ORIGINAL ARTICLE

The Effects of STEM Activities Conducted with the Flipped Learning Model on Primary School Students' Scientific Creativity, Attitudes and Perceptions towards STEM

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Abstract: *The aim of this study is to determine the effects of STEM activities carried out with the flipped learning model within the scope of science class on the scientific creativity, perceptions about STEM, and attitudes towards STEM of 4th grade primary school students and to reveal students' opinions about the learning process. The sample of this study consisted of 57 fourth grade students attending a public primary school in a city center in the Eastern Black Sea region in the spring semester of the 2021-2022 academic year. Mixed method was used in the study. Quasi-experimental method with experimental and control groups was used in the quantitative dimension of the study, and case study was used in the qualitative dimension. In the study, data were collected using the "Scientific Creativity Scale", "STEM Attitude Scale", "STEM Perception Test" and a "semi-structured interview form" developed by the researcher. SPSS 21 package program was used to analyze the collected quantitative data and content analysis was used to analyze the qualitative data. The quantitative results of the study revealed that STEM activities conducted with the Flipped Learning Model had a positive effect on students' scientific creativity levels and STEM perceptions, but had no effect on their attitudes towards STEM. The qualitative results of the study revealed that students mostly found the activities useful, instructive and fun. In line with the results obtained from the study, the use of STEM activities supported by the Flipped Learning model is recommended at all levels of education.*

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Introduction

IT is not wrong to call the 21st century the age of technology, where it develops and changes rapidly and where accessing, disseminating and learning information has become more comfortable. This technological age we are in is witnessing races between countries in the shadow of advancing technological developments. Economic success, technological development and education policies can be given as examples of these races (Yıldırım and Selvi, 2017).

Many published reports emphasize that societies will need individuals who can keep pace with change, contribute to the needs of the age, think creatively, have the ability to innovate and have multiple disciplines (National Academy of Engineering [NAE] & National Research Council [NRC], 2009; NRC, 2012; Next Generations Science Standards [NGGS], 2013). The transformation from science education to STEM education started in the United States of America and continues in some European countries and the studies are increasing rapidly. STEM education has become an integral part of 21st century learning programs (Honey, Pearson & Schweingruber, 2014; NAE & NRC, 2009; NRC, 2014). As science and technology progress in the world, the value of STEM education will become more important (Holdren, Lander, & Varmus, 2010).

In Turkey, the Science Curriculum revised in 2013 emphasized the need for STEM integration in learning environments (Ministry of National Education [MoNE], 2013). MoNE also included the engineering discipline in the science curriculum (MoNE, 2017). STEM education aims to enable learning by doing, researching and questioning in the fields of Science, Technology, Engineering and Mathematics, as well as creating an original product. Therefore, by understanding not only how to learn but also how to use knowledge, students will contribute to scientific and technological developments in countries and thus to economic development (Gonzalez & Kuenzi, 2012; Yıldırım & Altun, 2015; Bybee, 2010; Brenner, 2009; National Research Council [NRC], 2011; Scott, 2009; West, 2012). In this way, with an interdisciplinary education approach, students can associate and use the concepts and skills of many disciplines in school with their own life problems, and at the same time, effective teaching can occur (Bybee, 2016). A proper STEM education in accordance with the rules of its implementation improves students' abilities such as understanding the working methods of tools and equipment and using technology effectively (Bybee, 2010).

We observe that certain problems arise during the implementation of the STEM education approach. The intensity of the existing curriculum during the implementation of STEM education (Akın, 2019; Köken, 2020), situations where the class size is too crowded (Köken, 2020), the time allocated for the implementation is not enough (Ozan, 2019; Şen, 2019; Tomaç, 2019; Yazıcı, 2019), communication-related problems between student groups during teamwork (Doğan, Savran-Gencer, & Bilen, 2017; Şen, 2019; Yazıcı, 2019) can be given as examples of these problems. The problems mentioned and the difficulties caused by these problems indicate that STEM education cannot be implemented efficiently enough in learning environments. In this case, in order to implement STEM education effectively, there is a need for new teaching environments that will increase the effectiveness of face-to-face education in learning environments with the support of technology. Within the scope of these goals, one of the models discussed and studied to be developed is the flipped learning model.

The flipped learning model, which emerged by blending the strengths of face-to-face and distance learning, is an approach that utilizes the advantages of both learning environments (Ünsal, 2018). In other words, it is the combination of face-to-face education in the classroom with the learning activity that the student carries out outside the classroom with various online tools, where he/she can adjust the time, place and pace according to his/her needs (Staker & Horn 2012). That is; the student benefits from the advantages of both technology-supported learning environments and face-to-face instruction. When foreign studies on the flipped instruction model are investigated, we see that the concept is defined as "inverted classroom" (Bates & Galloway, 2012; Gannod, Burge, & Helmick, 2008; Lage et al., 2000; Morin, Kecshemety, Harper, & Clingan, 2013; Strayer, 2012, Talbert, 2012) or "flipped classroom" (Bergmann & Sams, 2012; Bishop & Verleger, 2013; Butt, 2014, Enfield, 2013; Hertz, 2012; Milman, 2012).

The concept of flipped learning is considered as a model where learning is performed by students at home with their own means, and homework practices, which are traditionally given by the teacher to be done at home, are done in the classroom environment (Bergmann & Sams, 2012). In the flipped learning approach, which can be briefly defined as a lesson at home and homework at school, resources are provided to the learner so that learning can take place in an individual environment. These resources are various multimedia tools such as videos, slide shows, texts related to the subject. Thus, in the time saved from direct teaching in the classroom, a more effective learning can be provided to the student in the classroom environment. In this context, it is a fact that the process of learning the preliminary theoretical knowledge required for STEM education will be realized in the out-of-school learning environment, and time will be saved in teaching by having only STEM applications in the classroom. McLean et. al. (2016), in their work, students reported that with the flipped approach they developed independent learning strategies, spent more time on the task, and engaged in deep and active learning.

Flipped learning is considered to be a useful model because it allows students to experience their learning. In flipped learning, students can access the topics required for the course at any time according to their learning time. In this way, students have the opportunity to re-access and learn the lessons they cannot reach or watch with the necessary materials (video, presentation, online tool, etc.). Likewise, the teacher can determine the individual needs of the students with the tools used by technology and respond appropriately in the classroom environment (Hertz, 2012). Thus, in STEM education, in and out of the classroom, the research dimension and the elimination of prior knowledge deficiencies are provided by flipped learning.

According to Bergmann and Sams (2012), flipped learning is not only about the use of online tools, but also about interactive activities during the lesson. Today, STEM education, which is applied in educational environments where the student is at the center and technology is used effectively, can be considered as an example of educational models that cause educational systems to change, just like flipped learning. In the same way, the flipped learning model and STEM education can be said to overlap in terms of targeting high-level learning skills, using technology in the process, giving great importance to the use of technology, and activating the student in the process (Söndür, 2020). Considering these issues, we believe that the STEM activities carried out with the Flipped Learning Model in the content of this study will support the development of students.

At the same time, the effects of the flipped learning model on achievement, motivation, self-efficacy, self-directed learning, cognitive load, computer thinking, risk taking and retention were examined and the model was examined in terms of student views (Arshad & Imran, 2013; Berret, 2012; Boyraz, 2014; Demirlay & Karataş, 2014; Johnson & Renner, 2012; Sezer, 2015; Sever, 2014; Yesterbasky, 2015).

While there are scientific studies on the Flipped Learning model (Şerefli, 2020; Yu, 2022; Ünlü, 2022) and STEM activities (Park & Ko, 2012; Kyere, 2017) separately in the literature, there are few studies investigating the effect of the Flipped Learning model and STEM activity applications together (Söndür, 2020; Coşkun, 2021; Birgin, 2022; Ramírez, Hinojosa & Rodríguez, 2014). When the studies are examined, we see that the studies on the flipped classroom model are mostly on foreign languages and computers, and there are very few studies on its use in science classs. In addition, there were no studies on scientific creativity in the studies using the flipped classroom model. Likewise, in the studies on the flipped classroom model and STEM education approach, there was no study on primary school 4th grade students. Considering these issues, we believe that this study will contribute to the literature in this respect.

In addition, there are very few studies in the literature measuring the effects of the Flipped Learning model on scientific creativity (Harjono, et. al. 2022; Ariani, et. al. 2022). The studies conducted on the flipped learning model mostly investigated the effect of the flipped learning model on academic achievement (Güven-Demir, 2018; Ök, 2019; Koçak, 2019; Şerefli, 2020; Tekin, 2020; Demir, 2020; Ünlütürk, 2022).This study aims to examine the effect of STEM activities carried out with the Flipped Learning Model on the learning products of Primary School 4th grade students. The fact that there is no such study in terms of the content study group and the method tools used within the scope of the study increases the importance of this study in terms of contributing to the literature. Clark (2013) and Coufal (2014) found it wrong to use the flipped learning model only in the educational life of university students and to conduct research only at this level. The most important factor that reveals the originality of this study is that the study was conducted with students at the primary school level (4th grade) and is an experimental study, aiming to find solutions to the current educational problems and problems in the process of more effective implementation of STEM education.

Study Questions

The aim of this study is to determine the effects of STEM activities carried out with the flipped learning model within the scope of science class on the scientific creativity, attitudes towards STEM and perceptions about STEM of 4th grade primary school students and to reveal the students' opinions about the learning process. The questions of the research are as follows:

i. Is there a significant difference between the mean pre-test and post-test scores of the students in the experimental group on the Scientific Creativity Scale?
ii. Is there a significant difference between the mean pre-test and post-test scores of the students in the control group on the Scientific Creativity Scale?
iii. Is there a significant difference between the mean post-test scores of the students in the experimental group and the students in the control group on the Scientific Creativity Scale?
iv. Is there a significant difference between the STEM Attitude Scale pre-test-post-test mean scores of the students in the experimental group?
v. Is there a significant difference between the STEM Attitude Scale pre-test-post-test mean scores of the students in the control group?
vi. Is there a significant difference between the mean STEM Attitude post-test scores of the students in the experimental group and the students in the control group?
vii. Is there a significant difference between the mean STEM Perception pre-test and post-test scores of the students in the experimental group?
viii. Is there a significant difference between the STEM Perception pre-test-post-test mean scores of the students in the control group?

ix. Is there a significant difference between the mean STEM Perception post-test scores of the students in the experimental group and the students in the control group?

x. What are the opinions of the students in the experimental group about the STEM activities carried out with the Flipped Learning Model before the implementation?

xi. What are the opinions of the students in the experimental group about the Flipped Learning Model and the STEM activities carried out after the implementation?

The Aim of the Study

The aim of this study is to determine the effects of STEM activities carried out with the flipped learning model within the scope of the 4th grade science class on the scientific creativity, perceptions about STEM and attitudes towards STEM of 4th grade elementary school students and to reveal student views on the learning process.

Materials and Methods

The Model of the Study

This study utilized a mixed method. Qualitative and quantitative data were collected together within the scope of the aims and sub-objectives of the study. The mixed design is based on the belief that using quantitative or qualitative analysis results alone from the statistical data obtained by the researcher is not sufficient to reflect the problems of the research, while combining statistical trends (quantitative data) with stories and personal experiences (qualitative data) is necessary to better understand the research problem (Creswell & Sözbilir, 2017). In the quantitative dimension of the study, the quasi-experimental method with experimental and control groups was used, and in the qualitative dimension, the case study method was used.

Population and Sample

The sample of this study consisted of 57 fourth grade students attending a public primary school in a city center in the Eastern Black Sea region in the spring semester of the 2021-2022 academic year. The sample was selected by convenience sampling method. Two 4th graders were selected as experimental and control groups. In this context, the frequency values of the sample are given in **Table 1**.

Table 1. Frequency Values Of The Students In The Experimental and Control Groups.

Groups	Gender	f	%
Experimental	Male	17	61
	Female	11	39
	Total	28	100
Control	Male	13	45
	Female	16	55
	Total	29	100
Total	Male	30	53
	Female	27	47
	Total	57	100

Data Collection Tools

In this study, quantitative data were collected with the Scientific Creativity Scale, STEM Perception Scale, STEM Attitude Scale and qualitative data were collected with a semi-structured interview form developed by the researcher.

Quantitative Data Collection Tools

- *Scientific Creativity Scale*

In this study, the Scientific Creativity Scale, which was developed by Hu and Adey (2002) and adapted into Turkish by Deniş-Çeliker and Balım (2012) as a quantitative data collection tool to determine the scientific creativity levels of the students, was applied to the experimental and control groups as pre-test and post-test. The Cronbach Alpha reliability coefficient of the measurement tool, which consists of seven open-ended questions, is 0.86.

Reliability calculations of the scale were made by the researcher in terms of internal consistency. For the scoring of the Scientific Creativity Scale, the researcher who adapted the scale was contacted and permission was obtained. Afterwards, the scoring of the scale was carried out in accordance with the determined stages. Total scores were calculated for seven items of the Scientific Creativity Scale. The Cronbach alpha internal consistency coefficient of the scale was found to be 0.82. A positive and high item-total correlation indicates that the items exemplify similar characteristics and the internal consistency of the test is high (Büyüköztürk, 2008).

- *STEM Perception Test*

This study used the STEM Perception Test adapted into Turkish by Gülhan (2016) to determine students' perception levels towards STEM. This test is of the type of "Osgood type emotional meaning scale" (in other words, semantic differences test) and was developed to measure what a situation means to an individual. This test also has a scale type that is simple in terms of ease of application to all age groups and economical in terms of time (Tavşancıl, 2014). The STEM Perception Test consists of 5 sections with sub-headings as science-technology-engineering-mathematics-career. In the test, for each sub-heading and section (science-technology-engineering-mathematics-career), there are 5 adjectives with opposite meanings and 5 more adjectives that are differentiated in terms of opposition. There are 7 different possibilities between the two opposites. These options are listed in a graded format. The students are asked to choose the adjective with the closest meaning to their current emotional state and check the box symbolizing closeness to the chosen adjective.

Reliability calculations of the scale were made by the researcher in terms of internal consistency. The Cronbach α reliability coefficient calculated for the reliability of the scores obtained with the STEM Perception Scale used in the study was α = 0.92.

