving skill levels?
2. Is there any effect of the science activities prepared with the interdisciplinary teaching approach on 5th grade students' 21st century skill levels?

METHOD

This research designed with one group pre-test/post-test pre-experimental design. In this design, the effect of the experimental procedure was tested on a single group. The effects of the independent variable, which is interdisciplinary science activities in this research, on the dependent variables were obtained by using the same data collection tools before the application as the pre-tests and afterwards as the post-tests (Büyüköztürk et all., 2018). Experimental design of the study is given in Table 1 and in Figure 1.

Table 1: Experimental Design of the Study

Group	N	Pre-test Application	Experimental application	Post-test Application
One group	50	CPSAI[1] 21 CST[2]	Science Activities	CPSAI[1] 21 CST[2]

CPSAI[1]: Creative Problem Solving Attribute Inventory
21 CST[2]: 21st Century Skills Test

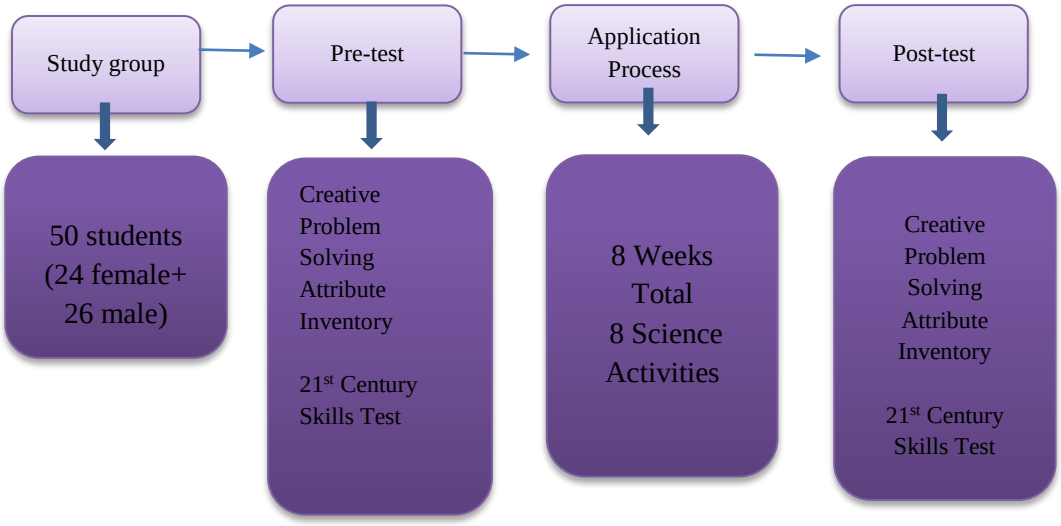

Figure 1. The research design

In the study, the same tests were applied before and after the application, and it was examined whether there was a significant difference between the pre-test scores and the post-test scores, and whether the applied science activities had an effect on students' creative problem solving and 21st century skills.

STUDY GROUP

The study group consisted of 50 students in total, 24 girls and 26 boys, in 5th grade who studied at a public school in Çankaya, Ankara in the 2018-2019 academic year. Participation in the study was on a voluntary basis and all fifth grade students were willing to participate.

DATA COLLECTION INSTRUMENTS

The Creative Problem Solving Attribute Inventory (CPSAI) and the 21st Century Skills Test (CST) were used as data collection tools.

The Creative Problem Solving Attribute Inventory (CPSAI)

The The Creative Problem Solving Attribute Inventory, developed by Lin (2010) and adapted to Turkish by Baran Bulut, İpek, and Aygün (2018) consists of 40 items in total. The original inventory developed by Lin (2010) is in 5-point Likert type and consists of 49 items and five factors. Convergent thinking, divergent thinking, motivation, environment, general knowledge and skills are the domains of the inventory and they remained as the same for the Turkish version. As a result of the validity and reliability analyses done by Baran Bulut, İpek, and Aygün (2018) it has been proven that the Turkish adapted inventory is a valid and reliable measurement tool that can be used to determine the creative problem-solving skills of secondary school students.

The scores for five domains in the Creative Problem Solving Attribute Inventory , indicate the levels of the creative problem solving skills for each domain. The score ranges determined for the items are as follows:
1.00 - 1.79 "very low," 1.80 - 2.59 "low," 2.60 - 3.39 "intermediate" 3.40 - 4.19 "high," and 4.20 - 5.00 "extremely high."

The 21st Century Skills Test (CST)

The 21st Century Skills Test, was developed by Kang, Kim, Kim and You (2013) and adapted into Turkish and validity and reliability analyses were done by Karakaş (2015). The key competencies for 21st century skills, are classified in three fields as cognitive, affective and sociocultural domains by Kang et. all. (2010). In table 2 the domains, sub-dimensions and the definitions of sub-dimensions of the 21st Century Skills are given.

