The effects of E-STEM (Entrepreneurship-Science-Technology-Engineering-Mathematics) Implementations on 21st Century Skills and STEM Attitudes of Primary School Students[1]

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Abstract:

In this reseach, it was aimed to examine the effect of E-STEM implementations on primary school students' 21st century skills and STEM attitudes. The implementation process of this research in the 2023-2024 academic year was carried out with students enrolled in the 3rd grade in a public primary school in Afyonkarahisar-Türkiye. The study group was selected using convenience sampling. In the study, a quasi-experimental design with pre- and post-test control group was preferred among quantitative research methods. The experimental (27) and control groups (29) consisted of two different classes at the same grade level. "Multidimensional 21st Century Skills Scale" and "STEM Attitude Scale" were used as data collection tools. When the results of the data analysis were analyzed, it was seen that there was no significant difference between the students when the pre-test mean scores of both the experimental group and the control group students were compared before the implementation. When the total pre-test and post-test scores of the Multidimensional 21st Century Skills Scale were compared, no change was observed in the control group, while there was a statistically significant increase in the experimental group. Likewise, when STEM Attitude Scale total pre- and post-test scores of both groups were compared, no change was observed in the control group, while there was a statistically significant increase in the experimental group.

Keywords: E-STEM, 21st century skills, STEM attitudes, 3rd grade primary school students

1. Introduction

Today, it is aimed to raise individuals who are entrepreneurial, creative and innovative, have effective communication skills, solve problems rationally, and are aware of world problems (Partnership for 21st Century Skills, 2009). The most effective approach in raising these individuals with 21st century skills is undoubtedly STEM (Science-Technology-Engineering-Mathematics) education (Reeve, 2015; Roberts, 2012). The general aims of STEM education include training workforce in STEM fields and maintaining existing jobs, raising STEM literate individuals in society, and producing innovations that will contribute to the national economy (Thomas, 2014). In this context, the aim of STEM education is to raise self-confident individuals who have 21st century skills, think creatively, solve problems, are innovative, interested in technology, and have effective communication skills from preschool to university (Stohlmann et al., 2012). Therefore, STEM education prepares students for the real world outside of school. Individuals who receive STEM education gain basic characteristics such as problem solving, self-confidence, logical thinking, being innovative, rational thinking, being

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technologically literate, and establishing a relationship between school and real life (Morrison, 2006).

Entrepreneurship should be a part of education if students are to be fully and competently prepared for the business life of the future and to be innovative, rational and entrepreneurial in solving problems. STEM education and entrepreneurship have an important place at this point (Nambisan, 2014). They stated that E-STEM activities, which are a process in which individuals can think reflectively and empathically, provide more permanent learning in individuals and provide individuals with a multidimensional perspective. It was stated that combining STEM applications with entrepreneurship creates a positive perception on individuals and E-STEM activities are a feasible approach (Aydoğdu et al., 2020). Based on this understanding, it is considered appropriate to start E_STEM education from an early age. Saiden (2017), who emphasized that individuals raised in countries where entrepreneurship education is provided from primary school onwards provide a noticeable improvement to the country's economies, stated that STEM education should be associated with entrepreneurship.

When the literature is examined, there are almost no E-STEM studies conducted with primary school students. Based on this need, the aim of this study is to determine the effect of E-STEM applications in the 3rd grade of primary school on students' 21st century skills and STEM attitudes. The hypotheses to be tested in line with this research are as follows:

1. There is a statistically significant difference in favor of the post-test scores when the pre-test and post-test scores of the "Multidimensional 21st Century Skills Scale" of the experimental group students who were implemented E-STEM activities are compared.

2. There is a statistically significant difference in favor of the post-test scores when the pre-test and post-test scores of the "STEM Attitude Scale" of the experimental group students who were applied E-STEM activities are compared.

2. METHOD

2.1. Research Model

In this study, which investigates the effect of E-STEM applications in the third grade of primary school on students' 21st century skills and STEM attitudes, a quasi-experimental design with pre- and post-test control groups was preferred among quantitative research methods.

Ethics committee permission was obtained for the study. (22.05.2024-271155)

2.2. Study Group

The convenience sampling method was used to select the study group in this study. In this context, 56 third grade students of a public primary school in Afyonkarahisar province in the 2023-2024 academic year constitute the study group of this research. There were 27 students in the experimental group, 11 of whom were male and 16 of whom were female. There were 29 students in the control group. 12 students were male and 17 students were female in the control group.

