ORIGINAL ARTICLE

The Effect of STEM Activities in Out-of-School Learning Environments on the Scientific Creativity of Middle School Students: Insect Hotel

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Abstract: *This study aimed to determine the effect of the implementation of the STEM content "insect hotel" activity in out-of-school learning environments on the scientific creativity of middle school students. In the study, a quasi-experimental model with a pre-test post-test control group was used, which is one of the quantitative research methods. While the lessons were processed with STEM content activities in out-of-school learning environments in the experimental group, the lessons were carried out with current curriculum prepared by the Ministry of National Education in the control group. In the study conducted with 50 students, data were collected using the Scientific Creativity Test. Descriptive statistics and ANCOVA were used in the data analysis.*
It is observed that scientific creativity skills are at a higher level in the experimental group where STEM education is applied in out-of-school environments than in the control group where the current program is applied, and that STEM activities in out-of-school environments have a significant effect on students' scientific creativity skills. It is thought that the application of STEM content activities in out-of-school learning environments is the biggest factor in increasing the creativity dimension of students by thinking, discussing and designing on the problem rather than theoretical knowledge.

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Introduction

CREATIVITY is defined as bringing different solutions to a problem situation, discovering something new that can lead to differences, designing a different thought structure, and demonstrating originality (Summers et al., 2019). Creative thinking is the process of generating different ideas of one's own and coming up with solutions from these ideas and includes various steps. These steps are explained as recognizing and limiting the problem, creating hypotheses about the problem, testing the hypothesis, finding the hypothesis result (acceptance, rejection or correction) (Aktamış & Ergin, 2007). Scientific creativity is defined as the capacity of individuals to generate original ideas, develop alternative solutions and solve scientific problems in creative ways using scientific processes (Hu & Adey, 2002; Torrance, 1974). Torrance (1990) stated that creativity has three basic components: fluency, flexibility and original thinking. Fluency is defined as the number of original ideas produced, flexibility is defined as the number of themes of ideas produced, and originality is interpreted statistically. The development of this skill supports not only students' academic achievement but also their potential for scientific thinking and innovation.

It is possible for an individual to acquire 21st century skills, including scientific creativity skills, through the integration of disciplines. STEM (Science, Technology, Engineering and Mathematics) is one of the leading educational approaches in which all sciences are integrated and intertwined in an interdisciplinary way (Merrill, 2009). STEM education can be explained as an education that combines many disciplines to provide high-level thinking, increase efficiency in learning, and increase life skills such as transferring what is learned to daily life (Breiner et al., 2012). STEM in education can also be defined as a form of problem solving that enables to look at the problems encountered in a multidimensional way and to think in a systemic way that emphasizes creativity with science and engineering applications by using many disciplines together (Thomasian 2011). STEM education enables individuals to produce more than one solution in the event of a problem encountered and to learn permanently in a fun way that is intertwined with life (Rockland et al., 2010). However, the potential of STEM education should not be limited to the classroom environment. Since out-of-school learning environments offer ideal opportunities to realize STEM practices in a more flexible and creative way, it is important to implement out-of-school learning environments together with STEM activities in realizing the goals of STEM education carried out with a student-centered approach.

While out-of-school education is defined as education provided outside the school walls, provided that it adheres to the curriculum during school time (Hannu, 1993), it is revealed that education in out-of-school learning environments has a supportive, enriching and complementary effect on the education applied at school (Şen, 2019). Bunting (2006) explained that out-of-class learning has three dimensions; the first dimension, expansion, is the processing of the subject with different activities outside the school, the second dimension, content, is the effect of the environment on people, and the last dimension, method, is the development of the connection between cognitive, affective and psychomotor areas with out-of-class activities. With out-of-school learning, individuals will acquire learning skills that can be developed based on experiences and that can continue for a lifetime (Kreuzer et al., 2017). Out-of-school learning is an approach that allows individuals to learn at different speeds and in different ways, but despite these differences (Melber et al., 1999). Out-of-school learning has positive effects on students in terms of interest and motivation, such as arousing curiosity in students, raising their motivation to a high level, making the lesson fun, etc. (Braund & Reiss, 2006). While out-of-school learning has a positive effect on students in terms of interest and motivation, such as arousing curiosity, raising motivation to a high level, making the lesson fun, it also has features that develop students' high-level thinking skills such as creativity (Ramey, 1997).

