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Investigation of the Effectiveness of the Program for Coping with Negative Perfectionism

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Abstract

The purpose of this research is to test the effectiveness of the program for dealing with negative perfectionism. For this purpose, a quasi-experimental design was chosen with pre- and post-test measurements in both experimental and control groups. In the quasi-experimental design, pre-test is applied to both experimental and control groups before the experimental process. Then the experimental group is included in the experimental process. No experimental procedure is applied to the control group. Finally, a post-test is applied to both the experimental group and the control group as a result of the experimental process. As a result, the effectiveness of this experimental procedure is tested. There are 14 participants in the study group, who attend a public university's faculty of education at various grade levels and who are between the ages of 19 and 22 (X = 20.85, Ss = 1.09). The data are obtained from the Multi-dimensional Perfectionism Scale. Data were analyzed using nonparametric statistical techniques Wilcoxon Signed Ranks Test and Mann Whitney U test. The evaluation of the effectiveness of the program revealed that while the levels of perfectionism were reduced towards self-oriented and other-oriented from the dimensions of perfectionism; however, the program had no effect on social-oriented perfectionism.

Introduction

Humans are beings with various characteristics. Humans have many personality traits associated with their mental health. One of these traits is perfectionism. Perfectionism is generally examined in two important points in the literature. For example, by Hamachek (1978), perfectionism has been classified into two dimensions as normal and neurotic. Ashby and Rice (2002) mention two criteria for measuring perfectionism. The first of these is maladaptive evaluation concerns associated with depression and negative emotions, while the other is the positive striving factor associated with positive emotions. Perfectionism was dimensioned as positive and negative perfectionism by Kırdök (2004). Perfectionism has been grouped in two dimensions as healthy and unhealthy by Parker (2000). Perfectionism; anxiety for mistakes, high parental expectations, high personal standards, order, suspicion of behavior, and parental criticism were addressed in six dimensions (Frost et al., 1990). Perfectionism was classified as contradiction, standards and order by Slaney et al. (2001). Perfectionism is discussed in three dimensions by Hewilt and Flett (1991). These are perfectionism towards self, perfectionism towards others and social perfectionism. In negative perfectionism, setting unrealistic goals, and when these goals are not achieved, negative consequences such as inadequacy, anxiety and depression occur (Eryılmaz & Kara, 2017). At this point, when perfectionists struggle for unrealistic and unattainable goals, both for perfectionism towards self, perfectionism towards others and social perfectionism, they are on the side of negative perfectionism (Eryılmaz & Kara, 2016).

As a result, normal or neurotic, in healthy or unhealthy perfectionism classifications, the type of perfectionism that negatively affects the functionality of individuals is negative perfectionism. Negative perfectionism is defined as individuals' establishing high criteria for themselves or people that they consider important in their environment, and when these criteria are not met, they tend to criticize either themselves or those they consider important in their environment (Hewilt & Flett, 1991). In another definition, negative perfectionism is a psychopathological condition in which individuals ignore their positive aspects and focus more on their mistakes and label themselves as failures (Pacht, 1984). A number of experimental studies are needed to deal with this problem, which reduces the functionality of individuals.

When the experimental studies about perfectionism in the literature are examined; in these studies, it is seen that different group methods are used, based on different psychotherapies and using different group methods. For

example, in the studies of Abdollahi et al. (2021), 8-week perfectionism programs based on cognitive behavioral therapy were developed on individuals diagnosed with social anxiety. Hewitt et al. (2020) implemented the CORE program, which is a combination of psycho-educational and cognitive behavioral group therapy, in the perfectionism program prepared for adult psychiatric patients. In another study, 60 primary school students (30 mothers with perfectionism and 30 mothers without perfectionism) were subjected to the integration education program in the 14-Session perfectionism program developed by Pourtaleb et al. (2018). Shafran et al. (2017) developed a 12-Session perfectionism program based on internet-guided cognitive behavioral therapy and self-help for 62 people participating in the experimental group. A pilot study was conducted by Fairweather-Schmidt and Wade (2015) based on cognitive behavioral therapy and a school-based intervention program in reducing perfectionism in pre-adolescent children for 2 class hours. A 12-week web-based cognitive behavioral therapy-based perfectionism program was applied by Radhu et al. (2012) on university students.

There are also studies on negative perfectionism in the in Turkey literature. For example, an 11-session psycho-education program on perfectionism based on rational emotional behavioral approach was prepared by Şirin (2011) for 8th grade primary school students. In Kurtulmuş's (2010) studies, 8-Session group education supported computer-based education program was carried out on families of gifted children to reduce perfectionism. The training for dealing with perfectionism, which was prepared by Kağan (2006) on athletes based on cognitive behavioral therapy, was carried out in 8 Sessions. A 7-Session biblio-therapy-based training program was conducted by İlter (2015) on gifted children. An 8-session perfectionism psycho-education program based on cognitive behavioral therapy was carried out on mothers by Uzun (2018). Both in Turkey and international studies reveal the importance of cognitive-behavioral approach in perfectionism. On the other hand, Positive Psychotherapy approach provides important and functional explanations for the intervention to perfectionism (Peseschkian, 1996). In addition, literature information also makes significant contributions to the intervention of perfectionism (Abdollahi et al., 2021; Fairweather-Schmidt & Wade, 2015; Frost et al., 1990; Hewilt & Flett, 1991; Slaney et al., 2001). However, it is seen that there are very few multidimensional intervention studies that includes Positive Psychotherapy and Cognitive and Behavioral approaches.

Within the scope of multidimensional interventions, Eryılmaz (2019) developed a "multidimensional intervention" program. When the content of this program is examined; Defining the problem (taking history), applying behavioral control technique (cognitive, behavioral and positive psychotherapy) to find dysfunctional emotions, thoughts and behaviors, using the balance model to determine symptoms (positive psychotherapy), finding the causes of problems (literature information), cognitive and It consists of behavioral intervention (cognitive and behavioral therapy), problem-specific intervention (literature information) and process evaluation (Eryılmaz, 2019). In this study, the Multidimensional Intervention Method, in which group counseling method is also added, is given in Figure 1.

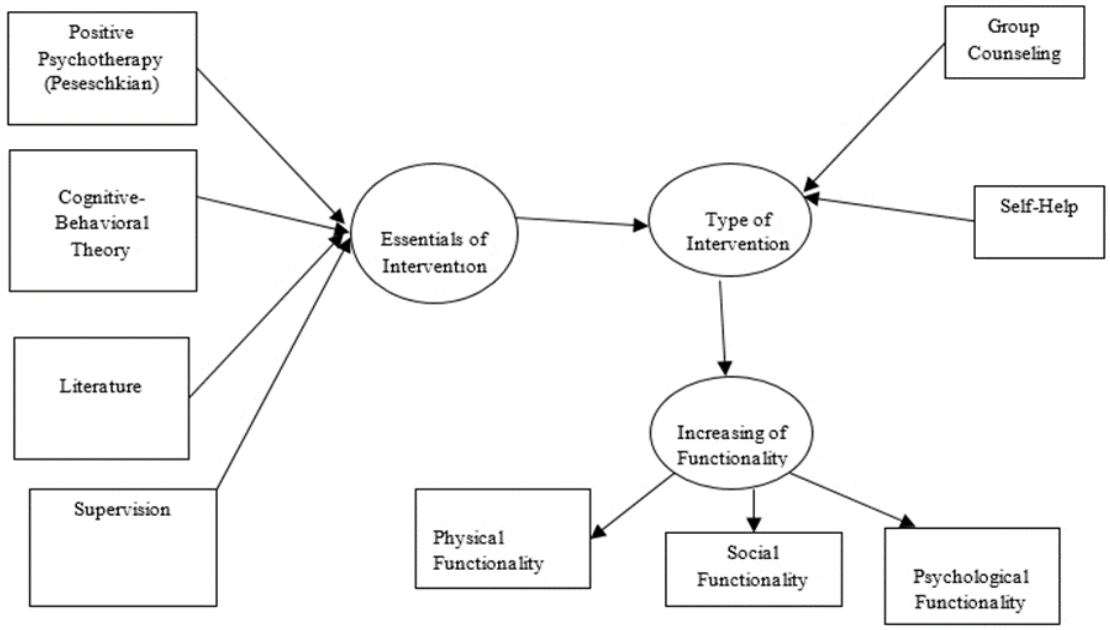

Figure 1. Elements of the multidimensional intervention model (Eryılmaz, 2019).

The effectiveness of the multidimensional intervention model was examined in qualitative and quantitative terms based on 10 Sessions of individual psychological counseling with 12 clients including negative perfectionism problems. The multidimensional intervention model has been found to reduce the anxiety and depression levels of the clients. However, this model was carried out in the form of psychological counseling with the individual. On the other hand, the effectiveness of the multidimensional intervention model was found to be effective in reducing shyness through group counseling (Eryılmaz & Altınsoy, 2021). It is seen that the same model is not examined through group counseling with individuals who are negative perfectionists. Handling the model with a different sample and group counseling method can help to see both the effectiveness of the model and the place of intervention in negative perfectionism (Eryılmaz, 2019).

More empirical research is needed on reducing negative perfectionism. Because reducing negative perfectionism in individuals makes many positive contributions to their spiritual development. For example, individuals with reduced negative perfectionism; continue the struggle for the aims (Eryılmaz & Kara, 2016); their emotional intelligence (Abdollahi & Abu Talib, 2015); academic achievements (Altun & Yazıcı, 2010); self-esteem (Çelik & Güzel, 2018); academic self-efficacy (Yu et al., 2016); It increases their psychological well-being (Kanten & Yeşiltaş, 2015) and hope levels (Arslan et al., 2018). On the other hand, individuals to reduce negative perfectionism; their social anxiety and social phobias (Saboonchi & Lundh, 1997); shyness and depression levels (Ashby et al., 2006); academic procrastination (Saddler & Sacks, 1993); academic burnout and extrinsic motivation (Chang et al., 2015); their concerns (Abdollahi & Abu Talib, 2015); reduces eating disorders (Costa et al., 2016) and stress levels (Wang & Li, 2017). As a result, the aim of this research is to test the effectiveness of a counseling program with a group aiming to deal with negative perfectionism.

1. The experimental and control groups participating in the program for coping with negative perfectionism:
a. Is there a significant difference between the Multidimensional Perfectionism Scale (self-directed, others, and social perfectionism) pre-test scores?
2. The experimental and control groups participating in the program for coping with negative perfectionism:
a. Is there a significant difference between the Post-test scores of the Multidimensional Perfectionism Scale (for self, others and social perfectionism)?
3. The experimental group participating in the program for dealing with negative perfectionism:
a. Is there a significant difference between the mean rank of the multidimensional Perfectionism Scale (self-directed, self-directed, and social perfectionism) pre-test and post-test scores?
4. The control group participating in the program to deal with negative perfectionism:
a. Is there a significant difference between the mean rank of the multidimensional Perfectionism Scale (self-directed, self-directed, and social perfectionism) pre-test and post-test scores?

Method

Research Design

This research was carried out in a quasi-experimental design (Table 1) with pre-test and post-test measurements with experimental and control groups. In the quasi-experimental design, pre-test is applied to both experimental and control groups before the experimental process. Then the experimental group is included in the experimental process. No experimental procedure is applied to the control group. Finally, a post-test is applied to both the experimental group and the control group as a result of the experimental process. As a result, the effectiveness of this experimental procedure is tested (Büyüköztürk, 2016). Experimental designs are created by establishing cause-effect relationships (Büyüköztürk et al., 2014). The reason variable (independent variable) of this research is the 11-Session program of dealing with negative perfectionism applied to the experimental group. The outcome variable (dependent variable) is the perfectionism level of the students. As a result, the model of this research is shown in table 1.

Table 1. Experimental design

Groups	Pre-test	Process	Post-test
Experimental group	Multidimensional perfectionism scale	Program for dealing with negative perfectionism	Multidimensional perfectionism scale
Control group	Multidimensional perfectionism scale	Does not apply	Multidimensional perfectionism scale

Content of the Experimental Program

Table 2. Group counseling program coping with perfectionism

Sessions	Events	Aguesatatıon	Session Process
Session 1	Meet, Configure	To learn about the program and the process	-
Session 2	My Perfectionism	Group members define their perfectionism problems.	In this Session, the client is asked to describe a perfectionist situation that he experienced last. For this, the My Perfectionism activity is carried out. In addition, in this session, the ways clients experience perfectionism are analyzed with 5W1K questions.
Session 3	5W questions	Group members explain their experiences related to perfectionism problems.	The perfectionism of the client is analyzed with the behavioral control technique. For this, behavioral control technique and perfectionism analysis form are used.
Session 4	Behavioral Control Technique	Group members express their perfectionism problems. They state the reflections of perfectionism problems on the field of body, success, future and relationship.	This Session examines the way clients express perfectionism and the symptoms and effects of perfectionism. For this purpose, my expressions of perfectionism and the signs / effects forms of my perfectionism are used.
Session 5	My expressions of perfectionism and the signs / effects of my perfectionism activities	Group members find the causes of their perfectionism problems.	This Session focuses on the reasons for perfectionism of the clients. For this, my perfectionism reasons form is used.
Session 6	The reasons for my perfectionism	Group members change the meanings they upload to make mistakes.	This Session focuses on the meaning attributed by clients to making mistakes and changing these meanings. For this, I am changing my perception to make mistakes form is used.
Session 7	Changing my perception of making mistakes	Group members learn to change perfectionism cycles, both for themselves and in the social dimension.	This session focuses on the perfectionism cycles of the clients in the individual context and its change. For this, the perfectionism loop form is used. In addition, the perfectionism cycles of the clients in the social context and its change are emphasized. For this, the form of perfectionism among people is used
Session 8	My cycle of perfectionism and my cycle of perfectionism between people	Group members are ensured to set achievable and realistic goals. They develop functional thoughts for the problem of perfectionism.	This Session focuses on the clients to set realistic goals. For this, I set realistic and achievable goals form is used and non-functional thoughts of the clients are emphasized. For this, I am editing my thoughts form is used.
Session 9	I set realistic and achievable goals and	Group members discover their strengths.	In this Session, the achievements of the clients are studied using the “my achievements to date form”.
Session 10	I organize my thoughts	Group members gain problem skills.	In this Session, clients' problem solving skills are made using the I solve the problem form that caused my perfectionism.
Session 11	My achievements to date	Group members evaluate the program process.	

Study Group

The study group consists of 14 participants ($\bar{X}$= 20.85, Sd = 1.09) between the age of 19 and 22, who are studying at different grade levels in the education faculty of a public university. 7 of the study group were assigned to the experimental group, and 7 to the control group, using the group matching technique (Neuman, 2016). Matching the groups, the scores of the participants in the experimental and control groups on the multidimensional perfectionism scale (in Table 5) and the gender distribution (3 males and 4 females in the experimental group; 3 males and 4 females in the control group in the same way). It was made according to the fact that. Also participants filled out an informed consent form. In addition to these, at least three participants are sufficient to form a group (Koydemir, 2011). Based on this, it can be said that a sufficient number has been reached to form a group, since there were seven participants in each group in the current study.

The Application Process of the Experimental Program

This research was carried out in 11 Sessions. In addition, the multidimensional perfectionism scale (Oral, 1999) was applied to the experimental and control groups for pre-test measurements before the experimental process. In addition, at the end of the experimental process, the multidimensional perfectionism scale (Oral, 1999) was applied for post-test measurements in the experimental and control groups. The structured perfectionism program in this research was conducted on the experimental group. It was not studied on the control group. The group counseling room of a public university was chosen as the practice site. Application frequency is once a week. The application time is between 10.00-11.30 on Thursday. The application of the experimental program was made by the researchers. Both researchers alternately assumed the role of group leader. In addition to these, a democratic leadership style has been adopted.

Data Collection Tool

Multidimensional Perfectionism Scale (MPS) was developed by Hewilt and Flett (1989). The adaptation of MPS to Turkish and its reliability studies were carried out by Oral (1999). MPS consists of 45 items. It is a 7-point Likert type. It has three dimensions. These dimensions are it is self-directed, directed towards others, and social perfectionism. As a result of the reliability studies of MPS conducted by Hewilt and Flett (1989), it was determined that the internal consistency coefficient was 0.86 for self-perfectionism, 0.82 for others, and 0.87 for social perfectionism. In addition, the internal consistency coefficients were put forward as 0.91 for self-directed perfectionism, 0.80 for socially oriented perfectionism and 0.73 for perfectionism towards others by Oral (1999).

Data Analysis

Preliminary analysis was carried out before analyzing the data. Shapiro-Wilk analysis was performed as a preliminary analysis. With this analysis, it is tested whether the data show a normal distribution or not. In this study, the measures in the pre-test scores of multidimensional perfectionism were tested by Shapiro-Wilk analysis. Looking at the Shapiro-Wilk analysis results, the p value was found to be .00. According to this finding, it was determined that the data did not show a normal distribution. As a result, the data were analyzed with non-parametric statistical techniques, considering the reasons for the number of participants in this study being less than ($n < 30$) and the data not showing normal distribution.

Nonparametric statistical techniques Wilcoxon Signed Ranks Test and Mann Whitney U test were used in this study. In the Wilcoxon Signed Ranks Test, the significance of the difference and the direction of the difference between the pre-test and post-test related measurements of both the experimental group and the control group are determined. In the Mann Whitney U test, it is revealed whether there is a significant difference between the pre-test and post-test unrelated measurements of the experimental and control groups (Büyüköztürk, 2016). In addition to these, the level of significance was accepted as 0.05 in this study.

Validity Study

Internal and External Validity

Internal validity is the assumption that the independent variable (perfectionism program) alone has an effect on the dependent variable (perfectionism levels). External validity is the generalizability of the findings revealed in the experimental process to other environments or situations (Neuman, 2016).

Methods for Increasing Internal Validity

1. Time: Controlling other variables on the dependent variable. Time prolongation can make this control difficult. Therefore, in order to check the internal validity, the experimental process is performed in 11 weeks in a way that will ensure that the psychological counselor candidates are effective on perfectionism but reduce the effects of other variables to the least (Neuman, 2016).
2. Testing: It is making pre-test measurements on the dependent variable before the experiment. These pre-test measures actually appear to act as a stimulant. In another saying; motives encourage subjects to posttest measurements after the experimental procedure. In this study, firstly, pre-test measurements were made to both experimental and control groups. Then, an 11-week perfectionism program was applied to the experimental group. Finally, post-test measurements were performed on both experimental and control groups first (Neuman, 2016).
3. Tool usage: It is about the measurement tool used in data collection. Using the same measurement tool for pre-test and post-test measurements for both experimental and control groups is known as a method that increases internal validity. In this study, the multidimensional perfectionism scale was used for pre-test pre-test measurements for both the experimental group and the control group, and for the post-test measurements after the experiment (Neuman, 2016).
4. Subject loss: There was no subject loss in this study. For this, the psychological counselors were informed about the experimental process before the experimental process. It has been stated that continuity is important (Neuman, 2016).

Methods of Increasing External Validity

1. Reactivity: It is the reaction of the participants different from the natural life as a result of the psychological effect created by the artificial environment created by the experimental environment. This response has no relationship between the responses to the independent variable. Therefore, it was emphasized that instead of stating that the perfectionism program prepared for psychological counselor candidates was a research, it was a group practice based on psychological counseling prepared for psychological counselor candidates (Neuman, 2016).

Results

In this study, firstly, descriptive statistics about the sub-dimensions of the multidimensional perfectionism scale, pre-test and post-test findings were mentioned. Secondly, Mann Whitney U pre-test and post-test findings about the sub-dimensions of the multidimensional perfectionism scale are given. Finally, Wilcoxon Signed Ranks Test findings of the experimental group's pre-test and post-test scores, followed by the Wilcoxon Signed Ranks Test findings of the pre-test and post-test scores of the control group were mentioned.

Table 3. Descriptive statistics pre-test findings related to the sub-dimensions of the multidimensional perfectionism scale

Dimensions	Group	$\bar{X}$	SS
SOP	Experiment	91.00	3.65
	Control	89.57	6.82
OOP	Experiment	71.57	6.80
	Control	73.28	10.04
SoOP	Experiment	64.28	7.15
	Control	70.71	5.43

Note: SOP: Self-oriented perfectionism; OOP: Other-oriented perfectionism; SoOP: Social-oriented perfectionism

When Table 3 is examined, the average scores of the individuals participating in the experimental group in terms of the pre-test regarding the sub-dimensions of the multidimensional perfectionism scale are respectively; perfectionism towards self ($\bar{X}$: 91.00), perfectionism towards others ($\bar{X}$: 71.57) and social perfectionism ($\bar{X}$: 64.28); The average scores of the individuals participating in the control group regarding the sub-dimensions of

the multidimensional perfectionism scale in terms of the pre-test were respectively; perfectionism towards self ($\bar{X}$: 89.57), perfectionism towards others ($\bar{X}$: 73.28) and social perfectionism ($\bar{X}$: 70.71).

Table 4. Descriptive statistics post-test findings related to the sub-dimensions of the multidimensional perfectionism scale

Dimensions	Group	$\bar{X}$	SS
SOP	Experiment	42.57	15.09
	Control	76.71	23.14
OOP	Experiment	40.85	13.59
	Control	69.00	17.33
SoOP	Experiment	44.14	13.88
	Control	63.57	18.04

Note: SOP: Self-oriented perfectionism; OOP: Other-oriented perfectionism; SoOP: Social-oriented perfectionism

Looking at Table 4, the average scores of the individuals participating in the experimental group in terms of post-test related to the sub-dimensions of the multidimensional perfectionism scale are respectively; perfectionism towards self ($\bar{X}$: 42.57), perfectionism towards others ($\bar{X}$: 40.85) and social perfectionism ($\bar{X}$: 44.14). In addition, the average scores of the individuals participating in the control group regarding the sub-dimensions of the multidimensional perfectionism scale in terms of the post-test were respectively; perfectionism towards self ($\bar{X}$: 76.71), perfectionism towards others ($\bar{X}$: 69.00) and social perfectionism ($\bar{X}$: 63.57).

Table 5. Mann Whitney U pre-test findings related to the sub-dimensions of the multidimensional perfectionism scale

Dimension	Group	N	Mean rank	Total rank	U	p
SOP	Experiment	7	8.43	59.00	18.00	.39
	Control	7	6.57	46.00		
OOP	Experiment	7	7.21	50.50	22.50	.79
	Control	7	7.79	54.50		
SoOP	Experiment	7	5.36	37.50	9.50	.05
	Control	7	9.64	67.50		

Note: SOP: Self-oriented perfectionism; OOP: Other-oriented perfectionism; SoOP: Social-oriented perfectionism

In Table 5, Man Whitney U pre-test findings related to the sub-dimensions of the multidimensional perfectionism scale of the experimental and control groups are included. According to these findings, perfectionism towards self ($u = 18.00$; $p > 0.05$), perfectionism towards others ($u = 22.50$; $p > 0.05$) and social perfectionism ($u = 22.50$; $p > 0.05$) = 9.50; $p > 0.05$) scores were found to not differ significantly. These findings show that both groups are equated groups.

Table 6. Mann Whitney U post-test findings related to the sub-dimensions of the multidimensional perfectionism scale

Dimension	Group	N	Mean rank	Total rank	U	p
SOP	Experiment	7	4.86	34.00	6.00	.01
	Control	7	10.14	71.00		
OOP	Experiment	7	4.86	34.00	6.00	.01
	Control	7	10.14	71.00		
SoOP	Experiment	7	5.57	39.00	11.00	.08
	Control	7	9.43	66.00		

Note: SOP: Self-oriented perfectionism; OOP: Other-oriented perfectionism; SoOP: Social-oriented perfectionism

In Table 6, Man Whitney U post-test findings related to the sub-dimensions of the multidimensional perfectionism scale of the experimental and control groups are shown. According to these findings, it was found that the scores of perfectionism towards self ($u = 6.00$; $p < 0.05$) and perfectionism towards others ($u = 6.00$; $p < 0.05$) that the individuals in the experimental group received from the multidimensional perfectionism sub-dimensions after the experiment differed significantly from the students in the control group; It was determined that there is no significant difference between the scores they got from social perfectionism ($u = 11.00$; $p > 0.05$). These findings show that the program to cope with negative perfectionism is effective in reducing individuals' negative perfectionism.

Table 7. Wilcoxon Signed Ranks Test findings of the experimental group's pre-test and post-test score

Dimension	Rank Markers	N	Mean rank	Total rank	Z	P
SOP	Negative İ.	7	4.00	28.00		
	Positive İ.	0	0	0.00	-2.36	.01*
	Equal İ.	0				
OOP	Negative İ.	7	4.00	28.00		
	Positive İ.	0	0	0.00	-2.36	.01*
	Equal İ.	0				
SoOP	Negative İ.	7	4.00	28.00		
	Positive İ.	0	0	0.00	-2.36	.01*
	Equal İ.	0				

Note: SOP: Self-oriented perfectionism; OOP: Other-oriented perfectionism; SoOP: Social-oriented perfectionism

Table 7 shows the Wilcoxon Signed Ranks Test results of the individuals in the experimental group. According to these findings, the psychological counselor candidates in the experimental group had perfectionism towards themselves (Z = -2.36; p <0.05), perfectionism towards others (Z = -2.36; p <0.05) and social perfectionism (Z = -2.36; p <0.05). It was found that the scores of 0.05) decreased. These findings reveal that the negative perfectionism program prepared has an important effect in reducing the negative perfectionism of individuals. The effect size was also calculated in the study. According to the analysis result, the effect size of the study was found to be 0.5031. At this point, the experimental procedure was found to have a moderate effect size.

Table 8. Wilcoxon Signed Ranks Test findings of the pre-test and post-test scores of the control group

Dimension	Rank Markers	N	Mean rank	Total rank	Z	P
SOP	Negative İ.	4	4.75	19.00		
	Positive İ.	3	3.00	9.00	-.84	.39
	Equal İ.	0				
OOP	Negative İ.	4	4.50	18.00		
	Positive İ.	3	3.33	10.00	-.67	.49
	Equal İ.	0				
SoOP	Negative İ.	3	5.67	17.00		
	Positive İ.	4	2.75	11.00	-.50	.61
	Equal İ.	0				

Note: SOP: Self-oriented perfectionism; OOP: Other-oriented perfectionism; SoOP: Social-oriented perfectionism

In Table 8, the findings of the Wilcoxon Signed Ranks Test of the psychological counselor candidates in the control group are shown. According to these findings, the individuals in the control group had self-perfectionism (Z = -.84; p> 0.05), perfectionism towards others (Z = -.67; p> 0.05), social perfectionism (Z = -.50; p. > 0.05) scores do not seem to differ significantly. These findings indicate that the perfectionism towards self, perfectionism towards others and social perfectionism scores of the individuals in the control group did not change according to the pre-experiment.

Discussion and Conclusion

This research was conducted to examine the effectiveness of a group counseling program in dealing with negative perfectionism. The program, whose effectiveness was examined in the research findings, was found to reduce the perfectionism levels towards self and others from the dimensions of perfectionism. However, it was found that the program had no effect on social perfectionism.

When looking at the literature, it is seen that there are studies on the effectiveness of negative perfectionism reduction programs (Abdollahi et al., 2021; Fairweather-Schmidt & Wade, 2015; Hewitt et al., 2015; Hewitt et al., 2020; İlter, 2015; Pourtaleb et al., 2018; Kağan, 2006; Kurtulmuş, 2010; Radhu et al., 2012; Rosser et al., 2003; Shafran et al., 2017; Steele et al., 2013; Şirin, 2011). In these studies, cognitive behavioral approach and psycho-education group method were generally used. However, in this study, a multidimensional intervention model was applied to negative perfectionism. This method of intervention is more holistic than previously applied methods. Because in this intervention; It includes individual-centered counseling theory, cognitive-behavioral approach, positive psychotherapy approach, self-help model and literature information.

The effectiveness of the aforementioned model has been tested in the individual counseling process (Eryılmaz, 2019). A second contribution of this study is that it has worked with more than one person in providing psychological help. The results of this and previous study demonstrated the effectiveness of the multidimensional intervention model conducted on the basis of both individual and group counseling in the intervention of negative perfectionism. As a result, an important contribution of this study to the literature is that it has added a new one to negative perfectionism intervention methods.

The results of this study showed that the participants made positive improvements in the "perfectionism for themselves and others" program for dealing with negative perfectionism. The reason for this situation can be found in the content of the program for dealing with perfectionism. Because, in this program, both positive psychotherapy, cognitive, behavioral and literature-based interventions; clients need to achieve achievable goals, form their self-values according to internal criteria rather than external criteria, change their mistakes and negative meanings attributed to them (Abdollahi et al., 2019; Hewitt et al., 2015; Hewitt et al., 2020; ; Rosser et al., 2003; Shafran et al., 2017). In addition to all these; In the effectiveness of the program, it did not appear during the counseling process with the individual and appeared in the group counseling process; "healing powers" such as universality and group harmony may have a positive effect.