- *STEM Attitude Test*

The study aims to determine students' attitudes towards STEM in terms of different variables, and the data related to this issue were obtained using the STEM Attitude Scale developed by Faber, Wiebe, Corn, Townsend, and Collins (2013) and adapted into Turkish by Özyurt, Kayiran, & Başaran (2018). The scale is a 5-point Likert-type scale consisting of 37 items and four subscales: math, science, engineering, and 21st century skills; and the construct validity of the rating scale was tested using confirmatory factor analysis by the researchers who adapted it into Turkish.

The reliability calculations of the scale were also made by the researcher in terms of internal consistency. The Cronbach α reliability coefficient calculated for the reliability of the scores obtained from the STEM Attitude Scale used in the research was found to be α=0.95.

Qualitative Data Collection Tools

Semi-Structured Interview Form

In the study, a semi-structured interview form was used as a qualitative data collection tool. For this method, which was preferred in order to obtain more comparative results, the researcher conducted the necessary research based on the information in the literature and prepared semi-structured interview questions to be applied as a pre-test consisting of 10 questions and post-test semi-structured interview questions consisting of 12 questions within the scope of the research scales. In the preparation process of the interview questions prepared by the researcher, attention was paid to criteria such as the question structures being simple and clear, not directing the respondent to different dimensions, being in a dimension to cover the criteria whose effect is measured within the scope of the research, and being at a level that students at the 4th grade level can understand (Bogdan & Biklen, 1992; cited in Yılmaz & Altınkurt, 2011). In order to check the extent to which the prepared semi-structured interview form would help the purpose of the study, its simplicity and applicability, an expert in the field and a classroom teacher were consulted in line with these issues. In line with the feedback received, the interview form was finalized and validity was ensured.

Implementation Process of the Study

The necessary permissions were obtained from the Ministry of National Education in order to carry out the activity implementations in the school where the research would be conducted and the studies were started to be carried out in the school mentioned for the implementation.

The study was conducted in a primary school in a provincial center in the Eastern Black Sea Region in the spring semester of the 2021-2022 academic year. In the first week of the study, experimental (f:25) and control (f:29) groups were determined and pre-tests were administered to both groups. The study groups (experimental and control groups) were administered the Scientific Creativity Scale, Attitude towards STEM Scale and Perception towards STEM Scale as pre-test and post-test. At the same time, focus group interviews were conducted with 8 students selected from the experimental group students before and after the application.

Before starting the implementation in the experimental group, the groups were formed by the classroom teacher to be heterogeneous. In the experimental group of 28 students, 2 were mainstreaming students.1 student could not attend the lessons regularly due to various health reasons. For this reason, 25 students actively participated in the application in the experimental group. In line with the opinions of the classroom teacher, the class was divided into 4 different heterogeneous groups, 3 groups consisting of 6 students and 1 group consisting of 7 students.

In the applications, science discipline was centered and integrated with other STEM disciplines, including at least one other discipline (mathematics, social sciences, Turkish, etc.).

Experimental Group Implementation Process

The study covered a 5-week period and before this process, students were given brief information about the flipped teaching model and STEM education approach and the implementation process was mentioned. At the same time, a meeting was held with the parents of the students in the experimental group in the presence of the class teacher and the activity implementation process was mentioned. In particular, the importance of the support that the parents will give to the students for the out-of-class applications of the flipped teaching model was mentioned. The main purpose here is to provide students and parents with general information about the flipped teaching model and STEM education before the study.

STEM activities were implemented in the experimental group for 5 weeks, 3-4 hours a week. Five different STEM activities prepared by the researcher were applied to the students for a total of 18 hours. The activities were prepared by the researcher taking into account the achievements specified in the 4th grade education curriculum of the Ministry of National Education.

In the out-of-class activities of the flipped learning model, students used EBA. In addition to lectures, animations and activities, students also watched presentations, documents and videos prepared by the researcher and previously uploaded to EBA (STEM technology dimension). Whether the students did the out-of-class activities was checked both from EBA data and from the students at the beginning of the lesson (5 minutes) with a question-answer activity. Thus, it was tried to prevent situations such as whether out-of-class applications were done or not. In addition, the first 5-10 minutes of the application lessons in the experimental group were spent in a mini question-answer round to check the readiness of the students and to go over the parts they could not fully understand. The students imagined their designs in line with the STEM activity problems given to them, and noted the problems that might occur in the design and their ideas on how the problems could be solved (STEM engineering dimension). Students calculated the dimensions of their imagined designs and how much of which material they would use (STEM mathematics dimension). The activities were planned based on the science class outcomes. As a subject, students were encouraged to make predictions and inferences about science concepts and to associate these concepts with daily life (STEM science dimension).

Control Group Implementation Process

In the control group, teaching was carried out by the classroom teacher within the scope of the Science class curriculum, using the textbooks of the Ministry of National Education and the smart board as teaching materials. In the control group classes, the researcher attended the lessons as an observer. Lecture, question and answer, brainstorming, demonstration, etc. were generally used as teaching methods in the learning environment, while the activities in the textbook were also utilized. In addition, class discussions were held in order to better teach the subject in the classroom environment and the evaluation questions in the textbooks were answered. The researcher observed that the control group did not include flipped teaching and STEM activities.

Collection of the Data

"STEM Attitude Scale", "STEM Perception Scale" and "Scientific Creativity Scale" were applied to the control and experimental groups as pre-test before the teaching process of the related units started. At the end of the teaching process, the "STEM Attitude Scale", "STEM Perception Scale" and "Scientific Creativity Scale" were reapplied to the experimental and control groups as a post-test.

In order to obtain more detailed data about the learning processes designed within the scope of the study and to understand the experiences of the students, qualitative data were collected through semi-structured interview forms and focus group interviews before and after the implementation. Face-to-face interviews were conducted with the students. The interviews lasted 25-30 minutes. Open-ended interview questions were asked to the children by the researcher and the answers were recorded by voice recording. The researcher told the participants about the importance of their answers in terms of the validity and reliability of the study and asked them to show the necessary sensitivity. No guidance was given during the interview. Afterwards, the audio recordings were transcribed and analyzed by the researcher.

STEM Activities Preparation Process

Before determining the STEM activities, a literature review was conducted to investigate which subjects were studied in the 4th grade science class. Within the framework of the 4th grade science education program, 5 weeks were planned for 5 activities. These activities consisted of the following contents:

***Activity 1**: "sound insulated house design". This activity was created with the "sound pollution" content of the "Lighting and Sound Technologies" unit. However, the activity that requires reducing sound pollution was prepared to cover science, engineering and mathematics disciplines.*

***Activity 2**: "economical irrigation system". This activity was organized taking into account the issue of economical use of resources. Within the scope of designing an irrigation system, it is aimed for students to blend science, mathematics, engineering, and technology disciplines.*

***Activity 3**: "I recycle my water design". This activity was organized to emphasize the importance of recycling the resources necessary for life. In this context, it was aimed for students to design creative recycling materials with household waste.*

***Activity 4**: "lighting tool design". This activity was organized to emphasize the importance of recycling the resources necessary for life. In this context, it was aimed for students to design creative recycling materials with household waste.*

***Activity 5**: "designing appropriate lighting". This activity was designed for students to set up a working electrical circuit and learn that the switches and cables in the school are circuit elements.*

For each of the prepared and selected activities, an activity sheet was prepared to support the learning environment based on the STEM education approach. The activity sheets included sections such as the approach to the emergence of the problem, the outcome-oriented problem, the rules determined within the scope of the problem scenario, the selection of the materials and the reasons for the selection, and drawing the sketches of the design. In the experimental groups, theoretical information was presented to the students with the help of instructional technologies and EBA contents outside the classroom environment within the framework of the flipped learning model. Video teaching materials were determined by taking into account the achievements of the relevant units within the framework of the current curriculum. The prepared activities, activity sheets and out-of-class teaching materials were examined by the class teacher of the experimental group, a science teacher and an expert in the field of science education and reorganized in line with the suggestions. Before the application, the students in the experimental groups were determined to have the internet, tools and equipment necessary for them to access out-of-class teaching materials and EBA content. In addition, it was also checked by the classroom teacher whether the students regularly watched the EBA content.

Analysis of the Data

Analysis of the Quantitative Data:

In the study, t-test for Dependent Samples, t-test for Independent Samples, Wilcoxon signed-rank test, Mann-Whitney U test, Shapiro-Wilk test were used to analyze the data. In examinations using the entire study group, the Kolmogorov-Smirnov test was used when the number of individuals was greater than 30. In examining whether the scale/test scores showed a significant difference according to the group (experimental-control group) of the students, Independent Samples t-test from parametric tests and Mann-

Whitney U test from nonparametric tests were used (Büyüköztürk, Çokluk, & Köklü, 2014). Statistical Package for Social Sciences (SPSS), version 21.0 computer package program for Windows was used for statistical analysis of the research data.

Analysis of the Qualitative Data

Regarding the tenth question of the study, the opinions of the students in the experimental group about the activity set applications developed within the scope of the Flipped Learning Model and STEM before and after the application process were analyzed through content analysis. The reliability of the qualitative data was analyzed by the researcher and then the opinion of an expert who has a PhD in statistics was taken.

Codes and themes were created by the researcher. These codes and themes were checked by an expert in the field of statistics and an expert in the field of science to ensure inter-rater reliability. The data obtained were explained statistically in tables using frequency (f). Due to the ethics of the research, the students were given codes as S1, S2, S3....

RESULTS

Quantitative Results:

Findings Related to the Effect of STEM Activity Set on Students' Scientific Creativity Levels

Regarding the first question in the study, it was examined whether there was a significant difference between the pre-test and post-test mean scores of the students in the experimental group in the Scientific Creativity Scale. For the analysis of the data, the parametric test assumptions were checked first. In order for the scores of the control group obtained from the Scientific Creativity Scale to be suitable for parametric testing techniques, they must first meet the assumption of normal distribution. The results of the Shapiro-Wilk normality test for the distribution of the pre-test and post-test scores of the students in the experimental group from the Scientific Creativity Scale are given in **Table 2**.

According to the results of the Shapiro-Wilk Test, it is seen that the score distributions for both the pre-test and post-test do not differ from the normal distribution since the p significance level of the statistical values of the total scores obtained from the scale is greater than 0.05. Accordingly, it was decided that parametric tests could be used for the total scores of the Scientific Creativity Scale (Field, 2009). Accordingly, the t-test for Depend-

Table 2. Shapiro-Wilk Test Results Regarding the Normality of the Score Distributions Obtained from the Scientific Creativity Scale of the Students in the Experimental Group.

		Shapiro-Wilk Test		
		Statistics	SD	p
Pre-test	Scientific Creativity	0.979	25	0.866
Post-Test	Scientific Creativity	0.926	25	0.071

Table 3. Dependent Samples t Test Results for the Comparison of the Mean Scores of the Experimental Group Students' Scientific Creativity Scale Pre-Test and Post-Test Scores.

Group	n	Mean	Ss	Mean Difference	t	SD	p
Pre-test	25	39.08	12.52	-10.60	-4.471	24	0.000
Post-Test	25	49.68	12.86				

Table 4. Shapiro-Wilk Test Results Regarding the Normality of the Score Distributions Obtained from the Scientific Creativity Scale of the Students in the Control Group.

		Shapiro-Wilk Test		
		Statistics	SD	p
Pre-test	Scientific Creativity	0.972	29	0.625
Post-Test	Scientific Creativity	0.971	29	0.594

Table 5. Dependent Samples t Test Results for the Comparison of the Pre-Test and Post-Test Scores of the Scientific Creativity Scale of the Students in the Control Group.

Group	n	Mean	Ss	Mean Difference	t	SD	p
Pre-test	29	35.52	19.21	0.17	0.055	28	0.956
Post-Test	29	35.34	17.78				

ent Samples was used to examine whether there was a significant difference between the mean scores of the students in the experimental group in the pre-test and post-test of the Scientific Creativity Scale. The results obtained are given in **Table 3**.

When **Table 3** is examined, it is seen that there is a significant difference between the total scores of the students in the experimental group from the Scientific Creativity Scale pre-test and the total scores from the post-test ($t = -4,471$, $p < 0.05$). When the results are examined, it is seen that the difference is in favor of the post-tests. Accordingly, the mean of the post-test scores of the Scientific Creativity Scale (mean = 49.68) is significantly higher than the mean of the pre-test scores (mean = 39.08).

Regarding the second question of the study, it was examined whether there was a significant difference between the pre-test and post-test mean scores of the students in the control group on the Scientific Creativity Scale. For the analysis of the data, the parametric test assumptions were checked first. In order for the scores obtained from the Scientific Creativity Scale to be suitable for parametric testing techniques, they must first meet the assumption of normal distribution. The results of the Shapiro-Wilk normality test for the distribution of the pre-test and post-test scores of the students in the control group from the Scientific Creativity Scale are given in **Table 4**.

According to the results of the Shapiro-Wilk Test, the p significance level of the statistical values related to the total scores of the control group obtained from the scale is greater than 0.05, which indicates that the score distributions for both the pre-test and post-test are normally distributed. Accordingly, the t-test for Dependent Samples was used to examine whether there was a significant difference between the pre-test and post-test mean scores of the students in the control group. The results obtained are given in **Table 5**.

When **Table 5** is examined, it is seen that there is no significant difference between the total scores of the students in the control group from the Scientific Creativity Scale pre-test and the total scores from the post-test ($t = 0.055$, $p > 0.05$). Accordingly, it was determined that the mean of the post-test scores of the Scientific Creativity Scale (mean = 35.34) was lower than the mean of the pre-test scores (mean = 35.52), but this difference was not significant.

Regarding the third question in the study, it was examined whether there was a significant difference between the mean post-test scores of the students in the experimental group and the mean post-test scores of the students in the control group in the Scientific Creativity Scale. For the analysis of the data, the parametric test assumptions were checked first. In order for the post-test scores obtained from the Scientific Creativity Scale to be suitable for parametric test techniques, they must first meet the assumption of normal distribution. The results of the Kolmogorov-Smirnov normality test

Table 6. Kolmogorov-Smirnov Test Results Regarding the Normality of the Score Distributions of the Students in the Study Group Obtained from the Scientific Creativity Scale.

		Kolmogorov-Smirnov Test		
		Statistics	**SD**	**p**
Post-Test	Scientific Creativity	0.052	54	0.200

Table 7. Independent Samples t Test Results for the Comparison of the Posttest Mean Scores of the Scientific Creativity Scale of the Students in the Experimental and Control Groups.