In out-of-school learning, the student learns in a natural area outside the school. Thus, students interact directly with many stimuli through their own experiences and achieve permanent learning (Kab & Açıkalın, 2016). Out-of-school learning covers all applications outside the classroom. In this case, many places such as school gardens, parks, science centers, zoos, ruins, planetariums and observatories, museums, health institutions and organizations, botanical gardens, greenhouses and fields, nature, forests, etc. can be listed (Lâçin Şimşek, 2011). Whether the place of residence is a city center or a village school does not affect out-of-school learning processes. Since the science course is life itself, it is quite possible to find resources for the course in every environment (Pedretti, 2002). Out-of-school learning environments increase students' interest and achievement in science (Dori & Tal, 2000), create different learning styles, help each student to construct knowledge in line with his/her own capacity, and develop students' inquiry, discovery and research skills (Ainsworth & Eaton, 2010). In addition, STEM activities carried out in these environments allow students to reveal their individual curiosity and develop their creative potential. Out-of-school learning environments are environments where STEM practices are carried out in a more experiential, collaborative and free manner. STEM activities carried out in environments such as science centers, nature camps, museums, university laboratories and maker workshops offer students the opportunity to learn scientific concepts by experiencing them and to develop creative thinking skills (Falk & Dierking, 2010). It is thought that STEM approach applications in out-of-school learning environments where different disciplines are applied together will contribute to the development of scientific creativity, which is one of the skills of the 21st century, and will enable students to learn meaningfully by having fun, being curious and active.

When the literature is examined, there are many studies on STEM education and out-of-school learning separately. In the literature, there are studies that addressing STEM education with various variables positively affects students' academic achievement, interest, attitude, perception, scientific creativity, motivation (Mert, 2019; Atabaş, 2020; Emir, 2021; Demirkaynak, 2022; Öksüz, 2022). There are also studies in which out-of-school learning environments are examined in terms of various variables such as students' academic achievement, interest, attitude, perception, scientific creativity, motivation and their contribution to education and have a positive effect (Kılıç, 2020; Küçük, 2020; Güneş, 2021; Yılmaz, 2023; Büyükkurt, 2023; Utku, 2023). However, it has been observed that there are insufficient studies in which STEM education practices are carried out together in out-of-school environments. The effect of out-of-school learning environments and STEM education on scientific creativity skills has gained more and more importance in recent years. It has been determined that STEM activities carried out in these environments encourage students' creative thinking, improve their scientific process skills and support them to produce original ideas. In this study, the applicability of STEM education in out-of-school learning environments was studied in order to provide more effective and permanent learning. Since STEM education and out-of-school learning have many common components in terms of education, it is important to study their applicability together. It is thought that the integration of these two approaches will bring a different perspective to education. When STEM education and out-of-school learning environments are compared, it is seen that they have a common point in terms of developing scientific creativity. In terms of scientific creativity, technological advances and country development are directly related to people's creativity. As a matter of fact, it will be difficult for societies whose creativity is not developed and where products that meet the needs cannot be obtained to develop. It is very important to carry out various practices in order to develop creativity, which is emphasized in all its dimensions, from a country's development and progress to its contribution to the country's economy.

The aim of the research is to determine the effect of the implementation of the STEM-containing "insect hotel" activity in out-of-school learning environments on the scientific creativity of 5th grade middle school students.

Table 1. Research Design.