The results of this study showed that the participants made positive improvements in "social perfectionism" of the program for dealing with negative perfectionism. Especially the pretest and posttest scores of the experimental group decreased significantly and significantly. However, compared to the control group, this improvement was found to be statistically significant and not significant. It can be said that the reason for this situation is actually the nature of the types of perfectionism, because in perfectionism towards both oneself and others, individuals are the primary actors in terms of unattainable goals. However, the people who determine unattainable goals in social perfectionism are not themselves but other people in the circles of individuals (Hewilt & Flett, 1991). Only when individuals come into contact with these people will it be revealed whether they are affected by them. Therefore, social perfectionists need time and experience with people. Longitudinal studies are needed to examine this effect. In the future, people who participate in such programs can be examined longitudinally in terms of social perfectionism.

Recommendations

The results of this study showed that the participants made positive improvements in the "perfectionism for themselves and others" program for dealing with negative perfectionism. However, the program of dealing with negative perfectionism discussed in the study was found to have a moderate level of effectiveness. The reason for this may be that the study was conducted in 11 Sessions. It is important to increase the number of Sessions. Because the most important disadvantage of group counseling compared to counseling with individuals is the time allocated to individuals (Demir & Koydemir, 2016). In the future, studies can be carried out to increase the number of Sessions even more. In the future, negative perfectionism intervention studies can be carried out with the same model at the same time, with individual and group counseling methods. Comparison of the interventions can be made by looking at the effect size resulting from these studies. In the following processes, researchers can conduct qualitative research through focus group interviews with individuals who have negative perfectionism problems.The current study was designed in a quasi-experimental design with pre-test post-test measurement. The lack of a follow-up test in the current study can be considered as a limitation. In addition, the absence of a placebo group can be interpreted as another limitation.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in JESEH journal belongs to the authors.

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Examination of Secondary Students' Visual Images about Climate Change

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Abstract

In this study, it was aimed to examine the perceptions of secondary school students about climate change. The study was planned according to the phenomenological design. The research was carried out with the participation of 131 students selected according to the criterion sampling. Students were asked to draw pictures about climate change and the collected pictures were subjected to content analysis. Since 12 of the pictures could not be evaluated under any theme, they were excluded from the data set and coding were done on 119 drawings. As a result of the data analysis, three themes were determined as temperature increase and its effects, change in thermal and precipitation regime, and extreme weather events. Under these three themes, subcategories were created based on the drawings that were similar to each other. As a result of the research, it has been determined that secondary school students have a high awareness of climate-related events and the directly observable effects of climate change in the city they live in.

Introduction

Climate change refers to statistically significant changes in meteorological parameters, such as temperature or precipitation that persist for decades or more (Kahraman & Şenol, 2018). Climate change in early Earth's history was often the result of natural factors. In the process from the industrial revolution to the present, the most determining factor of climate change has been human (anthropogenic factors) activities. (IPPC, 2007; Türkeş, 2008). After the industrial revolution, with the use of fossil fuels, a significant amount of greenhouse gases [carbon dioxide (CO2), methane (CH4), nitrogen oxide (N2O), ozone (O3) and fluorinated gases] began to accumulate in the atmosphere (Demir, 2009; Türkeş, 2012), and the increase in greenhouse gas accumulation has led to changes in the climate system. These changes were manifested most clearly by the increasing trend in air temperatures (Erlat & Ölgen, 2008). So much so that the global temperature increase has increased **1.09** [0.95 to 1.20] °C higher in 2011–2020 than 1850–1900 (IPCC, 2021). Moreover, The IPCC (2001) predicts that the global average surface temperature will rise between 1.4 and 5.8 °C by 2100.

As a result of anthropogenic climate change, changes occur in the frequency, duration, severity and timing of extreme weather events (Erlat & Avşar, 2020). Due to the melting of glaciers and thermal expansion of ocean waters, the global sea level is rising, the start/end dates of phenological events in the biosphere are changing, and many species are on the facing of extinction. Extreme weather events such as drought, heavy rain, landslide, tornado, hurricane, frost and sandstorm are among the observed effects of climate change in daily life (Gezer & İlhan, 2021). In Figure 1, the possible effects of global climate change on living spaces are summarized (TEMA, n.d.). As seen in Figure 1, climate change makes itself felt in every aspect of life.

Climate Change in Turkey

Turkey is one of the countries most affected by climate change due to being surrounded by sea on three sides, being on a fragmented topography and orographic characteristics (Öztürk, 2002). The western and southern parts of Turkey belong to the Mediterranean climate, which is one of the most vulnerable regions to global warming and climate change (Sanchez et al., 2004). Along with the global temperature increase, a significant temperature increase is experienced in Turkey and the duration of the cold air waves is decreasing. For example, between 1950 and 2017 in Turkey, the duration of the warm period showed a tendency to lengthen; the cold period shortened considerably in the period from 1998 to 2017 (Erlat & Güler, 2018). In addition, since the mid-1980s in Turkey, there has been an increase in the number of tropic night and minimum temperature values. This increase causes a decrease in the daily temperature range and changes in the start and end dates of phenological events.

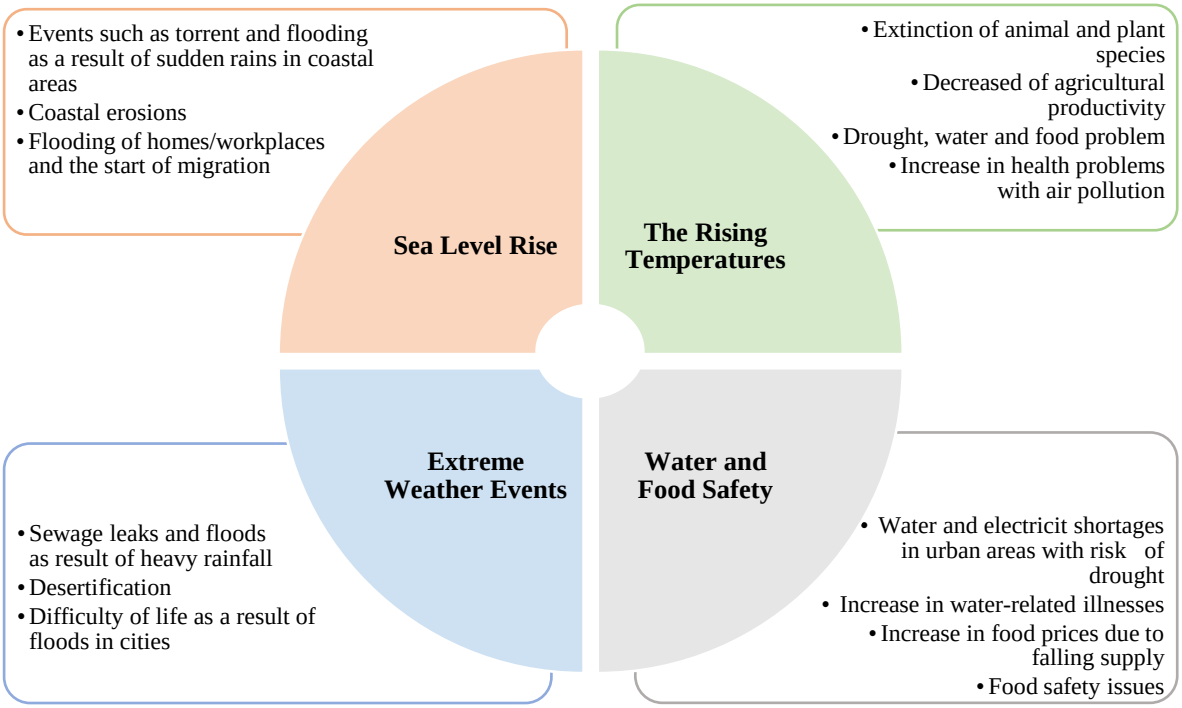


Figure 1. Possible effects of global climate change on habitats

Accordingly, differentiations are observed in the reproduction and survival times of agricultural pests and pathogens. The increase in night temperatures negatively affects human comfort, especially the population in big cities, and causes an increase in the number of cooling days and energy consumption (Erlat & Türkeş, 2017). Again in Turkey, with the increase in temperature, snow melts begin earlier and earlier shifts were observed in the current rivers fed by snow. It has been determined that Turkey's glaciers retreated an average of 10 m each year in response to the temperature increase. Measurements on the coast indicate that the sea level is rising by about 6 mm per year (Şen et al., 2013). It is forecasted that the recharge of groundwater will gradually decrease between 2015 and 2100, the snows will go into the melting phase more quickly in parallel with the increasing temperatures, and this situation will increase the water stress in the related regions in the late spring and summer months. In addition, it is thought that there may be an increase in snow avalanches and floods due to fusing and melting in areas covered by seasonal snow and permanent snow-ice cover (Kadıoğlu et al., 2017). Considering the precipitation regime of Turkey, it is seen that there are changes from the normal and a decrease in the precipitation amount. For instance precipitation, which is 631 mm on average in Turkey, decreased by 15% in 1999 and 7% in 2000 (Türkeş, 1999). It is predicted that the total precipitation in Turkey, especially in the Aegean and Mediterranean coasts and the East and Southeast regions, will decrease further as of 2050. On the other hand, it is expected that extreme precipitation events and flood risk in parallel are expected to increase in the Eastern Black Sea Region (Kadıoğlu et al., 2017).

Climate change; in recent years, in Turkey have also triggered hydro meteorological disasters such as heavy rains, storms, heat waves, forest fires, floods and tornado (Şen et al., 2013). According to the Turkey climate assessment report, 2020 is the year in which extreme weather events are experienced the most with 984 extreme events. Most of the extreme events recorded in 2020 were heavy rain/flood with 30%, storm with 27% and hail with 23%. Other events were lightning with 7%, snow with 5%, landslide with 2%, and frost, avalanche forest fire, sandstorm, high temperature and fog with 1% and less. Also in the same report, it was emphasized that there has been an increasing trend in extreme weather events, especially in the last two decades (Ministry of Agriculture and Forestry General Directorate of Meteorology, 2021). When all these are taken into account, as in the rest of the world, climate change can affect water resources, agriculture, industry, biodiversity, health, tourism, energy resources, etc. in Turkey profoundly affected many areas, and it's an undeniable the acceleration of this effect will increase day by day (Yılmaz & Imteaz, 2014).

Social Studies and Climate Change

As climate change becomes a more serious issue, climate literacy has turned into one of the skills that take place under the umbrella of scientific literacy (Dupigny-Giroux, 2010). As citizens of the world, all people should

have advanced climate literacy in order to better understand the impact of global climate change and its consequences (Harrington, 2008). Climate literacy is defined as the understanding the effects of the person on the climate and the effects of the climate on the person. Making sense of the basic concepts and principles related to climate, establishing meaningful connections between climate change and climate, and being able to make scientifically conscious decisions about climate are among the climate literacy skills (Yakar & Karakuş, 2020). Yakar and Karakuş (2020) collected climate literacy competencies that secondary school students should have in six categories: *i)* climate-related concepts, *ii)* basic climate information, *iii)* national and local climate information, *iv)* climate and life relationship, *v)* skills, and *vi)* attitudes and values.

Competencies expected from secondary school students regarding climate literacy, also included in the curriculum. When the curricula are examined, it is seen that the social studies program has an important place in providing students with the necessary knowledge, skills and behaviors about the human impact on climate change and the negative consequences that this effect possible to cause (Özkaral, 2019; Yakar & Karakuş, 2020). The love of nature, sensitivity to the natural environment and responsibility values, as well as the ability to perceive space and environmental literacy skill in the social studies program can be associated with climate change. Although there is no learning area, unit or subject that directly deals with climate change in the social studies program, some learning areas indirectly include concepts related to climate, climate elements and climate change. Table 1 shows the objectives that deal with climate change in the social studies curriculum (MoNE, 2018).

Table 1. Objectives about climate change in the social studies curriculum

Learning Area	Grade Level	Objectives
People, Places and Environments	4th grade	Observing the weather events occurring around her/him, he/she transfers her findings to illustrated graphics. Makes necessary preparations for natural disasters.
	5th grade	Explain the effect of the climate seen in the living environment on human activities by giving examples from her daily life. Questions the causes of disasters and environmental problems in the environment they live in. Explains the effects of natural disasters on community life with examples.
	6th grade	Examines the main physical geography features of Turkey, landforms, climatic features and vegetation on the relevant maps. Analyzes the effects of unconscious consumption of resources on live life.
Global Connections	7th grade	Together with her/his friends, she/he develops ideas for the solution of global problems.

The explanations made for these objectives in the curriculum have been effective in thinking that the achievements in Table 2 are related to climate change. That is, it was determined that the concept of global climate change was included in the explanation of the "Develops ideas suggestions for the solution of global problems with their friends" objective in the 7th Grade Global Connections learning area. In the objective of "Explains the effect of the climate seen in the environment in which they live, on human activities by giving examples from their daily lives", student is asked to examine the effect of the climate in the region they live in on human life. However, climate change is not mentioned in this objective. Again, in the objectives of "Analyze the causes of disasters and environmental problems in the environment they live in" and "Explains the effects of natural disasters on community life with examples", students were expected to evaluate human-environment interaction in terms of disasters and environmental problems in their region.

Nevertheless, the connection of these objectives just mentioned with climate change was not touched upon. In the objective of “Analyzes the effects of unconscious consumption of resources on living life”, the effect of unconscious consumption of natural resources on human life is taught to the student, but its connection with climate change is not taken into account. The concepts of global warming and drought, which are directly related to climate change, were included in Social Studies textbooks (5th and 6th grades). The concepts of climate change, greenhouse gases, deforestation, desertification and global warming are also mentioned in the 7th grade social studies textbook.

Purpose and Importance of the Research

Its effects, which reach life-threatening dimensions by disrupting the ecological balance, show that it is insufficient in the fight against climate change. The need is for well-equipped individuals who can cope with the uncertainty of the environmental, economic and political future that will be created by global climate change (Bangay & Blum, 2010). For this reason, the necessity of training climate literate citizens have emerged today (Arndt & LaDue, 2008). As a matter of fact, it is emphasized in the United Nations Framework Convention on Climate Change (United Nations Department of Public Information, 1994) that climate change education should be promoted and people's awareness of climate change should be increased (Barak & Gönençgil, 2020). Climate is influenced by both natural and anthropogenic elements on atmospheric composition, this situation making it difficult for students to understand climate change (Hansen, 2010). This understanding of students is critical because the younger generation will be faced with far more difficult choices and possible solutions regarding climate change mitigation and adaptation than today (Bodzin et al., 2014). It is very important to provide individuals with a planned education at an early age regarding global-scale problems such as climate change. With the objectives in the secondary school social studies curriculum, it was aimed to teach the subject of climate change, albeit partially. Coping with the problems stemming from climate change primarily depends on knowing how well the curriculum objectives are understood by the students. Therefore, it is important to determine the perceptions of secondary school students about the causes and possible consequences of climate change.

The issues climate change education and climate literacy are newly developing fields. Hence, research on climate change is limited in our country as well as in the world. There are studies in the literature that examine climate change theoretically. For example, Özkaral (2019) examined social studies curricula in Turkey, Canada (Ontario) and Hong Kong in terms of global warming and climate change. Yakar and Karakuş (2019) investigated the social studies programs between 1968 and 2018 in terms of climate literacy competencies. Demir (2019) scrutinize the 2018 social studies curriculum and textbooks in terms of climate change. Barak and Gönençgil (2020) compared in terms of climate change education the secondary school education programs implemented in high-achieving countries according to PISA 2015 results and Turkey. Furthermore, Görgülü Arı and Aslan (2020) developed a climate literacy scale for secondary school students. Atik and Doğan (2019) conducted a study to determine the opinions of high school students about climate change. However, no study has been found in the literature focusing on the perceptions of secondary school students about climate change. In this context, the present research, it is aimed to examine the drawings of secondary school students and thus to reveal their visual images about climate change.

Method

Research Model

The study is in the phenomenological design, which is one of the qualitative research models. In phenomenological research, it is aimed to evaluate the experiences of individuals regarding an event or phenomenon in detail (Yıldırım & Şimşek, 2011). Events such as earthquake, war, migration, and psychological-based situations such as racism, aggression, sexual abuse, addiction encountered in daily life can be the subject of phenomenological research (İlhan & Gezer, 2021). Meteorological parameters in the direction of increase and decrease were recently recorded in Diyarbakır. It has been determined that there is an increase in average temperatures and a decrease in total precipitation in Diyarbakır (Çelik & Toprak, 2016; Kınık, 2020; Özdel, 2020). Therefore, it can be said that secondary school students have common experiences regarding the observed effects of climate change in Diyarbakır. In this respect, it is thought that the study is suitable for the phenomenological design.

Table 2. Distribution of participants by their gender and grade level

	Female	Male	Total
7th grade	38	36	74
8th grade	18	27	45
Total	56	63	119

Study Group

The criterion sampling method, which is one of the purposive sampling techniques, was used to determine the participants. With the idea that the perception of climate change would be portrayed more clearly, secondary

school 7th and 8th grade students were determined as the study group. A secondary school in which families are homogeneous in terms of their socio-economic level was selected in the central district of Kayapınar in Diyarbakır province. The research was carried out with the participation of a total of 131 students. However, 12 forms were excluded from the study, and the coding was done on the drawings of 119 students. In the research, codes such as P1, P2, … P119 were used instead of participant names, and the distribution of participants according to gender and class levels is given in Table 2.

Data Collection and Analysis

Before collecting the research data, an application was made to the ethics committee about whether the study was in accordance with scientific ethics and ethics committee approval was obtained. Then, the data collection tool was distributed to the students and an explanation was given about the purpose of the research and it was stated that the participation was based on the principle of voluntariness. Besides, the students were reminded that the collected drawings would not be shared with third parties or institutions, and their names would be kept confidential. After the necessary reminders were made, they were asked to mark the information on the class and gender variables on the form and draw a picture about climate change in the area below. It took 40 minutes for the students to complete their drawings.

After collecting the research data, the data analysis phase was started. Data analysis in phenomenological research is carried out by content analysis. The aim is to conceptualize the data and reveal themes that can describe the phenomenon. Content analysis is mostly used in the analysis of data collected by written and visual methods. Primarily, words and pictures with close meanings are determined and categories related to the subject are developed in line with these (Batdı, 2021). Then, data with similar trends are placed in appropriate categories. The purpose of content analysis is to discover the concepts and connections that can explain the collected data, that is, to reveal the patterns hidden in the data (Yıldırım & Şimşek, 2011). Data analysis was carried out by the researcher. In order to ensure the reliability of the coding made in content analysis, it is recommended that the coding process be done by more than one person. However, in cases where there is no such possibility, the same person repeating the coding several times at different times also helps to achieve correct results (Batdı, 2021). The coding made in this context was reviewed by the researcher twice within 15 days and no difference was found between the coding's. In the study, three themes were determined as temperature increase and its effects, change in thermal and precipitation regime, and extreme weather events. Sub-categories were created based on the drawings that were similar to each other under the themes in question.

Results

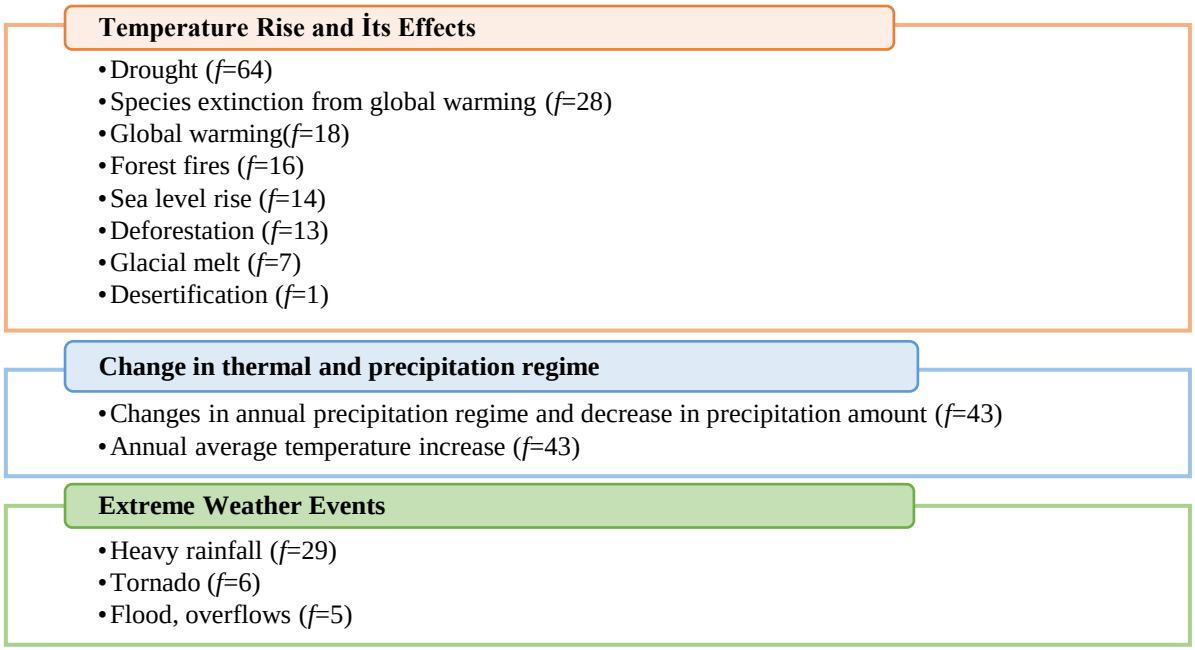
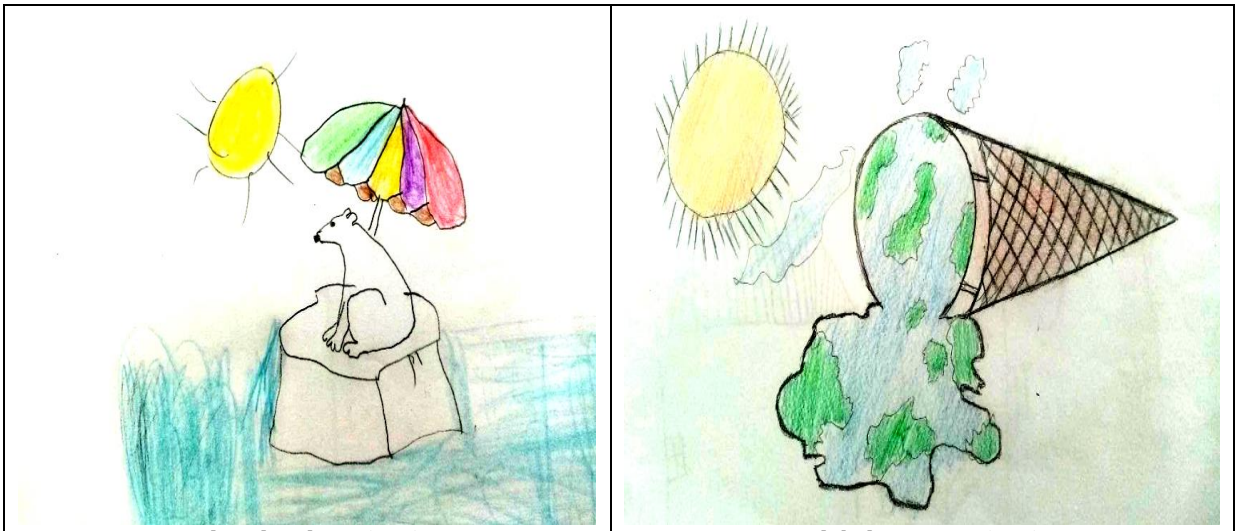


Figure 2. Themes and subcategories of participant opinions

As a result of the content analysis, the perceptions of secondary school students about climate change were gathered under three themes. These themes and subcategories of each theme are presented in Figure 2. As seen in Figure 2, the first theme is related to the temperature increase and its effects. This theme consists of the categories of drought, species extinction from global warming, global warming, forest fires, rise in sea level, deforestation, glacier meltdowns and desertification, respectively, according to the frequency of repetition. Examples of participant drawings for some of these categories are presented in Figure 3.



Glacial melting (P99) Global warming (P78)

Figure 3. Drawings of the theme of temperature increase and its effects

Participants reflected the results of climate change in their drawings, such as changes in the average temperature values and precipitation patterns according to the seasons, hotter summer, drier spring and autumn seasons, and reduced snowfall in winter. Since it includes the effects of climate change on temperature and precipitation regime, the label of change in thermal and precipitation regime are used for this theme. Under this theme, there are the categories of changes in the annual precipitation regime, decrease in precipitation and annual average temperature increase. Examples of participant drawings for this theme are presented in Figure 4.

Annual average temperature increase (P60)

Figure 4. Drawings on the theme of change in thermal and precipitation regime

The last theme that emerged as a result of the content analysis is the theme of extreme weather events. Under this theme, there were heavy rainfall, flood and flooding, tornado subcategories, respectively, according to the frequency of repetition. Examples of participant drawings for each of the listed categories are presented in Figure 5.

Heavy rainfall and flood (K13) Heavy rainfall and tornado (K55)

Figure 5. Drawings on the theme of extreme weather events

Conclusion and Discussion

As a result of the research, it was determined that the students' perceptions of climate change were gathered under three themes: temperature increase and its effects, change in thermal and precipitation regime, and extreme weather events. Under the theme of temperature increase and its effects, respectively, took place in drought, species extinction from global warming, global warming, forest fires, rise in sea level, deforestation, glacier melting's and desertification. These categories include the current reflections of climate change due to temperature increase. Although there is no study in the literature that directly overlaps with this finding, there are studies that indirectly support the research result.

Punter et al. (2011) found that secondary school students are knowledgeable about the physical consequences of climate change, such as melting, high temperature, drought, and sea level rise in the Polar Regions. Gezer and İlhan (2018), in their study in which they adapted the climate change knowledge test into Turkish, concluded that the knowledge of pre-service teachers about climate change is mostly related to the actual aspect of the subject. Similarly, Özdemir Özden and Özden (2015) and Özsoy (2012) revealed in their research that the environmental problems that children include in their drawings are mostly related to the problems that they can directly observed. Demirbaş and Pektaş (2009), on the other hand, examined primary school students' level of realization of basic concepts related to environmental problems and revealed that students mostly have knowledge about environmental problems they encounter in daily life.

When the student drawings were analyzed, the second theme was named as the changes in thermal and precipitation regime. Under this theme, the categories of increase in summer temperature, temperatures above seasonal norms in autumn and spring, decrease in precipitation in spring and autumn, decrease in snowfall in winter took place. Climate change studies conducted in Diyarbakır province (Çelik & Toprak, 2016; Kınık, 2020; Özdel, 2020) have proven that the changes in the annual total precipitation, number of rainy days, snow depth and number of snowy days in Diyarbakır are in the direction of decrease. In this sense, it is possible to say that students' awareness of climate-related events in the city they live in is high.

Regarding the third theme of the research, extreme weather events, the students mostly included heavy rainfalls, floods, overflows and tornadoes in their drawings. In recent years, it is seen that the effect of extreme weather events has increased in Turkey as in the world. For example, recent heavy rains in the Black Sea region have caused sea level rise and triggered extreme weather events such as floods and overflows. According to the 2020 climate assessment report of the General Directorate of Meteorology, 30% of the extreme events recorded in 2020 were heavy rainfalls and floods. In the last 10 years, there has been a significant increase in the frequency of tornado events compared to previous years. A notable example of this is the Çeşme tornado (February 11, 2021) has left deep traces in the memory of many people in the region. All of the listed effects are directly observed consequences of climate change today. It is not surprising that students have knowledge of these

effects. Because students are faced with the news in social media or in the written/visual media about the threat of drought, forest fires, desertification, etc. almost every day.

Indeed, when the word "climate change" is searched on Google, 45300 news are found in the last year. When the words climate change, drought and flood are scanned together, more than 1000 news items are encountered. When searching for climate crisis news, there are 21100 results for the last year. Therefore, it can be said that public perception is tried to be strengthened by including news such as climate change and climate crisis. As a matter of fact, there are studies in the literature that show parallelism with this finding (Boyes et al., 1993; Hansen 2010; Hestness et al., 2019). Hestness et al., (2019) examined the drawings of middle school students about climate change in their study. 75% of the students in the research group stated that local television news, internet tools such as google, wikipedia and publications such as books, magazines, newspapers, and articles were the sources of their learning about climate change. This indicates the importance of having digital literacy skills for students to acquire climate literacy skills.