Table 1: Domains of the 21st Century Skills

Domain	Sub-dimension	Definitions of sub-dimensions
Cognitive	Knowledge management skills	vehicle use use of resources questioning skill
	Knowledge construction ability	processing information reasoning skills

		critical thinking
	Knowledge use ability	analytical skills judgment and evaluation generating solutions
	Problem solving ability	metacognition creative thinking skills
Affective	Self-identity	self perception self respect self respect
	Self-value	awareness reliability honesty
	Self-management	self-efficacy goal setting obligation
	Self-responsibility	initiative insist responsibility
Socio-cultural	Social membership	social value system sense of community global citizenship
	Social sensitivity	intercultural understanding tolerance for differences
	Socialization ability	language fluency intercultural communication skills
	Social performance	leadership team work performing social services

According to table above the cognitive domain consists of knowledge management skills, knowledge construction ability, knowledge use ability and problem solving ability. The affective domain includes the fields of self-identity, self-value, self-management, self-responsibility, which are critical factors for learning success by increasing lifelong learning and educational opportunities in today's information society. The socio-cultural domain relates to sub-fields such as social membership, social sensitivity, socialization ability, and social performance (Karakaş, 2015).

The 21st Century Skills Test is 5-point Likert type and has three main domains and each domain has four sub-dimensions. The general 21st century skill levels of the students are calculated from the combination of the sub-dimensions. The average score obtained from the sub-dimension, domain and the overall scale shows the 21st century skill level of the student in that field.

These tools were applied as pre-test and post-test to the students before and after the application by the researcher to determine the effects of interdisciplinary science activities on the creative problem solving skills and 21st century skills of the study group.

In the analysis of the Creative Problem Solving Attribute Inventory and 21st Century Skills Test, "Dependent Samples t Test", and "Cohen's d" test as parametric tests were used.

APPLICATION PROCESS

The application was made in the spring term of the 2018-2019 academic year between the first week of April and the last week of May. Before the application all permissions were taken from the Minister of Education and the school administration was informed about the process. At the beginning of the study The Creative Problem Solving Attribute Inventory and the 21st Century Skills Test were given to the students as pre-tests. After the pre-tests processed, science activities prepared according to the Interdisciplinary Teaching Approach were conducted with the students as a workshop for eight weeks. After the end of the activities the The Creative Problem Solving Attribute Inventory, and the 21st Century Skills Test were given to the students as post-tests.

Preparation of the Activities

The following steps were followed in order to prepare science activities in accordance with the interdisciplinary teaching approach in order to develop students' creative problem solving and 21st century skills;

1. The 5th grade unit achievements were examined and it was ensured that all the eight interdisciplinary activities included each of the achievements of the 5th grade science curriculum.

2. The activities were designed in such a way that the student can work actively and look for a solution to a problem, including different disciplines.

3. When the activities got ready by the researchers, they were examined by another science teacher and another science education expert. According to their opinions and contributions the necessary corrections were made and the last version of the activities got ready to use.

4. Finally, for each of the prepared activitiy an achievement-skill-discipline and method/technique table was prepared.

Application of the activities

The workshops/activities implemented during the study are summarized in Table 2 below:

Table 2: Workshop and Activity Names and Application Plan Implemented in the Study

Week	Workshop	Activity
First week	Mathematics and Technology Workshop	Planets and Artificial Satellites
Second week	Living things and Life Workshop	End to Environmental Pollution
Third week	Daily life Workshop	Maps and Cartography/Orienteering
Fourth week	Mathematics and Technology Workshop	Scientists Compete
Fifth week	Living things and Life Workshop	My ecosystem
Sixth week	Design and Skills Workshop	Satellite Design
Seventh week	Daily life Workshop	My Electric Circuit
Eighth week	Design and Skill Workshop	Fast train

The application of the research was carried out with two classes of each 25 students. Classes were divided into groups with five students in each group. The application was made in the spring term of the 2018-2019 academic year between the first week of April and the last week of May and application of the activities took eight weeks. The activities were implemented by one of the researcher.

Sample activity

Workshop: Design and Skill Workshop

Activity: Satellite Design

In the sixth week an activity called "Satellite Design" was implemented in the Design and Skill Workshop. This activity was taken from the book of "Introduction to Engineering, Science, and Technology" pressed by NASA's Engineering Design Process Guide for Instructors (NASA, 2017), and the activity had been adapted for 5th grade level with minor changes. This activity can be described as a difficult activity when compared to the first five activities, which require engineering design processes and include many skills.

As the name of the activity suggests, the groups were asked to design a satellite that would land on the Moon. In the activity called planets and artificial satellites, which was applied in the first week, the satellites that they examined in four dimensions were the preliminary preparations for this activity. In this way, students had information about the appearance of satellites and for what they were launched. Application information is given below:

1. The groups were asked to design satellites with the materials (roll paper, plastic bottle cap, glue, sponge, etc.) given to them by the researcher.
2. During the design, they were asked to comply with the criteria given below.

- The materials you will put into your satellite cannot exceed 20 g.
- Your entire satellite must fit inside the pen holder on the desk.
- Your satellite must successfully pass the endurance test scale by being thrown from 1 meter.
- You can choose the following instruments to put on your satellite.

Camera (Total Mass: 2.5 g); Gravity Probe (Total Mass: 2 g); Temperature Sensor (Total Mass: 1.5 g);

- These tools need a certain solar cell to operate. The mass of each solar cell is 0.5 g

1 Camera – 3 Solar cells; 1 Gravity Probe – 2 Solar Cells; 1 Temperature Sensor – 1 Solar Cell

3. According to the criteria mentioned above, the students were asked to draw their satellites on millimetric paper and make their mathematical calculations.
4. Students who completed their designs were asked to make prototypes of the satellites they designed from the materials given by the researcher.