Group	n	Mean	Ss	Mean Difference	t	SD	p
Experimental	25	49.68	12.86	14.34	3.344	52	0.002
Control	29	35.34	17.78				

Table 8. Shapiro-Wilk Test Results Regarding the Normality of the Score Distributions Obtained from the STEM Attitude Scale of the Students in the Experimental Group.

		Shapiro-Wilk Test		
		Statistics	**SD**	**p**
Pre-test	Mathematics	0.966	25	0.547
	Science	0.937	25	0.125
	Engineering and Technology	0.946	25	0.202
	21st Century Skills	0.949	25	0.242
	Total	0.957	25	0.365
Post-Test	Mathematics	0.964	25	0.492
	Science	0.896	25	0.015
	Engineering and Technology	0.840	25	0.001
	21st Century Skills	0.901	25	0.020
	Total	0.903	25	0.021

for the distribution of the post-test scores of all students in the study group are given in **Table 6**.

According to the results of the Kolmogorov-Smirnov Test, since the p significance level of the statistical values related to the total scores is greater than 0.05, it is seen that the score distributions related to the post-test are suitable for normal distribution. In this direction, t-test for Independent

Samples was used to examine whether there was a significant difference between the mean scores of the post-test of the Scientific Creativity Scale of the experimental group and the mean scores of the post-test of the control Scientific Creativity Scale. The results obtained are given in **Table 7**.

When **Table 7** is examined, it is seen that there is a significant difference between the total scores of the students in the experimental group from the Scientific Creativity Scale post-test and the total scores of the students in the control group from the post-test ($t = 3.344$, $p < 0.05$). Accordingly, it was determined that the mean of the post-test scores of the students in the experimental group (mean = 49.68) was higher than the mean of the post-test scores of the control group (mean = 35.34) and this difference was significantly differentiated in favor of the experimental group. According to this result, when the post-test scores obtained as a result of the process applied to the experimental group are examined and compared with the post-test scores of the control group, it can be said that the process has a positive effect on the students' Scientific Creativity levels.

Findings Regarding the Effect of STEM Activity Set on Students' Attitude Levels towards STEM

Regarding the fourth question in the study, it was examined whether there was a significant difference between the STEM Attitude Scale pre-test and post-test mean scores of the students in the experimental group. For the analysis of the data, firstly, the parametric test assumptions were checked. In order for the scores obtained from the STEM Attitude Scale to be suitable for parametric testing techniques, they must first meet the assumption of normal distribution. The results of the Shapiro-Wilk normality test for the distribution of the pre-test and post-test scores of the students in the experimental group are given in **Table 8**.

When **Table 8** is examined, according to the results of the Shapiro-Wilk Test, it is seen that the score distributions for both the pre-test and post-test differ from the normal distribution since the p significance level of the statistical values for all sub-dimensions and total scores is not greater than 0.05. In this direction, Wilcoxon signed-rank test was used to examine whether there was a significant difference between the STEM Attitude Scale pre-test and post-test mean scores of the students in the experimental group. The results obtained are given in **Table 9**.

When **Table 9** is examined, it is seen that there is a significant difference between the total scores of the students in the experimental group from the STEM Attitude Scale pre-test and the total scores from the post-test ($z = -2.195$, $p < 0.05$). When the results are examined, it is seen that the difference is in favor of positive ranks, that is, post-tests. Accordingly, the mean of STEM Attitude Scale post-test scores (mean = 144.24) is significantly

Table 9. Wilcoxon Signed-Ranks Test Results for Comparison of STEM Attitude Scale Pre-Test and Post-Test Scores of Students in the Experimental Group.

	Post-Test-Pre-test	n	Rank Average	Rank Total	z	p
Mathematics	Negative	14	130.21	1850.00	-0.606	0.544
	Positive	11	120.73	1400.00		
	Equal	0				
	Total	25				
Science	Negative	6	120.75	760.50	-10.065	0.287
	Positive	14	90.54	1330.50		
	Equal	5				
	Total	25				
Engineering and Technology	Negative	6	120.08	720.50	-20.215	0.027
	Positive	18	120.64	2270.50		
	Equal	1				
	Total	25				
21st Century Skills	Negative	5	150.30	760.50	-10.872	0.061
	Positive	18	110.08	1990.50		
	Equal	2				
	Total	25				
Total	Negative	8	100.13	810.00	-20.195	0.028
	Positive	17	140.35	2440.00		
	Equal	0				
	Total	25				

Table 10. Shapiro-Wilk Test Results Regarding the Normality of the Score Distributions Obtained from the STEM Attitude Scale of the Students in the Control Group.

		Shapiro-Wilk Test		
		Statistics	SD	p
Pre-test	Mathematics	0.898	29	0.009
	Science	0.962	29	0.368
	Engineering and Technology	0.960	29	0.332
	21st Century Skills	0.946	29	0.148
	Total	0.981	29	0.858
Post-Test	Mathematics	0.948	29	0.161
	Science	0.957	29	0.283
	Engineering and Technology	0.964	29	0.419
	21st Century Skills	0.900	29	0.010
	Total	0.974	29	0.658

Table 11. Wilcoxon Signed-Ranks Test Results for Comparison of STEM Attitude Scale Pre-Test and Post-Test Scores of Students in the Control Group.

	Post-Test-Pre-test	n	Rank Average	Rank Total	z	p
Mathematics	Negative	11	140.91	1640.00	-0.602	0.547
	Positive	16	130.38	2140.00		
	Equal	2				
	Total	29				
Science	Negative	9	80.28	740.50	-30.096	0.002
	Positive	20	180.03	3600.50		
	Equal	0				
	Total	29				
Engineering and Technology	Negative	12	90.29	1110.50	-10.629	0.103
	Positive	14	170.11	2390.50		
	Equal	3				
	Total	29				
21st Century Skills	Negative	10	130.65	1360.50	-10.517	0.129
	Positive	18	140.97	2690.50		
	Equal	1				
	Total	29				
Total	Negative	10	120.55	1250.50	-10.990	0.057
	Positive	19	160.29	3090.50		
	Equal	0				
	Total	29				

higher than the mean of pre-test scores (mean = 135.80). Similarly, there is a significant difference between the pre-test and post-test scores of the students in the experimental group regarding the Engineering and Technology sub-dimension of the STEM Attitude Scale ($z = -2.215$, $p < 0.05$). When the results are examined, it is seen that the difference is again in favor of positive ranks, that is, post-tests. Accordingly, the mean of the post-test scores (mean = 35.60) for the Engineering and Technology sub-dimension of the STEM Attitude Scale is significantly higher than the mean of the pre-test scores (mean = 31.44). Finally, there is no significant difference between the pre-test and post-test scores of the STEM Attitude Scale Science, Mathematics and 21st Century Skills sub-dimensions ($p > 0.05$).

Regarding the fifth question of the study, it was examined whether there was a significant difference between the STEM Attitude Scale pre-test and post-test mean scores of the students in the control group. For the analysis of the data, firstly, parametric test assumptions were checked. In order for the scores obtained from the STEM Attitude Scale to be suitable for parametric testing techniques, they must first meet the assumption of normal distribution. The results of the Shapiro-Wilk normality test for the distribution of the pre-test and post-test scores of the students in the control group from the STEM Attitude Scale are presented in **Table 10**.

According to the results of the Shapiro-Wilk Test, it is seen that the score distributions for both the pre-test and post-test differ from the normal distribution since the p significance level of the statistical values for all sub-dimensions and total scores is not greater than 0.05. In this direction, Wilcoxon signed-rank test was used to examine whether there was a significant difference between the STEM Attitude Scale pre-test and post-test mean scores of the students in the control group. The results obtained are given in **Table 11**.

When **Table 11** is examined, it is seen that there is no significant difference between the total scores of the students in the control group from the STEM Attitude Scale pre-test and the scores related to all sub-dimensions except the Science sub-dimension and the post-test scores ($p > 0.05$). There is a significant difference between the pre-test and post-test scores related to the Science sub-dimension of the STEM Attitude Scale ($z = -3.096$, $p < 0.05$). When the results are examined, it is seen that the difference is in favor of positive ranks, that is, post-tests. Accordingly, the mean of the post-test scores (mean = 34.93) for the Science sub-dimension of the STEM Attitude Scale is significantly higher than the mean of the pre-test scores (mean = 30.72).

Regarding the sixth question in the study, it was examined whether there was a significant difference between the STEM Attitude Scale post-test mean scores of the students in the experimental group and the STEM Attitude Scale post-test mean scores of the students in the control group. For the analysis of the data, the parametric test assumptions were first checked. In order for the post-test scores obtained from the STEM Attitude Scale to be suitable for parametric testing techniques, they must first meet the assumption of normal distribution. The results of the Kolmogorov-Smirnov normality test for the distribution of the post-test scores of all students in the study group are given in **Table 12**.

When **Table 12** is examined, according to the results of the Kolmogorov-Smirnov Test, it is seen that the post-test score distributions differ from the normal distribution since the p significance level of the statistical values for all sub-dimensions and total scores is less than 0.05. In this direction, Mann-Whitney U test was used to examine whether there was a significant difference between the STEM Attitude Scale post-test mean scores of the students in the experimental group and the STEM Attitude Scale post-test mean scores of the students in the control group. The results obtained are given in **Table 13**.

Table 12. Kolmogorov-Smirnov Test Results Regarding the Normality of the Score Distributions Obtained from the STEM Attitude Scale of the Students in the Study Group.

		Kolmogorov-Smirnov Test		
		Statistics	**SD**	**p**
Post-Test	Mathematics	0.130	54	0.023
	Science	0.120	54	0.049
	Engineering and Technology	0.134	54	0.017
	21st Century Skills	0.128	54	0.027
	Total	0.093	54	0.020

Table 13. Mann-Whitney U Test Results for Comparison of STEM Attitude Scale Posttest Scores of Students in Experimental and Control Groups.

	Group	n	Rank Average	Rank Total	z	p
Mathematics	Experiment	25	230.82	5950.50	-10.598	0.110
	Control	29	300.67	8890.50		
	Total	54				
Science	Experiment	25	280.06	7010.50	-0.244	0.807
	Control	29	270.02	7830.50		
	Total	54				
Engineering and Technology	Experiment	25	310.12	7780.00	-10.574	0.116
	Control	29	240.38	7070.00		
	Total	54				
21st Century Skills	Experiment	25	290.92	7480.00	-10.053	0.292
	Control	29	250.41	7370.00		
	Total	54				
Total	Experiment	25	280.50	7120.50	-0.434	0.664
	Control	29	260.64	7720.50		
	Total	54				

When **Table 13** was examined, it was determined that there was no significant difference between the STEM Attitude Scale post-test mean scores of the students in the experimental group and the STEM Attitude Scale post-test mean scores of the students in the control group ($p > 0.05$).

Table 14. Shapiro-Wilk Test Results Regarding the Normality of the Score Distributions Obtained from the STEM Perception Test of the Students in the Experimental Group.

		Shapiro-Wilk Test		
		Statistics	**SD**	**p**
Pre-test	Science	0.818	25	0.000
	Math	0.867	25	0.004
	Engineering	0.898	25	0.017
	Technology	0.861	25	0.003
	Career	0.849	25	0.002
	Total	0.902	25	0.021
Post-test	Science	0.614	25	0.000
	Math	0.847	25	0.002
	Engineering	0.770	25	0.000
	Technology	0.757	25	0.000
	Career	0.844	25	0.001
	Total	0.851	25	0.002

Table 15. Wilcoxon Signed-Ranks Test Results for Comparison of STEM Perception Test Pre-Test and Post-Test Scores of Students in the Experimental Group.

	Post-Test-Pre-test	**n**	**Rank Average**	**Rank Total**	**z**	**p**
Science	Negative Sequence	8	70.38	590.00	-10.725	0.085
	Positive Sequence	12	120.58	1510.00		
	Equal	5				
	Total	25				
Mathematics	Negative Sequence	7	110.29	790.00	-0.973	0.330
	Positive Sequence	13	100.08	1310.00		
	Equal	5				
	Total	25				
Engineering	Negative Sequence	6	60.83	410.00	-20.175	0.030
	Positive Sequence	13	110.46	1490.00		
	Equal	6				
	Total	25				
Technology	Negative Sequence	7	100.50	730.50	-0.285	0.776
	Positive Sequence	9	60.94	620.50		
	Equal	9				
	Total	25				
Career	Negative Sequence	5	100.20	510.00	-10.507	0.132
	Positive Sequence	13	90.23	1200.00		
	Equal	7				
	Total	25				
Total	Negative Sequence	6	110.25	670.50	-10.917	0.055
	Positive Sequence	16	110.59	1850.50		
	Equal	3				
	Total	25				

Findings Regarding the Effect of STEM Activities on Students' Perception Levels Related to STEM

Regarding the seventh question in the study, it was examined whether there was a significant difference between the STEM Perception Test pre-test and post-test mean scores of the students in the experimental group. For the analysis of the data, firstly, the parametric test assumptions were checked. In order for the scores obtained from the STEM Perception Test to be suitable for parametric testing techniques, they must first meet the assumption of normal distribution. The results of the Shapiro-Wilk normality test regarding the distribution of the pre-test and post-test scores of the students in the experimental group are given in **Table 14**.

According to the results of the Shapiro-Wilk Test, it is seen that the score distributions for both the pre-test and post-test differ from the normal distribution since the p significance level of the statistical values for all sub-dimensions and total scores is less than 0.05. In this direction, Wilcoxon signed-rank test was used to examine whether there was a significant difference between the STEM Perception Test pre-test and post-test mean scores of the students in the experimental group. The results obtained are given in **Table 15**.

When **Table 15** is examined, it is seen that there is no significant difference between the total scores of the students in the experimental group from the STEM Perception Test pre-test and the total scores from the post-test ($z = -1.917$, $p > 0.05$). Similarly, there is no significant difference between the pre-test and post-test scores of the students in the experimental group regarding the STEM Perception Test Science, Mathematics, Technology and Career sub-dimensions ($p > 0.05$). Finally, there is a significant difference between the pre-test and post-test scores of the students in the experimental group regarding the Engineering sub-dimension of the STEM Perception Test ($z = -2.175$, $p < 0.05$). When the results are examined, it is seen that the difference is in favor of positive ranks, that is, post-tests. The mean of the post-test scores (mean = 31.04) for the Engineering sub-dimension of the STEM Perception Test is significantly higher than the mean of the pre-test scores (mean = 27.40).