In the study, it was observed that the theoretical aspect of climate change was not given much space in student drawings. For example, fossil fuels and the resulting greenhouse effect have little place in the drawings. Indeed, many studies in the literature (Boyes et al., 1993; Koulaidis & Christidou, 1999; Shepardson et al., 2012) indicate that students lack knowledge about global warming, greenhouse gases, the combination of greenhouse gases in the atmosphere, greenhouse effect, and climate system. In a similar vein, İlhan and Gezer (2018) found in their study that prospective teachers' actual knowledge about climate change is high, but their theoretical knowledge is limited. In other words, the elements that are not included in the drawings, such as the elements in the student drawings regarding climate change, are on the same axis with the studies in the literature.

Recommendations

Considering that students will be affected by the consequences of climate change throughout their lives, it is extremely important that they better understand its effects on humans and ecosystems. The main factor that will enable students to take action to reduce the potential consequences of climate change is their awareness of this issue. In this respect, it is imperative to develop students' climate literacy skills. Therefore, climate change education should be made a part of formal education and integrated into curricula. It is seen that learning experiences that will serve this purpose are not adequately addressed in the social studies curriculum. It is thought that the preparation of a curriculum that includes well-rounded learning about climate change will contribute to the development of literacy skills about climate change.

Scientific Ethics Declaration

I, the author, declare that the scientific ethical and legal responsibility of this article published in JESEH journal belongs to the author.

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Appendices-1

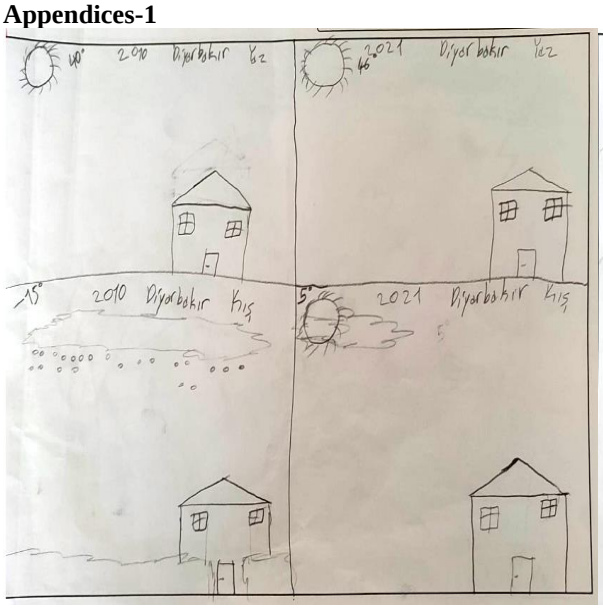

Figure 6. Change in annual temperature averages (P119)

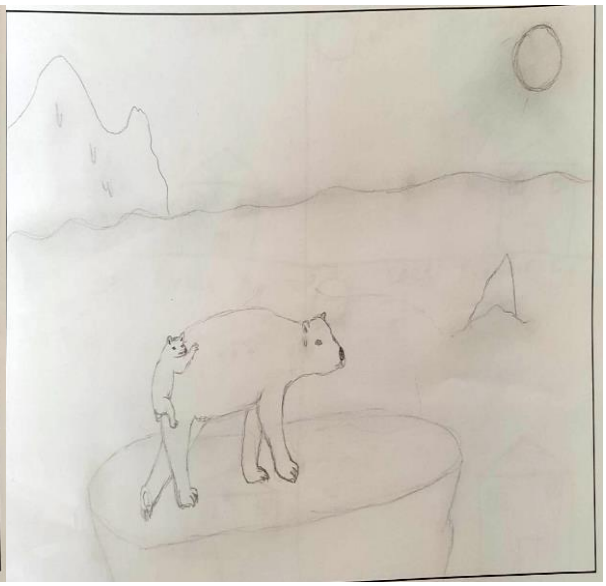

Figure 7. Glacier melting/ Extinction of animal and plant species (P87)

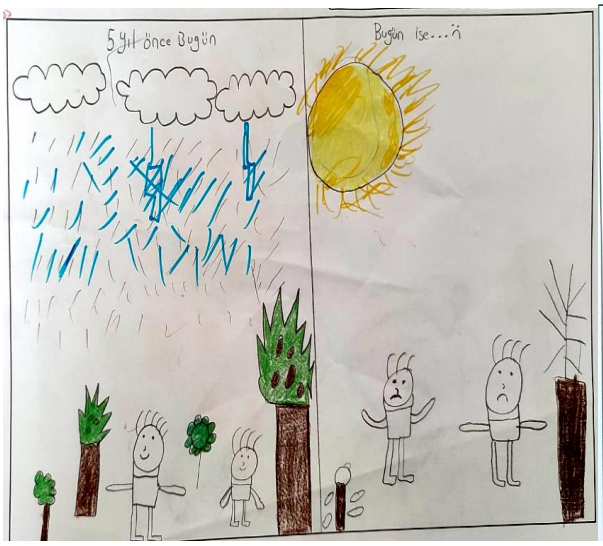

Figure 8. Change in thermal and precipitation regime(P105)

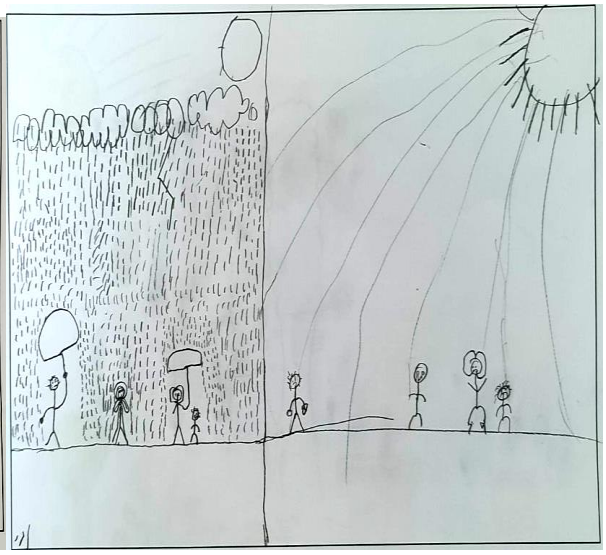

Figure 9. Decreased amount of precipitation (P35)

Figure *10.* Fossil fuels (P30)

Figure 11. Forest fires (P21)

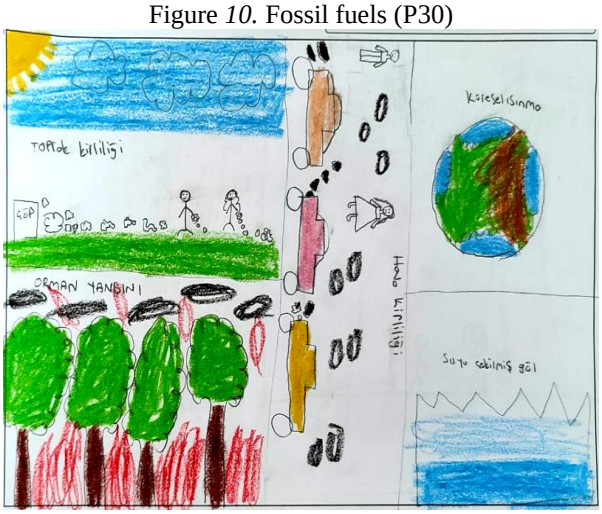

Figure 12. Enviromental pollution / Global warming

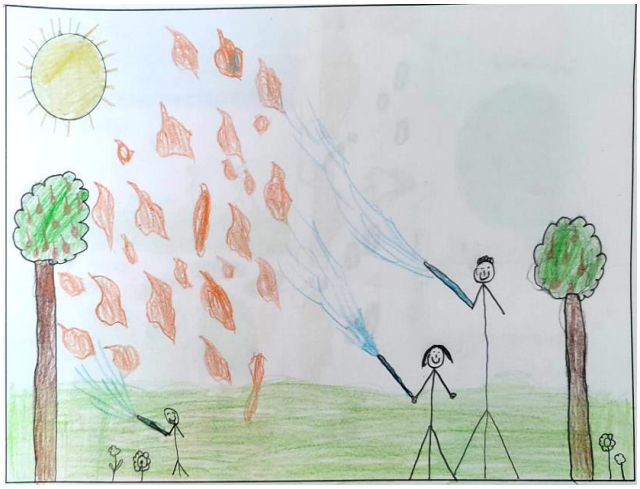

Figure 13.Forest fires (P38)

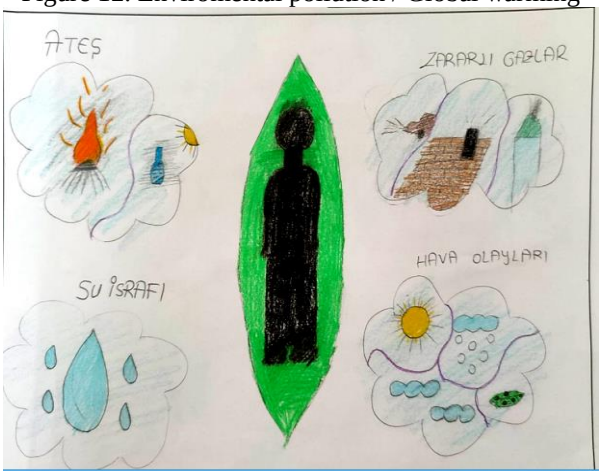

Figure 14. Fossil fuels (P89)

Figure 15. Drought (P108)

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A Bibliometric Analysis of out of School Learning Environments: Science Mapping

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Abstract

The aim of this study is to understand and analyze the status, development and current trends of out-of-school learning by evaluating scientific studies published in the field of out-of-school learning environments in terms of various parameters. The bibliometric analysis method and Web of Science (WoS) database were used to carry out the research and achieve the determined goals. The research was limited to the years 1982-2021 and 3101 studies were evaluated. In this study scientific studies published on out-of-school learning were examined within the framework of the annual number of publications, keyword analysis, citation analysis, active researchers, journals and countries. In the results of the study, it was determined that the publication trend about out-of-school learning started in 2008 and has continued until today, with the most references occurring in the last 10 years. In addition, it was determined that the most cited author was "Nada Dabbagh", the co-author was "Micheal Eraut", the active journal was "Educational Technology & Society", the most cited and co-cited journal was "Computer & Education" and the active collaborator country was "United States". In this context, it is recommended that researchers increase their studies depending on needs. Furthermore, with the disappearance of the effects of the Covid19 epidemic over time, it is thought that many studies can be conducted in out-of-school learning environments.

Introduction

Today's world undergoes continuous change with the developing technology and due to this change, trained manpower is needed in every field. These well-equipped individuals needed of society can only be raised with a qualified education (Küçükahmet, 1995). The desire to reach quality education makes the change and innovation in the education systems of the countries compulsory (Duman & Aybek, 2003). New approaches have been adopted in the curriculum for change and innovation. One of these approaches is the constructivist learning approach. The constructivist learning approach is based on the construct of knowledge by the learner. In addition, learning is defined as a process in which individuals integrate their knowledge with new ideas and add new meanings to it in the learning environment (Naylor & Keogh, 1999; Poelmans & Wessa, 2015). In the constructivist approach, it is thought that it will not be possible to gain the knowledge, skills and experiences required from the individual in the school environment, which is one of the formal learning environments. Because, within the scope of formal education offered in schools, learning takes place quite far from the real world and without life experiences emphasizing it with symbols and expressions, without allowing interaction with concrete and real objects (Laçin Şimşek, 2011). Learning takes place not only in the school and classroom setting, but also in the social and cultural contexts offered outside of school (Aikenhead, 2005; Osborne et al., 2003). Since a large part of learning takes place outside of formal learning, it is possible to think that school is only a context for learning, so formal and informal learning can take place inside and outside of school and institutional environments (Khaddage et al., 2016). Therefore, it can be concluded individuals can make up with informal learning for their inadequacies in formal learning. Informal learning is valid for situations which appear on their own in life, such as family environment, neighbourhood, etc. (Eshach, 2007). Improving the knowledge and skill level of the individual, being introduced to ideas that are new to them and interacting with new situations (Kara, 2010), being able to implement knowledge in areas outside of school, having the opportunity to integrate their knowledge to daily life, developing feelings of curiosity and exploration in individuals, showing that education and teaching can be sustained in all environments and developing the attitudes of individuals are listed as the aims of informal learning environments (Altıntaş, 2014).

Most of the individuals' own learning takes place through informal learning (Rehm et al., 2018). When the studies in the literature are analyzed, it can be seen that planned visits to different informal environments make

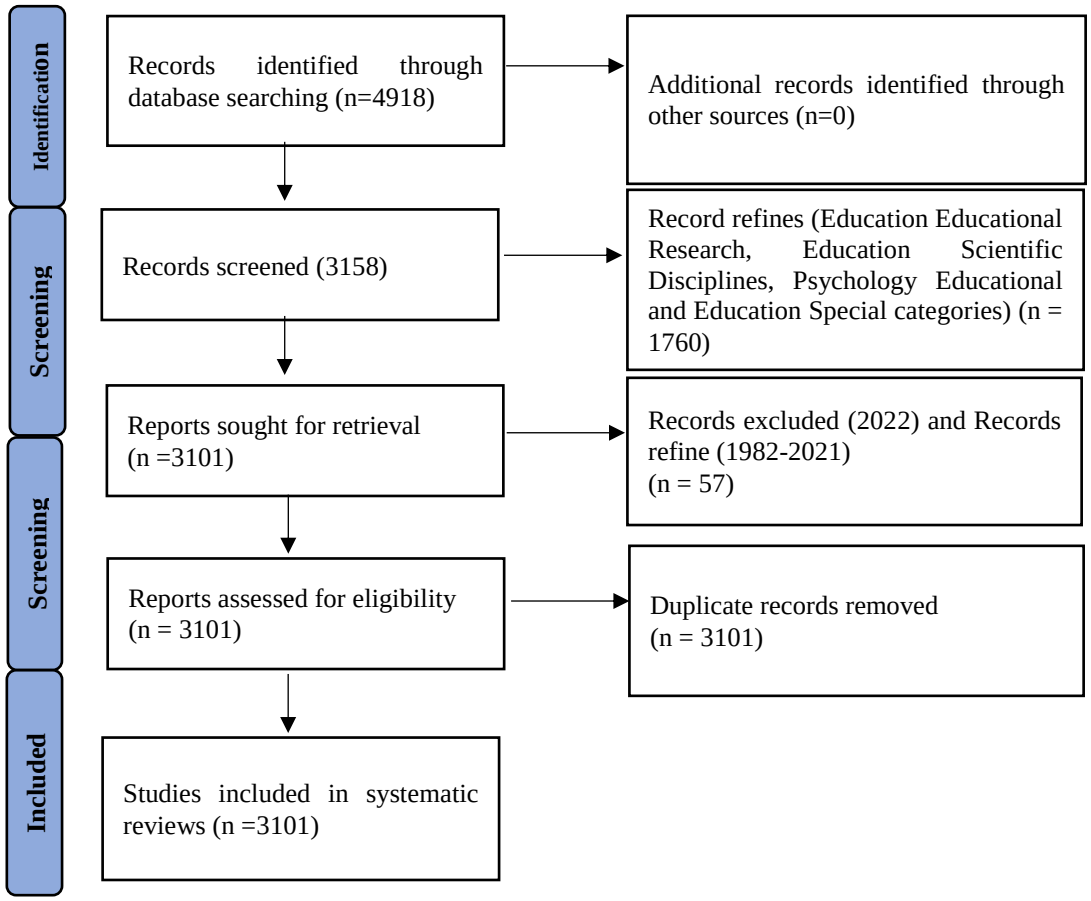
it possible for students to interact with real objects by engaging their interest and curiosity (Falk et al., 1986), contribute to finding the answers to the questions they are curious about (Tatar & Bağrıyanık, 2012), help them acquire concrete experiences (Bamberger & Tal, 2008), reach scientific information (Bamberger & Tal, 2008; Plummer, 2009), associate new learning with pre-learning (Bamberger & Tal, 2007), develop positive ideas on science (Jarvis & Pell, 2005) and positively affect their critical thinking tendencies (Ertaş Kılıç & Şen, 2014). In the literature, the concept of out-of-school education has been emphasized as an informal education resource used in formal education (Salmi,1993). Out-of-school education; covers learning processes that involve educational activities in nature and the living environment (Güngör & Göloğlu Demir, 2022). Therefore, the form of formal education supported by informal education resources is out-of-school education. Out-of-school education is defined as education which takes place in institutions and environments outside of the physical areas of the school building within school hours and scope, by adhering to the goals and gains of lessons in tandem with the education program (Salmi, 1993). The environments where these activities take place are defined as out-of-school learning environments. Mass communication tools, zoos and botanical gardens, family meetings, shopping malls, books, virtual museums, factories, supermarkets, aquariums, planetariums, libraries, homes, science centres, nature centres (Hill et al., 2005; Kelly, 2010; Laçin Şimşek, 2011; Salmi, 1993), industrial resources, resources in areas which are secured by the state (national and local parks, animal shelters, bird and insect areas, etc.), universities, resources based on society (Peters & Stout, 2006) are among out-of-school learning environments. In fact, when the literature is examined, it is seen that there is no clear definition of out-of-school learning (Bozdemir Yüzbaşıoğlu et al., 2021). The reason for this is that such learning can take place in many environments (Hofstein & Rosenfeld, 1996). There are also differences in naming. It is seen that names such as "out-of-school", "free-choice learning", "lifelong science learning", "public understanding of science" is used for this learning in the literature (Dierking et al., 2003). Today, out-of-school learning environments should be dealt with school learning in terms of their doing-experiencing learning aspect (Çığrık, 2016). In this sense, informal education resources should be used together with formal education and it should be made possible for individuals to reach real knowledge by doing research, questioning, exploring and structuring their knowledge in areas which we define as out-of-school learning environments and numerous skills of individuals such as critical thinking, problem solving and life skills should be developed. When the new knowledge, characteristics and skills individuals will acquire are taken into consideration, the importance of out-of-school learning environments become apparent. Out-of-school learning is a useful supplement to traditional lessons at school (Schürmann & Quaiser Pohl, 2022). In terms of this importance, there is an increasing need for studies related to this discipline.

The number and speed of academic studies in the recent years have been increasing and it has become quite difficult to be aware of each published study. Therefore, the need in literature reviews for efficient use of existing studies, advancement of research series and synthesis of past studies to provide some insight to future studies on any discipline has been increasing. One of the methods scientists use to understand and organize findings and present studies is bibliometry (Aria & Cuccurullo, 2017). Bibliometric studies allow scientific studies to be evaluated in terms of quantity and quality (Al & Soydal, 2012). Bibliometric analysis is a systematic method which is used to analyze bibliographic indicators in academic publications (Karagöz & Koç Ardıç, 2019) and it involves the analysis of numerous parameters such as the issuing of documents or publications, their subject, number of authors, publication information, keywords and number of quotes (Al & Coştur, 2007; Ulu & Akdağ, 2015). When the literature is reviewed, it can be seen that bibliometric analyses have been done in numerous areas such as accounting and finance (Aysan & Ünal, 2021; Hotamışlı & Erem, 2014), banking (Alkaç Özdemir & Altıntaş, 2021), management accounting (Çil Koçyiğit & Altsoy, 2021), tourism and entrepreneurship (Gazelci & Gazelci, 2021; Işık et al., 2019; Yılmaz, 2017), gastronomy (Ayaz & Türkmen, 2018), culture and literature (Dönbak, 2020; Karagöz & Şeref, 2019a), technology (Özispa & Akdaş, 2019), chemistry (Birinci, 2008), pharmacology (Bordons & Barrigón, 1992; Thompson, 2018) and health (Agar & Sahin, 2022; Demirci et al., 2022; Demirkol et al,, 2022; Turhan & Ünsal, 2021; Yıldırım Becerikli, 2013). In addition to these areas, it is possible to see that bibliometric analyses have been given place to in the area of education as well in the literature (Arici et al., 2019; Doğru et al., 2019; Gülmez et al., 2021; Karagöz & Koç Ardıç, 2019; Mutlu, 2018; Karagöz & Şeref, 2019b; Swain, 2014; Varışoğlu et al., 2013). Bibliometric analyses have also been given place to in the literature on some out-of-school environments which have great importance in today's education system such as museums (K. Bozdoğan, 2020) and planetariums (A. E. Bozdoğan, 2020). In this study, it is considered that the bibliometric analysis of studies published in certain indexes identified as criteria in the literature on out-of-school learning environments will guide educators and new studies to be carried out in the future. In the study, it is aimed at reaching a specific result by identifying out-of-school learning environments and published scientific studies in terms of various parameters. Therefore, the aim of the study is to understand and analyze the state, development and existing tendencies of out-of-school learning. Within this scope, the answers to the following questions were sought:

1. What is the numerical distribution of scientific studies published on out-of-school learning in terms of years?
2. What is the keyword network of scientific studies published on out-of-school learning?
3. What is the numerical distribution of scientific studies published on out-of-school learning in terms of the number of citations?
4. Who are the authors referred to the most (citation and co-citation) in scientific studies published on out-of-school learning?
5. Which journals have been given place to in scientific studies published on out-of-school learning and what is their number of publications?
6. Which journals have been referred to the most (citation and co-citation) in scientific studies published on out-of-school learning?
7. Which countries have been effective and have cooperated the most in scientific studies published on out-of-school learning?

Method

Bibliometric analysis method was used with the purpose of carrying out the study and reach the determined goals of the study. Bibliometrics is based on mathematical and statistical analysis methods to define certain parameters of scientific publications in certain areas (Pritchard, 1969). Bibliometrics is an important tool to evaluate and analyze academic studies developed in countries, research centres, research groups and journals. Bibliometrics provides objective criteria to the researcher to evaluate scientific quality and productivity. In addition, it contributes to the progress of science in various manners, such as evaluating progress, identifying the most reliable sources of scientific publications, creating an academic foundation to be able to evaluate new developments, identifying main scientific actors and evaluating academic outcomes (Martínez et al., 2015). There are various work-flow steps for the bibliometric method. These steps are successively, collecting data, pre-processing, eliminating, normalizing, mapping, analysis and visualization. At the end of this process, the researcher interprets the results and arrives at conclusions (Cobo et al., 2011).



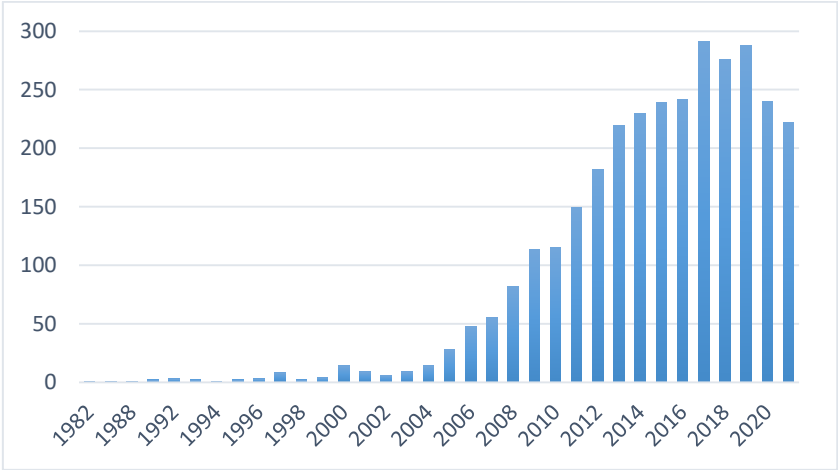
Graphic 1. Flow diagram according to PRISMA statement

Data Analysis

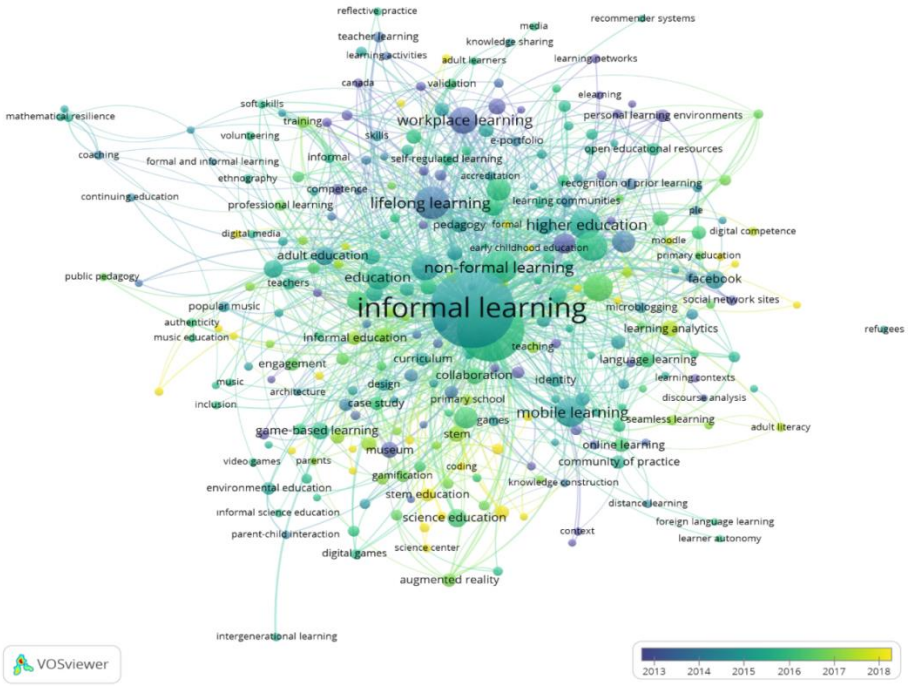
The data obtained in the study were analyzed in line with the bibliometric analysis technique. In the study, the scientific studies in the Web of Science data base were downloaded as full records and in Tab-Delimited (Win) format. The downloaded data were changed into a suitable format and uploaded to the VOSviewer (version 1.6.16) program. The VOSviewer program allows the creation, visualization and interpretation of maps based on bibliometric network data (Van-Eck &Waltman, 2010). The data uploaded through VOSviewer were analyzed in line with the aims of the study and visuals were presented. In addition, descriptive statistics such as percentage and frequency were used in the study as well.

Findings

In this study, the number of annual scientific publications on out-of-school learning, publication type, publication language, vocabulary analysis, citation analysis, active researchers, active journals, active organizations and active countries were analyzed and findings were reached. The numerical distribution of 3101 scientific studies obtained as a result of the scan on out-of-school learning in terms of years was analyzed and presented in Graphic 2.



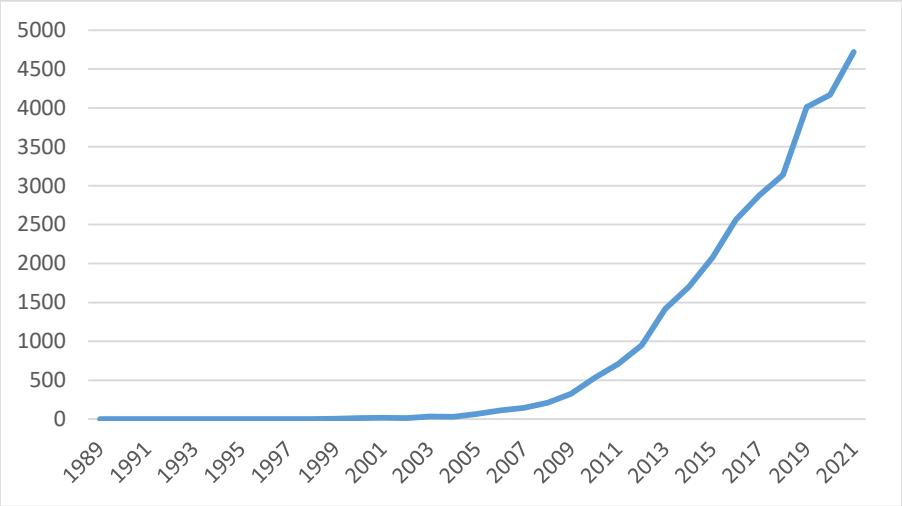
Graphic 2. The distribution of scientific publications on out-of-school learning in terms of years (N=3101)



Graphic 3. Analysis of keywords related to out-of-school learning and current topics

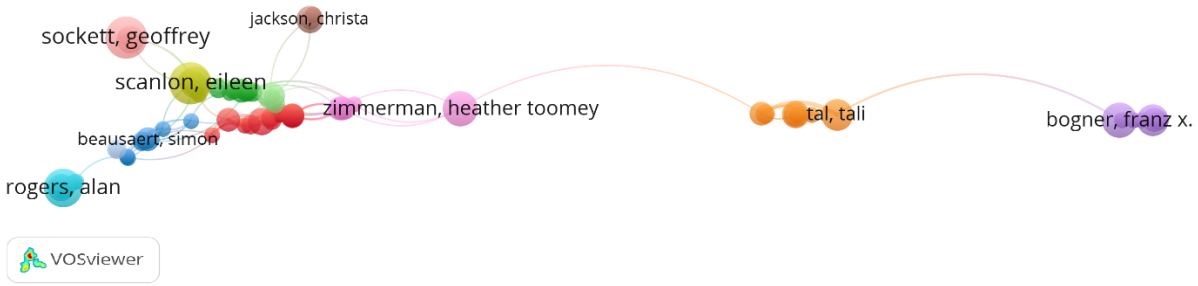
When Graphic 2 is analyzed, it can be seen that the increase trend in the number of studies on this field has started in 2008 and made a leap in 2015. When the data were analyzed, it was determined that the percentage of publications in the last five years was 62,4% and the percentage of publications in the last decade was 88,3%. In addition, it was seen that the highest number of publications on out-of-school learning belonged successively to the years 2017, 2019 and 2018. The decrease in the past year can be explained with the negative effects of the COVID-19 pandemic which broke out in the last months of 2019 and became effective all over the world in 2021. The scientific studies on out-of-school learning were analyzed in terms of keyword network and presented in Graphic 3.