Groups	Pre-test	Application	Post-test
Experimental	Scientific Creativity Test	In an out-of-school educational setting STEM	Scientific Creativity Test
Control	Scientific Creativity Test	In-school educational setting	Scientific Creativity Test

Method

In this study, quantitative research method was used to examine the effect of STEM-containing activities on the subject of "Let's Get to Know Living Things" in the Science course in out-of-school learning environments on the scientific creativity of middle school 5th grade students. In the study, a quasi-experimental pretest-posttest control group model was established from quantitative research methods. In the quasi-experimental design, the experimental group and the control group are selected without random assignment. Pre-test and post-test are applied to both groups, but the experimental process is applied only to the experimental group (Creswell, 2017).

The research was conducted in a public secondary school in Turkey. Among the 5th grade students with similar characteristics, two classes taught by the researcher were selected as experimental and control groups. The subject of "Getting to Know Living Things" (microscopic organisms, fungi, plants, animals), which is included in the annual plan of the fifth-grade science course, was taught with STEM-content activities in out-of-school learning environments in the experimental group, while in the control group, a non-STEM-based curriculum prepared by the Ministry of National Education (MEB) and implemented in the school environment was supported with interactive activities through EBA (Educational Information Network) and Morpa Campus (online social education network) platforms. The independent variable in the study was the STEM education in out-of-school settings and the education in the school for the control group. The dependent variables were the scientific creativity of the experimental and control groups.

The experimental design of the study is summarized in **Table 1**.

Sample

One of the researchers works in a secondary school in Turkey. In order to ensure easy accessibility, the researcher formed the study group from the school where he worked. The sample of the study consisted of 50 students studying in the 5th grade of a middle school in the 2023-2024 academic year.

The appropriate case sampling method was used in the study. This sampling type was used based on the knowledge that groups are accessible and easy to be included in the process (Ekiz, 2009). The researcher collects data from a sample that is easily accessible. In the school where the researcher worked, the 5-F class was randomly assigned as the experimental group and the 5-M class was assigned as the control group.

Data Collection Tool

The "Scientific Creativity Test" (SCT) was used to measure students' scientific creativity.

The SCT was applied to reveal to what extent the scientific creativity of the students changed depending on the application of STEM-containing activities in out-of-school learning environments. The SCT was developed by Hu and Adey (2002). The SCT was adapted into Turkish by Deniş and Balım (2012) and the validity and reliability of the test were examined by conducting the necessary studies. SCT consists of 7 open-ended questions (Deniş & Balım, 2012). Hu and Adey (2002) found the reliability coefficient of the scientific creativity test to be 0.86; Deniş and Balım (2012) found the reliability coefficient of the scientific creativity test to be 0.89. In this study, the reliability coefficient of the scientific creativity test was found to be 0.87.

Process/ Practice

1. The lesson plan, worksheets and product evaluation rubric were prepared by the researchers for out-of-school STEM activities suitable for the subject.
2. At the beginning of the 2023-2024 academic year, the SCT pretest was administered to both groups.
3. The experimental group received STEM activities-based applications in out-of-school learning environments, while the control group received the science teaching program with the applications in the current curriculum.
4. The lessons were conducted by one of the researchers who was a science teacher in both classes.
5. Worksheets and rubrics were used to evaluate the experimental group students during the process.
6. At the end of the process, the SCT posttest was applied to both groups.

Experimental Group Implementation Process

a-Before the zoo activity

Figure.1. Frames from the Zoo.

In the 5th grade Science course, a lesson plan, worksheets, product evaluation rubrics and an activity plan were made for the experimental group on the subject of "Let's get to know living things". The Zoo was planned to be visited for the out-of-school learning environment. Permissions and appointments were obtained by calling the necessary places. Students were given general information about the rules to be followed during the zoo activity.

b- During the zoo activity

Students were asked "What are the similarities and differences of the living things around us? In which characteristics are these creatures similar to humans? Where are the places where these creatures live?" The students were asked to visit and observe the zoo under the control of the teacher for the discovery of living things. Students were asked to share their observations with their friends and were supported with teamwork on common issues. During the activity, students were asked comparative questions about the similarities and differences, life styles, habitats, nutrition, mobility, etc. of the creatures we had the opportunity to observe. Students were encouraged to increase their level of awareness and make discoveries in their areas of interest, and questions were asked to arouse interest and curiosity in students. Students were reminded that they could take notes to remember what they saw during the activity (**Figure 1**).