Regarding the eighth question of the study, it was examined whether there was a significant difference between the STEM Perception Test pre-test and post-test mean scores of the students in the control group. For the analysis of the data, the parametric test assumptions were first checked. In order for the scores obtained from the STEM Perception Test to be suitable for parametric test techniques, they must first meet the assumption of normal distribution. The results of the Shapiro-Wilk normality test for the distribution of the pre-test and post-test scores of the students in the control group from the STEM Perception Test are given in **Table 16**.

Table 16. Shapiro-Wilk Test Results Regarding the Normality of the Score Distributions Obtained from the STEM Perception Test of the Students in the Control Group.

		Shapiro-Wilk Test		
		Statistics	**SD**	**p**
Pre-test	Science	0.897	29	0.008
	Math	0.919	29	0.028
	Engineering	0.960	29	0.325
	Technology	0.886	29	0.005
	Career	0.867	29	0.002
	Total	0.911	29	0.018
Post-test	Science	0.614	29	0.013
	Math	0.847	29	0.001
	Engineering	0.770	29	0.101
	Technology	0.757	29	0.007
	Career	0.844	29	0.004
	Total	0.851	29	0.174

Table 17. Wilcoxon Signed-Ranks Test Results for Comparison of STEM Perception Test Pre-Test and Post-Test Scores of Students in the Control Group.

	Post-Test-Pre-test	n	Rank Average	Rank Total	z	p
Science	Negative	13	140.96	1940.50	-0.863	0.388
	Positive	12	100.88	1300.50		
	Equal	4				
	Total	29				
Math	Negative	10	110.35	1130.50	-0.423	0.672
	Positive	12	110.63	1390.50		
	Equal	7				
	Total	29				
Engineering	Negative	12	130.67	1640.00	-00.601	0.548
	Positive	15	140.27	2140.00		
	Equal	2				
	Total	29				
Technology	Negative	13	140.54	1890.00	-0.344	0.731
	Positive	13	120.46	1620.00		
	Equal	3				
	Total	29				
Career	Negative	12	130.08	1570.00	-0.770	0.441
	Positive	15	140.73	2210.00		
	Equal	2				
	Total	29				
Total	Negative	15	130.37	2000.50	-0.057	0.955
	Positive	13	150.81	2050.50		
	Equal	1				
	Total	29				

When **Table 16** is examined, according to the results of the Shapiro-Wilk Test, it is seen that the score distributions for both the pre-test and post-test differ from the normal distribution since the p significance level of the statistical values for almost all sub-dimensions and total scores related to the STEM Perception Test is less than 0.05. In this direction, Wilcoxon signed-rank test was used to examine whether there was a significant difference between the STEM Perception Test pre-test and post-test mean scores of the students in the control group. The results obtained are given in **Table 17**.

When **Table 1**7 is examined, it is seen that there is no significant difference between the total scores and sub-dimension scores of the students in the control group from the STEM Perception Test pre-test and the total scores and sub-dimension scores from the post-test ($p > 0.05$).

Regarding the ninth question in the study, it was examined whether there was a significant difference between the STEM Perception Test post-test mean scores of the students in the experimental group and the STEM Perception Test post-test mean scores of the students in the control group. For the analysis of the data, the parametric test assumptions were checked first. In order for the post-test scores obtained from the STEM Perception Test to be suitable for parametric test techniques, they must first meet the assumption of normal distribution. The results of the Kolmogorov-Smirnov normality test for the distribution of the post-test scores of all students in the study group are given in **Table 18**.

When **Table 18** is examined, according to the results of the Kolmogorov-Smirnov Test, it is seen that the post-test score distributions differ from the normal distribution since the p significance level of the statistical values for all sub-dimensions and total scores is less than 0.05. In this direction, Mann-Whitney U test was used to examine whether there was a significant difference between the STEM Perception Test post-test mean scores of the students in the experimental group and the STEM Perception Test post-test mean scores of the students in the control group. The results obtained are given in **Table 19**.

When **Table 19** is examined, it is seen that there is a significant difference between the STEM Perception Test post-test total mean scores of the students in the experimental group and the STEM Perception Test post-test total mean scores of the students in the control group ($z = -1.822$, $p < 0.05$). Considering the rank averages, it was found that the STEM Perception Test post-test total mean score of the students in the experimental group (31.70) was significantly higher than the mean score of the students in the control group (23.88). Similarly, it was revealed that there was a significant difference between the STEM Perception Test Science sub-dimension post-test mean scores of the students in the experimental group and the STEM Perception Test Science sub-dimension post-test mean scores of the students in the control group ($z = -2.585$, $p < 0.05$). Considering the rank averages, it was

Table 18. Kolmogorov-Smirnov Test Results Regarding the Normality of the Score Distributions Obtained from the STEM Perception Test of the Students in the Study Group.

		Kolmogorov-Smirnov Test		
		Statistics	SD	p
Post- test	Science	0.815	54	0.000
	Math	0.853	54	0.000
	Engineering	0.884	54	0.000
	Technology	0.850	54	0.000
	Career	0.867	54	0.000
	Total	0.922	54	0.002

Table 19. Mann-Whitney U Test Results for Comparison of STEM Perception Test Post-Test Score Means of Students in Experimental and Control Groups.

	Group	n	Rank average	Rank total	z	p
Science	Experiment	25	330.42	8350.50	-20.585	0.010
	Control	29	220.40	6490.50		
	Total	54				
Math	Experiment	25	270.02	6750.50	-0.211	0.833
	Control	29	270.91	8090.50		
	Total	54				
Engineering	Experiment	25	350.64	8910.00	-30.563	0.000
	Control	29	200.48	5940.00		
	Total	54				
Technology	Experiment	25	300.78	7690.50	-10.441	0.149
	Control	29	240.67	7150.50		
	Total	54				
Career	Experiment	25	270.94	6890.50	-0.193	0.847
	Control	29	270.12	7860.50		
	Total	54				
Total	Experiment	25	310.70	7920.50	-10.822	0.048
	Control	29	230.88	6920.50		
	Total	54				

found that the STEM Perception Test Science sub-dimension post-test mean score of the students in the experimental group (33.42) was significantly higher than the mean score of the students in the control group (22.40). It was also determined that there was a significant difference between the

STEM Perception Test Engineering subdimension post-test mean scores of the students in the experimental group and the STEM Perception Test Engineering subdimension post-test mean scores of the students in the control group ($z = -3.563$, $p < 0.05$). Considering the rank averages, it was found that the STEM Perception Test Engineering sub-dimension post-test mean score of the students in the experimental group (35.64) was significantly higher than the mean score of the students in the control group (20.48). Finally, it was concluded that there was no significant difference between the post-test mean scores of the students in the experimental group on the STEM Perception Test Mathematics, Technology and Career sub-dimensions and the STEM Perception Test post-test mean scores of the students in the control group ($p > 0.05$).

Qualitative Results

Findings Related to Student Opinions on Conducting of STEM Activities in the Classroom and Learning Environments outside the Classroom

- Findings Regarding Student Opinions before Conducting STEM Activities

Table 20 shows that the most common answer under the theme "teaching methods" was "conducting experiments (f:7)". Other answers were "with the help of visuals-slides" (f:4), "using the textbook" (f:3), "using the interactive board" (f:2) and "making a presentation" (f:1).

Table 21 shows that the most common answer under the theme "teaching method" was "teaching by experimentation (f:5)". Other answers were "games" (f:4), "using laboratory" (f:4), "question and answer method" (f:3), "brainstorming (f:2)" and "discussion method" (f:2).

Table 22 shows that under the theme "suggestion", the most common answer was "homework should be in the form of research (f:5)". Other answers were: "it is fun" (f:2), "it should be more difficult" (f:3), "it provides repetition" (f:1), "it provides learning the subject (f:2)".

Table 23 shows that under the theme of "making preparations", the most common response was "making preparations from the textbook (f:6)". Other answers were: "preparing with the help of the internet (f:2)", "preparing with the help of family" (f:3) and "preparing by reading past subjects" (f:1). In addition, under the theme of "not preparing", there was the answer "I do not prepare (f:1)".

Table 20. Findings Related to the Question "How Do You Conduct the Science Class? Explain in Detail."

Theme	Code	Participant	f	Opinions
Teaching methods	Conducting experiments	S1,S2,S3,S4, S5,S6,S8	7	S1: We teach our lessons with the help of slide shows. However, we do experiments and projects using the smart board.
	With the help of visuals-slides	S3,S4,S5,S8	4	S4: We usually teach the lesson from the book. Occasionally we do experiments.
	Using the textbook	S2,S6,S7	3	
	Using the interactive board	S1,S3	2	
	making a Presentation	S1	1	

Table 21. Findings Related to the Question "How Would You Like the Science Class to Be Taught? Explain in Detail."

Theme	Code	Participant	f	Opinions
Teaching method	Teaching by experimentation	S1,S2,S4,S5,S6	5	S2: I would like to do experiments, activities, and learn by playing games. She did it on filtration and we had a lot of fun.
	Games	S2,S3,S4,S5	4	S8: I would like to do activities in the laboratory. I would like my teacher to make us think, such as question and answer, brainstorming methods.
	Using laboratory	S1,S4,S6,S7	4	
	Question and answer method	S3,S4,S6	3	
	Brainstorming	S6,S8	2	
	Discussion method	S4,S8	2	

Table 22. Findings Related to the Question "What are Your Opinions about the Homework Given by the Teacher in the Science Class? Explain in Detail."

Theme	Code	Participant	f	Opinions
Suggestion	Homework should be in the form of research	S4,S5,S6, S7,S8	5	S2: Our teacher always gives homework. I think it is useful, it helps us learn the subject better.
	It should be more difficult	S4,S6,S7	3	S5: Homework is generally good. However, I do not like writing-based homework, my hand hurts a lot. However, I like homework based on research based on our own learning.
Beneficial	It is fun	S3,S5	2	
	It provides repetition	S1	1	
	It provides learning the subject	S1,S2	2	

Table 23. Findings Related to the Question "Can You Give Information about Your Preparation Process before Coming to the Science Class? Explain in Detail."

Theme	Code	Participant	f	Opinions
Making Preparations	Making preparations from the textbook	S1,S3,S4,S6, S7,S8	6	S4: I get help from my family to prepare for the science class before coming to class. Since our teacher recommends a single source book, I try to prepare by examining the subject from there.
	Preparing with the help of the internet	S4,S5	2	S6: I read the subject from the book before coming to class.
	Preparing with the help of family	S1,S4,S8	3	
	Preparing by reading Past subjects	S2	1	
Not Preparing	I do not prepare	S5	1	

Table 24. Findings Related to the Question "What are the Resources You Use in Terms of Accessing Information in Out-of-Class Applications for the Science Class? Explain in Detail."

Theme	Code	Participant	f	Opinions
Resources	İnternet	S1, S2, S3, S4, S5, S6, S7, S8	7	S1: I check on the internet. S7: First I look in the book, then I ask my family. If it is something they do not know, I check on the internet.
	Family	S2,S3, S4, S5, S7, S8	6	
	Book	S2, S4, S6,S7	4	
	Teacher	S8	1	

Table 25. Findings Related to the Question "Do You Have Any Knowledge about the Units 'Lighting and Sound Technologies, Human and Environment, Simple Electrical Circuits' in Science? If Yes, What Do You Know? Explain in Detail."

Theme	Code	Participant	f	Opinions
I have knowledge	Natural and artificial envi-ronment	S1,S3,S6	3	S3: There are natural and artificial environments. I don't know about other units. S6: I do not know these units. I only know light pollution about lighting technologies. There are natural artificial elements. I don't have any other information.
	Light pollution	S6	1	
I don't know	I have no idea	S1,S2,S3,S4, S5,S6,S7,S8	8	

Table 26. Findings Related to the Question "Do You Know about STEM Activities, Have You Done STEM Activities in Science Class? What Did You Do? Explain in Detail."

Theme	Code	Participant	f	Opinions
I don't know	I have no idea	S1,S2,S3,S4,S5, S6,S7,S8	8	S3: I don't know, no
Negative	No	S1,S2,S3,S4,S5, S6,S7,S8	8	

Table 27. Findings Related to the Question "What Are Your Thoughts about the Science Class You Are Studying? Explain in Detail."

Theme	Code	Participant	f	Opinions
Positive	Fun	S1,S2,S5,S6	4	S1: This is also fun. There we only used to learn from the book. Our teacher explains the lesson to us, but STEM activities are more fun and I like them more.
	Preferring a different environment - laboratories	S4,S2,S8	3	S8: It would be even better if we used a laboratory.
Suggestion	Doing different activities in different places and with different materials		1	

Table 28. Findings Related to the Question "What Are Your Thoughts about the STEM Activities You Did during the Science Class? Explain in Detail."

Theme	Code	Participant	f	Opinions
Positive	Fun	S1,S2,S3,S4,S6	5	S1: It was fun, I liked it a lot, I think it was useful.
	Liking Useful Instructive	S1,S2,S4,S5, ,S6,S7 S8 S1,S4,S5 S4,S5	8 3 2	S2: It was good, it was fun, but I would have liked everyone in the group to participate in the process. Some of our friends did not participate in the activities in the group, but other than that, I liked it a lot, we had a lot of fun.
Suggestion	Group participation should be improved To continue	S2,S3 S8	2 1	

Table 24 shows that the most common answer under the "resources" theme was "internet" (f:7). Other answers were: "family" (f:6), "book" (f:4) and "teacher" (f:1).

Table 25 shows that under the theme "I have knowledge", students mostly gave the answer "natural and artificial environment" (f:4). Other answers were: "Light pollution " (f:1). In addition, the answers under the theme "I don't know" was "I have no idea" (f:8).

Table 26 shows that all of the students answered "no" (f:8) under the theme "negative" and "I have no idea" under the theme "no idea" (f:8).

● Findings Regarding Student Opinions after Conducting STEM Activities

Table 27 shows that the most common answer under the "positive" theme was "fun" (f:4). Under the "suggestion" theme, they gave the answer "preferring a different environment" (f:3), "doing different activities" and "doing different activities in different places and with different materials" (f:1).