"Co-occurrence" analysis was used to identify scientific studies on out-of-school learning in terms of keyword network and "author keywords" was selected. As a result, 5151 words were reached and this number was reduced to 106 when the frequency number was limited with 10. As a result of the analyses, it was seen that the most used keywords were informal learning (842), lifelong learning (91), non-formal learning (88), formal learning (74), higher education (74), mobile learning (73), social media (65), workplace learning (60), learning (59), education (47), professional development (43), e-learning (41), out-of-school learning (40), collaborative learning (39), web 2.0 (35) and motivation (33). In addition, it was determined with these keywords that there is a tendency towards these subjects. The numerical distribution of the citations made on scientific studies published on out-of-school learning were analyzed in terms years and presented in Graphic 4.



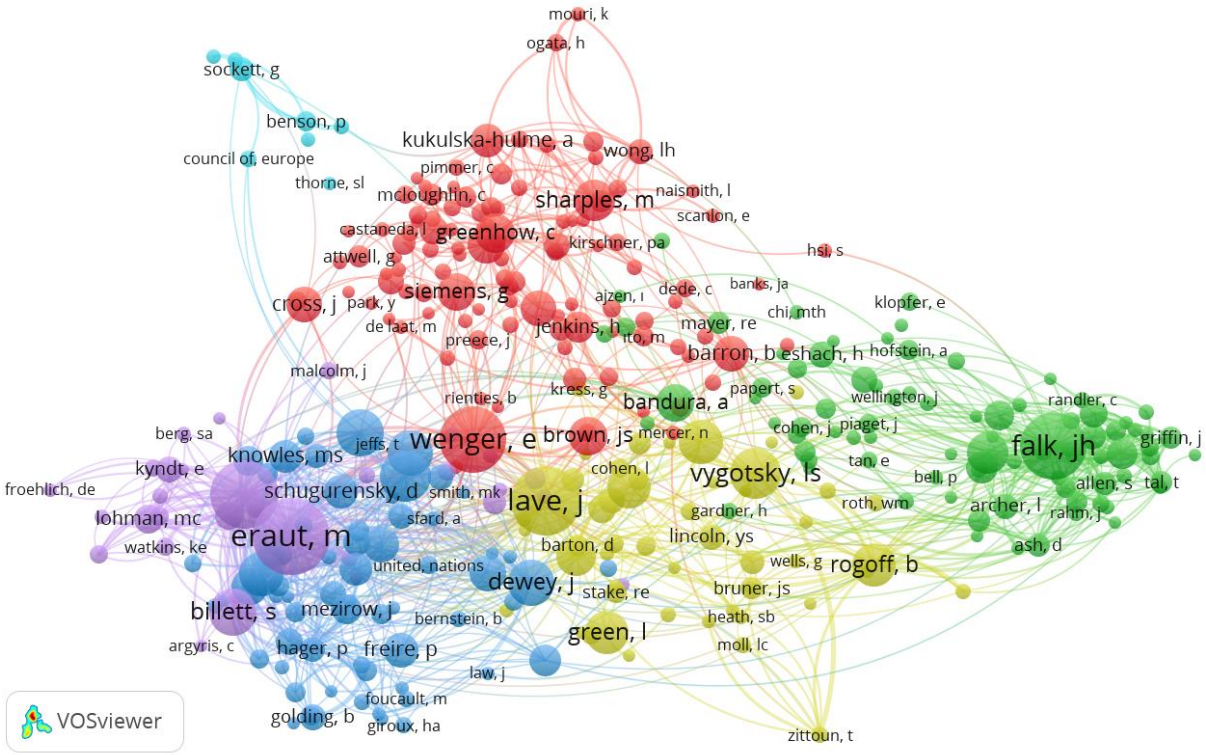
Graphic 4. Numerical distribution of the citations made on scientific studies published on out-of-school learning in terms of years

When Graphic 4 was analyzed, it was seen that the citations made on scientific studies on out-of-school learning began in 1989 and that this increase has reached the highest levels in the last decade. It was determined that a total of 24042 citations were made in terms of years and that the average citation per item was 10,02 and that h-index was 72. In addition, when the citation percentage distribution was analyzed, it was determined that the percentage of citations in the last five years was 63,4% and the percentage of citations in the last decade was 92,54%. The scientific studies published on out-of-school learning were analyzed and the authors who were cited the most and the citation network are presented in Graphic 5.



Graphic 5. Authors who were cited the most (citation analysis)

"Citation" analysis was used to determine the authors who have been cited the most in scientific studies published on out-of-school learning and to view the citation network; "authors" was selected and 5368 authors were reached. With the purpose of determining the authors who have been cited the most among these authors and to view the citation network, at least 3 scientific studies published on this field and 10 citation criteria were selected and the number of authors was reduced to 126 as a result. After the analyses, the authors who have been cited the most were determined as Nada Dabbagh (730 citations), Chee-Kit Looi (586 citations) and Lung-Hasiang Wung (521 citations). Scientific studies published on out-of-school learning were analyzed and the authors who have been cited the most (co-citations) and the citation network is presented in Graphic 6.



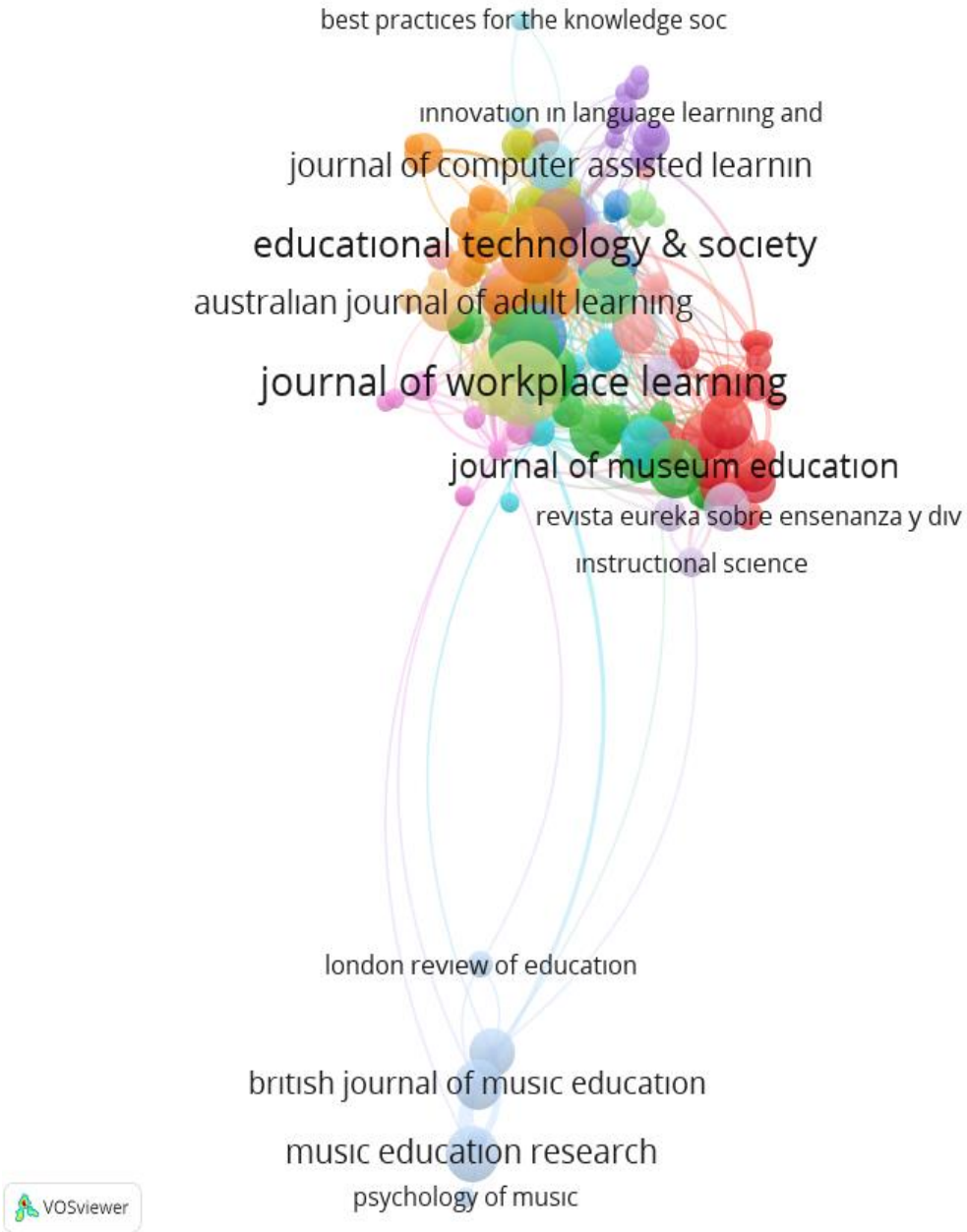
Graphic 6. Most cited authors (co-citation analysis)

"Co-citation" analysis was used to determine the authors who have been co-cited the most in scientific studies published on out-of-school learning and "cited-authors" was selected and 43182 authors were reached. In order to determine the authors who have been cited the most among these authors and to view the citation network, at least 20 citation criteria identified automatically were selected and the number of authors was reduced to 351 as a result. After the analyses, it was determined that the authors who have been cited the most (co-citation) on out-of-school learning were Micheal Eraut (339 citations), Jean Lave (291), Victoria J. Marsick (286 citations) and Etienne Wenger (270 citations). Journals active within the scope of scientific studies on out-of-school learning were analyzed. As a result, 855 sources on out-of-school learning were reached and the first 10 journals which published the highest number of studies on the field are presented in Table 1.

Table 1. Journals active within the scope of scientific studies on out-of-school learning (N=3101)

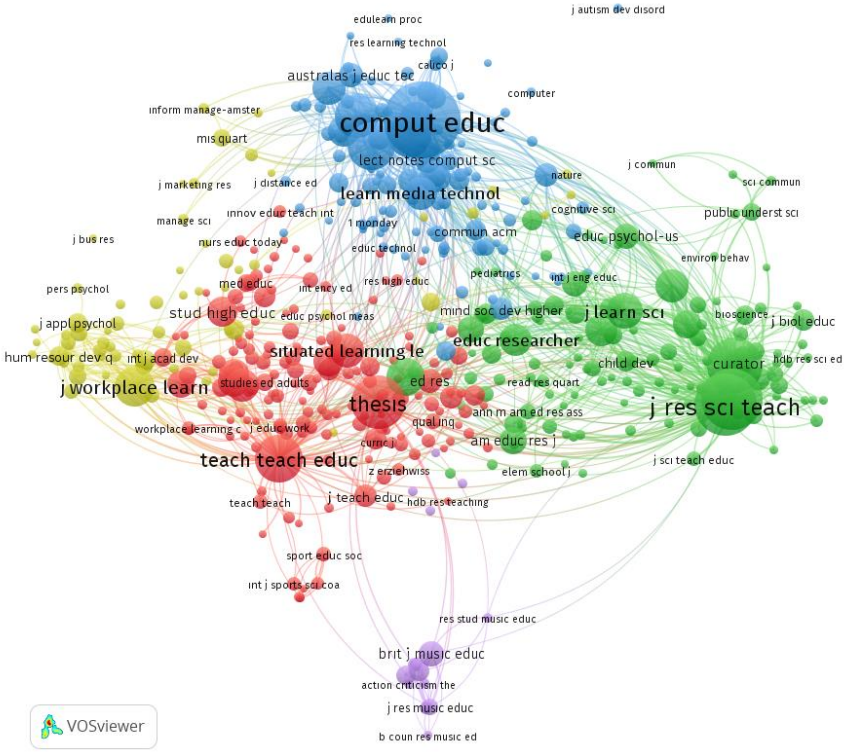
Journal		Frequency (n)
1.	Journal of Workplace Learning	43
2.	Educational Technology & Society	36
3.	International Journal of Lifelong Learning	34
4.	Interactive Learning Environments	26
5.	Adult Education Quarterly	26
6.	British Journal of Educational Technology	23
7.	Journal of Museum Education	22
8.	Music Education Research	20
9.	Computers & Education	20
10.	Learning Media and Technology	19

Table 1 shows the journals which are active on out-of-school learning and contribute the most to the field. The leading journal among these was Journal of Workplace Learning (43 scientific studies). This journal was followed successively by Educational Technology & Society (36), International Journal of Lifelong Learning (34 scientific studies) Interactive Learning Environments (26 scientific studies) and Adult Education Quarterly (26 scientific studies). The scientific studies published on out-of-school learning were analyzed and the most cited journals and the citation network are presented in Graphic 7.



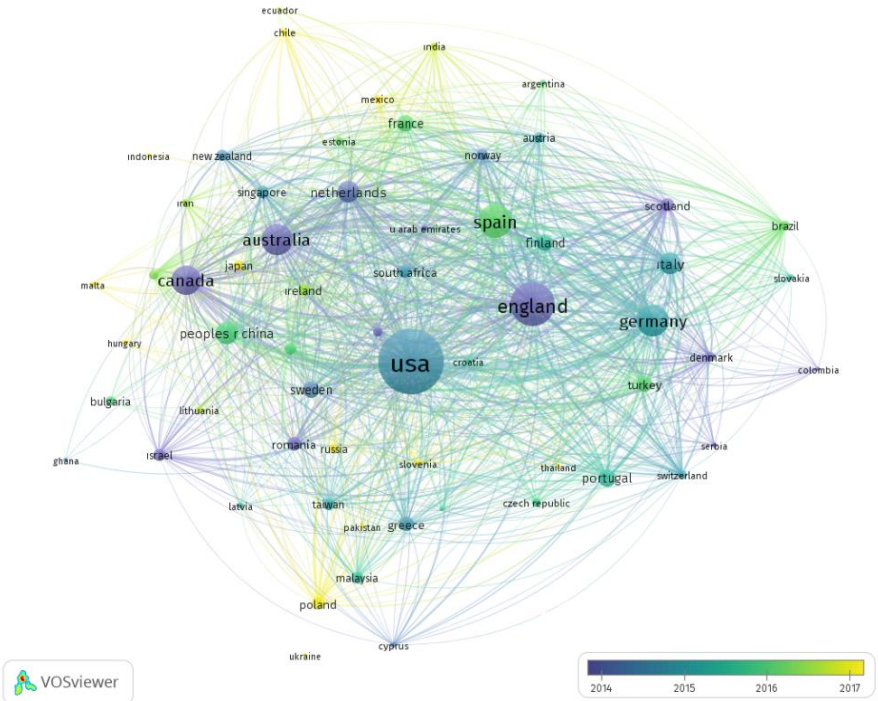
Graphic 7. Most cited journals (citation analysis)

"Citation" analysis was used to determine the most cited journals in scientific studies published on out-of-school learning and to view the citation network; "source" was selected and 902 sources were reached. In order to determine the most cited source among these sources and to view the citation network, at least 3 scientific studies published on this field and 10 citation criteria were selected and the number of journals was reduced to 176 as a result. After the analyses, it was determined that the most cited journals were Learning Media and Technology (1404 citations), Computer & Education (1150 citations), and Educational Technology & Society (1024 citations). The scientific studies published on out-of-school learning and the most cited journals and the citations network is presented in Graphic 8.



Graphic 8. Most cited journals (co-citation analysis)

"Co-citation" analysis was used to determine the most co-cited journals in scientific studies published on out-of-school learning and to view the citation network; "cited-source" was selected and 35381 sources were reached. In order to determine the most cited source among these sources and to view the citation network, at least 20 citation criteria identified automatically were selected and the number was reduced to 498 as a result. After the analyses, it was determined that the most cited journals were Computer & Education (1050 citations), Science Education (711 citations), Journal of Research in Science Teaching (731 citations) and International Journal of Science Education (600 citations). The scientific studies published on out-of-school learning were analyzed and the active countries which cooperated the most and the publication network are presented in Graphic 9.



Graphic 9. Active countries which cooperated the most in terms of out-of-school learning

"Bibliographic coupling" analysis was used to identify active countries which cooperated the most on scientific studies related to out-of-school learning and to view the publication network; "country" was selected and 99 countries were reached. In order to determine the most active and cooperative countries among these sources and to view the publication network, at least 5 publication criteria identified automatically were selected and the number was reduced to 61 as a result. After the analyses, it was determined that the first 10 countries which were active and cooperated the most were the USA (583 publications, 8589 citations), England (293 publications, 5892 citations), Germany (164 publications, 1378 citations), Spain (181 publications, 722 citations), Italy (84 publications, 298 citations), Australia (158 publications, 1577 citations), Netherlands (83 publications, 1299 citations), Canada (146 publications, 1179 citations), Finland (52 publications, 1121 citations), Scotland (34 publications, 374 citations) and Turkey (46 publications, 164 citations).

Conclusion, Discussion and Suggestions

In this study, it was aimed at presenting a holistic evaluation on the general state of international literature related to out-of-school learning environments. There has been a need to carry out a bibliometric study in line with this aim, because bibliometric studies are regarded as extremely important in terms of obtaining the "big picture" related to their subject fields (Karagöz & Şeref, 2019a). Bibliometric studies present the opportunity to get to know journals or branches of science in a better manner and obtain information about the subject field, find out what the efficiencies and inadequacies of scientific publications are, identify the positive, strong, inadequate and weak sides of scientific publications and evaluate the performances of publications (Hotamışlı & Efe, 2015). In this study, it was aimed at presenting the big picture by determining the general framework of out-of-school learning environments. The scientific studies related to out-of-school learning were analyzed within the framework of number of annual publications, keyword analysis, citation analyses, active researchers, active journals and active countries in the study.

When the studies on the related field were analyzed, it was concluded that the increase trend in the number of studies started in 2008, made a leap in 2015 and the highest number of studies were carried out in 2017. In Saraç's study (2017), it was determined that researches related to out-of-school learning environments started increasing in number in 2010. The decrease in 2020 can be explained with the negative effects of the COVID-19 pandemic which broke out in the last months of 2019 and continue to be effective all over the world. It is considered that as the effects of the COVID-19 pandemic gradually subside, numerous studies will be carried out on out-of-school learning environments.

It was concluded that the keywords used most in scientific studies within the scope of out-of-school learning are informal learning, lifelong learning, non-formal learning, formal learning, higher education, mobile learning etc. In addition, the analysis of obtained studies led to the idea that there is a tendency towards specific out-of-school learning environments rather than viewing these environments in a general framework and that there is an accurate tendency towards the related subjects with these words.

It was concluded that citations of scientific studies related to out-of-school learning began in 1989; this increase has reached the top level in the last decade and that when the citation percentage distribution was analyzed, it was determined that the citation percentage of the last five years was lower than the citation percentage of the last decade. Although the rate of increase decreased in 2019 and 2020, when COVID-19 started, this situation returned to its previous position in 2021.

When the authors who is the most cited analyzed, it was found that them are Nada Dabbagh, Chee-Kit Looi and Lung-HasiangWung. When analyses were done to determine the authors who were co-cited the most in scientific studies published on out-of-school learning, it was seen that Micheal Eraut, Jean Lave, Victoria J. Marsick and Etienne Wenger have been co-cited the most in relation to out-of-school learning. It can be suggested to researchers who will be doing research on out-of-school learning to review the studies of active authors mentioned above to develop their point of view, acquire sufficient knowledge on the field and direct their studies.

The journals active within the scope of scientific studies on out-of-school learning were analyzed and 855 sources related to out-of-school learning were reached. In the light of the obtained findings, it was determined that the active journals which contributed the most to the area of out-of-school learning were successively "Journal of Workplace Learning", "Educational Technology & Society", "International Journal of Lifelong Learning" and "Interactive Learning Environments". As a result of the analyses to determine the most cited journals in scientific studies published on out-of-school learning, it was concluded that the most cited journals

successively were “Learning Media and Technology”, “Computer & Education” and “Educational Technology & Society”. 35381 sources were reached to determine the most co-cited journals in scientific studies published on out-of-school learning. As a result of the analyses done to determine the most-cited source among these sources, it was concluded that the most cited journals successively were “Computer & Education”, “Science Education”, “Journal of Research in Science Teaching” and “International Journal of Science Education”. It can be suggested to researchers who will be doing researches on out-of-school learning to access these journals to acquire knowledge on the field and evaluate the findings of their own researches in comparison to the other studies in the literature. It is considered that this will allow the researchers to save time and access numerous authentic studies on this field.

As a result of the analyses done to determine active countries which cooperated the most in scientific studies on out-of-school learning, it was concluded that the first 10 active countries which cooperated the most were the USA, England, Germany, Spain, Italy, Australia, Netherlands, Canada, Finland and Scotland. In the light of this finding, it is considered that countries who have contributed less to this field will contribute greatly to the literature and research groups by increasing the number of studies and strengthening cooperation with other institutions.

This study is limited with 3101 studies obtained from the Web of Science data base, carried out between the years 1982-2021. In this light, the exclusion of studies outside the Web of Science data base from this study is considered as the main limitation of the study. In this context, researchers are suggested to analyze studies or postgraduate theses obtained from different data bases in future bibliometric studies to be carried out in this field. It is considered that the results of the study will present researchers with ideas in terms of acquiring information on studies about out-of-school learning, identifying inadequacies and needs and putting forward important issues to be analyzed.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in JESEH journal belongs to the authors.

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Strengthening Pre-Service Science Teachers' Entrepreneurial Self-Efficacy through Design Thinking Process on the Eco-Printing STEAM-Project

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Abstract

Further development of a pedagogic framework to teach design thinking processes needs to be designed and implemented to strengthen pre-service science teachers' entrepreneurial self-efficacy (PSTs' ESE). This research aims to analyze the stages of the design thinking process in the eco-printing STEAM-projects, as well as to review the differences in PSTs' ESE after participating in this program. The participants are 22 PSTs consisting of 18 PSTs in the 3rd year of the program and other students in the 2nd year of the training program. Qualitative data were collected by observing, documenting the process of activities, interviews, and reflection questionnaires from the implementation of the program. Quantitative data were obtained from the entrepreneurial self-efficacy questionnaire. Interventions for PSTs include three main phases of the design thinking stage consisting (1) Understand; (2) Explore; and (3) Materialize. The existing stages not only teach the product design process, but also the design of the teamwork pattern that is formed. The ESE covers aspects, namely (1) searching, (2) planning, (3) marshaling, (4) implementing-people, and (5) implementing-financial. The change in category only occurs in the "planning" aspect. While the significance of the changes can be seen in two aspects, namely the "searching" and "planning" aspects. The PSTs have a positive response to what they do. PSTs also provide an overview of responses to entrepreneurial attitudes that have been learned during the process of strengthening programs dominated by "Collaboration" and "Time discipline" responses.

Introduction

As professional educators, teachers have the main task of educating, teaching, guiding, directing, training, assessing, and evaluating students. Teachers in formal education, primary and secondary education, play an important role in the success of the educational process. The exemplary attitude of a teacher is very important so that it can be used as a reference for students to behave and act in everyday life, especially in the learning process at school. One of the "exemplary" attitudes and behaviors can be found in the entrepreneurial character which includes discipline, energetic, creative, innovative, and productive characters (Rohmah, 2017). Teachers who have an entrepreneurial spirit will dare to take risks, are highly motivated, creative, innovative, productive in presenting classroom teaching or in managing their own lives. Teachers who have entrepreneurial characters can imitate and be imitated as well as have high productivity. The entrepreneurial spirit can be owned by anyone with a variety of professions. An entrepreneur is a person who can see and assess business opportunities, gather the necessary resources to take advantage of them, and take appropriate action to ensure success (Suherman, 2008). Thus, it is crucial to prepare pre-service teachers with "exemplary" characters because they will bring the characters into their profession as professional teachers. In addition, pre-service teachers need to be prepared to be work-ready after completing the teacher training program, whether they will work in the field of formal or non-formal education, or start their own business. The personal characteristics of entrepreneurs are considered to play an important role in environmental adaptation and personal achievement (Byrne & Shepherd, 2015) of future teacher candidates.

Entrepreneurship education has a relationship with design thinking in enriching the implementation of current entrepreneurship education (Huber et al., 2016). Design thinking is an interesting perspective for learners to learn about customer development, problem-solving, product solutions, creativity, divergent and convergent thinking, iteration, failure, resilience, and teamwork. Through processes in design thinking, pre-service teachers can develop their creative beliefs and transform entrepreneurial self-efficacy (ESE). One of the central roles in the regulatory process between motivation and the achievement of work performance is one's self-efficacy

(Fallast & Vorbach, 2019). Self-efficacy can predict the extent of entrepreneurial achievement, and entrepreneurial intention (Li, 2017). ESE is a construct that measures a person's belief in their skills to be able to successfully start entrepreneurship. ESE is particularly useful because it combines personality as well as environmental factors, and is considered a strong predictor of entrepreneurial intention and ultimately entrepreneurial action (Mcgee et al., 2009). On the other hand, design thinking-based teaching seeks comprehensive design-thinking skills. In this case, design thinking education is indispensable basic research to understand and enhance human creativity and innovation in various fields (Georgiev, 2012). Design thinking is a natural connector that blends art into the STEM (science, technology, engineering, and mathematics) field of work. Through design thinking, there is a great opportunity to incorporate engineering design principles across curriculums (The Institute for Arts Integration and STEAM, 2021) that could potentially be packaged into entrepreneurship education. Entrepreneurship education has a trend showing the increasing demand from universities and higher education institutions (Fallast & Vorbach, 2019).

Design thinking can be described as a paradigm, not as an example of a method or methodology. An understanding of the design thinking paradigm begins with an analysis of the designer's thought process. This process has long been the focus of research efforts to analyze design activities (Cross, 1982; Lawson, 2004). This paradigm directs design thinkers to avoid absolute answers and to deductive logic to obtain alternative answers that are not perfect (Collins, 2013). This process allows learners to deeply analyze and internalize various concepts and ideas. Design thinkers emphasize the communication and collaboration skills of learners which are at the core of constructivism. This is in line with STEAM learning which starts with defining real problems in everyday life (Boakes, 2020) and provides solutions by focusing on problem-solving skills (Herro et al., 2017) and team collaboration (Kijima et al., 2021). This paradigm extends further and includes how knowledge of such approaches, adopted by designers, can be imparted, taught, and applied in addressing (or providing answers) to further problems. The existing curriculum is sometimes not sufficient for the needs of the labor market. Existing education is often away from real situation conditions and problem-solving (Kersanszki & Nadai, 2020).

A pedagogical framework for teaching design thinking needs to be developed. Teaching approaches address some of the aspects of design thinking or design thinking teaching models (Oxman, 2004). Currently, project-based learning (PBL), explored by Dym et al. (2005), is the most frequently practiced for teaching design thinking. STEAM learning with projects makes it possible to teach these design thinking skills well. One form of project that can be implemented for pre-service science teachers is an eco-printing project. Eco-printing is a natural dyeing technique that transfers color and produces natural shapes from plants, such as leaves and flowers, fruits, vegetables, and organic waste materials (Pancapalaga et al., 2021). This dyeing process involves chemical bonds between natural dyes and fibers in the fabric (Kasipah et al., 2015). This project involves components that exist in integrative learning that combine science, technology, engineering, arts, and mathematics. Previous research has shown that there is a positive impact on learning, namely students' ability in presenting their creative ideas based on the development of eco-printing materials so that good works of art can be created (Syaifudin, 2018). Learning with eco-printing techniques can be an example of multi-disciplinary learning that combines learning about art and the environment (Kharishma & Septiana, 2019). Other research has also shown that eco-printing projects also have the potential for students' business ideas to be developed further (Husna & Nahari, 2021). This project has the potential to strengthen entrepreneurial self-efficacy with the knowledge of science concepts possessed by learners, Pre-service science teachers (PSTs). Through this research, further development of a pedagogic framework to teach design thinking processes needs to be designed and implemented to strengthen PSTs' ESE. This research aims to analyze the stages of the design thinking process in eco-printing STEAM projects, as well as to review the differences in PSTs' ESE after participating in this program. For PSTs, this will be the foundation to be able to teach design thinking in their future classrooms.