Before the activity, students were asked to fill in the worksheets given to them according to their observations. The questions on the worksheet are as follows:

- What kind of creatures live in the zoo? Explain?

- What are the common or different characteristics of the creatures you have seen? What would you do if you wanted to group and classify them?

- Can you count how many animals you have seen at the zoo?

- Who could have brought the creatures in the zoo there?

- What could we do if we wanted to bring the creatures around us together?

- What could we do if we wanted to create a habitat for the tiny creatures around us?

- What could we do if we wanted to create a tiny animal habitat in our school?

- What do you think about animal hotels?

- If we wanted to build animal hotels in the form of insect hotels, what kind of structure would we build?

c- After the zoo activity

After learning about the similarities and differences between living things and the diversity of their habitats through a zoo activity, the students were asked to build an insect hotel based on the habitats of insects, a type of living thing. The students were given time to get more detailed information about the structure and design they had determined to make an insect hotel. Students received guidance from the teacher during this process. The teacher provided guidance for the process to be carried out appropriately. Opportunities were given to produce alternative solutions for the insect hotel. The imaginary product decided for the solution suggestions was determined and prototype design was started. The process was carried out in the following order:

- Students made drawings for the structure and model they developed in their minds.

- The tools and materials planned to be used by the students in the activities (wooden materials of various sizes, cardboard sheets, various plastic waste materials, waste parcels, laths, pushpins, small nails, hammers, adhesives or glue, etc.) are provided by the teacher and general information about them is given.