5. After making their satellites, the students were asked to write their hypotheses on the activity papers before the test of being thrown from a height of 1 meter, and the students who observed during the endurance test were asked to indicate whether their satellites were damaged during the test. If there was a damaged satellite, they were asked to write what could be the reason, and finally, in the endurance test, the groups whose satellites were damaged were asked to improve their satellites.

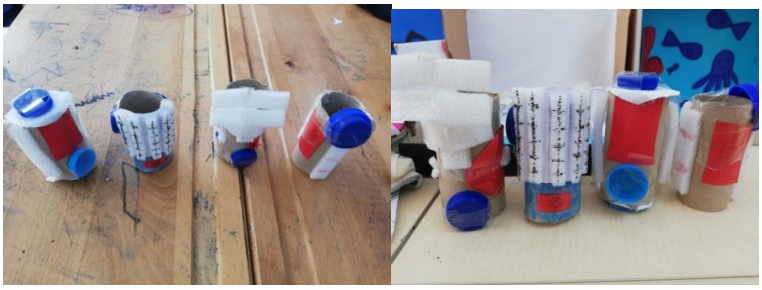

Fig 2: The pictures of the examples of the satellites developed by the students

In table below Achievement - Skill - Discipline and Method Techniques the Satellite Design Activity is given.

Table 3: Achievement - Skill - Discipline and Method Techniques Table for Satellite Design Activity

Achievements	**Target Skillls**	**Disciplines**	**Method / Techniques**
1- Express the importance of interaction between human and environment. The negative effects of environmental pollution on people's health are mentioned (F.5.6.2.1.). **2-** Provides suggestions for the solution of an environmental problem in his/her immediate surroundings or in our country (F.5.6.2.2.). **3-**Gives examples of frictional force from daily life (F.5.3.2.1.). **4-** Produces new ideas to increase or decrease friction in daily life (F.5.3.2.3.). **5-** Observes and shows with a drawing that the light emerging from a source follows a linear path in every direction. (F.5.5.1.1.). **6-**Defines a problem from daily life. a. It is desired that the problem is aimed at improving the tools, objects or systems used or encountered in daily life. b. At this stage, it is expected that the problem will be handled within the scope of material, time and cost criteria. c. It is expected that the problems will be related to the subjects included in the course from the beginning of the academic year (F.5.8.1.1.). **7-** Generates posdible solutions for the problem and compares them and chooses the appropriate one within the scope of the criteria (F.5.8.1.2.). **8-** Designs and presents the product. a. Product design and construction is done in the school.	<u>21st Century Skills</u> -Creativity and Intellectual Curiosity -Critical Thinking and Systems Thinking -Interpersonal and Collaborative Skills -Problem Defining, Formulating and Solving Skills <u>Life Skills</u> -Deciding -Creativity -Team work -Analytical Thinking <u>Engineering and Design Skills</u> - Innovative Thinking - Turkish Skills - Speech Skills	Science Mathematics Visual Arts Engineering and Design	Material Design Simple Technical Drawing Presentation Team work

b. Students are expected to make experiments during the product development phase, record the qualitative and quantitative data they have obtained as a result of these trials, and evaluate them with their ability to read or create graphs. (F.5.8.1.3.).			

In Table 3 the achievement - skill - discipline and method/techniques information is given for the Satellite Design Activity. The same table was prepared for all the other activities, similar to Table 3. It was ensured that all the eight interdisciplinary activities included each of the achievements of the 5th grade science curriculum.

DATA ANALYSIS

All of the data collected from the students with the The Creative Problem Solving Attribute Inventory and 21st Century Skills Test before and after the activity applications as pre-tests and post-tests were analysed by SPSS 23.0 program. In order to select the appropriate analysis methods, it was examined whether the data were normally distributed or not with Kolmogorow-Smirnow test. According to the test results all groups scores showed normal distribution. So parametric analyses techniques were used in the study.

FINDINGS

Since the The Creative Problem Solving Attribute Inventory and 21st Century Skills Test scores of the students provide a normal distribution, the pre-test and post-test scores of the students were analyzed using dependent samples t-test. The results are given in below:

Findings for the Creative Problem Solving Attribute Inventory

Descriptive Statistics of the study group's results from The Creative Problem Solving Attribute Inventory; mean of test scores, standart deviation (sd) values; are given in table below:

Table 4: Descriptive Statistics of the Study Group's The Creative Problem Solving Attribute Inventory Pre-test and Post-test Scores (N=50)

Domain/Inventory	**Pre-test**		**Post-test**	
	$\overline{X}$	***sd***	$\overline{X}$	***sd***
Divergent Thinking	3,67	0,64	3,88	0,64
Convergent Thinking	4,01	0,55	4,15	0,51
Motivation	3,74	0,66	3,99	0,74
Environment	4,29	0,62	4,39	0,65
General Knowledge And Skills	3,54	0,61	3,82	0,62
Creative Problem Solving Attribute Inventory	**3,85**	**0,45**	**4,05**	**0,50**

In Table 4, the average scores of all five domains of the the pre-tests and post-tests of the The Creative Problem Solving Attribute Inventory results of the study group are given. According to the table above there is an increase in favor of the post-test scores for all the domains and for the total inventory score.