Method

Research Design

This research is a classroom action research that aims to strengthen PSTs' ESE so that the orientation of future educators instills an entrepreneurial spirit that is visionary, creative, and innovative concerning the substantive context of science. Action research is an appropriate means of improving quality on a classroom scale (Cohen et al., 2007). This study leads to an understanding of the ongoing phenomenon, so this is descriptive research (Sagor, 2005). The action research cycle begins with the stage of clarifying the vision that aims to build assessment criteria (in this case ESE). In the next stage, the theory is articulated related to the STEAM design

thinking process and eco-printing projects. The stages are continued by implementing actions, as well as reflecting and planning improvements in the next cycle if further actions are taken. The details of this cycle are depicted in Figure 1.

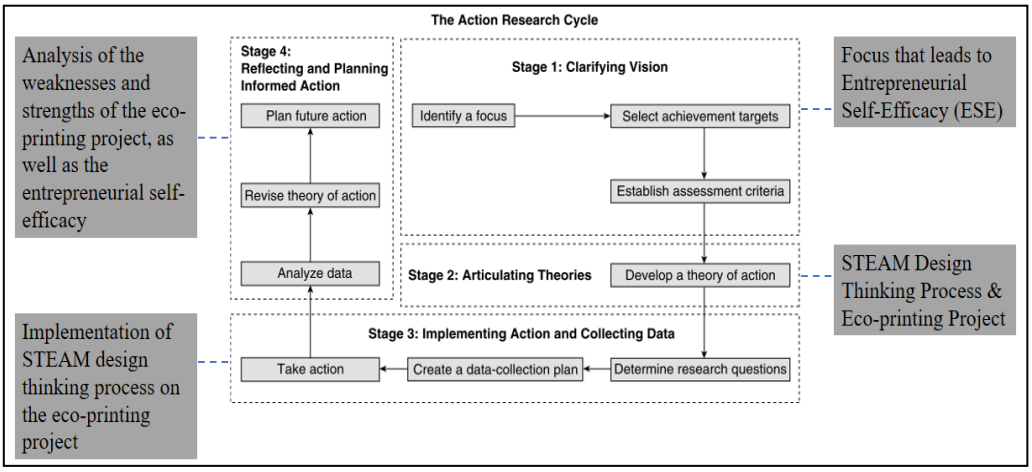

Figure 1. The modified action research cycle of Sagor (2005)

Data Collection & Analysis

The data in this study include qualitative data and quantitative data. Qualitative data includes various process findings at the stage of strengthening entrepreneurship as well as PSTs responses. Quantitative data includes entrepreneurial self-efficacy (ESE) scores. Qualitative data were collected by observing, documenting the process of activities, interviews, and reflection questionnaires from the implementation of the program consisting of (1) Yes/No questions and (2) open-ended questions. The validity of the qualitative data used a credibility test through member checking, which is the process of checking the data obtained by the researcher to the data provider. The purpose of which is that the information used in writing the report will be appropriate to what was intended by the data source or informant. The reliability of the qualitative data, which in this case is termed dependability, was obtained by an independent audit using a reflective journal (Cohen et al., 2007). Qualitative data were analyzed with narrative descriptions, furthermore, the results of reflection in the form of Yes/No questions were presented with a recapitulation table. The PSTs' reflections were analyzed using QDA Miner software to obtain word clouds and bar charts.

Quantitative data were obtained from the entrepreneurial self-efficacy questionnaire which consisted of 19 items for efficacy. Item validity using Pearson Correlation which is the lowest result at r= 0.486 and the highest at r=0.870. The reliability of the instrument was tested using Cronbach's Alpha (0.962). The validity and reliability of each indicator item are shown in Table 1. The existing indicators refer to Mcgee, Peterson, Mueller, & Sequeira (2009). The ESE data were categorized as 1,00 ≤ Mean < 2,33= Low (L) ; 2,33 ≤ Mean < 3,66 = Medium (M); 3,66 ≤ Mean ≤ 5,00 = High (H). The ESE data were analyzed by testing the significance of the differences before and after the program using the Wilcoxon test. This test is a non-parametric test that is used to measure the difference between 2 groups of paired data on an ordinal scale but the data are not normally distributed.

Table 1. Validity and reliability of each indicator of the entrepreneurial self-efficacy questionnaire

No	Indicator	Number of Items	Validity (Pearson Correlation)	Reliability (Cronbach's Alpha)
1	Searching	3	0.486; 0.718; 0.897	0.820
2	Planning	4	0.724; 0.836; 0.768; 0.731	0.872
3	Marshaling	3	0.687; 0.673; 0.800	0.762
4	Implementing-people	6	0.804; 0.816; 0.822; 0.792; 0.870; 0.620	0.913
5	Implementing-financial	3	0.576; 0.763; 0.732	0.845
	Total	19		

Profile of Pre-service Science Teachers

The total number of PST participants who participated in this research was 22 PSTs consisting of 18 PSTs in the 3rd year of the program and other students in the 2nd year of the training program. The selection of participants is based on the willingness of prospective teachers to fill out a volunteer form, which requires PSTs to be students who have taken courses in Organic Chemistry and Inorganic Chemistry in which the context of chemistry in coloring has been discussed. PSTs have received Organic Chemistry lectures which discuss secondary metabolites that affect color in plants, as well as Inorganic Chemistry lectures which discuss complex reactions on metal elements in the binding of textile dyes. Participants were selected based on the results of the development of the course project on the eco-printing that had been made and the willingness of PSTs to follow the series of processes. Details of the characteristics of PSTs participants can be seen in Table 2.

Table 2. Description of participants in research

No	Characteristics	N	No	Characteristics	N
A	Gender			b. Mother's Education	
	1) Male	5		1) <Elementary School	1
	1) Female	17		2) Elementary School	9
B	Family Background			3) Junior High School	7
	a. Father's occupation			4) Senior High School	4
	1) Teacher	4		5) Bachelor's Degree and above	1
	2) Government Employees	1	C	Obtaining Allowance from Parents	
	3) Farmer	5		1) Yes	20
	4) Traders	1		2) No	2
	5) Labor	5	D	Business Ownership/Part-Time Work	
	6) Tailor	1		1) Yes	8
	7) Entrepreneurship	3		2) No	14
	8) Not Working	2	E	Type of Business / Work Part-Time	
	b. Mother's occupation			1) Mentor at the Tutoring Institute	4
	1) Housewife	10		2) Selling Food	1
	2) Teacher	1		3) Online Shop	3
	3) Farmers	1	F	Income from Part-Time Work / Business	
	4) Traders	2		1) < IDR 1,000,000 (USD 69.03)	7
	5) Labor	3		2) IDR 1,0000,000 – IDR 2,000,000 (USD 69.03 – USD 138.05)	1
	6) Entrepreneurship	5	G	Participation in entrepreneurial development activities	
	c. Father's Education			1) Yes	19
	1) <Elementary School	1		2) No	3
	2) Elementary School	5			
	3) Junior High School	6			
	4) Senior High School	6			
	5) Bachelor's Degree and above	4			

The Intervention

Interventions for PSTs include three main phases of the design thinking stage (Gibbons, 2016) which consist of (1) Understand; (2) Explore; and (3) Materialize. In the first phase, PSTs are directed to analyze the understandings of product design users and determine problems based on research and field findings. In the explore stage, PSTs have the opportunity to create various product development ideas and design prototypes. In the final stage, PSTs test the product to users, evaluate the feedback provided by users and improve the quality of the final product.

Results and Discussion

The Stages of Design Thinking Process on the Eco-Printing STEAM-Project

Design thinking is a perspective that is accompanied by a process. This perspective involves a direct, user-focused approach to solving various problem findings that lead to product innovation that is differentiated and competitively superior (Gibbons, 2016). The framework of design thinking includes a series of stages 1) understand, 2) explore, and 3) materialize. These three stages include six phases, in which the understanding phase includes empathizing and defining phases, the second phase includes ideating and prototyping, and the last phase consists of test and implementation phases.

Stage of Understanding in Design Thinking Process

In the first stage, PSTs try to develop knowledge about what users do, say, think, and feel. This is the empathize phase of the design thinking framework series. PSTs researched to develop their knowledge related to textile dyeing techniques with eco-printing technology. Eco-printing is an environmentally friendly coloring technique through dyes made using a selection of natural materials, such as fruit, flowers, and plants that can be used for clothing, linens, curtains, and even paper (Brojt, 2021). This is done by mixing it into a paste or boiling it into a liquid or using the pounding technique. The use of natural dyes mostly involves the presence of metal ions (mordant) which can form chemical bonds between textile fiber polymer chains and adsorbed dyes (Dean, 2010; Montazer et al., 2004) to increase the colorfastness of the dyed fibers (Prabhu & Teli, 2011). This is as shown in Figure 2. by illustrating one of the natural dyes, namely alizarin. Natural dyes include reactive dyes because natural dyes are dyes that can color cellulose fibers. Textile fibers have a negative charge while dyes in general also have a negative charge. This is what causes the diffusion of dyes in textile fibers to be hampered. Therefore the reactive groups of dyes which can be in the form of triazine, pyrimidine, konoaxali, vinylsulfon, or acrylamide are easily released. After releasing the reactive group, the reactive dye will be positively charged which can react by addition or substitution with the negative group of the cellulose fiber (Kasipah et al., 2015).

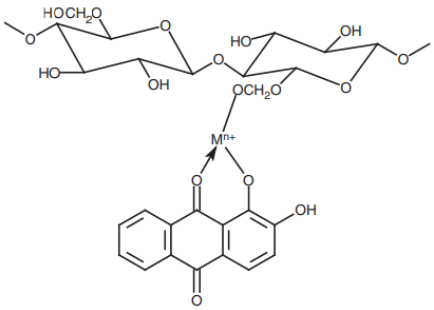

Figure 2. Chemical bonding between natural dyes (illustrated is alizarin) and cellulose through the presence of mordant (Mn+) (Ding & Freeman, 2017)

In empathize phase, PSTs in groups tried to understand eco-printing techniques by testing various natural materials to produce color variants, as well as testing the composition of the mordant materials. The simple mordants they used were alum, limestone, and chalk (Figure 3.). In the end, the choice of the most appropriate mordant material for their project was alum, and vinegar was used to clean the impurities on the leaves used for coloring and motifs, as well as to sharpen the colors obtained from natural materials.

Figure 3. PSTs try to consider various materials that are mixed in natural dyes and fabrics to obtain an accurate composition and eco-printing technique.

Understanding the concept and practice of making eco-printing, the PSTs group also tried to review the market potential and condition of product competitors around them (Figure 4.). Comparative study activities and small group discussions were carried out with eco-print entrepreneurs as resource persons and also teachers at one of the vocational high schools in Kudus Regency. The results of the product diversity information obtained from

this resource show the potential for further development of eco-print products that can be created by PSTs. This stage is the defining phase, in which the PSTs have been able to determine user needs and begin to highlight opportunities for product innovation. During the "empathy" and "defining" phases, students can engage directly with their peers to understand community needs related to the design of the product to be created (Dotson et al., 2020).

Figure 4. Comparative study of eco-print products and small group discussions

Stage of Exploring in Design Thinking Process

The second stage is the exploration process which begins with the ideate phase. This stage emphasizes the process of brainstorming various creative ideas to meet user needs identified in the define phase. Each PSTs are given total freedom to express their ideas for the process of implementing the eco-print product commercialization project. PSTs determine the division of teams and work consisting of 1) development team including a) Leader group, b) Media Team, c) Technical Team, d) Promotion Team, and 2) Production team. This process conditions that teaching is a collaborative work that ultimately distributes a variety of skills. This is contrary to the concept that prospective teachers must have the same knowledge (Paulino Preciado Babb et al., 2016). Through this design thinking process, each PST has great potential to contribute to the eco-printing of the STEAM project. PSTs coordinate teams to exchange ideas and combine ideas. In this phase, the results of collaborative ideas are obtained with several important points for the next stage which includes product development variants, product branding, and technical implementation of production. The details are shown in Table 3.

Table 3. Various ideas emerged and were compromised at the ideate stage.

No	Items	PSTs' Ideas
1	Product variant	Tote bag
2	Product branding	The product brand is "Tabassam" with the tagline "*Menyapa Alam dengan Seyuman*" (Greet nature with a smile). The logo brand is as shown in the picture. 
3	Production technique	1) Pre-production schedule and location 2) Recipes on the composition of materials, techniques, and types of fabrics for trial activities. The method or technique used is the pounding technique without steaming, and the mordanting process is carried out at the beginning before the design is printed and after the design is formed. The materials are calico fabric and canvas which are used for the production of tote bags.

After creating ideas, PSTs execute existing ideas through eco-print-based product production activities. PSTs try to create various motifs with predetermined techniques and print them on materials that have also been selected in the previous stage. Some of the motif design results in this phase are shown in Figure 5. This stage is the prototype phase. The results of this prototype will be tested at the next stage to obtain the final results that will

be implemented. The ideate and prototype phases are multiple alternative phases in short iterations (Carlgren, 2016). The group then presented the design matrix, explained resource constraints, and received feedback from peers (Dotson et al., 2020).

Stage of Materializing in the Design Thinking Process

At this stage, the development product has been obtained. Before arriving at the stage of implementing the product, testing is carried out first. The test was carried out by reviewing the responses of several respondents qualitatively on the designs that had been made, as well as testing prices and marketing processes. The results of design changes at the prototype stage are shown in Figure 5.

Figure 5. Design of motifs and products in the prototype phase, as well as their change in the test phase.

Trials were also carried out on the suitability of prices with consumer interest in marketing activities. Trials on promotion and marketing were carried out through social media accounts via Facebook and Instagram. The official Instagram account for the promotion is the IG account: @tabassam.eco. However, the social media accounts of each PSTs and the student community also support the promotion of the Tabassam eco-printing product as shown in Figure 6.

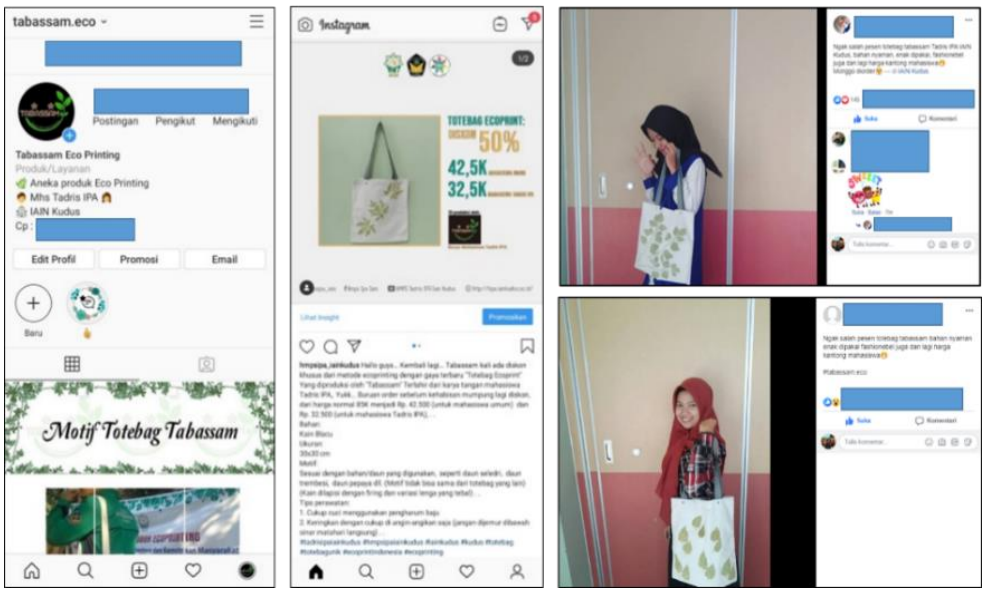

Figure 6. Several promotional techniques are carried out by the developer PSTs group through official product accounts (Instagram), student community accounts (Instagram), and PSTs personal accounts (Facebook).

The trial results of offering prices to the market and promotions through social media indicate a positive response from the public to PSTs products. For 1.5 months, 122 tote bag orders were obtained. At this stage, the organizational work design pattern is implemented. Due to limited human resources and time, the PSTs team limited the number of orders even though they had tried to also carry out partnership activities with the community. Production is carried out in 10 stages of production as shown in Figure 7. The weakness of the PSTs group in organizing a large number of orders at this stage has not been overcome. The design of the production organization will be further improved at the stages in the design thinking process cycle in the next period.

Figure 7. The production process to fulfill Tabassam product orders.

The PSTs group also introduced this tote bag through exhibitions and workshops. PSTs also think about packaging so that the resulting product is suitable as a souvenir and looks practical when it is in the hands of consumers. Products that are ready to sell and arrive at the hands of consumers as shown in Figure 8.

Figure 8. The final design of Tabassam products that are ready to be accepted by consumers.

The three stages in the design thinking process cycle in the PSTs' ESE strengthening process have been carried out by considering the time aspect of PSTs. This is because PSTs must also consider that they are students who should complete their studies. Teamwork and good time management are key in this process. The existing stages not only teach the product design process, but also the design of the teamwork pattern that is formed. Lecturers act as guides to stimulate conversation and research by PSTs. PSTs are allowed to evolve through the design and redesign phases of the design process, this is where creativity and problem solving begin to grow (Mayes et al., 2018). 21st-century learning can be driven by the process of design thinking through its application in complex interdisciplinary projects in a holistic constructivist manner (Scheer & Plattner, 2011). One of the forms of this project is the production and marketing of eco-print products. As a holistic concept, design thinking enables participants to work successfully collaboratively in a multidisciplinary field of study to solve difficult real-life problems (Rauth et al., 2010).

The Entrepreneurial Self-Efficacy of Pre-Service Science Teachers

One of the things that PSTs must have to start entrepreneurship is entrepreneurial self-efficacy (ESE) which is an important starting point for the intention to open a new business (Barbosa et al., 2007). ESE is an important factor in encouraging one's entrepreneurial intentions (Krueger, 2003). Entrepreneurial self-efficacy describes the self-confidence that leads to the behavior of someone who successfully runs the entrepreneurial process (Hisrich et al., 2017). In a recent study, it was found that self-efficacy in entrepreneurship in individuals can be increased through training and education. PSTs' ESE was reviewed from five indicators and analyzed their condition before and after the completion of the design thinking stage in the strengthening program through the eco-printing project. The details of the changes are shown in Figure 9.

Figure 9 shows the most visible change conditions in the "searching" aspect. In each indicator, there is an increased condition as referred to in recent research that self-efficacy in entrepreneurship in individuals can be increased through training and education (Hisrich et al., 2017; Wijangga & Sanjaya, 2018). Santrock (2011) also stated the importance of students having work readiness before entering a career. Therefore, the introduction to the world of entrepreneurship with the formation of comprehensive competencies is considered important for students (Wijaya, 2007). Entrepreneurship education for students, especially in Indonesia, can be one of the factors driving the emergence of entrepreneurial intentions. A good education will increase entrepreneurial self-efficacy so that it raises entrepreneurial intentions. Entrepreneurial self-efficacy is a construct that shows that behavior, cognition, and the environment are interconnected (Wijangga & Sanjaya, 2018). ESE is the degree to

which a person believes or believes that he or she can successfully start and run a new business (Bandura, 1997). In this study, the detailed conditions of changes in each indicator and their level of significance are shown in Table 4.

Figure 9. PSTs' ESE changing conditions on each indicator

Tabel 4. Categorization of conditions and significance of PSTs' changes

No	Aspect	Mean response per item		Rank			Sig	Significance of the difference (<.005)
		Pre-program	Post-Program	[-]	[+]	Ties		
1	Searching	3.74 (H)	4.08 (H)	3	14	5	0.003	Significant
2	Planning	3.57 (M)	3.81 (H)	2	11	9	0.006	Significant
3	Marshaling	3.67 (H)	3.77 (H)	7	12	3	0.423	Not significant
4	Implementing-people	3.70 (H)	3.74 (H)	9	10	3	0.731	Not significant
5	Implementing-financial	3.77 (H)	3.83 (H)	9	9	4	0.597	Not significant
Entrepreneurial Self-Efficacy		3.69 (H)	3.85 (H)	9	13	0	0.338	Not significant

(H) = High category; (M) = Medium category

Table 4 shows that category change only occurs in the “planning” aspect, namely from the medium category (M) to the high category (H). While the significance of the changes can be seen in two aspects, namely the "searching" and "planning" aspects. The “searching” aspect is an aspect that involves unique ideas and their development by PSTs. This aspect refers to creative talent and the ability to innovate. Entrepreneurs differ from managers in terms of their ability to understand and take advantage of opportunities that exist before they are recognized by many people (Hisrich et al., 2017). This shows that the eco-printing project provides an overview of unique ideas and business opportunity ideas that are meaningful to PSTs. This aspect is contained in a series of activities in the "Understanding" and "Exploring" stages. The search for the right formula for production activities, design, promotion techniques, and marketing is something that is mostly done by PSTs.

In the planning aspect, PSTs through the team initiate activities which consist of activities in which entrepreneurs turn ideas into viable business plans. At this stage, the PSTs are not actually writing a formal business plan. However, the PSTs group tried to evaluate the possibilities needed to initiate ideas related to an eco-printing idea project. PSTs carry out planning activities at the “Exploring” and “Materializing” stages. The plan answers questions such as: Who are the target customers? Where is the production location? What are the product specifications? How and by whom will the product be produced? What is the initial cost? What is the cost of recurring operations in doing production? Will the business be profitable? (Mcgee et al., 2009). The aspect of self-efficacy in planning shows a change in the level category from medium (M) to high (H), and is significantly different.

In the marshaling aspect, there were no significant changes in categories and differences. This aspect involves assembling the existing resources in the PSTs group. To realize the previously planned business, entrepreneurs collect various necessary resources such as capital, labor, customers, and suppliers for business sustainability (Mueller & Goic, 2003). In this activity, the production process is carried out in one cycle of the design thinking process and is only used to fulfill the order target for one month. This aspect has not seen any significant changes considering the product development process has not been done much in the design thinking cycle period. This marshaling phase includes assembling natural and human resources to make the existing business

concept a reality (Mcgee et al., 2009). The phase carried out in this research is only at the initiation stage and has not been processed in a continuous cycle. During this initial process, the skills of this aspect have not yet developed in PSTs.

Table 5. PSTs' responds to the ESE strengthening program through an eco-printing project

No	Statements	Number of Answers		
		Yes	No	Maybe
1	[-] When it comes to bringing materials for eco-print production activities such as leaves, cloth, and so on, I feel bit awkward or embarrassed.	1	20	1
2	[-] I feel it is inappropriate if I have to be involved in the eco-print production process because it is a job that involves hand labor (coolie work).	0	21	1
3	[+] I don't hesitate to show my eco-print to my family or friends.	17	5	0
4	[-] I feel awkward using my own eco-print products.	0	22	0
5	[+] I enjoy promoting my eco-print products both directly and through social media.	19	0	3
6	[+] I feel I can inspire others through my eco-prints	17	1	4
7	[+] I want other people to be interested and buy my eco-print	21	0	1
8	[+] I hope to profit from my eco-print products	17	1	4
9	[+] I am proud to introduce and sell eco-print products to the wider community.	22	0	0
10	[+] I want to have many partners in producing and marketing eco-prints.	22	0	0
11	[+] This eco-printing project taught me how to behave, act well, and be ethical	20	0	2
12	[+] In the eco-printing project, I learned some knowledge related to science material	20	1	1
13	[+] Through the eco-printing project, I am motivated to hone my skills and skills in entrepreneurship (not only eco-print production).	18	0	4

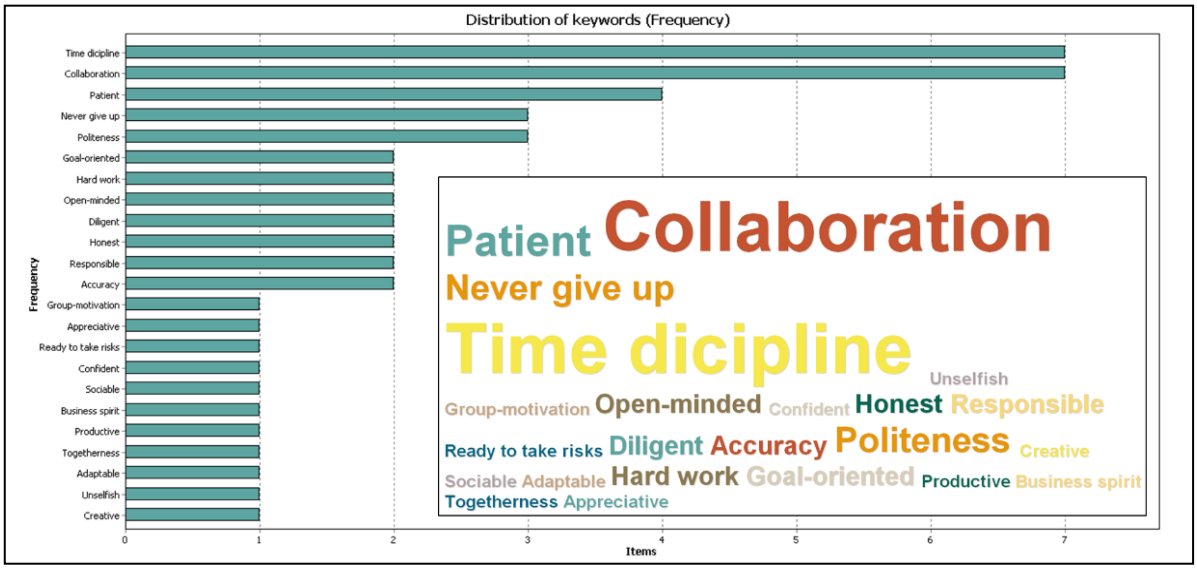

Figure 10**.** PSTs' responses to what was learned in the process of the eco-printing project

Another aspect that is part of the ESE is the implementation aspect which also in this study did not change in the category of efficacy level, and there was also no significant change. This aspect shows the entrepreneur's belief in being responsible for developing the business and sustaining the business through its growth period. This aspect includes the human and financial components. As entrepreneurs, PSTs must have confidence in strategic planning and managing various business relationships with suppliers, customers, employees, and capital providers. In addition, PSTs are the main risk bearers in eco-printing projects where this risk is always in the financial interest as long as the business grows and achieves its long-term success (Mueller & Goic, 2003). The short program duration for the materializing stage has not been able to show significant changes in the implementation aspects of PSTs' ESE. Thus, the overall change in ESE has not shown a significant difference, although it can be seen that before the implementation of the strengthening program, the average PSTs' ESE was

already at a high level. Only in the aspect of searching and planning, the condition of strengthening the efficacy of PSTs in starting entrepreneurship through eco-printing projects can be shown significantly.

The strong condition of ESE is also shown by the pattern of responses to statements related to the eco-printing project as shown in Table 5. In general, the answers show that the PSTs have a positive response to what they do. PSTs also provide an overview of responses to entrepreneurial attitudes that have been learned during the process of strengthening programs (Figure 10.) which are dominated by “Collaboration” and “Time discipline” responses.

Conclusion

The strengthening program for PSTs' ESE is carried out through mentoring which is constructed through a STEAM approach with a design thinking paradigm. The design thinking paradigm includes the stages to produce products through eco-printing technology which include 1) understanding, 2) exploring, and 3) materializing. The design thinking with the STEAM paradigm can teach PSTs to work together successfully by solving the problems and challenges of eco-printing products, namely the design of development products and the acquisition of profits on product sales. PSTs have succeeded in proving the implementation of the stages to the implementation phase and showing that tote bag products can be sold and profitable. However, not all aspects of PSTs' ESE changed significantly during the process.

Self-efficacy in the aspects of "searching" and "planning" has changed significantly during this action research. From the start of the program, PSTs' ESE has been at a high level. The changes in ESE in all aspects did not show a significant difference. The PSTs’ responses showed positive conditions on what has been done during the eco-printing project process. The response during the process showed the expression of words that are dominated by "Collaboration" and "Time discipline".

Recommendations

This research has limitations, namely, it is only carried out at one stage of the design thinking cycle and on a limited variety of eco-print products. In the future, components on duration, product variety coverage, and expansion of PSTs work patterns by involving partnerships with surrounding communities need to be followed up. Thus, the focus of the design of PSTs is not only on the product, but also on the managerial work of the team in the production process, management, and product promotion.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in JESEH journal belongs to the authors.