2.3. Data Collection Tools

The data of the study were collected using the "Multidimensional 21st Century Skills Scale" and "STEM Attitude Scale". Çevik and Şentürk (2019) developed a multidimensional scale consisting of 41 items with 5 sub-factors to determine 21st century skills. This scale is a Likert-type scale. Cronbach Alpha Reliability Score was calculated as 0.86.

In order to determine the STEM attitudes of the students in the study, the STEM Attitude Scale (STAS) revised by Faber et al. (2013) and adapted into Turkish by Yıldırım and Selvi (2015) was used. This scale includes 37 items in total and has a five-point Likert-type structure. Cronbach Alpha Reliability Score was calculated as 0.93.

2.4. Data Collection and experimental process

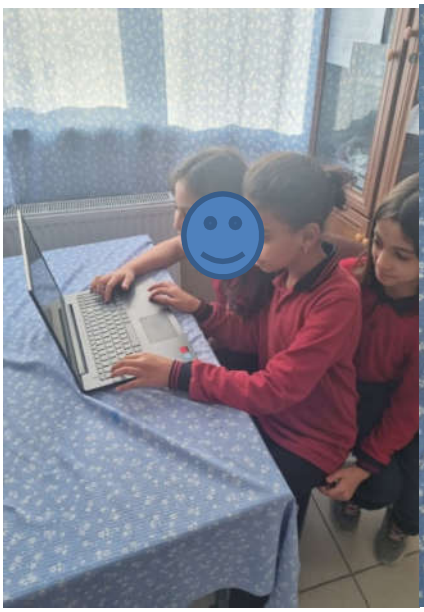
The experimental study was conducted as an application process of 12 lesson hours. In line with the science curriculum, the control group students were taught with the activities in the textbook, while the experimental group students were taught with E-STEM applications. At the beginning and at the end of the experimental process, the scales were applied to the experimental and control groups in pretest-posttest format.

Seven heterogeneous groups were formed considering the academic achievement and gender of the 3rd grade students in the experimental group. At the beginning of the implementation process, each group was asked to give a name. The experimental process was implemented as presented in Table 1.

Table 1. Experimental process

Weeks	Activities
Week 1	Classroom organization was provided for heterogeneously formed groups. Each group gave itself a group name. Multidimensional 21st Century Skills Scale and STEM Attitude Scale pretests were administered to the students in the control and experimental groups. Experimental group students were given a case study and problem situation taken from a news article. They were made to watch a video on zero waste related to the subject. Letters assumed to be from the future environment were distributed to the students. Visuals related to the subject were examined. Student opinions about the problem situation were taken. In this direction, students were asked to prepare research questions on the subject, make observations in playgrounds for environmental problems, conduct research in the digital environment, examine the protocols signed by Turkey on the environment in the international arena, and interview the authorized person about environmental pollution encountered in playgrounds in parks. As a result of their research, the students presented their research in the classroom environment, expressed their opinions, suggested possible solutions, and were encouraged to find the best solution. It was stated that students should keep a diary. The groups determined their own solution suggestions for the

	given problem. They drew these solutions in the engineering design notebook. Calculations were recorded. Based on the drawings, the materials to be used were selected. 
Week 2	They started to create the product they drew in line with the selected materials. They aimed to eliminate the factors that cause environmental pollution in the prototype created. It was also aimed to create a product in such a way that the materials used would provide a lot of benefit with little economy. Each stage was recorded in student diaries and followed in terms of development. 

Week 3	The available materials are analyzed and cost calculations are made. Efforts were made to improve the prototype. After the products were tested, deficiencies were tried to be eliminated. The product was finalized. Performance rubrics were created with student participation.  
Week 4	Economic calculations were made. Each group prepared a poster for the product they designed and promoted the product. The poster prepared with Canva, a Web 2.0 tool for prototypes, was presented. Multidimensional 21st Century Skills Scale and STEM Attitude Scale post-tests were applied to the students in the control and experimental groups. 

2.5. Data Analysis

In line with the quantitative research method, the data obtained from the scale before and after the application of STEM to the study group were analyzed using the statistical package program in the computer environment.