According to the pre-test scores of the students, at the beginning of the study the strongest creative problem solving skill field for them was *environment* ($X_{Environment}$ =4,29±0,62; Very high level). *Convergent thinking* ($X_{Convergent\ thinking}$ =4,01±0,55 High level), *motivation* ($X_{Motivation}$ =3,74±0,66; High level), *divergent thinking* ($X_{Divergent\ thinking}$ =3,67±0,64; High level) and *general knowledge and skills* ($X_{General\ knowledge\ and\ skills}$ =3,54±0,61; High level) followed-up respectively according to pre-test scores. The students' *general creative problem solving skill* levels were also found to be "High" with the mean as $\overline{X}_{Creative\ problem\ solving\ (General)}$=3,85±0,45.

According to the post-test scores of the students, after the application of the interdisciplinary activities, the strongest skill level was the *environment* ($X_{Environment}$=4,39±0,65; Very high level). *Convergent thinking* ($X_{Convergent\ thinking}$ =4,15±0,51; High level), *motivation* ($X_{Motivation}$ =3,99±0,74; High level), *divergent thinking* ($X_{Divergent\ thinking}$ =3,88±0,64; High level) and *general knowledge and skills* ($X_{General\ knowledge\ and\ skills}$ =3,82±0,62; High level) followed-up respectively according to post-test scores. The students' *general creative problem solving skill* levels were also found to be "High" with the mean as$X_{Creative\ problem\ solving\ (General)}$= 4,05±0,50.

To see whether the activities had an effect on the creative problem-solving skills of the students, the pre-test and post-test scores of the 5th grade students were compared statistically. In cases where there was a significant difference between the pre-test and post-test skill scores, the effect of the applied activities on the skill levels was calculated with Cohen's d. In the evaluation of the degree of impact, .20 and below were accepted as "small", up to .50 as "intermediate", up to .80 as "large" and above .80 as "very large" (Leech, Barrett ve Morgan, 2005).

Table 5: The Results of the Dependent Samples t-Test Analysis for The Creative Problem Solving Attribute Inventory Pre-test and Post-test Scores

Domain/Inventory	Test	Descriptive Statistics			*T* test			Effect (*d*)
		N	$\overline{X}$	*sd*	*t*	*sd*	*p*	
Convergent thinking	Pre-test	50	3,67	0,64	2,68	49	0,010*	0,38
	Post-test	50	3,88	0,64				
Divergent thinking	Pre-test	50	4,02	0,55	2,22	49	0,031*	0,31
	Post-test	50	4,15	0,51				
Motivation	Pre-test	50	3,74	0,66	2,47	49	0,017*	0,35
	Post-test	50	3,99	0,74				
Environment	Pre-test	50	4,29	0,62	1,43	49	0,159	-
	Post-test	50	4,39	0,65				
General Knowledge and Skills	Pre-test	50	3,54	0,61	3,37	49	0,001**	0,48
	Post-test	50	3,82	0,62				
Creative Problem Solving Attribute Inventory	Pre-test	**50**	**3,85**	**0,45**	**4,08**	**49**	**0,000*** **	**0,58**
	Post-test	**50**	**4,05**	**0,50**				

**p<.05, **p<.01, ***p<.001*

As indicated in Table 5, except for the *environment* domain there was a statistically significant difference in favor of post-test scores.

There was a statistically significant difference between pre-test ($X_{Pre\text{-}test}$=3,67) and post-test ($X_{Post\text{-}test}$=3,88) scores of *convergent thinking* skill levels of the students and this difference was in favour of the post-test [$t_{(49)}$ =2,68; *p*=.010]. It was found that the effect of the applied activities on the *convergent thinking* skill levels of the students was "intermediate" (d=0.38).

There was a statistically significant difference between pre-test ($X_{Pre\text{-}test}$=4,02) and post-test ($X_{Post\text{-}test}$=4,15) scores of *divergent thinking* skill levels of the students and this difference was in favour of the post-test [$t_{(49)}$ =2,22; *p*=.031]. It was found that the effect of the applied activities on the *divergent thinking* skill levels of the students was "intermediate" (d=0.31).

There was a statistically significant difference between pre-test ($X_{Pre\text{-}test}$=3,74) and post-test ($X_{Post\text{-}test}$=3,99) scores of *motivation* skill levels of the students and this difference was in favour of the post-test [$t_{(49)}$=2,47; *p*=.017]. It was found that the effect of the applied activities on the *motivation* skill levels of the students was "intermediate" (d=0.35).

There was a statistically significant difference between pre-test ($X_{Pre\text{-}test}$=3,54) and post-test ($X_{Post\text{-}test}$=3,82) scores of *general knowledge and skills* levels of the students and this difference was in favour of the post-test [$t_{(49)}$=3,37; *p*=.001]. It was found that the effect of the applied activities on the *general knowledge and skills* levels of the students was "intermediate" (d=0.48).

When the total scores of the The Creative Problem Solving Attribute Inventory was evaluated, it was seen that there was a statistically significant difference between pre-test ($X_{Pre\text{-}test}$=3,85) and post-test ($X_{Post\text{-}test}$=4,05) scores of *general creative problem solving skill* levels of the students and this difference was in favour of the post-test [*t*

$_{(49)}$=4,08; p<.001]. It was found that the effect of the applied activities on the *general creative problem solving skill* levels of the students was "high" (d=0.58).