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The Effects of Augmented Reality Applications on Secondary Students' Academic Achievement in Science Course

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Abstract

The aim of this study is to investigate how the use of augmented reality (AR) applications in educational environments affects students' achievement levels. The study was carried out through two dimensions; a quantitative and a qualitative aspect. The study was conducted with 7th-grade students in a public secondary school in Turkey as part of a science course. For this purpose, AR applications and activities were implemented that were suitable for the topic of Astronomy. The quasi-experimental model and one of the quantitative research methods were used for the study. As data collection instruments an achievement test and an interview form were made use of. AR activities were used for teaching in the experimental group, while the traditional method for the control group. The quantitative results of the study showed that there was a significant difference in the achievement level of learners in favor of the experimental group. The interviews with the students revealed that the AR applications used in the course were interesting, that they increased interest, desire, and motivation in class, and that they facilitated learning. However, students indicated that the cost of the AR materials was high, that they had difficulty in obtaining the materials, and that they sometimes had technical problems. Another limitation was expressed as that the excess the number of students makes it more difficult to take the advantage of AR activities. Students suggested that lowering the cost of AR materials and using them in other lessons can be more effective in learning environment.

Introduction

Information and communication technologies (ICTs) that facilitate our daily activities have gradually become an integral part of our lives and a necessity. As ICT becomes increasingly important in our daily lives, the effective use of technological tools is also getting more important in education day by day (Alkan, 1999). The use of technology improves students' interest and motivation in the course and makes it easier to memorize the subject. In addition, the information presented to students is conveyed in a simpler way through technology so that they can have concrete learning experiences (İşman et al., 2002). It is believed that technology should be used by teachers and students to improve the quality of education (Çakır & Yıldırım, 2009). This situation has led to the need for societies to follow and adopt new technological developments that play significant role in the development of the educational process (Uşun, 2003). Many countries are seriously investing in integrating technology into the education system to ensure the quality of education and train their citizens according to the needs of modern society (Topuz & Göktaş, 2015). Various technology-producing countries, especially the U.S. and EU countries, have begun to use technological developments in education. However, to get the most out of technology, it is necessary to properly understand education and training based on virtual and digital technologies.

Nowadays, there are many innovations related to the use and application of technology in education. A number of innovations, methods, and technologies can be used in education, especially in situations that are invisible, intangible, and problematic. These innovations in educational technology support and enrich education to address the shortcomings of the traditional method. One of the new technologies entering the educational environment is AR technology, which has the potential to combine virtuality and reality. The goal of this technology is to allow people to interact with both digital space and the real world. AR technologies that can be accessed via applications downloaded to vehicles, such as smartphones and tablets, are becoming increasingly popular due to their ease of use.

One indicator of the increasing influence of information and communication technologies on education is the rapid development of AR applications in recent years (Arici et al., 2019). This technology has changed and evolved over time and has come to the present in a systematic change. Although the birth of AR dates back to earlier times, this concept was first titled by Tom Caudell in 1990 (Lee, 2012). The first examples of applications of AR are cameras attached to simulators, helmets, and wearable vehicles. With the development of communication and technology, the applications have acquired various functions. These technologies became widespread through the use of pilot schemes in the 1990s. Before 2010, many applications of AR were complex and high-cost systems. One of the most important reasons for the rapid spread of AR technology and its easy accessibility is that it has moved away from expensive and complex equipment (Wu et al., 2013). Especially with the integration of AR applications to mobile devices, the number of these applications has increased in recent years. In 2012, Google Glass, which is produced based on AR technology and described as a wearable technology, was introduced by the Google Company and an important step was taken for this technology. In 2016, Microsoft developed the HoloLens, which offers its users a mixed reality experience. Also in July 2016, the game Pokémon Go was released. In addition, the use of tools and devices such as smart glasses, 3D projections, laptops, tablets, and mobile phones for AR applications is increasing day by day. Rapid development, especially in smartphones and tablet computers, has meant that applications of AR can no longer be used only in the laboratory environment, but can also be easily accessed and run on smart devices (Batdı & Talan, 2019). Therefore, these technologies have created new alternatives to improve the educational environment and become an easily accessible technology for everyone (Garzón, Pavón & Baldiris, 2019; Ozdemir et al., 2018). The annual reports of Horizon highlight that AR applications will have a significant impact on education soon (Arici et al., 2019; Cai, Wang & Chiang, 2014). The same report emphasizes that AR will be widely used in higher education in the medium term (Johnson et al., 2016). The report, published by Educause, also predicts that the use of AR applications will be popular in higher education and K-12 schools (Fidan & Tuncel, 2019; Pomerantz, 2018). The use of AR in education will have an important place in the entertaining teaching process by simplifying complex information and making abstract concepts concrete.

The purpose of virtual reality (VR) is to create virtual environments that allow interaction free of the real world. AR, a derivative of VR (Azuma, 1997), bridges the gap between reality and virtuality (Azuma, 1997; Cai, Wang & Chiang, 2014; Carmigniani et al., 2011). This technology enables interactive experiences by enriching the real world with virtual elements, rather than creating a completely virtual and artificial environment (Höllerer & Feiner 2004). Unlike VR, AR aims to make virtual objects more interactive by building on real images (Batdı & Talan, 2019; Cai, Wang & Chiang, 2014). Therefore, AR technology differs from VR in that users are not completely disconnected from the physical world. In other words, the most characteristic feature of AR is the use of the physical and the virtual environment for a specific purpose. This concept can be briefly defined as an interactive platform that provides a combination of reality and virtuality (Akçayır & Akçayır, 2017; Azuma, 1997; Milgram & Kishino, 1994). In other words, AR is a modern technology that makes encoded multimedia content visible by adding a digital layer (e.g. video, graphics, animation, text or sound, etc.) to real objects generated by a camera (Craig, 2013; Taskiran, 2019; Yılmaz & Batdı, 2016). Therefore, AR is also referred to the enrichment of the real world in light of technological developments through various animation, sound and multimedia tools (Bower et al., 2014; Craig, 2013; Dunleavy, Dede & Mitchell, 2009; Rabbi & Ullah, 2013; Wu et al., 2013). AR is a new tool for human-machine interaction that embeds computer-generated digital information interactively in a real environment (Ong, Yuan & Nee, 2008; Wu et al., 2013). Thanks to the renewed and advanced technology of AR, it can be used on laptops, mobile devices, and smartphones. In addition, AR technologies are widely used in social media such as Instagram and Snapchat, which have a large number of users worldwide.

The Use of AR in Education

Although AR has been used for years with the help of computers, today it is used in many different applications in mobile and portable devices due to the changes and developments in the technological field. Thanks to the development of AR technology, it has been used in all fields in recent years. AR is used in various fields such as the automotive industry, military, medicine, tourism, construction, architecture, sport, entertainment, engineering, assembly, navigation, museology, maintenance, product design, telerobotics, marketing, and advertising (Altinpulluk, 2019; Fidan & Tuncel, 2019; Ong, Yuan & Nee, 2008). After successful results in these fields, the usage areas of AR technology have increased day by day. AR is also used in education, and many researches have been conducted in this field in recent years. With the widespread use of mobile devices, the applications of AR, which are used in education, are updated and their number is rapidly increasing. AR applications are also designed to work with more and more different devices and systems as technology advances. For example, AR applications have begun to be used in wearable tech products as well as mobile

devices. With the use of AR applications in education, beneficial content is put into a fun and interesting form and presented to students. The use of AR in education is a very important development in terms of effectiveness, efficiency and accessibility in teaching and learning process.

AR is a popular technology that has added a new dimension to education and has become the focus of educational research in the last decade (Ibáñez & Delgado-Kloos, 2018; Sırakaya & Alsancak Sırakaya, 2020). A good many studies have highlighted trends, benefits, opportunities, challenges, and impacts of AR technology on education. The most important point in using AR technology in the classroom is that it is appropriate to the level of the students and the curriculum of the course, and the process is carried out regularly. Moreover, this technology provides opportunities for learning experiences and teaching processes by creating an interactive and immersive environment (Bujak et al., 2013; Dunleavy, Dede & Mitchell, 2009; Fidan & Tuncel, 2019). Unlike traditional methods and techniques, the use of technology in science education with AR applications is of great importance to schools where the laboratory environment is not accessible. Therefore, the AR technology can also be used as supplementary or evaluative material, especially in the context of laboratory or workshop studies and virtual classroom activities.

It can be stated that schools are becoming more technological every day and many new technologies are being used in the classroom to meet the age and expectations of students and enhance their learning. One of the technologies whose effectiveness in education has been widely studied in recent years is AR. Since it has been observed that more than one sense can be actively used when using this technology, it is assumed that real learning experiences can be made with this technology. Thanks to its features, AR technology has managed to attract attention of learners in all levels of education from preschool to university (Sırakaya & Alsancak Sırakaya, 2020; Talan, 2021). In fact, research shows that AR technology is suitable for all ages (López-Belmonte et al., 2020). AR can be used many different disciplines such as science, foreign language teaching, geography, mathematics, and geometry (Altinpulluk, 2019; Sırakaya & Alsancak Sırakaya, 2020; Taskiran, 2019). One of the areas where AR can be used effectively is astronomy education. Because of its relationship to the basic sciences, astronomy occupies a very important place in science education (Kurnaz & Değermenci, 2011). People who do not receive a good astronomy education are exploited with topics such as astrology, horoscopes, fortune-telling, UFOs (Unidentified Flying Objects), and aliens (Düşkün, 2011). AR is one of the immersive technologies that, thanks to its potential, it could be promising to mitigate the challenges in astronomy education.

Today's and future students, growing up with technology, want their educational environment to be integrated with innovative approaches such as AR-based applications (Altinpulluk, 2019; Klopfer & Yoon 2004). It should also be mentioned that scientific studies on AR have gained momentum and some researchers have started to attract attention. In fact, the studies show that AR brings a different dimension to education and offers many advantages in education. For example, AR technology can increase interest, desire, attention, and motivation in the classroom by activating students (Chen & Tsai, 2012; Huang, Chen & Chou, 2016; López-Belmonte et al., 2021; Sumadio & Rambli, 2010; Wojciechowski & Celary, 2013) and creating an effective and productive learning environment (Iordache, Pribeanu & Balog, 2012; Sırakaya & Alsancak Sırakaya, 2020). In addition, AR makes abstract concepts concrete (Cheng & Tsai, 2013; Martin-Gonzalez, Chi-Poot & Uc-Cetina, 2016; Yoon et al., 2017). As a result, students learn the concepts more easily and accurately. In addition, AR enables students to learn by doing and increases student engagement in the classroom by making lessons more fun (Giasiranis & Sofos, 2017; Wojciechowski & Cellary, 2013; Yoon et al., 2012). Some studies have shown that AR applications have a positive impact on learning outcomes such as academic success, motivation, attention, attitude, and retention in the learning process (Akçayır & Akçayır, 2017; Batdı & Talan, 2019; Erbas & Demirer, 2019; Fidan & Tuncel, 2019; Talan, 2021). The common finding of various studies is that AR technologies can increase learning motivation, the learning process and effectiveness (Tzima, et al., 2019). With these aspects, it can be said that AR applications are a useful alternative to traditional teaching materials. For this reason, AR has become a topic that increasingly attracts the attention of educators and academics because of its possibilities and potential.

Although AR offers many benefits to learners and educators in education, its limited aspects hinder its widespread use. But these limited aspects do not have a significant effect on disusing AR technology, it is important to be informed in order to take precautions at some points. In the literature, excessive cognitive load in multiple and mixed tasks (Cheng & Tsai, 2013; Fidan & Tuncel, 2019; Wu et al., 2013), lack of usability (Akçayır & Akçayır, 2017), monitoring and calibration issues, and difficulties in social acceptance (Van Krevelen & Poelman 2010) are cited as limitations of AR applications (Altinpulluk, 2019; Batdı & Talan, 2019; Fidan & Tuncel, 2019). In addition, hardware and technical problems are also considered important limitations (Dunleavy & Dede, 2014). The difficulty of developing AR instructional materials (Chang, Chung & Huang,

2016) and the limited number of AR instructional materials are also barriers for the use of AR in education (Sırakaya & Alsancak Sırakaya, 2020). The fact that devices such as tablets, smartphones, computers, in which the AR technology is used, do not have sufficient hardware functions, leads to some limitations. One of the disadvantages is that content development is difficult and time-consuming. Such problems can cause significant disruption by hindering the applicability of AR technology. However, to achieve successful implementation, the applications of AR should be well designed and necessary precautions should be taken to identify such negative aspects. On the other hand, the suitability of such applications for the content of the course and the target audience (students) is very important, and the limitations on this point also affect the success of the applications.

Purpose of the Research

One of the most used and searched topics in recent times is AR applications. The use of these applications in education is important to bring innovation in education. Based on the research results, it was found that the use of AR applications in education has a positive impact on the learning environment (Batdı & Talan, 2019; Erbas & Demirer, 2019; Fidan & Tuncel, 2019; Iordache, Pribeanu & Balog, 2012; Sırakaya & Alsancak Sırakaya, 2020; Wang & Chi, 2012). Although there are many researches on this topic in the literature, it can be seen that there are still deficiencies in this topic (Eroglu, 2018; Kucuk, Kapakin & Goktas, 2016; Sahin & Yilmaz, 2020). In addition, although various scientific topics have been addressed in research on the impact of AR, the topic of astronomy has not been explored in detail. It can also be said that there is prejudice against the use of the application by teachers and even students because it is difficult to develop AR applications specifically for educational environments and these applications require knowledge.

AR is important to enrich the learning environment, provide students with a realistic environment related to the subject, and create an environment where they can learn by seeing abstract concepts more clearly. In this way, students can make a connection between the real world and virtual objects without being isolated from the real environment in which they are located. Also, it is believed that by using AR technology in astronomy lessons, the content of the subject is visualized, student participation and interest increases together with their success, attitudes and motivation towards the lesson. Thus the information they learned becomes more permanent. Similarly, in the literature, it is come out that applications such as AR enrich the written content of instruction, help students develop a different perspective, and increase learners' interest in instruction (Çakır, Solak & Tan, 2015).

Elementary and middle school students have difficulty in understanding complex abstract concepts. For example, the abstractness of basic astronomy concepts prevents students from understanding the material and negatively affects their attitudes toward the courses (Sahin & Yilmaz, 2020). To overcome these difficulties, abstract concepts in science should be made concrete through the use of visuals in the classroom. In this way, a more meaningful learning environment can be created in which better learning outcomes can be expected. For the future of education, it is important to study the impact of the use of AR in education, to show the results in each area of education, and to reveal the negative aspects. In addition, the advantages of using AR in educational environments have a significant impact on the selection of this technology within the scope of the study. Considering the importance of the applications of AR, this study aims to investigate the effects of AR technology on secondary students' achievement in science course. In addition, students' opinions and assessments regarding the use of the AR applications were determined. It is expected that these opinions obtained from students will contribute to other studies in the field of developing and evaluating the course environments supported by AR applications. For this purpose, an experimental and a control group were created. The group taught with the AR application was referred as the experimental group while the group with the traditional face-to-face learning environment was as the control group. In accordance with the purpose of this study, answers to the following research questions are sought:

1. Is there a statistically significant difference between the academic achievement post-test mean scores of the experimental group and the control group?
2. What are the opinions of the students in the experimental group about the applications of AR?

Method

This section provides explanations of the research design, study group, experimental process, data collection instruments used in the research, and analysis of data in accordance with the research objectives.

Research Design

This research examined the effects of AR applications on students' academic achievement in a 7th-grade science course. For this purpose, the study used an explanatory design, which is one of the mixed research methods. This design consists of two phases. In the first phase, data are collected and analyzed using quantitative research techniques. Then, the quantitative data is examined in more detail by using the qualitative method (Fraenkel et al., 2012; McMillan & Schumacher, 2010).

A quasi-experimental research technique was used for the academic achievement test in the quantitative dimension of the study. Quasi-experimental studies are used in cases where subjects in the experimental and control groups are selected by measurement rather than randomly. Also, in these studies, it is randomly decided which group will be the control or experimental group (Ekiz, 2003; Fraenkel et al., 2012).

Before the experimental process, pre-tests were administered to both the experimental and control groups to determine the students' prior knowledge. Students in the experimental group implemented the content of the 7th-grade astronomy course with the AR activities. Students in the control group, on the other hand, followed the traditional curriculum. After the experimental process, a post-test was conducted to determine the learning success of both control and experimental group students. Qualitative data were collected after the experimental procedure to investigate and elaborate the quantitative data and to ensure the validity and reliability of the research. For this purpose, the opinions of the experimental group students regarding the AR activities were obtained.

Study Group

The study group of the research consisted of 7th-grade secondary school students in Turkey. The research was conducted in science course.

Table 1. Gender distribution of the experimental and control groups

Groups	Female		Male		Total	
	f	%	f	%	f	%
Experimental group	6	35	14	67	20	53
Control group	11	65	7	33	18	47
Total	17	100	21	100	38	100

As indicated in Table 1, a total of 38 students, 17 female, and 21 male, participated in the study. 20 of the participants were in the experimental group while 18 were in the control group. Experimental and control groups were randomly selected in the study.

Experimental Process

Prior to the experimental process, a course plan was prepared for teaching subject to the experimental group. While preparing the course plan, a collaboration with science teachers and filed experts was made and the content, objectives, and outcomes of the lesson were took into account. In addition, the materials, activities, and functions of AR were determined in accordance with the course plan which would be used only in the experimental group. The prepared materials were reviewed by the course instructor and three experts in the field. Based on their feedback, the necessary corrections were made. In addition, the materials were tested in a different class and researchers put a final touch on the materials and activities before applying them in the experimental group.

All the students selected for the research were informed about the purpose of the study, the requirements of the course, and the procedure of the implementations a week before the applications. Once the control and experimental groups were determined, a pre-test was used. The course instructor taught both the experimental and control groups each week according to the syllabus. But students in the experimental group participated in activities using classroom applications of AR. These applications were used for three weeks under the supervision of the course instructor. The students in the experimental group learned 3D content and videos on smartphones, tablets, and smartboards by using the AR activities in the classroom. The students in the control group, on the other hand, learned through the traditional methods like following the pictures and examples in

their textbooks, listening to the instructor and participating the activities just when questions are directed to them. Sample images for the AR application can be found in Figure 1.

Figure 1. Sample images for the application process of the experimental group

Tools such as flash cards, virtual reality glasses, smartphones, laptops, and tablets have been provided to ensure that the application runs more effectively and that there are no problems. Space 4D +, an AR application that enables spacecraft to move, was installed on these tools. AR applications were used in the course, where images of the planets were obtained by reading flash cards through tablets, phones, and computers. In addition, virtual reality glasses and the images from the tablet were provided to the students in the experimental group so that all students could see and examine well. The function in the course was systematic and orderly, the preparations were completed before the beginning of the course and the applications were conducted according to prepared specific plan regarding the curriculum. At the end of the experimental process, an achievement test (post-test) was administered to the experimental and control groups to see the effect of the AR applications. In addition, an interview was carried out with the students who volunteered in the experimental group. They were requested to express their opinions about the implementation process. The experimental process of the study was schematized and presented in Figure 2.

Data Collection Instruments

In the quantitative dimension of the study, achievement tests (pre-test and post-test) were used as instruments for data collection. The achievement test was used by the researchers to determine the effects of AR applications on students' academic achievement in science course. The achievement test was prepared by Arıcı (2013) based on the unit entitled as "Solar System and Beyond" in the 7th-grade science course. The achievement test consists of 20 questions with 4 options. The necessary calculations for the validity and reliability of the test were performed. The Cronbach's Alpha coefficient of the test was determined to be as 0.73. The value of Cronbach's alpha which is among $0.6 \leq \alpha < 0.80$ means that the scale is quite reliable.

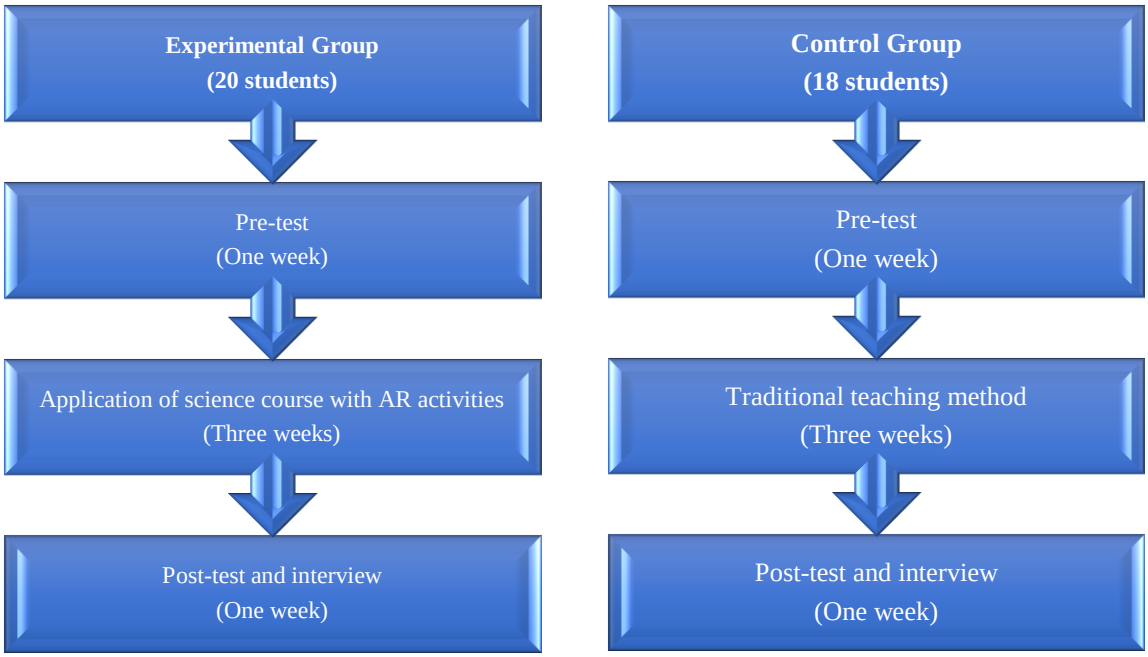

Figure 2. Experimental process

In the qualitative dimension of the research, a semi-structured interview form developed by the researchers was used. This form was prepared at the end of the research to find out the opinion of the students in the experimental group on the activities of AR. To ensure the validity and reliability of the interview form, two experts were interviewed in addition to the researchers. The necessary adjustments were made according to the experts' recommendations.

Data Analysis

In the statistical analysis of the quantitative data collected in accordance with the general aim of the study, the SPSS 18.0 Statistical Analysis Program was used. The conformity of the data to the normal distribution and the homogeneity of the variances were investigated in order to determine the appropriate statistical methods for the analysis of the data. For the assumption of normality, the Kolmogorov-Smirnov test was used, while for the determination of the homogeneity of the variances of the data, the Levene test was used. As a result of the analysis, it was decided to use parametric tests because the data set had a normal distribution ($p>.05$) and the group variances were homogeneous.

The independent sample t-test was used to analyze the data reached from the pre-test and post-test academic achievement of the experimental and control groups. Following the experimental application, a descriptive analysis of the qualitative data acquired from the interviews with the students was performed. In addition, the content analysis method was used to analyze the students' opinions. Content analysis is defined as reaching the concepts and relationships in order to explain the obtained data (Yıldırım & Şimşek, 2013). The content analysis directly quoted some of the students' opinions on each topic to ensure the validity of the study. The quotes were taken from the participants' interviews and were reproduced without any changes. Additionally, abbreviations (S1, S2, S3 …) were used to explain which student said each direct quote. To increase the reliability of the qualitative data analysis, coding was performed by two different experts apart from the researchers. In the study, the reliability formula (Miles & Huberman, 1994) was used to calculate the reliability of data analysis. As a result of the calculation, the reliability was found to be 92%. This result was accepted as reliable in the study. By the way, the MAXQDA 11 program was used to analyze and organize the qualitative data attained from the interview.

Results

The Results of the Academic Achievement Test in the Science Course

The difference between the post-test academic achievement results of the experimental group, in which AR applications were used, and the control group, in which traditional teaching method was used, was calculated through the independent sample t-test. In addition, the homogeneous distribution of variances was determined by using Levene test. The results of analysis were presented in Table 2.

Table 2. The results of the t-test with regard to the post-test results of the experimental and control groups

Groups	n	$\bar{X}$	sd	df	Levene		t	p
					F	P		
Experimental	20	11.92	1.87	34	2.746	0.117	2.318	0.035*
Control	18	10.19	2.93					

*p<0.05

Table 2 shows that the variances are homogeneously distributed [F=2.746; p=.117], and a statistical significance was determined between the post-test scores of the groups (t=2.318, p<.05). It was appeared that the value of significant difference was 1.75 and the difference was in favor of the experimental group ($\bar{X}_{experimental}$=11.92; $\bar{X}_{control}$=10.19). Related results show that students in the experimental group have higher academic achievement scores than students in the traditional learning method.

The Opinions of Students in the Experimental Group on AR Applications

Following the application of experimental process, students' opinions regarding the AR activities were obtained. In this context, students were primarily asked to explain their opinions about the contribution of AR applications to the learning environment. Their opinions are analyzed, turned into models and presented in Table 3.

Table 3. Contribution of AR applications to the learning environment

Providing effective learning and rich visual environments
Providing the opportunity to benefit from technology
Providing rich material opportunities
Providing research and questioning skills
Activating visual intelligence
Providing observation opportunity
Ensuring memorability
Providing easy learning
Offering the opportunity to reinforce
Permanent learning, enabling knowledge
Providing the opportunity to learn the realities of life
Providing efficient realistic and multidimensional learning opportunities
Providing detailed learning
Allowing easy learning
Arousing curiosity
Being interesting
Activating affective skills
Developing imagination
Offering the opportunity to embody
Being a remarkable application
Providing effective and productive classroom environments
Providing understandable learning

As it is presented in Table 3, students explain many opinions about the contribution of the AR applications to the learning environment. The application of AR has positive aspects such as the ability to embody something, providing rich material opportunities, being interesting, developing imagination and providing effective learning and rich visual environment. At this point, a student commented as "*I learned better because it was visual. In this way, I was able to acquire the knowledge better.*" (S5). Similarly, another student stated that "*It was so real that I felt like I was in the middle of the action. The pictures of the planets were very realistic.*" (S1) while the other one asserted that "*I was very fascinated by that. I would like to see us use this application in other lessons.*" (S9). Another student stated that "*I can say that using the AR application in the lesson makes learning more permanent. Thanks to the application, I understood the concepts more easily and my interest in the lesson increased.*" (S12). Another student said "*The application AR was fascinating for the subject. Moreover, the rich*

visual environments of the application make the lessons enjoyable and entertaining. This ensures easy learning." (S6).

On the other hand, the study comprised students' opinions on the negative aspects of the AR applications and their suggestions for solving the problems. The related opinions of the students are shown in Table 4.

Table 4. Negative aspects of the applications of AR and suggestions.

Categorty	
Negative Aspects of the AR applications	Having the student in the role of passive listener and observer
	Decreased student participation in class
	Lack of unity in the classroom
	Loss of time
	High cost
	Unavailability
	Confusing
	Everyone may not use it
	Teachers can be lagged behind
	Complicating different views
	Difficult to apply as the number of students increases
Suggestions Related to AR Applications	It can be explained by concretizing in an advanced dimension
	Suggestions should be taken at each step and continued
	Real sounds can be produced
	More realistic images should be created
	It should be more interesting
	Cost can be reduced
	It must be related to the astronomy
	It can be used in all courses
	Applicability level can be increased
	It should be projected onto the board with projection
	It should be projected somewhere in three dimensions
	Student should pretend to be in the moment
	Ensuring that experiments are carried out with an AR application

In Table 4, it is clear that problems such as the high cost, the fact that the teachers' being lagged behind, students' passive role, the difficulty to apply due to the excess number of students, unavailability, and the loss of time leapt to the eye. Considering these problems, the students put forward some suggestions such as increasing the level of application by making it more interesting, reducing the cost, and creating more realistic images and sounds. At this point, a sample expression form a student can be stated as "*It is not good that the connection and the technical problems we had in class take a lot of time.*" (S2). Another student's opinion regarding the negative aspects of AR applications can be mentioned as "*It is a very nice app, but it is not good because we do not have money to buy it and it is expensive.*" (S6). In addition, the others remarked that "*I had a hard time understanding it because it sometimes caused confusion in our class.*" (S3); "*What if I wanted to touch the sun. If we could just touch it and see what happens.*" (S14); "*In my opinion, AR is an unnecessary and time-consuming application for the course. The student observes the virtual object. I don't think it's a useful application.*" (S11); and "*I think it would be good for my brother if this was used in all courses.*" (S7). The participant students expressed their dissatisfaction concerning the use of AR and proposed some suggestions as seen in Table 4. For instance, a student put forward his/her ideas on the application as: "*The application was interesting and exciting, but more realistic sounds and images could be used during the application*." (S12). Another student commented on this issue as: "*Since these applications are costly, not every student can use them. It is important to develop low-cost applications.*" (S8).