FINDINGS

In the study, “Multidimensional 21st Century Skills Scale” and “STEM Attitude Scale” were applied as pre-test and post-test, and categorical variables were presented as percentage and frequency. When continuous variables were analyzed, they were presented as mean and standard deviation. The suitability of continuous variables for normal distribution was checked by Kolmogorov Smirnov test, Shapiro Wilk test and visual histograms. Independent sample t-test was used to compare continuous variables that were normally distributed between the experimental and control groups, and Mann-Whitney U test was used to compare continuous variables that were not normally distributed.

The hypothesis that there is a statistically significant difference in favor of the post-test scores was tested when the pre-test and post-test scores of the “Multidimensional 21st Century Skills Scale” of the experimental group students to whom E-STEM activities were applied.

According to the data obtained from the “Multidimensional 21st Century Skills Scale”, the findings regarding the pre and post-test scores are presented in Table 2.

Table 2. Comparison of the changes in the pre and post-test scores of the experimental and control groups

Scale score	Pre-test (mean±Standard deviation)	Post-test (mean±Standard deviation)	p
Experimental Group	155,89±19,1	168,52±17,8	0,001
Control Group	152,38±30,2	156,24±26,7	0,206

According to the data obtained from the multidimensional 21st century skills scale, when the total pre-test and post-test scores were compared, no statistically significant difference was observed in the control group (Z=-1,266 and p= 0,206), while in the experimental group there was a statistically significant difference in the pretest-posttest scores in favor of the post-test (Z=-3,377 and p= 0,001). This finding confirms the hypothesis.

The hypothesis that there was a statistically significant difference in favor of the post-test scores was tested when the pretest-posttest scores of the “STEM Attitude Scale” of the experimental group students to whom E-STEM activities were applied. According to the data obtained from the “STEM Attitude Scale”, the findings regarding the pre-test and post-test scores are presented in Table 3.

Table 3. Comparison of the changes in the pre and post-test scores of the experimental and control groups

Scale score	Pre-test (mean±Standard deviation)	Post-test (mean±Standard deviation)	p
Experimental Group	131,22±32,1	144,07±24,5	0,006
Control Group	126,41±40,6	132,10±42,1	0,082

According to the data obtained from the STEM attitude scale, when the total pre-test and post-test scores were compared, no statistically significant difference was observed in the control group (Z= -1,741 and p= 0,082), while in the experimental group there was a statistically significant difference in the pretest-posttest scores in favor of the post-test (Z= -2,773 and p= 0,006).

DISCUSSION, CONCLUSION AND SUGGESTIONS

In this study, it was concluded that the effect of E-STEM applications on the 21st century skills of primary school 3rd grade students was positive. Similarly, Stehle and Peters-Burton (2019) revealed that STEM provides environments that support the development of 21st century skills. In another study conducted by Han, Kelley, and Knowles (2021), it was observed that STEM practices directly or indirectly affect students' 21st century skills, STEM career awareness and achievement.

In this study, it was concluded that E-STEM applications positively affected the STEM attitudes of 3rd grade primary school students. Similar to this result, Aydın (2021) stated in his study that when the STEM attitude posttest rank averages of both groups were examined, the experimental group had significantly higher rank averages than the control group. When the difference in rank means between the two groups was examined, it was statistically significant in favor of the experimental group students. Rehmat (2015) stated in his study that STEM activities contributed positively to the attitudes of primary school 4th grade students towards STEM. Bircan (2019) stated that the average STEM attitude scores of students who practiced with STEM activities increased at the end of the application. Hişmi (2022) applied STEM to the study group in his research, and as a result, when the pre-test and post-test scores were compared, a significant difference was observed in favor of the post-test. In the study conducted by Han, Kelley, and Knowles (2021), it was revealed that STEM activities conducted with students positively affected their STEM attitudes. In the study investigating students' STEM attitudes, it was stated that science fairs positively affected students' STEM attitudes (Schmidt and Kelter. 2017). Murphy (2011), in his study investigating the attitudes of 4th grade students towards STEM, found that STEM education had a positive effect on the STEM attitudes of 4th grade primary school students.

In the light of these results, some suggestions for practitioners and researchers for future research are as follows:

In this study, the effects of E-STEM activities on students' 21st century skills and STEM attitudes were determined. In future research, the effects of E-STEM practices on different variables can be examined.

In this study, E-STEM activities were prepared in accordance with the 3rd grade science course outcomes. In future studies, E-STEM activities can be applied at different grade levels or courses.

In this study, experimental design was used within the scope of quantitative research methods. In future research, mixed method studies or action research can be designed.

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