Findings for the 21st Century Skills Test

Descriptive Statistics of the study group's results from 21st Century Skills Test; mean of test scores, standart deviation (sd) values; are given in table below:

Table 6: Descriptive Statistics of Students' 21st Century Skills Test Pre-test and Post-test Scores (N=50)

Domain/Inventory	Pre-test		Post-test	
	$\overline{X}$	*sd*	$\overline{X}$	*sd*
Knowledge Management Skill	4,29	0,50	4,45	0,55
Knowledge Construction Ability	4,19	0,52	4,40	0,51
Knowledge Use Ability	3,52	0,74	4,01	0,89
Problem Solving Ability	4,29	0,60	4,23	0,64
Cognitive	**4,07**	**0,44**	**4,27**	**0,51**
Self Identity	4,42	0,63	4,60	0,58
Self Value	4,74	0,44	4,75	0,38
Self Management	4,34	0,63	4,53	0,69
Self Responsibility	4,48	0,51	4,56	0,58
Affective	**4,50**	**0,43**	**4,61**	**0,43**
Social Membership	4,40	0,67	4,57	0,57
Social Sensitivity	4,47	0,65	4,53	0,60
Socialization Ability	3,82	0,98	4,20	0,81
Social Performance	3,67	0,76	4,17	0,77
Socio-cultural	**4,09**	**0,52**	**4,37**	**0,49**
21st Century Skills Test	**4,22**	**0,40**	**4,42**	**0,40**

In Table 6, the average scores of all five domains of the the pre-tests and post-tests of the 21st Century Skills Test results of the study group are given. According to the table above there is an increase in favor of the post-test scores for all the domains/sub-dimensions (except Problem Solving Ability) and for the total test scores.

According to the pre-test scores of the students, at the beginning of the study the strongest 21st Century skill field was belonged to *Affective* domain ($X_{Affective}$=4,50±0,43; Very high level). *Socio-cultural* domain ($X_{Socio\text{-}cultural}$ =4,09±0,52; High level) and c*ognitive* domain ($X_{Cognitive}$=4,07±0,44; High level) followed-up respectively according to the pre-test scores. The students' general 21st Century skill levels were also found to be "Very High" with $X_{21^{st}\ Century\ skill\ (General)}$= 4,22±0,40.

According to the pre-test scores the strongest skill level for the sub-dimensions were the *knowledge management skill* (X =4.29±0.50) and the *problem-solving ability* (X=4.29±0.60) and the weakest skill level sub-dimension was the *knowledge use ability* (X =3.52). ±0.74) for the *cognitive* domain. The strongest skill level was *self value* (X =4.74±0.44) and the weakest was *self management* (X=4.34±0.63) for the Affective Field. The strongest skill level was *social sensitivity* (X =4.47±0.65) and the weakest one was *social performance* X=3.67±0.76) for the *socio-cultural* domain.

When the students' 21st Century Skills Test post-test scores were examined there was an increase compared to the pre-tests. It was seen that the strongest skill levels were beloged to the *affective* domain ($X_{Affective}$=4,61±0,43; Very high level). *Socio-cultural* domain $X_{Socio\text{-}cultural}$ =4,37±0,49; Very High level) and c*ognitive* domain ($X_{Cognitive}$=4,27±0,44; Very High level) followed-up respectively according to the post-test scores. The students' *general 21st Century skill levels* were also found to be "Very High" with $X_{21^{st}\ Century\ skill\ (General)}$= 4,42±0,40.

According to the post-test scores the strongest skill level for the sub-dimension was the *knowledge management skill* (X=4,45±0,55) and the weakest skill level sub-dimension was the *knowledge use ability* (X=4,01±0,89) for the *cognitive* domain. The strongest skill level was *self value* (X=4,75±0,38) and the weakest was *self management* (X=4,53±0,69) for the *affective* domain. The strongest skill level was *social membership* (X=4,57±0,57) and the weakest one was *social performance* (X=4,17±0,77) for the *socio-cultural* domain.

To see whether the activities had an effect on the 21st century skills of the students, the pre-test and post-test scores of the 5th grade students were compared statistically.The results analysed with the depended samples t-test. In cases where there was a significant difference between the pre-test and post-test skill scores, the effect of the applied activities on the skill levels was calculated with Cohen's d. In the evaluation of the degree of impact, .20 and below were accepted as "small", up to .50 as "intermediate", up to .80 as "large" and above .80 as "very large" (Leech, Barrett ve Morgan, 2005).

Table 7: The Results of the Depended Samples t-Test Analysis for 21st Century Skills Test Pre-test and Post-test Scores