Table 28 shows that the most common answer under the theme "positive" was "Liking" (f:8), "fun" (f:5). Other answers were "group participation should be improved" (f:2), "useful" (f:2) and "instructive" (f:2).

Table 29 shows that under the theme "positive", the participants mostly answered as "participation in the lessons increased" (f:3). Other answers were "my self-confidence increased" (f:3) and "my creativity increased" (f:2). Under the "Negative" theme, there was the answer "it was not useful" (f:1). Also, under the theme "undecided" theme one student was found to be "undecided".

Table 30 shows that under the theme "positive", the most common answer was "it was useful" (f:8). Other answers were "it helped me learn better (f:3)" and "it helped us design" (f:2).

Table 31 shows that under the theme of "activities", the most common answer was "irrigation by saving" (f:3). The other answers were "Sound insulated house design activity" (f:2), "electricity activity" (f:2), " water treatment design" (f:1) and "All activities " (f:2).

When **Table 32** is analyzed, under the "no" theme, students answered "I did not have any difficulty" (f:5). The answers under the theme "(yes) I had difficulty with activities" were "sound pollution" (f:1), "water treatment" (f:1) and "electricity" (f:1).

Table 33 shows that under the theme of "courses", the most common answer given by the students was "Science" (f:6). Other answers were "Mathematics" (f:5), "Turkish" (f:4), "Engineering" (f:3), "Social" (f:2) and "Informatics" (f:1).

Table 34 shows that under the "positive" theme, the most common answer given by the students was "must continue" (f:8) and they also gave the answers "fun" (f:4), "better learning" (f:4), "useful" (f:2) and "increases creativity" (f:2).

Table 35 shows that under the "environment" theme, the most common answers given by the students were "more spacious" (f:3) and "quiet" (f:3), and the least common answers were "in the laboratory" (f:1). In the

Table 29. Findings Related to the Question "Did the STEM Activities Carried out during the Teaching of Science Class Have an Effect on Your and Your Friends' Participation in the Lesson? How?"

Theme	Code	Participant	f	Opinions
Positive	Participation in the lessons increased	S2,S3,S6	3	S5: It contributed a lot, I always come up with design ideas in other lessons. Even at home, I don't let my mother throw garbage anymore, I check the materials to see what I can do.
	My self-confidence increased	S2,S3,S7	3	S7: I feel confident now. I feel that my ideas are valued.
	Design ideas - my creativity increased	S4,S5	2	
Negative	It was not useful	S1	2	
Undecided	I am not sure	S8	1	

Table 30. Findings Related to the Question "Do You Think That the STEM Activities You Did during the Teaching of Science Class Helped You Learn the Subject Better? Explain Your Answer in Detail with the Reasons."

Theme	Code	Participant	f	Opinions
Positive	It was useful - effective	S1,S2,S3,S4, S5,S6,S7,S8	8	S2: I think it was very effective, I understood the topics very well because we came to the lesson knowing the unit. You made us think by asking a lot of questions in the lesson and it was very useful. It was also reinforced with the designs.
	It helped me learn better	S1,S2,S8	3	S8: I think it was useful. Coming to the lesson as having studied and your activities, STEM activities, those designs were very nice. It helped me understand better.
	It helped us design	S1,S2	2	
	In creative thinking	S3	1	

Table 31. Findings Related to the Question "Did You Like the STEM Activities You Did in Science Class? Which Activities Did You Like and Why?"

Theme	Code	Participant	f	Opinions
Activities	İrrigation by saving	S2,S3,S5	3	S3: Yes. I liked the irrigationby saving the most because we won first place in that design by designing the saving system used by my grandfather. It made me very happy to design something I saw at home.
	Sound insulated house design activity	S4	1	S8: Yes. I cannot distinguish, I liked them all very much.
	Electricity activity	S1,S2	2	
	Water treatment design	S6	1	
	All activities	S7,S8	2	

Table 32. Findings Related to the Question "Were There any Parts of STEM Activities That You Had Difficulty with? If Yes, Which Part? Why Do You Think You Had Difficulty in This Part? Explain."

Theme	Code	Participant	f	Opinions
Negative	I did not have any difficulty	*S1,S2,S3,S6,S8*	*5*	*S3: We did not have any difficulty, it would have been more comfortable if my friends had participated in the process.* *S4: I had a little difficulty with electricity, but then we understood it and made our design.*
Activities they are challenged with	Sound pollution	*S5*	*1*	
	Water treatment	*S7*	*1*	
	Electricity	*S4*	*1*	

Table 33. Findings Related to the Question "Which Other Courses Did You Associate the Science Class with While Making Your Materials/Designs during the Science Class? Why?"

Theme	Code	Participant	f	Opinions
Courses	Science	S1,S2,S4,S6, S7,S8	6	S6: Mathematics, Science, Engineering. Turkish. S7: Science, Mathematics, Social Studies. Because we thought and designed from life
	Mathematics	S1,S5,S6,S7,S8	5	
	Turkish	S3,S5,S6,S8	4	
	Engineering	S5,S6,S8	3	
	Social	S3,S4	2	
	Informatics	S2	1	

Table 34. Findings Related to the Question "Would You Like the STEM Activities You Did in the Science Class to be Continued in the Future? Why?"

Theme	Code	Participant	f	Opinions
Positive	Must continue Fun	S1,S2,S3,S4,S5, S6,S7,S8 S2,S6, S7,S8	8 4	S1: I would like to because I learned a lot and it improved my other lessons, for example, I think my math, Turkish and social lessons also improved. S4: I feel more knowledgeable and creative.
	Better learning	S1,S2,S3,S4	4	
	Useful	S2,S3	2	
	Increases creativity	S3,S4	2	

Table 35. Findings Related to the Question "What Would You Like to See Different in the STEM Activities Carried out during the Science Class?"

Theme	Code	Participant	f	Opinions
Environment	More spacious	S2,S5	3	S1: If the in-group discussion time was longer. It would have been better if we had done individual design instead of group activity. S4: The noises outside distracted me. I wish it was in a quieter environment.
	Quiet	S3,S4,S5	3	
	Laboratory	S3	1	
	Must do activities in all classes	S5	1	
Group	Using your own materials	S7,S8	2	
	Discussion time	S1	1	
Design	Individual design	S1,S2	2	

Table 36. Findings Related to the Question "Considering the STEM Activities We Did in the Science Class, Did You Feel Yourself as an Engineer of the Future? Do You Think about Being an Engineer in the Future?"

Theme	Code	Participant	f	Opinions
Positive	I felt like an engineer	S1,S2,S3,S4,S5, S6,S7,S8	8	S2: Yes, I did, I even felt myself as a scientist. S3: Yes, I did, I would like to be a computer engineer.
	The scientist	S2,S8	2	
	I don't want to be an engineer	S1,S5,S7,S8	4	
Profession	Computer engineer	S3	1	
	Design engineer	S4	1	
	Scientist	S4	1	
	Civil engineer	S6	1	

Table 37. Findings Related to the Question "What Are Your Thoughts about the Out-of-Class Lecture Videos You Made in the Science Class, Were These Videos Useful for You to Learn the Subject, Did You Have Any Difficulties in the Process? Explain in Detail?"

Theme	Code	Participant	f	Opinions
Positive	It was instructive	S1,S2,S4,S5, S6,S8	6	S4: This method is very clever. The idea of learning at home and coming back is very nice, I loved the videos, it was very instructive. Sometimes the connection was lost, I had no other difficulties. S3: There was no school, it was as if we were learning by ourselves, it was very fun, we were waiting with excitement, it was very useful to see what to watch. I watched it easily and had no difficulties. S5: I did not have any difficulty. I liked the videos very much, I think they were instructive.
Negative	It was fun connection problem	S3,S5 S4,S7	2 2	

Table 38. Findings Related to the Question "Do You Have Any Suggestions about the Process in General?"

Theme	Code	Participant	f	Opinions
Satisfaction	It is fun	S1	1	S1: I think it was very fun, it was very good, I liked it very much.
	They want to do it individually	S5	1	S5: I think we should have done these activities and designs individually, I did not like that we were a group.
	Change of groups in the process	S6	1	
	Inter-school competition	Ö4	1	
	Liking	S1,S3,S4,S8	4	

second theme, "group", the answers given by the students were Using Your Own Materials (f:1) and discussion time (f:1). Under the design theme, it was determined that they gave the answer "individual design" (f:1).

Table 36 shows that under the theme of "Positive", students mostly gave the answers" I felt like an engineer" (f:8), " I do not want to be an engineer" (f:4) and "scientist" (f:2). It is seen that answers were given as computer engineer (f: 1), design engineer (f: 1), scientist (f: 1), and civil engineer (f: 1) under the theme of "profession".

Table 37 shows that under the theme "positive", all of the students answered were "it was instructive" (f:6) and "it was fun" (f:2). Under the "negative" theme, the "connection problem" (f:2) was answered.

Table 38 shows that under the theme of "Satisfaction", students mostly gave the answer "it is fun" (f:1), they also gave the answers "they want to do it individually" (f:1), " Change of groups in the process " (f:1), "inter-school competition" (f:1) and "Liking" (f:4).

Discussion

Results and Discussion on Scientific Creativity

In terms of the results related to scientific creativity, the study showed that the application based on the STEM education approach supported by the Flipped Learning model increased the scientific creativity level of 4th grade students. Based on this result, STEM activities supported by the Flipped Learning model support the creativity of 4th grade students. In this context, we can say that students' spending more time with STEM activities, thinking about the problem, making discussions, drawing their designs and being free in the realization process, rather than theoretical knowledge in the classroom learning processes, increased the creativity dimension. It can be said that the flipped learning model provides the necessary time spent at school for creativity to develop. In addition, as stated by Şerefli (2020) and Demir (2020), the fact that the application based on the Flipped Learning model is an application that children easily adapt to may have led to this positive result. The fact that the STEM approach is an integrated approach that includes different disciplines such as science, technology, engineering and mathematics (Yakman, 2008), current issues and daily life (Park & Ko, 2012) may have increased students' scientific creativity. It has been stated that creativity is like a muscle and can be developed and strengthened through appropriate exercises (Yatt & McCade, 2011). STEM trainings may have served as appropriate exercises for creativity. Flipped Learning model may also be effective in increasing creativity by increasing student motivation, communication and interaction (Yu, 2022; Ünlü, 2022), enabling students to learn actively, providing high participation, and increasing interest (Kyere, 2017).

Looking at other studies that support this result we see that; Korucuk (2021) conducted a study to examine the effect of flipped learning practices on university students' creative thinking tendencies, communication skills, motivation and academic achievement and found that flipped learning practices had a positive effect on university students' creative thinking tendencies., Al-Zahrani (2015), in his research conducted with the students of the Faculty of Education, determined that the creativity levels of the students who attended the class designed with the Flipped Learning model were higher than those of the control group, Tsai et al. (2020) examined the effects of the flipped learning model on students' learning performance, motivation, student-teacher interaction and creativity and found that the flipped learning model increased students' creativity, Moghadam and Razavi (2022) conducted an experimental study with 3rd grade middle school students and found that students' creativity increased when the flipped learning method was used. In a parallel result, Rodrı́guez et. al. (2019) reported that students perceived that they developed creative and critical thinking skills and social awareness during the flipped classroom intervention and that after the flipped classroom intervention, students developed different creative skills such as identifying and analyzing problems, generating original ideas, exploring different options, incorporating different perspectives into complex situations, producing sound arguments, and communicating complex arguments while emphasizing main ideas. Nida (2019), on the other hand, found that the Flipped Classroom model was more effective than the direct learning model in increasing students' Mathematical Creative Thinking Skills. As a different study, Wannapiroon & Petsangsri (2020) in their study, which aimed to investigate and develop the STEAMification model in a flipped classroom learning environment to develop creative thinking and creative innovation, they concluded that the creativity of students working through

STEAMification was higher than students working with the normal model. Harjono et al. (2022), as a result of their studies, the experiments in which they aimed to identify those involving creative thinking with the video-supported blended flipped classroom model on students' work and energy materials, they determined that the video-supported blended flipped classroom model can develop creative thinking. Likewise, Farajallah & Al -Najjar (2022) as a result of their study, which aimed to reveal the effect of flipped classroom practice on the development of creative thinking skills and attitudes towards self-directed learning in mathematics in tenth grade students, it was concluded that there was a statistically significant difference between the post-test mean scores of the students in the experimental group and the control group in favor of the experimental group. The results of other studies (Hsia, et. al. 2021; Widyaningrum, 2020) in different fields investigating the effect of flipped learning on creativity have also revealed that it has a positive effect on creativity.

Looking at the studies on STEM education supported by the flipped learning model, these studies generally examined the effects of the flipped model supported by the flipped learning model and STEM applications on academic achievement, self-directed learning with technology, and interest in STEM professions (Söndür, 2020). Another study analyzed the effects of STEM activities implemented with the flipped model on pre-service teachers' self-efficacy beliefs and STEM education orientation (Coşkun, 2020).

The results of some studies showing that STEM activities are effective on creativity are in parallel with this result. Cho and Lee (2013) found that the creative personality, creative problem solving and learning levels of the experimental group students who received STEM programs increased in a study conducted with middle school students. Mayasari et al. (2016) found that STEM applications affect creativity; Gülhan (2016) found that STEM activities had partial effects on scientific creativity in a study conducted with 5th grade middle school students. Konca-Şentürk (2017), in a study conducted with 7th grade middle school students, found that the levels of creative thinking and the levels of flexibility and rationality sub-dimensions of creativity of the experimental group students who received STEM program were higher than those of the control group. Çiftçi (2018) conducted a study with 7th grade middle school students and found that STEM activities increased students' scientific creativity. Genek (2018) investigated the effects of STEM education on scientific creativity in a study with primary school students and found that the scientific creativity level of 4th grade students who started STEM education earlier was higher than that of 2nd and 3rd grade students. Kurtuluş (2019) found that STEM-based lego activities significantly increased students' scientific creativity levels in his research with 6th grade middle school students; Sarıçam (2019) conducted a study with 6th grade middle school students and showed that students' scientific creativity levels increased after STEM education; Baltabıyık (2019) showed that STEM applications had a positive effect on students' scientific creativity in her research with middle school 7th grade students; Asal (2020) showed that the scientific creativity levels of the experimental group students who took engineering design-based science classs with primary school 4th grade students were significantly higher than those of the control group; in the study conducted by Atabaş (2020) with primary school 4th grade students, it was shown that the scientific creativity levels of the students in the experimental group who received STEM education increased significantly; Öz çelik (2021) showed that STEM applications positively affected creative thinking, working collaboratively, communicating, problem solving, and self-regulation in a study conducted with middle school 7th grade students.