Discussion

As abstract concepts are often used in science courses, students have difficulty in understanding the topics covered in these courses (Palmer, 1999). To overcome these difficulties, learning environments need to be turned into more concrete forms by linking them to the technologies of AR (Sahin & Yilmaz, 2020). It can be argued that the use of technologies like AR is more effective than traditional face-to-face instruction in teaching concepts that are difficult to learn and study in science courses. Thus, AR applications can increase student interest in the course and can facilitate understanding of abstract concepts by making them concrete (Arici et al.,

2019; Rehmat & Bailey, 2014). Especially in recent years, the AR applications, which are used as effective learning and teaching tools in many fields, have attracted researchers' attention. This study investigated the effects of AR applications on students' academic achievement in a science course by visualizing them on tablets, cell phones, and smartboards. By this way, the course content was illustrated through AR applications to better convey abstract concepts that were difficult to learn. Similarly, AR applications have been used as learning activities in the relevant literature, especially for visualization and concretization (Akçayır et al., 2016; Aldalalah et al., 2019; Erbas & Demirer, 2019; Estapa & Nadolny, 2015; Fidan & Tuncel, 2019; Ibanez, Castro, & Kloos, 2017; Sahin & Yilmaz, 2020).

This study found that the applications of AR had a significant impact on students' academic achievement compared to traditional learning methods. In the interviews with students, it was found that the applications of AR enabled effective and sustained learning, reinforced learning, made classes interesting and fun, and improved visual intelligence. These positive opinions of the students can be considered as the reason for the increase in their academic achievement. The fact that AR applications are a process that enables interactive and applied learning by enriching the real world with virtual elements (Höllerer & Feiner 2004) can be cited as a reason for increasing students' achievement. Also the fact that AR facilitates learning by embodying abstract concepts can result in an increase of academic achievement (Martin-Gonzalez, Chi-Poot & Uc-Cetina, 2016; Walczak, Wojciechowski & Cellary, 2006), in student motivation, interest and attention (Ab Aziz et al., 2012; López-Belmonte et al., 2021; Sumadio & Rambli, 2010; Taskiran, 2019). AR applications ensures that lessons are fun and students are active participants (Wojciechowski & Cellary, 2013; Yoon et al., 2012). In addition, the applications of AR enrich students' imagination and creativity (Yuen et al., 2011) and enable them to engage in sustained learning (Walczak, Wojciechowski & Cellary, 2006).

In examining the literature on the applications of AR in education, it was found in many studies that AR is used in many fields such as health, mathematics, geography, history, foreign languages, engineering, architecture and science courses, and improves students' academic achievement and laboratory skills development (Akçayır et al., 2016; Aldalalah et al., 2019; Estapa & Nadolny, 2015; Fidan & Tuncel, 2019; Ibáñez et al., 2020; Sahin & Yilmaz, 2020; Yen, Tsai & Wu, 2013). Meta-analyses on this topic also conclude that the applications of AR have a positive effect on students' academic achievement (Batdı & Talan, 2019; Garzón, Pavón & Baldiris, 2019). However, there are also studies in the literature stating that AR does not have a large impact on students' academic achievement (Abdusselam & Karal, 2012; Erbas & Demirer, 2019). The reason for the different results in these studies may be the application of AR activities in different ways, the type and the quality of materials used in the applications. Another reason for this difference is that the teacher who uses AR applications manages and plans the process in a different way. In addition, the process of implementing the AR applications, the attitude and motivation towards the course and technology may also lead to different results. In this direction, it can be said that the activities of AR should be created accurately and solidly according to the pattern and thus the teaching should be well planned.

It was found that the students who participated in the research explain many positive opinions about the applications of AR. In examining the students' opinions, it was found that AR applications provide visuality and flexibility in learning process by providing an interactive environment that can be adapted to the real-world environment. As a result, AR applications facilitate learning by providing a three-dimensional visualization of concepts that are difficult to visualize. In addition, students who indicate that the period of class has become more effective and productive believe that the applications of AR enable sustained learning because they reinforce what is learned. In addition, students indicated that they felt more active in class with the AR applications and that these applications contributed to better learning by improving their imagination and visual intelligence in class. In addition, the students whose opinions were queried indicated that they were more actively engaged in the learning process thanks to the applications of AR and that they were at the center of the process. In parallel with the results of this study, it was found that students in many studies thought similarly positive about the applications of AR (Cai, Chiang & Wang, 2013; Dunleavy, Dede & Mitchell, 2009; Erbas & Demirer, 2019; Höllerer & Feiner 2004; Pozo-Sánchez et al., 2021; Walczak, Wojciechowski & Cellary, 2006; Yoon et al., 2012).

While searching the literature, we have found that courses taught with AR applications are more student-centered (Delello, 2014). Studies have also showed that AR makes learning effective and durable by making abstract information concrete and eliminating monotony (Walczak, Wojciechowski & Cellary, 2006; Yoon et al, 2012). As indicated in the results of this study, it can be said that AR is a process that provides opportunities for interactive learning (Cai, Chiang & Wang, 2013; Dunleavy, Dede & Mitchell, 2009; Höllerer & Feiner 2004). It was also found that AR provides a flexible, fun, and exciting learning environment and is therefore popular among students (Barsom, Graafland & Schijven, 2016; Gun & Atasoy, 2017; Wojciechowski & Cellary, 2013).

The relevant literature revealed that the applications of AR provide more efficient learning environments (Arici et al., 2019; Cai, Wang & Chiang, 2014), reduce cognitive load in the learning process (Bower et al., 2014), and provide significantly more motivation, self-efficacy, and interest (Seifert & Tshuva-Albo, 2014; Taskiran, 2019).

According to the results of the research, there are also negative aspects of AR applications. When the students' opinions on the AR application were considered, it was found that the high-cost and difficulty in obtaining the materials were the most prominent. The fact that the teacher is in the background and the student is in the passive role is also mentioned as another negative aspect of the process. However, students also made several suggestions for such problems. For example, students suggest that the applications of AR should be more interesting and that their applicability should be increased by lowering their costs.

When examining the negative aspects of AR application in the relevant literature, similar problems can be encountered such as the lack of technical tools, monitoring and calibration problems, and technical limitations (Akçayır & Akçayır, 2017; Cheng & Tsai, 2013; Rabbi & Ullah, 2013; Sırakaya & Alsancak Sırakaya, 2020; Van Krevelen & Poelman 2010; Wu et al., 2013). There are also ethical issues such as confidentiality, security, and privacy (Altinpulluk, 2019; Berryman, 2012). In addition, excessive cognitive load in multiple and mixed tasks, lack of difficult design and ease of use, and difficulties in developing AR training materials are cited in the literature as limitations to its usage (Akçayır & Akçayır, 2017; Altinpulluk, 2019; Chang, Chung & Huang, 2016; Cheng & Tsai, 2013; Sırakaya & Alsancak Sırakaya, 2020; Wu et al., 2013). For an effective use of the application, in education, these negative aspects must be eliminated. In this direction, it is of great importance to bring students' access to technological tools and resources to an appropriate level. Otherwise, inadequacies in the area of technology may cause significant disruption as AR makes implementation difficult. In addition, taking into account the ability of students to use these technological tools, studies should be conducted to develop these skills. It can be said that these problems can be overcome and the effectiveness of the application will be increased if technical support is provided to students to eliminate the negative aspects.

With the development of mobile and wearable technologies, AR is attracting the attention of researchers day by day thanks to the new opportunities it offers to the world of education. This application is an important and popular technology that is used extremely effectively and efficiently in various fields such as military, health, marketing, tourism, shopping, and entertainment. With the use of AR in all fields, educators have started to benefit from this technology and use it in the learning process. Investment in this technology has increased especially in these days when the use of technology is widespread in education. In the literature, various studies have been published recently on the use of AR applications in education (Arici et al., 2019). However, it can be stated that the number is still not enough on such a popular topic. Thus, the aim of the present study was to determine the effects of AR applications on students'' achievement levels. In addition, students' opinions regarding AR applications were also investigated. The AR experiences of the students in the experimental group are limited to the Space 4D+ application provided by the researchers. Similar studies can be conducted through other teaching methods and approaches by using professional drawings. The research is limited to the subject of astronomy in the science course. Only secondary school students were included in the study. In order to make general assessments and comparisons, similar studies can be conducted by different researchers at other educational levels and/or in other courses.

The implementation period of the study (experimental procedure) was limited to three weeks. For AR applications, it may be useful to demonstrate the effects of a longer-term training program on a larger scale. Descriptive and experimental studies can be used to examine the effects of AR applications on students' motivation, concerns, and attitudes toward the course, as well as the permanence of the information learned. Future studies can further investigate the applicability and effectiveness of the AR application through using such variables. In addition, data can be analyzed using a mixed methodology that includes individual interviews or focus group interviews in AR applications. Again, studies can be conducted on the advantages and disadvantages of using AR in education. It is recommended that researchers of the future studies should arrange the classroom environment in advance and take necessary precautions to avoid problems during the application. AR applications can be developed in accordance with various course contents and contribute to the education process. With the proliferation of wearable technologies, similar studies can be conducted using technologies such as Google Glass or HoloLens in teaching and learning activities, and the impact of these technologies on the teaching process can be studied. In addition to the applications of AR, hologram or Metaverse technologies, which are relatively new applications for students, can contribute to students' cognitive and affective development by including them more in educational programs.

Scientific Ethics Declaration

We, the authors, declare that the scientific ethical and legal responsibility of this article published in the JESEH journal belongs to the authors.

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Effects of STEM Activities in Nature on Students' Environmental Attitudes, STEM Career Interests, and Engineering Perceptions

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Abstract

This study aimed to determine the effects of STEM Activities in Nature on students' environmental attitudes, STEM career interests, and engineering perceptions. In the research, the qualitative method is embedded in the quantitative method in an embedded mixed design. The quantitative dimension of the research was based on a quasi-experimental design with the pretest-posttest control group, and the qualitative dimension was based on a case study. The sample of the study consists of 74 seventh grade students from a moderate socio-economic level secondary school. In the study, STEM activities in the experimental group were carried out 2 hours a week for an 11-week period. In the control group, the activities were carried out in line with the Turkish Ministry of National Education's science applications course curriculum. According to the results of the research, STEM Activities in Nature in the experimental group positively affected students' environmental attitudes and STEM career interests. The activities improved students' engineering perceptions.

Introduction

In the face of the social, economic, cultural, and political problems of the world in global competition, the qualities of qualified individuals appear as the 21st-century skills (National Research Council [NRC], 2009; 2011). Partnership for 21st Century Learning [P21] (2009) classified 21st-century skills as follows: Learning and innovation skills (4C) (creativity, collaboration, critical thinking, and problem-solving); Information, media, and technology skills (information literacy, media literacy, and technology literacy); and, Life and career skills (resilience, assertiveness, adaptability, self-directedness, productivity, responsibility, social and intercultural skills, leadership). The desire to teach these skills has brought about the emergence of different educational approaches. In the 21st century, an education model in which different disciplines are integrated in order to realize well-equipped learning in terms of quality and content has been advocated (Aranda et al., 2019; Bybee, 2013; English, 2015).

STEM education is an education model based on a holistic approach that emerged with the cooperation of multiple disciplines such as science, engineering, technology, and mathematics (Bybee, 2010; Erdogan et al., 2017; Savran Gencer et al., 2019). The concept of STEM was first defined by the US National Science Foundation as an abbreviation of science, technology, engineering, and mathematics disciplines (Breiner et al., 2012). The International Association of Technology and Engineering Educators (ITEEA) defines STEM as a new interdisciplinary course in schools that combines the disciplines of science, technology, engineering, and mathematics in a single field (Mitts, 2016). The purpose of STEM education is to increase the skilled workforce and scientific literacy in STEM fields (NRC, 2011). Such endeavors aim to create a workforce of STEM literate individuals, to make innovations that will create an economic advantage for countries, and to be competent in business fields of the future (Thomas, 2014). For example, the need for STEM-related professions in the USA has doubled in 5 years, and it has been emphasized that students should be encouraged to choose STEM fields in order to meet this need in the field of engineering and science, where the number of people trained in this field can only meet half of the demand (Dave et al., 2010). An individual's level of knowledge about STEM directly affects their attitude towards pursuing a career in STEM fields in the future. It is more probable that a student who does not have sufficient knowledge will not choose a career in the STEM field. If students do not have knowledge about STEM, their interest in making a career in STEM will decrease and this will negatively affect their willingness to participate in activities that serve to increase STEM career knowledge and awareness (Blotnicky et al., 2018).

One of the STEM career fields is engineering. Engineering is defined as the process of designing the man-made world within the framework of science and engineering literacy prepared by the National Assessment of

Educational Progress (NAEP, 2014). For effective STEM education and to increase students' professional awareness, students' perceptions of engineers and engineering should be identified and educational settings should be tailored to the current context in real life. It has been observed that students' engineering perceptions affect their career choices (Chan et al., 2019). Students misconceive engineering as equipment repair and assembly, and engineers as people who work outdoors and do heavy work (English et al, 2011; Fralick et al., 2009; Liu & Chiang, 2019). Many studies have shown that engineering is perceived as men's work (Cunningham et al., 2005; Karataş et al, 2011; Koyunlu Ünlü & Dökme, 2017). Applied interdisciplinary education improves students' engineering perceptions (Hammack et al., 2015; Kuvaç, 2108; Oware et al., 2007; Lyons & Thompson, 2010). Engineers benefit from the engineering design process when reaching the best design in the face of a problem (Katehi et al., 2009). The engineering design process is defined in three stages, namely, define, design and optimize (Next Generation Science Standards [NGSS], 2013). The engineering design process brings together STEM disciplines as it requires the use of basic engineering knowledge and skills, as well as science and mathematics disciplines (Cantrell et al., 2006; Householder & Hailey, 2012; National Academy of Engineering [NAE] & National Research Council [NRC], 2009). In STEM Education, out-of-school learning environments can be used to bring the disciplines together and to realize an effective learning/teaching process.

Out-of-school learning is experiences that enable the realization of in-curricular and extra-curricular learning outside the school environment. It is student-centered learning that is structured with events and facts from the life and provided by interacting with primary sources (Department for Education and Skills [DfES]), 2006; Resnick, 1987). Students spend most of their daily lives outside of school (Eshach, 2007). In addition, it is thought that students can learn in these environments at their own learning pace and according to their individual differences (Melber & Abraham, 1999), and the use of out-of-school learning environments in a formal instructional design can increase the quality of learning and teaching processes. Furthermore, since STEM education aims to solve real-life problems for students (Burghardt & Hacker, 2004; Moore et al., 2014; Sevian et al., 2018), it is thought that out-of-school environments can provide opportunities for real-life problems for students, while at the same time, they can be used to integrate STEM disciplines into the teaching process. In addition, one of the 21st century interdisciplinary themes is environmental literacy (P21, 2009). STEM Activities in Nature can contribute to students' environmental literacy. In this research, environmental attitude was included in the research as a variable and it was also aimed to determine the effects of STEM activities taking place in nature on environmental attitude. Buldur et al. (2018) investigated the effect of an interdisciplinary nature education on environmental awareness, and they concluded that the nature education project reached the targeted levels in terms of environmental affective characteristics of the participants. Çalışıcı and Benzer (2021) stated that STEM practices they carried out with 8th-grade students positively affected the environmental attitudes of the students.

When STEM activities carried out in out-of-school environments are examined in the literature, Naizer et al. (2014) reported that, as a result of a summer STEM program in a group of secondary school students studying in the countryside, students' interest in mathematics, technology and problem-solving increased and the gap between male and female students in favor of males was closed. Şahin et al. (2014) reached the following results in realizing the goals set within the scope of STEM-related after-school program activities: collaborative group work is important; these activities increase students' interest in STEM disciplines; and, they encourage people to choose science and engineering disciplines in their future careers. Dabney et al. (2012) investigated the relationship between out-of-school science activities and majoring in STEM fields in university students. The results of the research revealed that participation in out-of-school science activities was as effective as gender and interest in science and mathematics in secondary school in majoring in STEM fields. According to Weber (2011), informal STEM education carried out in a natural environment with students' own experiences is extremely important in the development of STEM knowledge and interests of especially female students in STEM fields. Kong, et al. (2014) investigated the relationship between participation in science summer camps over two years and students' probability of choosing science and engineering professions. They revealed that students who attended the summer camp were more likely to choose a profession in science and engineering in the future than those who did not attend the summer camp. Baran et al. (2016) organized combined out-of-school STEM activities and investigated the participants' perceptions of these activities and reported that the students acquired meaningful knowledge about technology and computers via the activities; they developed skills; they would use the activities in the future; and they were able to offer suggestions about the activities. Dieker et al. (2012) revealed that STEM summer camps steered high school students with low socioeconomic status but were talented in STEM fields to STEM vocational fields. Dubetz and Wilson (2013) concluded that the activities implemented in the girls in engineering, mathematics, and science project provided students with additional learning experiences and increased their interest in STEM.

Research shows that well-designed out-of-school learning environments increase students' interest in STEM and their chances of pursuing a career in STEM. Out-of-school activities improve students' STEM competencies and increase their interest in STEM (Kitchen et al., 2018). The literature on the effectiveness of STEM instructional designs is increasing, but there are fewer STEM studies in out-of-school settings.

Purpose of the research:

This study aimed to determine the effects of STEM Activities in Nature on the environmental attitudes, STEM career interests, and engineering perceptions of seventh grade students. For this purpose, answers to the following questions were sought:

Is there a significant difference between the environmental attitudes of the experiment and control groups?
Is there a significant difference between the STEM career interests of the experiment and control groups?
Is there a significant difference between the STEM career interests of the experiment and control groups in relation with gender before and after the intervention?
What are the engineering perceptions of the experiment and control groups before and after the intervention?

Method

Research Design

In this research, an embedded mixed-method design, in which qualitative research is embedded into quantitative research, was used (Creswell et al., 2011). The pretest-posttest quasi-experimental research model was used as the quantitative method. The qualitative method was based on a case study. First, quantitative data were obtained and analyzed. Then, interviews were conducted with the participants selected from the experimental group in order to investigate the results in more depth. A program based on STEM Activities in Nature was applied in the experimental group for 2 hours a week for 11 weeks. In the control group, the students carried out activities and applications within the scope of the Science applications course curriculum guided by Turkish Ministry of National Education (MoNE, 2018). The research design and process are shown in Figure 1.

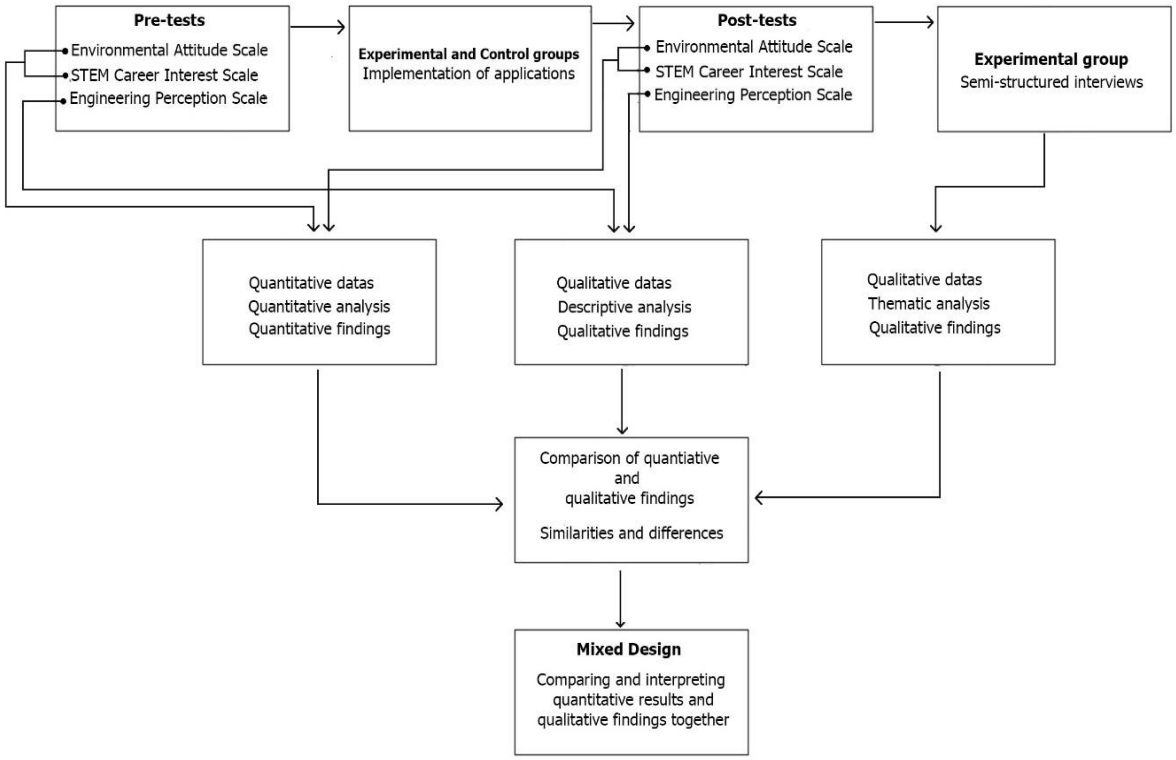

Figure 1. Research design and process

Study Group

Two classes were selected out of four classes of students who chose the science applications course in a secondary school located in a moderate socioeconomic region ın Turkey. Seventy-four students from these two classes formed the study group. One of the two classes was randomly selected as the experimental group and the other as the control group. Experimental and control group students were compared in terms of their academic success in science and mathematics in previous years, and there was no significant difference. Students in the groups were similar in terms of socioeconomic level, parental education level, academic achievement, and access to technological tools. The experimental group consisted of 28 girls and 10 boys, and the control group consisted of 20 girls and 16 boys. Semi-structured interviews after the experimental application were conducted with nine students from the experimental group. These students were selected on a voluntary basis from students who were high- and medium-levels from the posttest STEM career interest and Environmental Attitude scales according to the criterion sampling method. Six of the students were female and three were male.

Developing and Implementing STEM Activities

STEM activities were out-of-school-based and were developed to provide students with an experience in nature. The relevant literature was used in the development of the activities. Environmental awareness and human-environment interaction were taken into account. In the design of the activities, it was aimed to integrate STEM disciplines based on a problem or a need. Each activity was held outside of school. Three activities were performed as a STEM camp in nature. Students worked in groups of four or five.

Table 1. STEM activities and their relationships with STEM disciplines

STEM activities in nature	Science	Technology	Engineering	Mathematics
1-Let' s build our bridge in the nature 	Finding the center of gravity/ effects of force on objects	Making products using different techniques and materials	Designing a durable bridge	Dimensions of a bridge/measurement of force
2-Let' s build the tallest stone tower 	Friction force and effect of gravity	Creating products using different techniques	Designing a tower that is resistant to external factors	Calculating the dimensions of the tower and determining the placement angles of the stones
3-Let' s design a shelter for stray animals 	Balanced forces, thermal insulation	Creating an ideal shelter using suitable materials	Making an ideal design by considering many factors	Temperature measurements, geometric measurements
4- Let' s create an ant ecosystem and examine it 	The importance of biodiversity/needs of living things	Determining the method and material for an ant farm	Designing an ant farm	Measuring Dimensions calculation

5-Let' s design the best parachute 	Air resistance/friction force/gravity	Choosing the material for a parachute	Designing a parachute	Measurement of the dimensions of a parachute; Calculating airtime
6- Let' s design a treehouse 	Simple machines/Net force	Experimental selection of suitable materials	Treehouse design	Measurement of materials/calculation of joining angles
7- Let' s make our own pinwheel 	Energy production-saving resources	Determining the shape of the wing and determining the way it is created	Designing a pinwheel	Dimensions of the model and calculation of rotational speed
8- One-day STEM camp in a tent 	Human environment interaction/Balanced forces	Materials, techniques, and tools used during tent setup	Tent design	Calculation of tent dimensions (rope-slope-height, etc.)
9- Let' s observe the sky with our own telescopes (STEM camp) 	Lens/Features of celestial bodies	Selection of lenses and materials for the telescope	Designing a telescope	Calculating the dimensions of lenses and the tripod
10-Let' s design the best swing model.(STEM camp) 	Energy Conversion/gravity/friction force	Selection, testing, and identifying materials	Swing design	Calculating energy conversion; calculating the height-velocity relationship; calculation of oscillation period and aspect-to-mass ratios
11-Let' s produce our own vegetables with organic farming 	Required conditions for plants/photosynthesis	Determining the needs for organic farming/Selecting tools to be used	Determination and implementation of the irrigation system of the organic farm garden	Preparing the growth charts of the grown plants over time-calculating the distance between the seedlings-calculating the amount of fertilizer per seedling

In the applications, the engineering design process was utilized, which is defined as the identification of the problem or need, development of possible solutions, finding the optimal solution, prototyping and testing, and communication skills and sharing. First of all, the students determined the design criteria for the solution of the problem and conducted research about the design by asking questions. Second, they brainstormed possible solutions. They drafted reports and created prototypes for the proposed solutions, conducted group work, and used experimental data. Third, the students made a decision by making a profit-and-loss analysis and presenting the most appropriate solution and justifications for the best solution. Fourth, they tested the prototypes via appropriate methods, evaluated the prototype according to the test results, and finalized it. They made improvements and redesigned. Finally, students presented the final design, tested it, and modified it for optimization.

In the research, STEM applications in nature were carried out for 11 weeks and 2 hours a week in the experimental group. An implementation plan was prepared for each activity. In the control group, it was carried out in line with the Science Application course curriculum. Table 1 presents the list of STEM activities and their relationships with STEM disciplines.

Data Collection Tools

The Environmental Attitude Scale, the STEM Career Interest Scale, the Engineering Perception Questionnaire, and semi-structured interviews were used as data collection tools in the research.

Environmental Attitude Scale

The Environmental Attitude Scale developed by Özata Yücel and Özkan (2014) was used to determine the environmental attitudes of the students. The 5-point Likert-type scale consists of 35 items and two sub-dimensions. The first 14 items constitute the behavioral dimension of the scale, and the last 21 items form the emotion, thought, and willingness to take action dimension. The Cronbach's alpha internal reliability coefficient of the scale was calculated as 0.88 by Özata Yücel and Özkan (2014). In this study, it was calculated as .86.

STEM Career Interest Scale

The STEM Career Interest Scale developed by Kier et al. (2013) and adapted into Turkish by Bilen et al. (2015) was used to determine students' career interests in STEM (for professions in the fields of science, technology, mathematics and engineering). The scale consists of 44 items and four sub-dimensions (Science, Technology, Mathematics, and Engineering). There are 11 items in each sub-dimension of the scale. The scale is in the form of a 5-point Likert scale, where answers are: strongly agree, agree, undecided, disagree, and strongly disagree. In the adaptation process of the scale, it was stated that the reliability coefficients in the sub-dimensions ranged from .84 to .88. The reliability coefficients in this study were calculated between .80 and .86 in the sub-dimensions.

Engineering Perception Questionnaire

It is a measurement tool created to determine the engineering perceptions of students by examining the literature and consists of these questions: What is engineering? What does an engineer do? Explain by a drawing. Students were asked to answer the questions on an A4 paper. After their answers, the students were asked these questions so that the data was clear: what is the gender of the engineer in their drawings? Where are they currently working? What type of engineer is it? The Questionnaire was applied as a pre-test and post-test.

Semi-structured interviews

For the qualitative exploratory phase after the experimental process, interviews were conducted with students who scored moderate or high on the STEM Career Interest Scale and the Environmental Attitude Scale, using the criterion sampling method. With semi-structured interviews, it was aimed to reveal students' experiences, thoughts, and feelings about STEM Activities in Nature. For this purpose, a semi-structured interview form was created with five open-ended questions. In all of the questions, students were asked to elaborate more on their

answers by using probe questions. The teacher's field notes and literature were used in the preparation of the questions. Interviews with students took between 4 minutes and 6 minutes and 35 seconds.