Domain/Inventory	Test	Descriptive Statistics			*T* test			Effect (*d*)
		N	$\overline{X}$	*sd*	*t*	*sd*	*p*	
Knowledge Management Skill	Pre-test	50	4,29	0,50	2,14	49	0,038*	0,30
	Post-test	50	4,45	0,55				
Knowledge Construction Ability	Pre-test	50	4,20	0,52	2,63	49	0,011*	0,37
	Post-test	50	4,40	0,51				
Knowledge Use Ability	Pre-test	50	3,52	0,74	3,53	49	0,001**	0,50
	Post-test	50	4,01	0,89				
Problem Solving Ability	Pre-test	50	4,29	0,60	0,76	49	0,454	-
	Post-test	50	4,23	0,64				
Cognitive	**Pre-test**	**50**	**4,07**	**0,44**	**3,58**	**49**	**0,001****	**0,51**
	Post-test	**50**	**4,27**	**0,51**				
Self Identity	Pre-test	50	4,42	0,63	1,75	49	0,086	-
	Post-test	50	4,60	0,58				
Self Value	Pre-test	50	4,74	0,44	0,13	49	0,896	-
	Post-test	50	4,75	0,38				
Self Management	Pre-test	50	4,34	0,63	1,88	49	0,066	-
	Post-test	50	4,53	0,69				
Self Responsibility	Pre-test	50	4,48	0,51	1,06	49	0,293	-
	Post-test	50	4,56	0,58				
Affective	**Pre-test**	**50**	**4,50**	**0,43**	**2,12**	**49**	**0,039***	**0,30**
	Post-test	**50**	**4,61**	**0,43**				
Social Membership	Pre-test	50	4,40	0,67	1,85	49	0,071	-
	Post-test	50	4,57	0,57				
Social Sensitivity	Pre-test	50	4,47	0,65	0,69	49	0,497	-
	Post-test	50	4,53	0,60				
Socialization Ability	Pre-test	50	3,82	0,98	2,65	49	0,011*	0,38
	Post-test	50	4,20	0,81				
Social Performance	Pre-test	50	3,67	0,76	3,54	49	0,001**	0,50
	Post-test	50	4,17	0,77				
Socio-cultural	**Pre-test**	**50**	**4,09**	**0,52**	**4,10**	**49**	**0,000*****	**0,58**
	Post-test	**50**	**4,37**	**0,49**				
	Pre-test	**50**	**4,22**	**0,40**	**5,06**	**49**	**0,000*****	**0,72**

21st Century Skills Test	**Post-test**	**50**	**4,42**	**0,40**

**p<.05, **p<.01, ***p<.001*

As indicated in Table 7, it was seen that there was a difference in favor of the students' post-test scores for the domains/sub-dimensions and the overall scale. The detailed results are as below:

1) There was a statistically significant difference between pre-test ($X_{Pre\text{-}test}$=4,07) and post-test ($X_{Post\text{-}test}$=4,27) scores of *cognitive skill levels* of the students and this difference was in favour of the post-test [$t_{(49)}$=3,58; p=.001]. It was found that the effect of the applied activities on the *cognitive skill* levels of the students was "high" (d=0.51). When we look to the results of the analysis for the sub-dimensions of the *cognitive skill* field;
   a) There was a statistically significant difference between pre-test ($X_{Pre\text{-}test}$=4,29) and post-test ($X_{Post\text{-}test}$=4,45) scores of *knowledge management skill levels* of the students and this difference was in favour of the post-test [t (49)=2,14; p=.038]. It was found that the effect of the applied activities on the cognitive skill levels of the students was "intermediate" (d=0.30).
   b) There was a statistically significant difference between pre-test ($X_{Pre\text{-}test}$=4,20) and post-test ($X_{Post\text{-}test}$=4,40) scores of *knowledge construction skill levels* of the students and this difference was in favour of the post-test [$t_{(49)}$=2,63; p=.011]. It was found that the effect of the applied activities on the *knowledge construction skill levels* of the students was "intermediate" (d=0.37).
   c) There was a statistically significant difference between pre-test ($X_{Pre\text{-}test}$=3,52) and post-test ($X_{Post\text{-}test}$=4,01) scores of *knowledge use ability* of the students and this difference was in favour of the post-test [$t_{(49)}$=3,53; p=.001]. It was found that the effect of the applied activities on the *knowledge use ability* of the students was "intermediate" (d=0.37).
   d) There was no statistically significant difference between pre-test ($X_{Pre\text{-}test}$=4,29) and post-test ($X_{Post\text{-}test}$=4,23) scores of problem solving ability of the students[$t_{(49)}$=0,76; p=0,454].
2) There was a statistically significant difference between pre-test ($X_{Pre\text{-}test}$=4,50) and post-test ($X_{Post\text{-}test}$=4,61) scores of *affective skill levels* of the students and this difference was in favour of the post-test [$t_{(49)}$=2,12; p=.039]. It was found that the effect of the applied activities on the *affective skill* levels of the students was "intermediate" (d=0.30). When we look to the results of the analysis for the sub-dimensions of the *cognitive skill* field no statistically significant difference was found (p>.05).
3) There was a statistically significant difference between pre-test ($X_{Pre\text{-}test}$=4,09) and post-test ($X_{Post\text{-}test}$=4,37) scores of *socio-cultural* skill levels of the students and this difference was in favour of the post-test [$t_{(49)}$=4,10; p<.001]. It was found that the effect of the applied activities on the *socio-cultural* skill levels of the students was "high" (d=0.58). When we look to the results of the analysis for the sub-dimensions of the *socio-cultural* skill field;
   a) There was a statistically significant difference between pre-test ($X_{Pre\text{-}test}$=3,82) and post-test ($X_{Post\text{-}test}$=4,20) scores of *sociliazition ability* of the students and this difference was in favour of the post-test [$t_{(49)}$=2,65; p=.011]. It was found that the effect of the applied activities on the *sociliazition ability* of the students was "intermediate" (d=0.38).
   b) There was a statistically significant difference between pre-test ($X_{Pre\text{-}test}$=3,67) and post-test ($X_{Post\text{-}test}$=4,17) scores of *social performance* of the students and this difference was in favour of the post-test [$t_{(49)}$=3,54; p=.001]. It was found that the effect of the applied activities on the *social performance* of the students was "high" (d=0.50).
   c) There was no statistically significant difference between pre-test scores and the post-test scores of social membership ($X_{Pre\text{-}test}$=4,40; $X_{Post\text{-}test}$=4,57; $t_{(49)}$=1,85; p=.071) and social sensitivity ($X_{Pre\text{-}test}$=4,47;$X_{Post\text{-}test}$=4,53; $t_{(49)}$=0,69; p=.497) of the students.