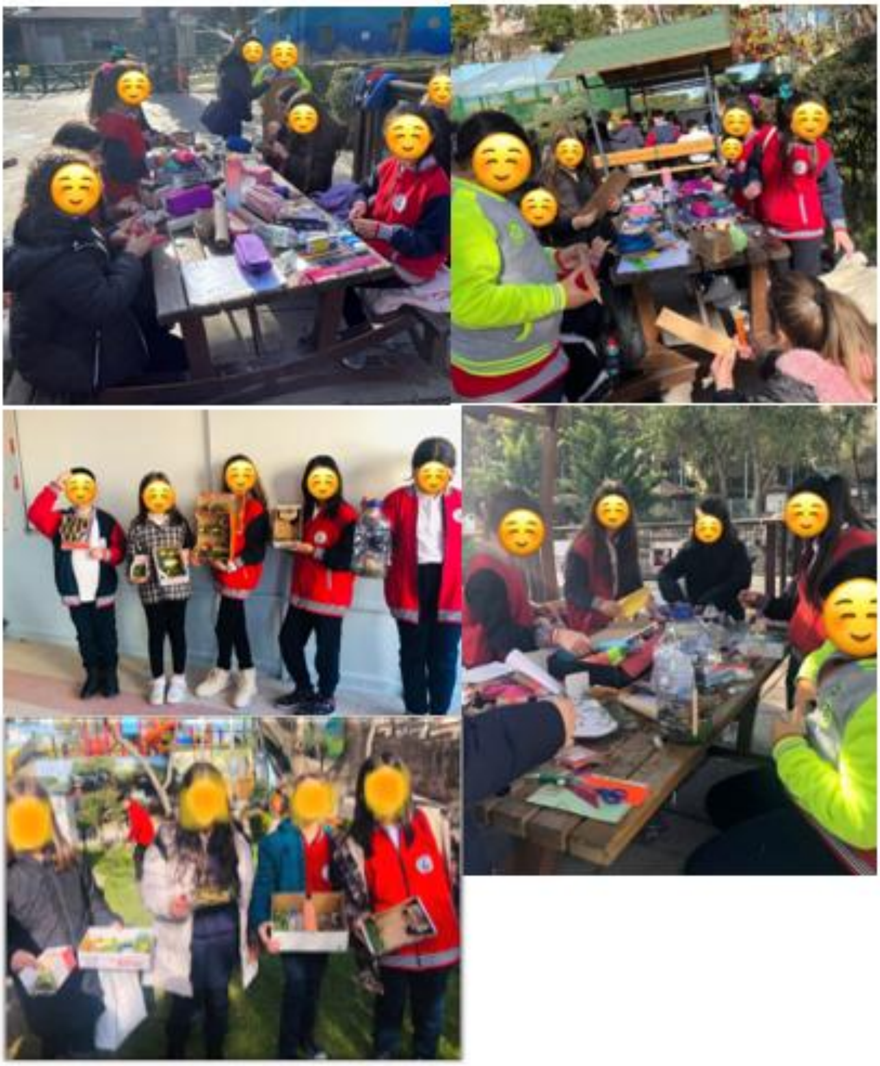

Figure 2. Insect Hotel STEM Activity Photographs.

- Students are reminded to take the necessary safety precautions before using the basic tools and materials they will use in the activities.

- Students are allowed to start modeling by selecting the appropriate tools for their drawings.

- Students' activities are occasionally checked by the teacher and feedback is given to the students. Students who cannot make progress during their work are provided with support to ensure progress.

- It is determined whether the prototype model provides a solution to the problem identified by the student, and if not, feedback is given on where there is a deficiency.

Table 2. Normality Test Results for the Scales

Test	n	$\overline{X}$	SD	Median	Shapiro-Wilk	p	Skewness	Kurtosis
SCT Pretest								
Experimental	25	30.44	10.99	29	0.959	0.403	0.62	0.52
Control	25	33.04	11.49	33	0.985	0.963	-0.01	-0.04
SCT Posttest								
Experimental	25	44.08	13.31	41	0.895	0.014	1.11	0.76
Control	25	29.92	11.97	26	0.929	0.084	0.53	-0.87

- If the student who created the prototype model fails to bring a solution to the problem, the teacher may suggest a method change.

- If the student who created the prototype model was able to provide a solution to the problem, he/she identified, he/she questions how he/she can transform it into a real scale model.

- The general evaluation of the worksheets and rubric evaluation forms applied throughout the whole training and the necessary feedbacks were given to the students.

*- The model made by the students is shared with other students. The models with the best, most durable and most successful visuals were decided unanimously and exhibited at the school (**Figure 2**).*

Control Group Implementation Process

- The SCT pretest was applied before the implementation.
- In line with the plan in the MoNE curriculum, lessons were taught in the classroom through EBA and Morpa Kampüs applications, and students were assigned homework at the end of the lesson. For the acquisitions of Let's Get to Know Living Things, it was defined as 12 lesson hours in the Science lesson plan.
- At the end of the implementation, the SCT posttest was applied.

Data Analysis

In order to decide which statistical techniques to use in the analysis of the data, it was examined whether the data showed a normal distribution. For this purpose, Shapiro-Wilk test was performed to analyze normality when the sample size was less than 50, histogram graphs, skewness and kurtosis values were examined. If the Shapiro-Wilk test probability value is greater than 0.05 ($p > 0.05$), the data are normally distributed; if it is less than 0.05 ($p < 0.05$), the data are not normally distributed (Büyüköztürk, 2007). Normality test results are given in **Table 2**.

The results of the Shapiro-Wilk test showed that the p-value was less than 0.05 and the dimensions were not normally distributed ($p < 0.05$). The

Table 3. Levene Homogeneity Test Result.

Test	F	p	Decision
SCT	0.002	0.964	Homogeneous

Table 4. Normality Results and Analysis Decisions by Group.

Test	Experiment	Control	Decision
SCT Pretest	Normal	Normal	ANCOVA
SCT Posttest	Normal	Normal	

decision was not only based on this test result, but the skewness and kurtosis values and histogram graphs were also analyzed. Skewness and kurtosis values between - 2 and +2 are accepted as normal distribution (Kline, 2000). Levene's homogeneity test result is given in **Table 3**.