Results and Discussion on STEM Attitude

In terms of the results related to attitudes towards STEM, the study showed that the application based on the STEM education approach supported by the Flipped Learning model did not affect the attitudes of 4th grade students towards STEM. The fact that the STEM attitude level of the students increased in both the experimental and control groups can be considered that this increase occurred due to other uncontrollable factors other than the application. Students' experiences in their lives outside of school could be another factor. On the other hand, it can be explained by the fact that attitude change is resistant and the implementation process is not long enough for attitude change. Similar to the results of this study; Rehmat (2015) found that STEM attitude levels were not affected in his research with 4th grade primary school students; Kong and Huo (2014) and Yıldırım (2016) found that STEM activities did not affect the level of attitude towards STEM field; Kurtuluş (2019) conducted a study with 6th grade middle school students and found that there was no difference between the control and experimental groups in any of the STEM attitude sub-dimension levels after STEM activities. The result of this study on the effect of the application based on the STEM education approach supported by the Flipped Learning model on students' attitudes towards STEM is in line with the results of other studies (Rehmat, 2015; Kong & Huo, 2014; Yıldırım, 2016; Kurtuluş, 2019) which concluded that the application based on the STEM education approach did not affect their attitudes towards STEM.

On the other hand, while this study shows that the application based on the STEM education approach supported by the Flipped Learning model does not affect students' attitudes towards STEM, unlike this result; Tseng et. al. (2013) found that STEM activities had positive effects on engineering, science and technology from STEM attitude sub-dimensions; Güzey, Harwell, and Moore (2014) found that the STEM attitude levels of students in schools where STEM activities were implemented were higher than those in schools where STEM activities were not implemented; and in the study conducted by Gülhan (2016) with 5th grade middle school students, it was found that the STEM attitude level of the experimental group increased in science, engineering, technology and total attitude levels, but not in mathematics and 21st century skills. In line with this, it was revealed that the total attitude scores of the experimental group STEM attitude post-test levels of science, engineering and technology were higher than those of the control group. On the other hand, Yavuz (2019) examined the effects of STEM activities on STEM professions, perceptions, and attitudes of primary school 4th grade students and found that STEM activities increased interest in STEM professions, positively affected STEM attitudes and perceptions, and STEM attitude total levels increased after the application; Bircan (2019) conducted a study with 4th grade primary school students and found that STEM education positively affected students' attitudes towards STEM fields (science, technology, engineering and mathematics); Şirin (2020) conducted a study with middle school 7th grade students and found that STEM activities increased STEM attitude level; Özçelik (2021) found that STEM practices positively affected STEM attitudes in a study conducted with middle school 7th grade students.

Results and Discussion on STEM Perception

The results of the study revealed that the application based on the STEM education approach supported by the Flipped Learning model positively affected 4th grade students' science and engineering STEM perception levels, but not their mathematics, technology and career STEM perception levels. Based on these results, we can say that the application based on the STEM education approach supported by the Flipped Learning model partially affected the STEM perception levels of 4th grade students. We can conclude that the effect of the application was especially evident on engineering perception and that this application increased students' perception of engineering. It is also possible to say that the students' practices such as planning, preparation, thinking about design, drawing and creating the design during the application were effective in the prominence of engineering perception. As for the science perception, the fact that the students practiced only the content-oriented practices in the classroom, other than the science content, can be considered as factors that increase the perception, as it made them participate more willingly and interested in the lesson in this process.

When the studies on STEM perception in the literature are examined, it is seen that STEM activities increase STEM perception positively in line with the results of this study (Knezek et al., 2013; Alıcı, 2018; Kuvaç, 2018; Yavuz, 2019; Öner, 2019; Öztürk-İrtem, 2021). In parallel with the findings of this study, Knezek et al. (2013) found that students' STEM perception, mathematics and career sub-dimension levels increased significantly in the trainings where STEM activities were applied. In the study conducted by Alıcı (2018) with 5th grade middle school students, it was determined that students' perceptions towards STEM professions and interest in engineering profession increased after the application. Yavuz (2019), in a study conducted with 4th grade primary school students, showed that STEM activities positively affected STEM perceptions. Öner (2019) investigated how the attitudes and perceptions of middle school 5th, 6th and 7th grade students towards STEM fields differed according to demographic variables and showed that the perception levels of female students and upper grades were higher. In another study examining the perception of scientists, engineers, STEM perception and attitudes towards technology of 5th, 6th and 7th grade students, Öztürk-İrtem (2021) found that the level of STEM perception and perception levels of science, mathematics, technology and career sub-dimension did not differ according to gender, but the level of engineer perception was higher in female students. According to grade level, STEM perception level and mathematics and career sub-dimension levels were found to differ in favor of lower grades. As a different case study, Kuvaç (2018) found that the level of science, mathematics, engineering and technology sub-dimensions and perception levels increased significantly after STEM activities, except for the career sub-dimension, and it was also found that STEM trainings contributed to the perceptions of engineers and engineering. The result of this study on the effect of the application based on the STEM education approach supported by the Flipped Learning model on students' perceptions of STEM is in line with the results of other studies (Knezek et al., 2013; Alıcı, 2018; Kuvaç, 2018; Yavuz, 2019; Öner, 2019; Öztürk-İrtem, 2021) that concluded that applications based on STEM education approach affect perceptions towards STEM.

In a few studies, contrary to this result, it was found that STEM activities did not affect STEM perception or affected it negatively. In the study conducted by Gülhan (2016) with 5th grade middle school students, even though it was found that engineering, technology, career and perception levels increased significantly in the experimental group, no significant difference was found in terms of STEM perception levels in the post-test comparisons of the control and experimental groups. In his study, Mills (2013) showed that the STEM field's career perception level of middle school students who were applied STEM activities decreased.

Qualitative Findings and Discussion

The qualitative findings of this study, which were obtained before the application based on the STEM education approach supported by the Flipped

Learning model, showed that the students mostly taught the Science class by conducting experiments, using visuals, slides and using the textbook, and for this reason, the students stated that they wanted to teach the Science class by conducting experiments and in a fun way. The study revealed that the students stated that they mostly prepared from the textbook before coming to the Science class, and the majority of them benefited from the internet, family and textbook for the classroom applications of the Science class. The study also found that the majority of the students were partially aware of the titles of the units of the Science class, had no previous knowledge about STEM and had not practiced STEM. In the preliminary interview results, it was determined that they did not have any knowledge about STEM education and that an application was made in the Science class.

The qualitative findings of this study, which were obtained after the implementation of the application based on the STEM education approach supported by the Flipped Learning model, indicated that all of the students found the STEM activities carried out during the implementation process fun, that they enjoyed them and that they did not have difficulty in performing the activities. On the other hand, in the quantitative results, it was concluded that the implementation did not affect the students' attitudes towards STEM. This result can be interpreted that the implementation period was not sufficient to show a significant increase in the quantitative results.

Students mostly thought that the activities carried out during the implementation process were beneficial in terms of participating in the lesson and understanding the lesson better. As a result of a similar study, they explained how student engagement increased with the use of the flipped approach (McCallum et al., 2015). The students also associated the Science class with Science, Mathematics and Turkish courses the most. Students suggested that STEM activities should be continued because they are fun and provide better learning, and that STEM activities should be carried out in a wider environment and with higher participation. While half of the students stated that they felt like future engineers during STEM activities, the other half stated that they did not want to be engineers. With this result, the increase in their perception of engineering may not be seen as a factor in their choice of engineering as a profession. Likewise, Rodríguez et. al. (2019), they concluded that the students were very satisfied with the flipped teaching model and recommended its regular implementation in the curriculum.

In terms of the qualitative results of this research, when the relevant literature on STEM activities is examined, there are studies that are similar to the findings of this research in terms of students finding the lessons with STEM activities more fun and satisfying (Kavak, 2019; Rehmat, 2015), thinking that learning is more permanent in lessons with STEM activities (Sarıçam, 2019), finding STEM activities more useful by students (Bircan, 2019; Yavuz, 2019), and students having positive opinions about STEM activities (Koçak, 2019).

In terms of the qualitative results of this research, there are studies that are in parallel with the findings of this study in terms of students' positive opinions about the use of the flipped classroom model (Aydın, 2016; Ünlü, 2022), the flipped classroom model increases students' participation in classroom activities (Güven-Demir, 2018), the flipped classroom model reduces anxiety levels towards science (Ünlütürk, 2022), and the flipped classroom model makes the lesson more fun (Ökmen, 2020; Şerefli, 2020), students' positive approach to learning (Long et al., 2016) and ease of access to resources (Talley & Scherer, 2013). In addition, they are in line with previous research showing that the flipped classroom approach to science education not only stimulates interest in the subject matter but also provides deeper knowledge, making it a more effective strategy than traditional learning (Stockwell, Stockwell, Cennamo, & Jiang, 2015). In contrast to this result, other studies have cited the perception of increased student workload as the reason for negative perceptions of a flipped approach (Khanova, Roth, Rodgers & McLaughlin, 2015; Hotle & Garrow, 2016). As a result of the study, students stated that they liked the out-of-class videos very much and that they were instructive and helped them to learn the content. Likewise another study (Ramírez, et.al. 2014) examining the advantages and disadvantages of reverse face-to-face education shows that the main advantages for students (according to their perceptions) are; flexibility to learn from videos, better comprehension of content, advantage to the class due to previous knowledge and motivation to learn, while among the disadvantages; technical problems, internet, software, etc. problems.

Suggestions

Based on the findings of the study, the following suggestions can be made for practitioners and researchers:

General Suggestions

- Since the findings of this study show that the STEM approach supported by the Flipped Learning model increased students' scientific creativity and STEM perception levels, the STEM education approach supported by the Flipped Learning model should be made widespread in schools. In addition, STEM activities supported by the Flipped Learning model should be used at all levels of education. STEM activities should be started at an early age.
- Since the Flipped Learning model requires students to have some tools and equipment, planning the applications according to the students' pos-

session of the necessary equipment can eliminate the inequality between students. Therefore, attention can be paid to this issue when implementing the Flipped Learning model.

- Teachers who are the implementers of the Flipped Learning model and STEM activities can be informed about these issues. For this purpose, the importance and necessity of these educational approaches can be explained to teachers and training programs can be created in this field both in university education and in vocational training in order to gain knowledge and experience.
- Teachers' ability to implement the Flipped Learning model and STEM activities efficiently depends on their ability to allocate additional time for planning and preparation. For this reason, teachers should be provided with this extra time when planning lessons and curricula.

Suggestions for Future Studies

- In this study, the effects of STEM approach supported by the Flipped Learning model on scientific creativity, STEM attitude and STEM perception were examined. Future research can examine the effects of these practices on other dependent variables.
- The sample of this study was selected from primary school 4th grade students. Future research can investigate the effects of applications based on the STEM education approach supported by the Flipped Learning model at other levels.
- In this study, the effects of demographic variables were ignored. Future studies should also examine the effects of demographic variables. In particular, it may be useful to investigate the moderating effects of demographic variables.

References

Akın, V. (2019). FeTeMM uygulamalarının 7. sınıf öğrencilerinin FeTeMM'e yönelik tutumlarına, bilimsel süreç becerilerine ve meslek seçimlerine etkisi. Yayımlanmamış Yüksek Lisans Tezi. Afyon Kocatepe Üniversitesi.

Alıcı, M. (2018). Probleme dayalı öğrenme ortamında STEM eğitiminin tutum, kariyer algı ve meslek ilgisine etkisi ve öğrenci görüşleri. Yüksek Lisans Tezi. Kırıkkale Üniversitesi.

Ariani, D. N., Sumantri, M. S., & Wibowo, F. C. (2022). The Impact of Android Module-Based Inquiry Flipped Classroom Learning on Mathematics Problem Solving and Creative Thinking Ability. *International Journal of Interactive Mobile Technologies*, 16(24):32-46. DOI: https://doi.org/10.3991/ijim.v16i24.35749

Arshad, K., & Imran, M. A. (2013). Increasing the interaction time in a lecture by integrating flipped classroom and just-in-time teaching concepts. *Compass: Journal of Learning and Teaching*, 4(7):84. DOI: https://doi.org/10.21100/compass.v4i7.84

Asal, R. (2020). Mühendislik Tasarım Temelli Fen Öğretiminin İlkokul 4. Sınıf Öğrencilerinin Bilimsel Yaratıcılık ve Eleştirel Düşünme Becerilerine Etkisi. Yüksek Lisans Tezi. Gazi Üniversitesi Eğitim Bilimleri Enstitüsü Temel Eğitim Anabilim Dalı.

Atabaş, Ü. (2020). STEM Eğitiminin Fen Bilimleri Dersinde Dördüncü Sınıf Öğrencilerinin Bilimsel Yaratıcılıklarına, Problem Çözmeye Yönelik Yansıtıcı Düşünme Becerilerine ve STEM Eğitimine İlişkin Görüşlerine Etkisi. Doktora Tezi. Marmara Üniversitesi Eğitim Bilimleri Enstitüsü Temel Eğitim Anabilim Dalı.

Aydın, G. (2016). Ters yüz sınıf modelinin üniversite öğrencilerinin programlamaya yönelik tutum, öz-yeterlik algısı ve başarılarına etkisinin incelenmesi. Yüksek Lisans Tezi. Dokuz Eylül Üniversitesi Eğitim Bilimleri Enstitüsü, Bilgisayar ve Öğretim Teknolojileri Eğitimi Anabilim Dalı.

Baltabıyık, Y. (2019). STEM uygulamalarının ortaokul öğrencilerinin kavramsal anlama ve bilimsel yaratıcılıklarına etkisi. Yüksek Lisans Tezi. Balıkesir Üniversitesi, Fen Bilimleri Enstitüsü.

Bates, S. & Galloway, R. (2012). The inverted classroom in a large enrolment introductory physics course: A case study. Paper presented. Annual Learning and Teaching Conference, University of Birmingham, United Kingdom.