When the total scores of the 21st Century Skills Test were evaluated, it was seen that there was a statistically significant difference between pre-test ($X_{Pre\text{-}test}$=4,22) and post-test ($X_{Post\text{-}test}$=4,4,42) scores of general 21st century skill levels of the students and this difference was in favour of the post-test [$t_{(49)}$=5,06; p<.001]. It was found that the effect of the applied activities on the general 21st century skill levels of the students was "high" (d=0.72).

CONCLUSION AND DISCUSSION

The average scores after the application of the creative problem skills inventory pre-test and post-test of the 5th grade students who participated in the research show in accordance with the general scale and all sub domains that there was an increase in favor of the post test. Deriving from these findings, it can be concluded that science activities prepared with the interdisciplinary teaching approach increase the creative problem solving skills of students. The creative problem-solving skill levels of the students were found to be "high" after the application of interdisciplinary activities. When students are given the opportunity to develop their creative problem skills, their creative problem skills are shown to change in a positive direction. Thus, Pannels (2010) observed in his study that students who did creative problem solving activities, changed in a positive direction regarding their creative

problem skills.The pre-test results of the students who participated in this study showed that the strongest skill level was *"environment*". *Convergent thinking, motivation, divergent thinking and general knowledge and skills* followed environment respectively. Paf (2019) in his similar study analyzed middle school students' creative problem solving skill levels and similarly found the strongest skill level as *environment* and the weakest skill level as *general knowledge and skills*. When students first encounter a problem, they generally prefer to seek help from the people in their environment. The students' convergent thinking skills were at a higher level than their divergent thinking skills in the study. Instead of developing a few solutions to a problem and choosing the best one from among those, students prefer to focus one solution. Totan and Kabasakal (2012) in their similar study showed that problem solving skills training increased students' sense of duty, self-regulation, problem solving skills, coping with stress skills, and social and emotional learning.

Another conclusion drawn from findings of the study was that science activities prepared with interdisciplinary teaching approach have a "big" degree effect on the *general creative problem solving skills* of the students. As for the sub domains, it was concluded that the activities had a "intermediate" degree effect. Because interdisciplinary teaching approach helps to look with the perspective of more than one discipline, it is helpful for creative problem solving. Özkök (2005) states that interdiscipanary teaching approach affects the creative problem skill levels of students. Bal İncebacak and Ersoy (2018) in their study where they analyzed the creative problem solving skills of middle school students, reached the conclusion that students who encounter a creative problem for the first time have difficulty solving this problem and their marks are low. This conclusion by Bal İncebacak and Ersoy (2018) differs with the conclusions of this study. There might be many reasons for this difference but the most influential factor in developing students' creative problem solving skills might be also teachers. Because of this, Özkök (2005) recommends that there should be the topic of creative problem solving teaching based on interdisciplinary teaching approach in teachers' pre-service and in-service programs. The idea that when appropriate learning settings are provided and the required activities are done, students can develop their creative problem solving skill level (Barak, 2012; Özkök, 2004, 2005; Pannells, 2010; Paf, 2019; Totan ve Kabasakal, 2012). As this study and related field studies support, science activities prepared with interdisciplinary teaching approach have a positive effect on increasing creative problem solving skill levels. In order for the interdisciplinary teaching approach to be used efficiently, teachers must be able to use this approach effectively in their lessons (Cura ve Ercan Yalman, 2019; Gürkan, 2019; Mikser, Reiska ve Rohtla, 2008). When the average scores of the students participating in the study were examined before and after the activities there was an increase in favor of the post-tests in general.

When the general 21st century skills, pre-test and post-test scores of the students participating in the study were examined, it was seen that they were at a "very high" level. Although the students' 21st century skills levels were found to be "very high" at the beginning of the study, it was observed that there was a statistically significant increase in the post-test scores at the end of the application.

In the study, the effect of the applied activities on the cognitive skill levels of the students was calculated and the degree of effect was found to be "large". As a result of the analysis of the sub-domains, it was found that the degree of influence was "intermediate". When the cognitive skills of the students were evaluated, it was concluded that the students collected information while studying without depending on the textbook, they could use the information that would help them in their homework, and they tried to integrate the information they learned in the lesson into daily life. Diker (2019) examined the 21st century skills levels of middle school students and found that students' cognitive skill levels were at a high level similar to this study. Wan Husin et al. (2016) examined the effect of an integrated STEM education program on students' 21st century skills and observed a significant increase in 21st century skills level. Similarly, in his study, Karakaş (2015) found that eighth grade students had a high level of 21st century skills for science lessons. Kotluk and Kocakaya (2015) examined the effects of digital storytelling on students' 21st century skills in physics teaching and stated that students' life and professional skills improved as they took an active role. Wan Husin et al. (2016) found that science and technology skills affect 21st century skills in their studies. It was seen that the sub-dimensions in which the students were strongest in the field of Cognitive skills were *knowledge management skills* and *problem solving skills*. It was seen that the weakest sub-dimension was the *knowledge contruction ability*.