Levene's Test for Equality of Variance tests whether the population variances are equal. Equality of population variances is a necessary precondition for comparisons between groups. For Levene's test result p value, if it is above 0.05, the variances are equal/homogeneous (Akbulut, 2013). Accordingly, the variances of the variables are homogeneous. Normality results and analysis decisions obtained by group are given in **Table 4**.

In summary, descriptive statistics (mean, standard deviation, minimum, maximum) and ANCOVA were used to analyze the data. Effect size (η2) was also analyzed. The effect size (η2) is considered as a measure of the practical significance of research results (Synder & Lawson, 1993). A partial eta squared value between 0.01-0.059 indicates a small effect size, while 0.060-0.13 indicates a medium effect size and .14 and above indicates a large effect size (Cohen, 1988). IBM SPSS 26 software was used to analyze the data within the scope of the research.

Results

Is there a significant difference between the pre-test and post-test scores of the scientific creativity test according to the groups?

In the analysis of the SCT according to the groups, the posttest means and the adjusted mean according to the pretest were calculated (**Table 5**).

Table 5. SCT Posttest Mean and Corrected Mean According to the Pretest.

Groups	n	Mean	Corrected Mean
Experimental	25	44.08	43.89
Control	25	29.92	29.66

Table 6. ANCOVA Results of SCT Posttest Scores Corrected According to SCT Pre-Test Score by Group

Source	Sum of Squares	sd	Mean Squares	of F	Sig.	η2
SCT Pretest	4.429	1	4.429	0.027	0.870	0.001
Group	864.167	1	864.167	5.304	0.026	0.103
Error	7494.144	46	162.916			
Total	**78644.000**	**50**				

When **Table 5** is analyzed, it is seen that the mean of the experimental group's SCT posttest was 44.08 and the mean of the control group was 29.92. When the scores were corrected according to the SCT pre-test scores, the averages were realized as 43.89 and 29.66, respectively. It is seen that there is a difference between the adjusted mean scores. ANCOVA test was conducted to examine whether this difference was significant (**Table 6**).

When the ANCOVA test results are examined, it is seen that there is a significant difference between the posttest mean scores of the students in the experimental and control groups, $F_{(1, 46)} = 5.304$, $p < 0.01$, $\eta^2 = 0.103$. The mean posttest score of the experimental group ($\overline{X} = 44.08$), was higher than the mean posttest score of the control group ($\overline{X} = 29.92$). Accordingly, it can be stated that STEM activities applied in out-of-school environments increased the scientific creativity of the experimental group more than the control group. The experimental procedure was found to be significantly effective.

Discussion

In this study, which examined the effect of implementing STEM activities in out-of-school learning environments on the scientific creativity of 5th grade students on the subject of "Let's get to know living things", a significant difference was observed between the test averages of the groups when the results of the SCT pre-test and post-test were examined. An increase was observed in the test averages of the experimental group after STEM activities in out-of-school environments, while no significant increase was observed in the test averages of the control group. Considering the findings, it is seen that the scientific creativity skills of the experimental group, in which STEM education in out-of-school environments was applied, were at a higher level than the control group, in which the current program was applied, and STEM activities in out-of-school environments had a significant effect on students' scientific creativity skills. Out-of-school STEM activities allowed students to experience scientific process skills in practice and paved the way for them to improve their scientific creativity indicators such as generating creative solutions.