Bergmann, J. & Sams, A. (2012). Before you flip, consider this. *Phi Delta Kappan*, 94(2):25-25. DOI: https://doi.org/10.1177/003172171209400206

Bergmann, J. & Sams, A. (2012). Flip your classroom: reach every student in every class every day. International Society for Technology in Education (ISTE), pp. 120-190. ISBN: 978-1-56484-315-9.

Berret, D. (2012). How ''flipping'' the clasroom can improve the traditional lecture. *The Education Digest*, 78(1):36.

Bircan, M. A. (2019). STEM eğitimi etkinliklerinin ilkokul dördüncü sınıf öğrencilerinin STEM'e yönelik tutumlarına, 21. yüzyıl becerilerine ve matematik başarılarına etkisi, Doktora Tezi. On Dokuz Mayıs Üniversitesi.

Birgin, A. & Özcan, H. (2022). 8. Sınıf öğrencilerinin mevsimlerin oluşumu ile ilgili bilgilerini ölçmeye yönelik bir başarı testinin geliştirilmesi. *Trakya Üniversitesi Sosyal Bilimler Dergisi*, 24(1):305-326. DOI: https://doi.org/10.26468/trakyasobed.817792

Bishop, J. L. & Verleger, M. A. (2013). The flipped classroom: A survey of the research. Paper presented. 120th ASEE Anual Conference and Exposition, Atlanta, GA.

Boyraz, S. (2014). İngilizce öğretiminde tersine eğitim uygulamasının değerlendirilmesi Yayımlanmamış Yüksek Lisans Tezi. Afyon Kocatepe Üniversitesi.

Brenner, N. (2009). Open questions on state rescaling. *Cambridge Journal of Regions, Economy and Society*, 2(1):123-139. DOI: https://doi.org/10.1093/cjres/rsp002

Butt, A. (2014). Student views on the use of a flipped classroom approach: Evidence from Australia. *Business Education and Accreditation*, 6(1):33-43.

Büyüköztürk, Ş., Çakmak, K., E., Akgün, E., Ö., Karadeniz, Ş. & Demirci, F. (2008). Bilimsel Araştırma Yöntemleri. Ankara: Pegem Akademi.

Bybee, R. W. (2010). What is STEM education? *Science*, 329(5995):996-996. DOI: https://doi.org/10.1126/science.119499

Bybee, R. W. (2016). A societal perspective for STEM education. *NSTA Reports*, 27(5).

Cho, B. & Lee, J. (2013). The effects of creativity and flow on learning through the steam education on elementary school contexts. Paper presented. International Conference of Educational Technology, Sejong University, South Korea.

Clark, K. R. (2013). Examining the effects of the flipped model of instruction on student engagement and performance in the secondary mathematics classroom: An action research study. Doctoral dissertation. Capella University.

Çiftçi, M. (2018). Geliştirilen STEM etkinliklerinin ortaokul öğrencilerinin bilimsel yaratıcılık düzeylerine STEM disiplinlerini anlamalarına ve STEM mesleklerini fark etmelerin etkisi. Yayımlanmamış Yüksek Lisans Tezi. Recep Tayyip Erdoğan Üniversitesi.

Çoşkun, G. (2020). Ters yüz eğitim modeliyle STEM etkinliklerinin fen bilgisi öğretmen adaylarının öz yeterlik inançlarına ve STEM eğitim yaklaşımına yönelik etkisi [Yüksek Lisans Tezi]. Akdeniz Üniversitesi Eğitim Bilimleri Enstitüsü Matematik ve Fen Bilimleri Eğitimi Ana Bilim Dalı.

Coufal, K. (2014). Flipped learning instructional model: perceptions of video delivery to support engagement in eighth grade math. Doctoral dissertation. Lamar University.

Creswell, J. W., & Sözbilir, M. (2017). Karma yöntem araştırmalarına giriş. Pegem Akademi.

Demir, E. (2020). 5. sınıf fen bilimleri dersi insan ve çevre ünitesinde ters yüz sınıf uygulamalarının çevre bilincine etkisinin incelenmesi. Yüksek Lisans Tezi. Kastamonu Üniversitesi Fen Bilimleri Enstitüsü.

Demiralay, R. & Karataş, S. (2014). Evde ders okulda ödev modeli. *Eğitim ve Öğretim Araştırmaları Dergisi*, 3(3):333-340.

Deniş, H., & Balım, A. G. (2012). Bilimsel yaratıcılık ölçeğinin Türkçeye uyarlama süreci ve değerlendirme ölçütleri. *Uşak Üniversitesi Sosyal Bilimler Dergisi*, 5(2):1-21. DOI: https://10.12780/UUSBD111

Doğan, H., Savran-Gencer, A. & Bilen, K. (2017). Fen ve mühendislik uygulaması: Yenilebilir ve yenilenebilir araba yarışması etkinliği üzerine bir durum çalışması. *Araştırma Temelli Etkinlik Dergisi*, 7(2):62-85.

Enfield, J. (2013). Looking at the impact of the flipped classroom model of instruction on undergraduate multimedia students at CSUN. *TechTrends*, 57(6):14-27. DOI: https://doi.org/10.1007/s11528-013-0698-1

Faber, M., Unfried, A., Wiebe, E. N., Corn, J., Townsend, L. W., & Collins, T. L. (2013, June). Student attitudes toward STEM: The development of upper elementary school and middle/high school student surveys. Paper presented. ASEE Annual Conference & Exposition, Atlanta, Georgia.

Farajallah, A. K. M., & Musa Al-Najjar, S. (2022). The effect of employing the flipped Classroom on developing creative thinking skills and the attitude towards self-learning in mathematics among the tenth grade students in Palestine. *Al-Anbar University Journal For Humanities*, (2):295-323. DOI: https://doi.org/10.37653/juah.2022.174783

Gannod, G. C., Burge, J. E. & Helmick, M. T. (2008, May). Using the inverted classroom to teach software engineering. Paper presented. In Proceedings of the 30th international conference on Software engineering, Leipzig Germany.

Genek, S. E. (2018). STEM programı uygulanan ilkokul öğrencilerinin bilimsel yaratıcılık düzeylerinin incelenmesi. Yüksek Lisans Tezi. Bahçeşehir Üniversitesi Eğitim Bilimleri Enstitüsü.

Gonzalez, H. B. & Kuenzi, J. J. (2012, August). Science, technology, engineering, and mathematics (STEM) education: A primer. Paper presented. Congressional Research Service, Library of Congress, Washington, DC.

Gülhan, F. (2016). Fen-teknoloji-mühendislik-matematik entegrasyonunun (stem) 5. sınıf öğrencilerinin algı, tutum, kavramsal anlama ve bilimsel yaratıcılıklarına etkisi. Doktora Tezi. Marmara Üniversitesi Eğitim Bilimleri Enstitüsü İlköğretim Anabilim Dalı Fen Bilgisi Öğretmenliği Bilim Dalı.

Güven-Demir, E. (2018). Ters yüz sınıf modeline dayalı uygulamaların ilkokul 4. sınıf öğrencilerinin akademik başarı ve planlama becerilerine etkisi. Doktora Tezi. Ondokuz Mayıs Üniversitesi Eğitim Bilimleri Enstitüsü İlköğretim Eğitimi Anabilim Dalı.

Güzey, S. S, Harwell, M. & Moore, T. (2014). Development of an instrument to assess attitudes toward science, technology, engineering, and mathematics (STEM). *School Science and Mathematics*, 114(6):271-279. DOI: https://doi.org/10.1111/ssm.12077

Harjono, A., Andani, T. G., Gunada, I. W., & Susilawati, S. (2022). Implementation of blended-flipped classroom model assisted by video to improve students' creative thinking skills. *Jurnal Penelitian Pendidikan IPA*, 8(6):3180-3186. DOI: https://doi.org/10.29303/jppipa.v8i6.2255

Hertz, M. B. (2012). The flipped classroom: Pro and con. Blended Learning, 15 Temmuz. https://www.edutopia.org/blog/flipped-classroom-pro-and-con-mary-bethhertz

Holdren, J. P., Lander, E.S. & Varmus, H. (2010). Prepare and inspire: K-12 education in science, tecnology, engineering, and math (STEM) for America's future(Excutive Report). President's Council of Advisors on Science and Technology. Available at: https://nsf.gov/attachments/117803/public/2a--Prepare_and_Inspire--PCAST.pdf

Honey, M., Pearson, G. & Schweingruber, H. (2012). National Academy of Engineering and National Research Council (2014). STEM integration in K-12 education: Status, prospects, and an agenda for research. National Academies Press, Washington, DC. 10:18612. DOI: https://doi.org/10.1126/science.1128690

Hotle, S., & Garrow, L. (2016). Effects of the traditional and flipped classrooms on undergraduate student opinions and success. *Journal of Professional Issues in Engineering Education and Practice*, 142(1):05015005. DOI: https://doi.org/10.1061/(ASCE)EI.1943-5541.0000259

Hsia, L. H., Lin, Y. N., & Hwang, G. J. (2021). A creative problem solving‐based flipped learning strategy for promoting students' performing creativity, skills and tendencies of creative thinking and collaboration. *British Journal of Educational Technology*, 52(4):1771-1787. DOI: https://doi.org/10.1111/bjet.13073

Hu, W. & Adey, P. (2002). A scientific creativity test for secondary school students. *International Journal of Science Education*, 24(4):389-403. DOI: https://doi.org/10.1080/09500690110098912

Johnson, L., & Renner, J. (2012). Effect of the flipped classroom model on a secondary computer applications course: Student and teacher perceptions, questions and student achievement. Unpublished doctoral dissertation. University of Louisville.

Kavak, T. (2019). STEM uygulamalarının dördüncü sınıf öğrencilerinin fen ve teknolojiye yönelik tutumlarına, bilimsel süreç ve problem çözme becerilerine etkisi. Yüksek Lisans Tezi. Fırat Üniversitesi.

Khanova, J., Roth, M.T., Rodgers, J. E., & McLaughlin, J.E. (2015). Student experiences across multiple flipped courses in a single curriculum. *Medical Education*, 49(10):1038-1048. DOI: https://doi.org/10.1111/medu.12807

Knezek, G., Christensen, R., Tyler-Wood, T. & Periathiruvadi S. (2013). Impact of environmental power monitoring activities on middle school student perceptions of STEM. *Science Education International*, 24(1):98-123.

Koçak, G. (2019). Ters yüz öğrenmenin 7. sınıf öğrencilerinin akademik başarısına etkisi Yüksek Lisans Tezi. İnönü Üniversitesi, Eğitim Bilimleri Enstitüsü, Eğitim Bilimleri Anabilim Dalı.

Konca Şentürk, F. (2017). FeTeMM etkinliklerinin fen bilimleri dersindeki kavramsal anlama ve bilimsel yaratıcılık üzerindeki etkileri ve öğrenci görüşleri. Yüksek Lisans Tezi. Muğla Sıtkı Koçman Üniversitesi, Eğitim Bilimleri Enstitüsü.

Kong, Y.T. & Huo, S. C. (2014). An Effect of STEAM activity programs on science learning interest. *Advanced Science and Technology Letters*, 59:41-45. DOI: http://dx.doi.org/10.14257/astl.2014.59.09

Korucuk, M. (2021). Ters-yüz edilmiş öğrenme uygulamalarının üniversite öğrencilerinin yaratıcı düşünme eğilimlerine, iletişim becerilerine, güdülenmelerine ve akademik başarılarına etkisi. Doktora Tezi. Atatürk Üniversitesi Eğitim Bilimleri Enstitüsü Eğitim Bilimleri Ana Bilim Dalı.

Köken, O. (2020). Öğretmenlerin fen, mühendislik ve girişimcilik uygulamalarındaki yeterlilikleri, sorunları ve çözüm önerileri. Yayımlanmamış Yüksek Lisans Tezi. Kırıkkale Üniversitesi, Fen Bilimleri Enstitüsü, Kırıkkale.

Kurtuluş, M. A. (2019). STEM etkinliklerinin öğrencilerin akademik başarılarına, problem çözme becerilerine, bilimsel yaratıcılıklarına, motivasyonlarına ve tutumlarına etkisi. Yüksek Lisans Tezi. Alanya Alaaddin Keykubat Üniversitesi, Fen Bilimleri Enstitüsü Fen Bilgisi Eğitimi Ana Bilim Dalı.

Kuvaç, M. (2018). Fen, teknoloji, mühendislik ve matematik (STEM) temelli çevre eğitimine yönelik öğretim tasarımının etkililiği. Doktora Tezi. İstanbul Üniversitesi-Cerrahpaşa, Lisansüstü Eğitim Enstitüsü, Matematik ve Fen Bilimleri Eğitimi Ana Bilim Dalı, Fen Bilgisi Eğitimi Bilim Dalı.

Kyere, J. (2017). The effectiveness of hands-on pedagogy in STEM education. Unpublished Doctoral Dissertation. Walden University.

Long, T., Logan, J., & Waugh, M. (2016). Students' perceptions of the value of using videos as a pre-class learning experience in the flipped classroom. *TechTrends:Linking Research & Practice to Improve Learning*, 60(3):245-252. DOI: https://doi.org/10.1007/s11528-016-0045-

4

Mayasari, T., Kadarohman, A., Rusdiana, D. & Kaniawati, I. (2016). Exploration of student's creativity by integrating STEM knowledge into creative products. *AIP Conference Proceedings 1708, 080005.* AIP Publishing. DOI: https://doi.org/10.1063/1.4941191

McCallum, S., Schultz, J., Selke, K., & Spartz, J. (2015). An Examination of the Flipped Classroom Approach on College Student Academic Involvement. *International Journal of Teaching and Learning in Higher Education,* 27(1):42-55.

McLean, S., Attardi, S., Faden, L., & Goldszmidt, M. (2016). Flipped classrooms and student learning: not just surface gains. *Advances in Physiology Education,* 40(1):47-55. DOI: https://doi.org/10.1152/advan.00098.2015

Mills, L. A. (2013). Indicators of science, technology, engineering, and math (STEM) career interest among middle school students in the USA. Doctoral dissertation.Doctoral dissertation. University of Norty Texas.

Milman, N. B. (2012). The flipped classroom strategy: What is it and how can it best be used?(Ends and Means). Distance Learning, for educators, trainers, and leaders. *Journal of STEM,* 9(3):85-87.