Data Analysis

Analysis of the Quantitative Data

A statistical software program was used in the analysis of the data. First, according to each sub-problem, a normality test was conducted to check whether the data showed normal distribution or not. Considering the number of samples and the numbers in the subgroups, an appropriate test of normality was applied. The Shapiro-Wilk test was considered appropriate when the number of subgroups was 30 or more, and the Kolmogorov-Smirnov test was considered appropriate when they were below 30. In addition, the skewness and kurtosis coefficients were examined, and when the skewness and kurtosis coefficients of the sub-dimensions ranged from +3 to -3, these sub-dimensions were considered to have conditions suitable for normal distribution parameters (Jondeau & Rockinger, 2003). One-way manova was not applied because the correlation values between dependent variables were lower than .80 (Field, 2013). In cases with normal distribution, t-test for independent samples and t-test for dependent samples were applied, and the Mann Whitney-U test was used in cases that did not show normal distribution. Effect size values in t-tests for independent samples were calculated using the $d = t\ x\ \sqrt{\frac{N1+N2}{N1\ x\ N2}}$ formula using the t value. It was calculated using the formula $d = \frac{t}{\sqrt{N}}$ for dependent samples. D effect size value is .80 for a large effect, .50 for a medium effect, and .20 for a small effect. In the Mann Whitney-u test applied in cases that did not show normal distribution, the effect size values were calculated with the $r=\frac{z}{\sqrt{N}}$ formula. Effect sizes were evaluated as .10 for a small effect, .30 for a medium effect, and 0.50 for a large effect (Green & Salkind, 2005).

Analysis of the Qualitative Data

Qualitative data obtained from the Engineering Perception Questionnaire were analyzed with the descriptive analysis method. A thematic analysis method was used in the analysis of the qualitative data obtained from the interviews. Thematic analysis is a strategy that enables the analysis of common points and similarities and differences between the data (Gibson & Brown, 2009). In this research, within the scope of the thematic analysis, firstly, a written transcript of the interview records of the students was prepared, and then all of these written documents were read and examined. Then, the interview records were re-examined and analyzed in order to generate the codes. The codes were evaluated together and categories were formed. Related themes were created by examining the categories, and the themes were named. Finally, the write-up was completed.

Validity and Reliability

Scales with established validity and reliability were used for quantitative data. In addition, internal reliability coefficients (Cronbach alpha values) were recalculated. In providing validity and reliability in qualitative data, in accordance with the qualitative methodology, credibility for internal validity, transferability for external validity, consistency for internal reliability, and confirmability for external reliability were found more appropriate (Yıldırım & Şimşek, 2016).

Persuasiveness: In the research, qualitative data were mainly collected after experimental applications in order to support the quantitative data in the research, and data diversity was provided in this way. Semi-structured interviews were conducted by the researcher who carried out the research practices. The researcher has been teaching these students science courses for two years. For this reason, it was thought that long-term interaction with the students before the interviews would enable the students to give sincere answers. Efforts were made to ensure that the interviews were conducted in a friendly atmosphere. The researcher aimed to reveal the connections between them by constantly comparing the results with each other. In order to diversify the data sources, interviews were conducted with both male and female students, and for a similar purpose, interviews were conducted with students with different levels of quantitative scores. The researcher sought expert support regarding the entire qualitative process, and the researcher's approach in this process was evaluated and he received feedback. The written transcripts of the data obtained in the interviews were examined with the students and they were confirmed.

Transferability: It was ensured that the qualitative data were transferred by adhering to their nature without adding comments, and they were described in detail by reference to direct quotations from the interviews. The students who will be interviewed were determined according to the purposeful criterion sampling. Receiving a medium or high scores from the STEM Career Interest Scale and the Environmental Attitude Scale was the only criterion. In this way, it was aimed to obtain more in-depth information.

Consistency: A similar approach was followed in all processes of qualitative research, such as preparing the interview questions, conducting the interviews, and analyzing the data obtained, and it was tried to establish the relationship between the data and the results.

Confirmability: It was ensured that the data, coding, and reports were recorded in a way that would enable the comparison of the results with the raw data.

Findings

Quantitative Findings

Quantitative findings on the effects of STEM Activities in Nature on students' environmental attitudes and STEM career interests are included.

The Effect of STEM Activities in Nature on Environmental Attitude

It was aimed to determine whether there was a significant difference between the environmental attitudes of the experimental and control groups. First, it was determined that the data showed normal distribution in subgroups according to the Kolmogorov-Smirnov test results (p>.05), and a t-test was applied for independent groups based on pre-test and post-test data. Analysis results are presented in Table 2.

Table 2. Environmental attitude scale independent t-test results

Tests	Environmental attitude and sub-dimensions	Groups	*N*	*X*	*S*	*SD*	*t*	*p*
Pre-test	Environmental Attitude	Experimental	38	3.69	.45	72	-.81	.89
		Control	36	3.77	.40			
	Behavior	Experimental	38	3.47	.57	72	-1.38	.17
		Control	36	3.46	.52			
	Emotion-Thought Willingness to take action	Experimental	38	3.83	.48	72	.13	.41
		Control	36	3.98	.41			
Post-test	Environmental Attitude	Experimental	38	3.99	.34	72	2.21	.030*
		Control	36	3.76	.51			
	Behavior	Experimental	38	3.80	.40	72	2.03	.046*
		Control	36	3.56	.62			
	Emotion-Thought Willingness to take action	Experimental	38	4.11	.44	72	1.74	.086
		Control	36	3.90	.58			

For the pre-test results, no significant difference was found between groups in terms of the environmental attitude and sub-dimension scores (p>.05). In the post-test results, a significant difference was found between groups in favor of the experimental group in environmental attitude scores (t (72) =2.21, p<.05). In the sub-dimensions, a significant difference was found in favor of the experimental group in the behavior dimension (t (72) =2.03, p<.05). It was determined that the effect sizes were moderate in both significant differences.

The Effect of STEM Activities in Nature on STEM Career Interest

Pre-test and post-test independent t-test results related to STEM career interests are presented in Table 3.

Table 3. STEM career interest pre-test post-test independent t-test results

Tests	STEM career interest and sub-dimensions	Groups	N	X	S	SD	t	P
Pre-test	STEM Career Interest	Experimental	38	167.78	24.59967	72	-0.335	0.739
		Control	36	169.72	25.01498			
	Science	Experimental	38	44.02	7.56767	72	-1.214	0.229
		Control	36	45.88	5.38133			
	Technology	Experimental	38	42.10	6.78149	72	-0.263	0.793
		Control	36	42.52	7.03658			
	Engineering	Experimental	38	39.15	7.90664	72	0.010	0.993
		Control	36	39.13	7.96834			
	Mathematics	Experimental	38	42.50	7.57931	72	0.171	0.865
		Control	36	42.16	9.15735			
Post-test	STEM Career Interest	Experimental	38	180.2368	21.73605	72	2.108	.038*
		Control	36	168.9722	24.20919			
	Science	Experimental	38	46.6842	5.80356	72	0.838	.405
		Control	36	45.4722	6.62673			
	Technology	Experimental	38	44.7632	7.12223	72	2.033	.046*
		Control	36	41.5000	6.66119			
	Engineering	Experimental	38	44.5526	8.08969	72	2.475	.016*
		Control	36	39.5556	9.26574			
	Mathematics	Experimental	38	44.2368	7.55318	72	0.989	.326
		Control	36	42.5000	7.54983			

Table 4. Control group STEM career interest pre-test and post-test Mann-Whitney U test results

Tests	STEM career interest and sub-dimensions	Gender	N	Rank mean	Rank sum	U	P
Pre-test	STEM Career Interest (Pre-test)	Female	20	14.98	299.50	89.50	.025*
		Male	16	22.91	366.50		
	Science (Pre-test)	Female	20	17.48	349.50	139.500	.513
		Male	16	19.78	316.50		
	Technology (Pre-test)	Female	20	14.33	286.50	76.50	.008*
		Male	16	23.72	379.50		
	Engineering (Pre-test)	Female	20	14.50	290.00	80.00	.011*
		Male	16	23.50	376.00		
	Mathematics (Pre-test)	Female	20	16.10	322.00	112.00	.126
		Male	16	21.50	344.00		
Post-test	STEM Career Interest (Post-test)	Female	20	13.90	278.00	68	.003*
		Male	16	24.25	388.00		
	Science (Post-test)	Female	20	16.53	330.50	120.550	.207
		Male	16	20.97	335.50		
	Technology (Post-test)	Female	20	13.93	278.50	68.500	.003*
		Male	16	24.22	387.50		
	Engineering (Post-test)	Female	20	13.88	277.50	67.500	.003*
		Male	16	24.28	388.50		
	Mathematics (Post-test)	Female	20	15.85	317.00	107	.091
		Male	16	21.81	349.00		

According to the pre-test results, no significant difference was found between groups in terms of STEM career interests and sub-dimensions (p>.05). When the experimental and control groups were compared in terms of post-test STEM career interests, a significant difference was found between groups (t (72) =2.108 p<.05). While there was no significant difference between groups in the post-test in science and mathematics sub-dimensions, a significant difference was determined in the sub-dimensions of technology (t (72) =2.033 p<.05) and engineering (t (72) =2.475 p<.05). Effect size values were calculated as moderate in the STEM career interest and engineering sub-dimension, and small in the technology sub-dimension. The Mann-Whitney U-test results,

which were conducted to determine whether there was a significant difference between the pre-test and post-test scores of the control group in relation with the gender variable of STEM career interests, are presented in Table 4.

In the control group, a significant difference was found between male and female students in both pre-test and post-test results in STEM career interest and technology and engineering sub-dimensions (p<.05). No significant difference was found in both pre-test and post-test sub-dimensions of science and mathematics (p>.05). The results of the Mann-Whitney U-test, which was conducted to determine whether there was a significant difference between the pre-test and post-test scores of STEM career interests in the experimental group in relation with the gender variable, are presented in Table 5.

Table 5. Experimental group STEM career interest pre-test and post-test Mann-Whitney U test results

Tests	STEM career interest and sub-dimensions	Gender	N	Rank mean	Rank total	U	P
Pre-test	STEM Career Interest (Pre-test)	Female	28	17.36	486.00	80.00	.047*
		Male	10	25.50	255.00		
	Science (Pre-test)	Female	28	18.64	522.00	116.00	.426
		Male	10	21.90	219.00		
	Technology (Pre-test)	Female	28	16.20	453.50	47.50	.002*
		Male	10	28.75	287.50		
	Engineering (Pre-test)	Female	28	17.27	483.50	77.50	.038*
		Male	10	25.75	257.50		
	Mathematics (Pre-test)	Female	28	18.45	516.50	110.50	.327
		Male	10	22.45	224.50		
Post-test	STEM Career Interest (Post-test)	Female	28	18.95	530.50	124.500	.607
		Male	10	21.05	210.50		
	Science (Post-test)	Female	28	18.66	522.50	116.500	.434
		Male	10	21.85	218.50		
	Technology (Post-test)	Female	28	17.73	496.50	90.500	.100
		Male	10	24.45	244.50		
	Engineering (Post-Test)	Female	28	19.66	550.50	135.000	.881
		Male	10	19.05	190.50		
	Mathematics (Post-Test)	Female	28	19.75	553.00	133.000	.816
		Male	10	18.80	188.00		

In the experimental group, a significant difference was found between male and female students in the STEM career interest pre-tests in favor of male students. A significant difference was found in favor of males in the sub-dimensions of Technology and Engineering (p<.05). There was no significant difference between male and female students in Science and Mathematics sub-dimensions (p>.05). In the post-test results of the experimental group, no significant difference was found between male and female students in STEM career interest and all sub-dimensions (p>05).

Qualitative Findings

Qualitative findings obtained from the engineering perception Questionnaire and semi-structured interviews are included. The codes created by analyzing the answers to the questions "What is engineering and what does an engineer do?" of the experimental and control group in the pre- and post-tests are presented in Tables 6 and 7.

When the answers given to the question “What is an engineer?” by the experimental and control group students were examined, the answers given by both groups in the pre-tests showed similarity. In addition to the students who did not have any knowledge about engineering, there were those who described engineering as a worker or a repair person. It is seen that the experimental group concentrated on more similar codes in the post-test. It is seen that the post-test codes of the control group were similar to the pre-tests.

Table 6. What is engineering?

Pre-test/ Codes	Experimental	Control	Post-test/ Codes	Experimental	Control
Design	8	9	Design	15	9
Development	3	3	Develop	12	4
to invent/make	4	3	Invent/Make	7	4
Doing/helping to do something for people	4	2	Making something		1
Using/calculating dimensions	-	2	Calculate/use dimensions		2
Engineering is a profession. That's what engineers do.	1	2	Engineering is a profession.		2
It is a profession that deals with all kinds of branches.		1	Realization of thoughts.		1
It is the making of thoughts.	1	1	Being an expert in a subject.	2	1
Planning / Adjusting					
To be an expert on something.	1	1	Construct.	1	4
To construct.	3	4	Mending		1
An engineer is a worker.	2	3			3
repairing something	3	1	Drawing.		
Does draw.	1	1	I don’t know.	-	3
I don’t know.	7	5			

Table 7. What does an engineer do?

Pre-test /Codes	Experimental	Control	Post-test /Codes	Experimental	Control
Designs	8	5	Designs	13	8
Designs homes.	2	2	Designs construction-building.	7	2
Makes house/bridge/machine-works	9	8	Designs computer-machine-tool-product.	6	2
Works/makes new things.	3	3	Develops product.	3	1
Makes plans/drawings of houses.	3	2	Invents/maintains and develops.	1	
Other (Computer engineer, civil)	2		Develops.		3
Takes care of/control food.	1		Draws- vehicle/home	1	6
Develops product.	3	6	Performs genetic tests.	2	
Makes calculations.	3	3	Inventor of new and useful products.	2	2
No answer	4	7	Makes house-bridge/works/makes new things.		7
			Makes new inventions using technology and brings them to life.		1
			Designs airplanes.	2	
			Software engineer codes new programs	1	
			No answer	-	4

It is seen that the pre-test responses of the experimental and control groups formed similar codes. In the post-tests, it was seen that the answers of the experimental group students focused on the code "designs". The codes created by the post-test responses in the control group were similar to those in the pre-tests. In addition, the control group student responses concentrated on the codes "Makes house-bridges/works/makes new things" and "Draws vehicle/home". Table 8 was created by analyzing the data obtained from the engineer drawings in terms of the gender and location of the engineers.

The pre-test drawings of the students in the control group and their post-test drawings were similar. The post-test drawings of the experimental group differed from the pre-tests in which female engineers were depicted more. When the drawings were examined in terms of space, the experimental group included engineer drawings in different environments. The pre-test and post-test drawings of the students in the control group were similar.

Engineer drawings of the experimental and control group students were analyzed in terms of engineering types in the pre-test and post-test and are presented in Table 9.

Table 8. Engineering perception in terms of gender and space

Pre-test	Groups		Post-test	Groups	
Engineer gender	Experimental	Control	Engineer gender	Experimental	Control
Male	20	22	Male	20	22
Female	4	4	Female	16	5
Unclear/no drawing	14	10	Unclear/no drawing	2	9
Space	Experimental	Control	Space	Experimental	Control
Indoor	15	15	Indoor	8	16
Outdoor	15	14	Outdoor (construction site)	4	12
None	8	7	Outdoor (Garden-Field-nature)	8	1
			Laboratory	5	
			Office	3	
			Classroom	4	

Table 9. Engineer perception of experimental and control group students in terms of engineering type

Code	Pre-test		Code	Post-test	
Engineer type	Experiment	Control	Engineer type	Experiment	Control
Construction engineer	18	16	Construction engineer	10	20
Mechanical engineer	4	3	Mechanical engineer	4	5
Mathematics Engineer	1	1	Mathematics Engineer	1	1
Electronics engineer	1		Electronics engineer	3	1
Computer engineer	5	4	Computer engineer	2	1
Food engineer	1		Food engineer	2	
Makes Design	3	4	Genetic engineer	2	
No answer	8	9	Agricultural engineer	3	
Electrical engineer	1		Plane engineer	3	
			Software engineer	1	
			Environmental engineer	6	
			Chemical engineer	2	
			Makes Design	-	4
			No answer	-	4

When Table 9 is examined, 7 types of engineers were drawn in the pre-test in the experimental group and 4 types of engineers in the control group. In the post-test, 11 types of engineers in the experimental group and 5 types of engineers in the control group were drawn. In the pre-test, it was observed that the students in the experimental and control groups made drawings that were similar in terms of engineer types and represented a limited number of engineer types. In the post-test, it was seen that the experimental group included more different types of engineer drawings compared to the control group.

Findings Obtained from Semi-Structured Interviews

As a result of the analysis of the semi-structured interviews with the students, the themes of *environmental attitude and awareness* and *getting to know STEM fields and engineering* were formed. Explanations on the features of the themes were supported by direct quotations.

Environmental Attitude and Awareness

This theme covers exploring the environment, awareness of the nature, and enjoying the nature. While the students were performing STEM Activities in Nature, it was observed that they associated their experiences and observations about nature with exploring the environment and awareness of nature. S-2, one of these students, emphasized that the activities carried out in nature and outside the classroom made them realize the characteristics of nature: *"We were able to find materials from the nature for the activities we did. There was everything we needed in nature. Nature is actually a great resource, but we must use those resources correctly. Otherwise, everything will run out."* S-3, while emphasizing the relationship between nature and science, stated

that they liked the time they spent as follows: *"Being in nature for a lesson made us forget that we were in a lesson. We had a very good and fun time. Science actually means the lesson of nature anyway"*.

S-1 explained the order in nature and the role of man in that order with the following statement: *"During our activities, we also had the opportunity to watch and examine nature. There are many living things in nature. They all live in harmony with nature. For example, they do not leave their garbage to nature or they do not harm nature. I think we also need to protect nature for all living things."*

Based on the students' views, we thought that STEM activities in nature created environmental awareness in students. For example, S-4: *"We studied the life of ants in an event we held and we were astounded. We only had the opportunity to examine the ants. Many living things in nature have such a life and it is necessary to be in touch with nature and to explore them."*

S-5 explained their thought as follows: *"It was nice to touch the soil freely in the activities we did in nature, rather than always learning the lessons in the classroom. Nature has a feature that relaxes people, but the fact that people build buildings everywhere shrinks the nature and harms it."*

One of the students, S-6, expressed their opinion as follows: *"When we look at the old photographs of our city, we see that the wooded areas are much more than they are now. If it continues like this, it will be very difficult to see nature. I think about ways to avoid this."*

S7 emphasizes that they observe the effects of the human factor in nature and how they should behave: *"During our time in nature, we saw many garbage belonging to people. We even wanted to use some of them as activity material, but we know that this garbage has a very long time to disappear in nature and harms the environment. We were careful not to harm the environment while leaving nature. We collected all our waste."*

S-8 explained their thoughts as follows: *"Many creatures live in nature and benefit from many resources. They can choose and find the most suitable place for them. When we wanted to build a home for them, we could not decide whether they would like it or not. If there is more living space for them in nature, they will be more comfortable."*

S-7 stated that nature has a structure that provides every opportunity for living things and that thus its protection is important for all living things. Regarding STEM activities, S-9 stated that the activities increased their curiosity about nature and provided fun time: *"It was very nice to spend time in nature. I think that the lessons do not have to be taught only in the classroom, there are many things we can learn outside the classroom that we can explore and use in the lesson. I want to learn more about the characteristics of nature and living things. These activities can be done with any class. It may be more beneficial for 5-6-year old children to play with soil instead of playdough.*"

S-1 similarly explained their views as follows: "*We had a lot of fun during our activities. At the same time, we learned about living things and nature. We should get to know nature and living things closely. There is so much to discover."*

Getting to Know STEM Fields and Engineering

This theme includes the interest of the participants in STEM fields and the engineering profession as a result of the STEM Activities in Nature. Students associated STEM activities in nature with an interest in engineering and recognizing different engineering fields.

S-1 is one of these students and explained their thoughts as follows: *"I didn't really think about becoming an engineer in the future. Engineering is a profession that seemed different to me. I didn't know exactly what engineers did, but the activities we did caught my attention. And I think engineers are doing good work for society. I would like to be an engineer in the future."*

S-7 stated that they learned about different engineering fields thanks to the activities: " *The first engineering type that came to my mind was civil engineering. However, now I realized that there are other engineers such as agricultural engineers and software engineers."*

S-8 explained their perspective on engineering and thoughts on their career plan as follows:

"*There are engineers in my family, but I always considered engineering as a male profession. However, when I thought about what we did at the events we held, it made me realize that engineering is not a gender-based profession and that girls can be engineers too. I wanted to be a teacher in the future, but I could also be an engineer. For example, an environmental engineer.*"

It was determined that the activities carried out affected students' interest in STEM professions positively. As a matter of fact, S-5 said that: "*During the activities, we had to use not only science but also mathematics. While making new designs, we had to try to think of many things at the same time and try to find the most appropriate one. And while it was hard, it was fun."* These statements of S-5 showed that they experienced the way engineers work.

S-2 explained that STEM activities provided them with the opportunity to get to know engineering closely*: " I understood that before I had little knowledge about engineering and how engineers work. We tried to make different designs during the events. We examined. We calculated. We thought about what materials we could use. When I think about what we've done, engineers do good things."*

S-6 expressed their views with the following statement: *"Engineering is fun. I saw this at the events we held. I wanted to be an engineer in the future, my opinion hasn't changed. Because engineers do useful work for people."*

S-9 expressed their appreciation of the events and their perspective on the engineering profession as follows: *"During our activities, we tried to solve a problem like engineers. This process was a lot of fun for me. It was even better to see that they were working when we tested our projects. In this process, we used different school subjects. Science alone was not enough for us."*

S-3 said regarding STEM activities that: *"During the events, the applications positively affected my thoughts towards engineering. Engineering must be an enjoyable job because it was very enjoyable in our work."* S-6 drew attention to areas other than science regarding the characteristics of the activities carried out and said that: "*Solving questions about these activities gave me a lot of insight into what engineers do. Now I think that engineering includes different courses."*

S-4 said: "*When it comes to engineering, my thoughts have changed with the applications we have made because I realized that I didn't have a full knowledge of what engineers did before."*

Conclusion, Discussion, and Recommendations

In this study, the effects of STEM Activities in Nature on students' environmental attitudes, STEM career interests, and engineering perceptions were examined. STEM Activities in Nature significantly affected the environmental attitudes of the experimental group students compared to the control group students. It was concluded that the activities carried out in nature outside the school improved the environmental attitudes of the students. In the semi-structured interviews held with the experimental group students after the activities, the opinions of the students regarding their environmental attitudes showed that STEM education was effective. Quantitative and qualitative findings obtained in the study support each other in terms of the students' environmental attitudes. In particular, it was observed that environmental attitude was more effective in the behavioral dimension. It is important that the students stated that their desire to explore nature increased and that they have gained environmental awareness. It was determined that the STEM Activities in Nature developed the environmental attitudes of the students. In this study, the active participation of students in out-of-class practices may have been effective in the emergence of this result. In the literature, there are many studies reporting that applied trainings are effective in improving environmental attitudes. In this study, environmental attitude was included as a variable as a sub-dimension of environmental literacy, one of the 21st century interdisciplinary themes. The effects of STEM Activities in Nature on environmental attitudes can be interpreted as an indirect effect on environmental education. The result of this research is similar to the results of Buldur et al. (2018) and Çalışıcı, and Benzer (2021) in terms of improving environmental affective characteristics. Even if all the activities did not focus directly on the environmental theme, it can be said that the realization of the activities in nature ensures that the application environment is effective on affective characteristics.

While there was no significant difference between groups in terms of STEM career interests before the applications, a significant difference was determined in favor of the experimental group in the post-tests. STEM activities in nature positively affected students' STEM career interests. This interest was seen in especially

engineering and technology careers in the STEM disciplines. There was no significant difference between groups in science and mathematics career interests. STEM Activities in Nature had a positive impact on students' STEM career interests, especially in the fields of engineering and technology careers. Another purpose of STEM education is to ensure students' interest in professions in STEM disciplines and to encourage them to choose that profession in the future. Studies conducted in the out-of-school setting in the literature have reported similar results, such as Dieker et al. (2012)'s STEM summer camp and Şahin et al. (2014)'s after-school program activities, both of which have shown an increase in students' interest in STEM careers.

When the STEM career interests of male and female students in both the experimental and control groups were compared before STEM Activities in Nature, it was seen that male students in both groups had a higher level of interest and they differed significantly from female students. Many studies (Christensen & Knezek, 2018; Naizer et al., 2014) have shown that female students are less interested in STEM careers than male students. In this study, the difference in favor of boys between male and female students before the applications supports this situation. After the experimental application, there was a significant difference between male and female students in the post-test results of the control group, but no significant difference was found in the experimental group. It was seen that male and female students in the experimental group had similar STEM Career interest levels. STEM Activities in Nature resulted that the difference in the level of interest in STEM career fields between male and female students observed in the pre-test disappeared. It increased the interest level of female students more. The following research results agree with the present results: Weber (2011) stated that STEM activities in an informal environment were effective in increasing STEM interests and knowledge of female students; Dubetz and Wilson (2013) stated that STEM education increased the interest of female students in STEM fields; and, Naizer et al. (2014) stated that STEM education closed the STEM career interest gap between male and female students. It is important to increase interest in STEM fields at an early age for female students to be able to steer them to STEM career fields.

To determine the effects of STEM Activities in Nature on the engineering perceptions of the students, the data obtained from the Engineering Perceptions Questionnaire of the experimental and control groups were compared. In addition, the experimental group interview responses were analyzed. The answers of the experimental and control groups in the pre-test to the question of “what is engineering?” appeared to be similar. As a matter of fact, before the application, the students explained the concept of engineering as “a profession", "builder", and "repairer". The answers to the question "What does an engineer do?" given by the experimental and control groups in the pre-tests were similar. While the students incorrectly defined engineers as "workers", it was observed that some students defined engineering as making calculations by generalizing operations such as "calculation" that engineers do. Looking at these definitions, it is thought to be due to the lack of knowledge about engineering. Similarly, in studies in the literature (English et al., 2011; Fralick et al., 2009, Liu & Chiang, 2019), it has been reported that students perceive engineering as "equipment repairing and assembly" and engineers as "working outdoors doing hard work", which supports this conclusion of the research. In the post-test, while the definitions of the control group students were similar to the pre-tests, it was determined that the experimental group students focused on definitions like "design-development" and made more accurate definitions. While the answers of the control group in the post-tests were similar to those obtained before the application, the answers of the students in the experimental group showed positive changes. Students focused on "designer", "developer", and "problem solver" answers. Engineering drawings of the students were examined. In the pre-tests, it was seen that the gender of the engineers whose drawings were drawn by the experimental and control groups were mostly males in both groups. Many studies have shown that engineering is perceived as “men's work” (Cunningham et al., 2005; Karataş et al., 2011; Koyunlu Ünlü & Dökme, 2017). While the post-test drawings were similar to the pre-test drawings in the control group, the proportion of female engineer drawings increased in the experimental group. This is a result consistent with the research findings in the literature (Koyunlu Ünlü et al., 2018). In particular, the fact that female students in the experimental group made drawings of female engineers can be interpreted as an indicator of their identification with engineering. The findings obtained from the interviews also supported the positive change in the engineering perceptions of female students. Engineer drawings were also analyzed in terms of space. In the pre-tests, the drawings of the students in the experimental and control groups were similar. In these drawings, engineers were usually seen indoors using computers or outdoors at construction sites. When the post-test drawings after STEM activities were compared with the pre-tests, the control group drawings were similar to the pre-tests. The post-test drawings of the experimental group differed from the pre-test results. It is seen that more outdoor drawings were made in these drawings and that the spaces in the drawings differed from the pre-tests, such as garden/field/forest. When the drawings of the students were examined in terms of engineering types, it was seen that the experimental group students knew different engineering fields compared to the control group. Although the students' drawings of civil and computer engineers before the application were mostly similar after the application, the fact that the students had drawings of Genetic Engineers, Agricultural Engineers, Aeronautical

Engineers, Software Engineers, Environmental Engineers, and Chemical Engineers can be interpreted as a positive effect of the application on students' knowledge and awareness of engineering fields. This research shows that STEM activities affect students' engineering perceptions positively. This result is similar to the results of applied studies in the literature (Hammack et al., 2015; Kuvaç, 2108; Oware et al., 2007; Lyons & Thompson, 2006) that have improved students' perceptions of engineering. In the interviews, the experimental group students expressed their thoughts on the following subjects: they gained knowledge about engineering, they noticed the types of engineering, and that women can be engineers too. In addition, the definition of engineers as "problem solvers" and "designers" shows that STEM Activities in Nature improve students' perception of engineering.

In the research, experimental evidence was obtained that STEM Activities in Nature, applied in an 11-week period, positively affected students' environmental attitudes and engineering perceptions, and increased students' STEM career interests. In addition, educators can benefit from the activities included in the research, considering that the students had a good level of motivation during the STEM Activities in Nature and had an enjoyable education process. The research has a limitation. The data were obtained from students studying in a secondary school. Therefore, this should be taken into account when generalizing the results.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in JESEH journal belongs to the authors.

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