According to Yıldırım and Altun (2015), the most important aim of STEM education, which provides high-level thinking by combining many disciplines, is to gain creativity and creative thinking skills. STEM activities trigger a sense of curiosity and encourage students to generate, hypothesize and test their own questions. This process is one of the basic components of scientific creativity (Ünver & Ayvacı, 2019). Out-of-school STEM activities often include problem-based learning, project work, and design-oriented tasks. Such tasks allow students to try different solutions and encourage creative thinking (Şahin & Yıldırım, 2020). Yatt and McCade (2011) likened creativity to a "muscle" and said that creativity can be developed and strengthened if appropriate exercises are done. Considering these two approaches that aim for common goals, STEM applications in out-of-school environments may have replaced appropriate exercises for creativity. In this study, it is thought that students spending more time with STEM activities rather than theoretical knowledge, individual and group work applied in STEM activity plans, thinking about the problem, creating discussion environments, drawing designs, the learning motive that emerged in students during the activity, and the feeling of being free in the whole process are the biggest factors in increasing the creativity dimension. In addition, unlike the strict rules in the classroom, which are often structured and limited in the school environment, it allows students to think more freely and innovatively, make mistakes and take risks. It can be thought that such an environment creates a favorable environment for the development of scientific creativity. Thanks to group work and collaborative activities, social interactions increase and the opportunity to develop different perspectives arises (Falk & Dierking, 2010). Out-of-school-based educational environments support the development of scientific creativity because they offer students a more flexible, free, collaborative and applied learning experience (Eshach, 2007). In out-of-school learning environments, the goal is for students to learn independently, challenge themselves, think creatively, be logical, and be guided in problem-solving related to a situation they encounter (Karakaş & Sevim, 2019). In science class, all activities that will be carried out in order for students to produce realistic and creative solutions to the problem situations they encounter and develop solution methods will develop students' creativity (Shanahan et al., 2009). In this respect, STEM education practices in out-of-school environments are very important in terms of developing creative thinking and enriching the imagination.

However, the effectiveness of out-of-school STEM activities is directly related to how these activities are designed and implemented. Instead of activities that only provide students with ready-made information, open-ended and inquiry-based activities that encourage their active participation, curiosity and desire to explore are seen to be more effective. Therefore, it is of great importance that activities are pedagogically structured and planned in accordance with the student's level of interest and age characteristics.

The results obtained are also consistent with previous studies in the literature (Gerber, Cavallo and Marek 2001; Braund & Reiss, 2006; Eshach, 2007, Bereczki and Kárpáti 2018). In these studies, it was stated that one of the most effective examples of teaching environments that support creative thinking is informal STEM activities, and it was found that scientific activities carried out in out-of-school environments strengthen students' scientific reasoning and creative thinking skills.

Conclusion and Recommendations

In this study, which determined the effect of the implementation of the STEM content "insect hotel" activity in out-of-school learning environments on the scientific creativity of students, it is seen that STEM activities in out-of-school environments have a significant effect on the scientific creativity skills of 5th grade students. Based on this result, the following suggestions can be made:

- This research was conducted with 5th grade students. STEM education applications can be applied at all school levels in different dimensions and skills starting from much younger ages. Studies can be conducted especially on the imagination and creative thinking skills of younger age group students. Because children's imagination and creative thinking skills deteriorate as they age.
- This research was conducted in the "World of Living Things" unit. In order to investigate the effect of out-of-school STEM content activities on scientific creativity skills, similar studies can be conducted in different units to measure creativity skills.
- The size of the sample (50 student participants) is acceptable, but it is not representative enough. The evidence from one public secondary school may not be applicable to schools of other types and in different regions. While this is a limitation, future research could benefit from larger sample sizes. In other words, the sample size

should be expanded to increase the generalizability of the study results.

- Considering that even the smallest disruption in the activities organized to out-of-school environments in the research could affect the result, it is very important to review the entire process multiple times, and to plan in detail before, during and after the activities for the process to work correctly and for the application to be effective.
- Quality STEM activities carried out in out-of-school learning environments have the potential to support the scientific creativity of middle school students. In this context, it is recommended that education policies and teaching practices include regulations for using out-of-school learning environments more effectively and widely. Educators should consider STEM not only as a concept in the classroom; but as a process supported by out-of-school learning.
- In order for teachers to implement STEM activities effectively in out-of-school learning environments, they need to allocate additional time during the planning and preparation process. Therefore, when planning lessons and curricula, it should be considered that teachers are provided with this additional time.
- Since STEM activities are linked to other disciplines, it is thought that collaborating with other branch teachers within the boundaries of the curriculum will be beneficial.

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