During the application, it was observed that the students benefited from other information sources as necessary while managing the information. This supports the result that students have the highest average of *knowledge management skills* in the sub-dimensions of the *cognitive* domain. Diker (2019) similarly found in his study that the *knowledge management skill* sub-dimension is the strongest among the 21st century skills sub-dimensions. In the *problem solving ability* sub-dimension, it was observed that the students tried to calmly cope with the problems they encountered. In the sub-dimension of the *knowledge use ability*, it was concluded that the students were able to associate the information they learned at school with daily life. Compared to other sub-dimensions, students' *knowledge construction ability* averages were lower. *Cognitive skills* predict academic performance (Fin, Kraft et

al., 2014). A positive change may have occurred in the academic performance of the students together with the *general cognitive skill levels* of the students after the interdisciplinary science activities. Yılmaz, Özkaral, and Yavuz (2017) concluded that the interdisciplinary teaching approach increased students' academic achievement more than single-discipline-based learning. Özçelik (2015) similarly showed that the interdisciplinary teaching approach increases academic achievement.

In the study, it was found that the effect of the applied activities on the students' *affective skill levels* was "intermediate". When students' *affective* domain skills were examined; it can be concluded that students know their strengths and weaknesses, have future goals, question the reason for failure when they fail in their courses, try to be honest with themselves and their environment, and try to fulfill the responsibilities given to them. Top and Şahin (2017) showed the effect of STEM Students on the Stage (SOS) model on students' social and emotional gains in his study. He divided the skills acquired by the students into five groups; technology skills, self-confidence, life and career skills, communication skills and collaboration skills. It has been shown that the STEM SOS model has a positive effect on these skills, which are among the 21st century skills. Diker (2019) found in his study that students have a high level of *affective skills* domain, which are sub-dimensions of 21st century skills. Güven (2012), in his study, showed that environmental education given with an interdisciplinary teaching approach has a positive effect on students' behavior and attitudes towards environment. It has been seen that the most powerful sub-dimension of the students in the domain of *affective skills* was *self value* and the weakest sub-dimension was *self management skill*. It was concluded that the students tried to fulfill their promises and were honest in the *self value* sub-dimension from the *affective skill* domain. It was concluded that the students were aware of their own characteristics in the sub-dimension of *self identity*. In the sub-dimension of *self responsibility*, it was concluded that the students took care to fulfill the responsibilities assigned to them. Finally, it was concluded that students were aware of their shortcomings in the *self management* sub-dimension, where students were weaker compared to other sub-dimensions, and they tried to cope with their failures. Diker (2019) reached a similar conclusion with this research in his study. It was determined that the weakest sub-dimension of the students in the field of *affective skills* was *self management*, and the strongest area in the field of *affective skills*, unlike this study, was the sub-dimension of *self identity*.

In the study, it was found that the effect of the applied activities on the *socio-cultural skills* of the students was "great". When the sub-dimensions were considered one by one, it was found that the levels of the sub-dimensions, except for the *social performance* levels, were effective as "intermediate". At the level of *social performance*, it was found to be effective at a “great” degree. When the results of *socio-cultural skills* were examined; it was concluded that the students did not discriminate each other when choosing friends, they enjoyed cooperating during group work, and they made more effort when working in groups than individually.It has been seen that the sub-dimension in which the students were strongest in the field of *socio-cultural skills* was *social sensitivity* and the sub-dimension in which they were weakest was *social performance*. Karakaş (2015) and Diker (2019) reached similar results in their studies. It was concluded that the students did not have difficulty in making friends in the domain of *socio-cultural skills*, and did not discriminate between each other. It was observed that the students did not have difficulty in group work/cooperation in the sub-dimension of *socialization ability*. In the *social membership* sub-dimension, it was observed that the students were able to work with their friends and had no problems in socializing. When the last sub-dimension, *social performance*, was compared with the other sub-dimensions, it was seen that the students were weaker in this area. It was concluded that the students worked with more devotion when doing group work than individually. As supported by this study and related field studies, it is seen that science activities prepared according to the interdisciplinary teaching approach have a positive effect on 21st century skills.

Since science activities prepared according to the interdisciplinary teaching approach contain many skill areas, we need to include this approach in our education system. It is very important to apply the interdisciplinary education approach in middle schools. This will only happen if researchers, program makers and, of course, practitioners, teachers, realize that this approach is an approach that will give our children the features we want them to have in the future. It has been shown that the interdisciplinary activities implemented in this study are effective in helping our children gain the skills required by the current century and that they are effective in developing the creative problem-solving skills they will need to solve the problems they will encounter in the future. As a matter of fact, it is seen that this subject is included in the 2023 vision of the Ministry of National Education (MEB), and with the implementation of the "Design and Skill Workshops" pilot applications in our schools for the first time in February 2019, the studies on the implementation in schools all over our country have been accelerated until today.

SUGGESTIONS

In this research, the effects of science activities prepared according to the interdisciplinary teaching approach on the creative problem solving and 21st century skills of 5th grade students were investigated. Since this study is

limited to the 5th grades, similar studies can be carried out by expanding the scope of this limit in future studies. Since the interdisciplinary teaching approach is an approach that requires a process, the number of activities can be increased. In this study, a single group design was used. Similar studies to be done in the future can be done by including the control group. The activities applied in the study were prepared in accordance with science lesson achievements. A research can be conducted on gaining similar skills to students by targeting the achievements of other courses such as mathematics, social sciences and Turkish language. This study focused on creative problem solving skills and 21st century skills. The development of other high-level skills such as critical thinking skills can be examined.

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