Moghadam, S. N. & Razavi, M. R. (2022). The effect of the Flipped Learning method on academic performance and creativity of primary school students. *European Review of Applied Psychology,* 72(5):101592. DOI: https://doi.org/10.1016/j.erap.2022.100811

Ministry of National Education. (2013). Curriculum of science courses of primary education institutions (3, 4, 5, 6, 7 and 8th grades). Ankara: State Books Publishing House.

Ministry of National Education. (2017). Curriculum of science courses of primary education institutions (3, 4, 5, 6, 7 and 8th grades). Ankara: State Books Publishing House.

Morin, B., Kecskemety, K. M., Harper, K. A. & Clingan, P. A. (2013). The inverted classroom in a first-year engineering course. Paper presented.. 120th American Society of Engineering Education Annual Conference and Exposition, Atlanta, Georgia, United States.

Morrison, J. (2006). TIES STEM education monograph series. Attributes of STEM education. Baltimore.

National Academy of Engineering [NAE] & National Research Council [NRC] (2009). Engineering in K-12 education: Understanding the status and improving the prospects. L. Katehi and M. Feder (Eds.). The National Academies.

National Academy of Engineering and National Research Council (2014). STEM integration in K-12 education: Status, prospects, and an agenda for research. The National Academies Press.

National Research Council [NRC]. (2012). A framework for k-12 science education: Practices, crosscutting concepts, and core ideas. The National Academic Press.

Nida, N. K., Usodo, B., & Saputro, D. R. S. (2020). Effectiveness of the flipped classroom model on the students' mathematical creative thinking skills. In International Conference on Online and Blended Learning 2019 (ICOBL 2019) (pp. 107-110). Atlantis Press.

NGSS Lead States (2013). Next Generation Science Standards: For States, By States. Washington, DC: The National Academies Press.

Ozan, F. (2019). 5. sınıf "kuvvetin ölçülmesi ve sürtünme ünitesine yönelik fetemm uygulamalarının etkililiğinin çeşitli değişkenler bağlamında incelenmesi. Yayımlanmamış Yüksek Lisans Tezi. Amasya Üniversitesi.

Ök, S. (2019). Ters yüz öğrenme ortamlarında öğrencilerin akademik başarılarının ve öz-düzenleyici öğrenme becerilerinin araştırılması.Yüksek Lisans Tezi. Balıkesir Üniversitesi Fen Bilimleri Enstitüsü, Bilgisayar Ve Öğretim Teknolojileri Eğitimi Anabilim Dalı.

Ökmen, B. (2020). Basamaklandırılmış ters yüz öğrenme modeli öğretim sürecinin geliştirilmesi. Doktora Tezi. Düzce Üniversitesi Sosyal Bilimler Enstitüsü Eğitim Bilimleri Anabilim Dalı.

Öner, G. (2019). Ortaokul öğrencilerinin FeTeMM'e yönelik tutum, algı, problem çözme ve sorgulayıcı öğrenme becerileri arasındaki ilişkilerin incelenmesi. Yüksek Lisans Tezi. Tokat Gaziosmanpaşa Üniversitesi Eğitim Bilimleri Enstitüsü Matematik Ve Fen Bilimleri Eğitimi Ana Bilim Dalı.

Özçelik, C. (2021). Probleme dayalı STEM uygulamalarının öğrencilerin STEM'e ilişkin tutumlarına, öz düzenleme becerilerine ve bilişüstü yetilerine etkisi. Doktora Tezi. Bartın Üniversitesi Lisansüstü Eğitim Enstitüsü Eğitim Bilimleri Anabilim Dalı.

Öztürk-İrtem, E. (2021). Ortaokul öğrencilerinin teknolojiye yönelik tutumları ile bilim insanı, mühendis ve STEM alanlarına yönelik algılarının incelenmesi. Yüksek Lisans Tezi. Tokat Gaziosmanpaşa Üniversitesi Lisansüstü Eğitim Enstitüsü Matematik Ve Fen Bilimleri Eğitimi Anabilim Dalı.

Özyurt, M., Kayiran, B. K. & Başaran, M. (2018). İlkokul öğrencilerinin STEM'e ilişkin tutumlarının çeşitli değişkenler açısından incelenmesi. *Turkish Studies,* 13(4):65-82. DOI: https://doi.org/10.7827/TurkishStudies.12700

Park, N. ve Ko, Y. (2012). Computer education's teaching-learning methods using educational programming language based on STEAM education, IFIP International Conference on Network and Parallel Computing In: Park, J., Zomaya, A., Yeo, S., et al(eds.), 7513:320-327.

Ramírez, D., Hinojosa, C., & Rodríguez, F. (2014). Advantages And Dısadvantages Of Flıpped Classroom: STEM Students' perception. In ICERI 2014 Proceedings (pp. 121-127). IATED.

Rehmat, A. P. (2015). Engineering the path to higher-order thinking in elementary education: A problem-based learning approach for STEM integration. Unpublished Doctoral Dissertation. University of Nevada.

Rodríguez, G., Díez, J., Pérez, N., Baños, J. E., & Carrió, M. (2019). Flipped classroom: Fostering creative skills in undergraduate students of health sciences. *Thinking Skills and Creativity*, 33:100575. DOI: https://doi.org/10.1016/j.tsc.2019.100575

Sarıçam, U. (2019). Dijital oyun tabanlı STEM uygulamalarının öğrencilerin STEM alanlarına ilgileri ve bilimsel yaratıcılığı üzerine etkisi: Minecraft örneği, Yayımlanmamış Yüksek Lisans Tezi. Marmara Üniversitesi.

Scott, J. W. (2009). The politics of the veil. In The Politics of the Veil. Princeton University Press.

Stockwell, B. R., Stockwell, M. S., Cennamo, M., & Jiang, E. (2015). Blended learning improves science education. *Cell*, 162(5):933-936. DOI: https://doi.org/10.1016/j.cell.2015.08.009

Sever, G. (2014). Bireysel çalgı keman derslerinde çevrilmiş öğrenme modelinin uygulanması. *Eğitimde Nitel Araştırmalar Dergisi*, 2(2):27-42. DOI: https://doi.org/10.14689/issn.2148-2624.1.3s2m

Sezer, B. (2015). Gerçekleştirilen teknoloji destekli tersine çevrilmiş sınıf uygulamasının yansımaları [Bildiri Sunumu]. 3. Uluslararası Öğretim Teknolojileri ve Öğretmen Eğitimi Sempozyumu. Karadeniz Teknik Üniversitesi, Trabzon.

Söndür, D. (2020). STEM etkinlikleriyle desteklenmiş ters yüz öğrenme modelin çeşitli değişkenlere etkisi. Doktora Tezi. Erciyes Üniversitesi, Eğitim Bilimleri Enstitüsü, Matematik ve Fen Bilimleri Anabilim Dalı.

Staker, H. & Horn, M. B. (2012). Classifying K-12 blended learning. Innosight Institute, San Mateo.

Strayer, J. F. (2012). How Learning in an Inverted Classroom Influences Cooperation, Innovation and Task Orientation. *Learning Environments Research*, 15:171-193. DOI: https://doi.org/10.1007/s10984-012-9108-4

Şen, N. (2019). 7. sınıf elektrik enerjisi ünitesinde FeTeMM yaklaşımına dayalı tasarlanan öğrenme ortamının fen bilimleri eğitimine etkileri. Yayımlanmamış Yüksek Lisans Tezi. Uşak Üniversitesi.

Şerefli, B. (2020). Sosyal bilgiler öğretiminde ters yüz edilmiş sınıf modeli: akademik başarıya, tutuma etkisi ve öğrenci görüşleri. Yüksek Lisans Tezi. Gazi Üniversitesi Eğitim Bilimleri Enstitüsü Türkçe Ve Sosyal Bilimler Eğitimi Ana Bilim Dalı.

Şirin, E. (2020). Girişimcilik odaklı STEM etkinliklerinin 7. sınıf öğrencilerinin girişimcilik becerilerine ve STEM tutumlarına etkisi. Yüksek Lisans Tezi. Van Yüzüncü Yıl Üniversitesi, Eğitim Bilimleri Enstitüsü, Matematik ve Fen Bilimleri Eğitimi Ana Bilim Dalı, Kimya Eğitimi Bilim Dalı.

Talbert, R. (2012). Inverted classroom. *Colleagues*, 9(1):7. Available at: https://scholarworks.gvsu.edu/colleagues/vol9/iss1/7

Talley, C., & Scherer, S. (2013). The Enhanced Flipped Classroom: Increasing Academic Performance with Student-recorded Lectures and Practice Testing in a "Flipped"

STEM Course. *The Journal of Negro Education*, 82(3):339-347.

Tekin, D. (2020). Kimyanın temel kanunları, kimyasal hesaplamalar ve mol kavramı ünitelerinin yapılandırmacılık temelli ters yüz edilmiş sınıf modeli ile öğretimi. Yüksek Lisans Tezi. Marmara Üniversitesi Eğitim Bilimleri Enstitüsü Ortaöğretim Fen ve Matematik Alanları Eğitimi Anabilim Dalı.

Tomaç, C. (2019). Etkili STEM eğitim materyallerinin geliştirilmesi. Yayımlanmamış Yüksek Lisans Tezi. Orta Doğu Teknik Üniversitesi, Fen Bilimleri Enstitüsü.

Tsai, M. N., Liao, Y. F., Chang, Y. L. & Chen, H.C. (2020). A brainstorming flipped classroom approach for improving students' learning performance, motivation, teacher-student interaction and creativity in a civics education class. *Thinking Skills and Creativity*, 38:100747. DOI: https://doi.org/10.1016/j.tsc.2020.100747

Tseng, K., Chang, C., Lou, S. & Chen, W. (2013). Attitudes towards science, technology, engineering and mathematics (STEM) in a project-based learning (PBL) environment. *International Journal of Technology and Design Education*, 23(1):87-102. DOI: https://doi.org/10.1007/s10798-011-9160-x

Ünlü, S. (2022). Ters yüz öğrenme modeli ile kodlama eğitiminin fen bilgisi öğretmen adaylarının erişi ve tutumlarına etkisi. Yüksek Lisans Tezi. Necmettin Erbakan Üniversitesi Matematik ve Fen Bilimleri Eğitimi Anabilim Dalı Fen Bilgisi Eğitimi Bilim Dalı.

Ünlütürk, A. Ö. (2022). Ters yüz öğrenme ile yapılandırılmış okul dışı fen eğitiminin etkililiğinin çeşitli değişkenler bakımından incelenmesi. Yüksek Lisans Tezi. Karamanoğlu Mehmetbey Üniversitesi Fen Bilimleri Enstitüsü Matematik Ve Fen Bilimleri Eğitimi Ana Bilim Dalı.

Ünsal, H. (2018). Ters yüz öğrenme ve bazı uygulama modelleri. *Gazi Eğitim Bilimleri Dergisi*, 4(2):39-50. Available at: https://dergipark.org.tr/en/pub/gebd/issue/38655/437492

Wannapiroon, N., & Petsangsri, S. (2020). Effects of STEAMification model in flipped classroom learning environment on creative thinking and creative innovation. *TEM Journal*, 9(4):1647. DOI: https://doi.org/10.18421/TEM94-42

Widyaningrum, H. K., Hasanudin, C., Fitrianingsih, A., Novianti, D. E., Saddhono, K., & Supratmi, N. (2020). The use of Edmodo apps in flipped classroom learning. How is the students' creative thinking ability? *Ingénierie des Systèmes d Inf.*, 25(1):69-74. DOI: https://doi.org/10.18280/isi.250109

Yakman, G, (2008). STEM Education: an overview of creating a model of integrative education. Pupils Attitudes Towards Technology. Annual Proceedings. Netherlands.

Yatt, B. & McCade, J. (2011). Defining creativity and design. In S. A. Warner & P. R. Gemmill (Eds.), Creativity and design in technology & engineering education. (pp. 32-68). Council on technology teacher education. 60th yearbook. United States of America.

Yavuz, Ü. (2019). İlkokul fen bilimleri dersinin fen, teknoloji, mühendislik ve matematik (FETEMM) etkinlikleri ile işlenmesi. Yüksek Lisans Tezi. Afyon Kocatepe Üniversitesi Sosyal Bilimler Enstitüsü Temel Eğitim Ana Bilim Dalı.

Yazıcı, Y. Y. (2019). 6E öğrenme modeline dayalı FETEMM eğitiminin girişimcilik, tutum, meslek ilgisine etkisi ve öğrenci görüşleri. Yayımlanmamış Yüksek Lisans Tezi. Kırıkkale Üniversitesi, Fen Bilimleri Enstitüsü.

Yestrebsky, C. L. (2015). Flipping the classroom in a large chemistry class-research university environment. *Procedia-Social and Behavioral Sciences*, 191:1113-1118. DOI: https://doi.org/10.1016/j.sbspro.2015.04.370

Yıldırım, B. & Altun, Y. (2015). STEM eğitim ve mühendislik uygulamalarının fen bilgisi laboratuar dersindeki etkilerinin incelenmesi. *El-Cezeri*, 2(2):28-40.

Yıldırım, B. (2016). 7. Sınıf Fen Bilimleri Dersine Entegre Edilmiş Fen, Teknoloji, Mühendislik, Matematik (STEM) Uygulamaları ve Tam Öğrenmenin Etkilerinin İncelenmesi. Yayımlanmamış Doktora Tezi. Gazi Üniversitesi.

Yıldırım, B. & Selvi, M. (2017). STEM uygulamaları ve tam öğrenmenin etkileri üzerine deneysel bir çalışma. *Eğitimde Kuram ve Uygulama*, 13(2):183-210. DOI: https://doi.org/10.17244/eku.310143

Yu, E. (2022). Ters yüz öğrenme modeli ile yetişkinlere yabancı dil olarak korece öğretimi Doktora Tezi. Ankara Üniversitesi Sosyal Bilimler Enstitüsü Doğu Dilleri ve Edebiyatları Anabilim Dalı.

Yılmaz, K. & Altınkurt, Y. (2011). Göreve yeni başlayan özel dershane öğretmenlerinin kurumlarındaki çalışma koşullarına ilişkin görüşleri. *Kuram ve Uygulamada Eğitim Bilimleri*, 11(2):635-650

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