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The Effect of Common Knowledge Construction Model-Based Instruction on 5th Grade Students' Conceptual Understanding of Biodiversity

Veysel Haydari, Bayram Costu

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Abstract

The aim of this study is to investigate the effect of the Common Knowledge Construction Model (CKCM) based instruction on 5th grade students' conceptual understanding of the "biodiversity" topic. The study is conducted with 74 fifth grade female students at middle school in the district of Usküdar, Istanbul. Semi-experimental method is used. In this model, two experimental groups (Experiment 1 and Experiment 2) and a control group are randomly selected among 5th grade students. In the experiment group 1, teaching is carried out with CKCM, in the experiment group 2, CKCM supported out-of-school learning environments, and in the control group, instruction is carried out in accordance with the curriculum of Turkey. Experimental group 1 includes 24 students, 2 involves 25 students, and control group consist of 25 students. The data is collected through Biodiversity Conceptual Understanding Test (BCUT). Analyzing of BCUT data that require two-tier classification, the answers of the first tier of each question are provided by tabulating the percentages of the reasons chosen for these answers (the second tier). Which alternative concepts were chosen mostly and which ones were changed analyzed as percentage. The data collected from the students' responses to the two-tier BCUT are statistically analyzed with the help of SPSS 18.0™. Kruskal Wallis H-Test and Wilcoxon paired pairs test are employed to analyze the data. In addition, Tamhane's T2 test is employed from post hoc tests to determine the direction of the difference of biodiversity post-test scores. While most of the alternative concepts are remediated in experiment 1 and experiment 2 groups, in the control group it revealed that alternative concepts mostly continued. Result of the study show that CKCM is more effective in remediating alternative concepts than curriculum of the ministry of education. On the other hand, CKCM is more than curriculum of the ministry of education in terms of conceptual understanding of biodiversity. Teaching CKCM supported out-of-school learning environments do not differ in BCUT from the academic achievement only with CKCM teaching. When the post-test academic achievement of the groups is taken into consideration, a significant difference is observed between the experimental groups and the control group in favor of the experimental groups.

Introduction

Biological diversity (biodiversity) is one of the most important parts of the ecosystem on the earth. Biodiversity is created by different plants and animals which covers the diversity of all plants and animals on Earth at any given time (Öner, 2011). The beginning of the industrial age with rapid population growth resulted in disruption of the biodiversity on Earth. In 1992 The Biological Diversity Convention in Rio decided that current researches at all levels must focus on protecting and developing biodiversity around the world (Keating, 1993). Therefore, the importance of preparing teaching activities on biodiversity is increasing day by day. The diversity of plant and animal species of a country contributes to economy of the country in different fields such as medicine, industry, forestry and etc. Biodiversity also contributes enrichment of a nation culturally and economically. One of the most important reasons for the decline of biodiversity in a country is to harm living species. Decrease in plant and animal species showed people that biodiversity is very important (Gayford, 2000). If Turkey wants to keep development in every field, society must preserve biological diversity. Turkey needs individuals who have awareness about biodiversity and who know how to protect the natural environment. Hence, Turkey has developed science education programs in biodiversity to educate students at all levels (Ministry of National Education [MoNE], 2018). It is crucial to learn the concepts and the importance of biodiversity at an early age.

If students fail to understand a concept correctly, learning doesn't occur (Schulte, 2001). Incorrectly held scientific concepts by children referred to in the literature as misconceptions or alternative conceptions (Doran, 1972; Driver & Easley,1978; Treagust & Mann, 1998), inadequate understanding of science (Osborne & Freyberg, 1985; Treagust, 1988), general sense concepts, and spontaneous information. The main reason why researchers and teachers are interested in alternative conceptions of students is that these affects subsequent learning and render learning of new concepts difficult (Coştu et al., 2012). Contrary to these models, Marton (1981) developed the variation theory of learning known as phenomenography. Phenomenography supports the knowledge that emerges as a result of the interaction between human beings and the world (Coştu et al., 2012; Ebenezer & Fraser, 2001; Walsh, 2009).

Researchers claim that primary and secondary school students have alternative conceptions about the classification of living things and biodiversity, and they have difficulties in understanding biodiversity (Braund, 1991, 1998; Cardak, 2002; Kellert, 1985; Trowbridge & Mintzes, 1985). However, most of these studies do not elaborate students ' alternative conceptions. Moreover, different studies done in the literature except biodiversity and alternative concepts. The results of some of these studies; Uzun et al. (2010), asked biology teacher candidates about the concept of biodiversity and they stated that biology teacher candidates generally talk about diversity of species and the teacher candidates have limited knowledge about biodiversity. Further, Dervişoğlu (2010) investigated that college students have value orientations towards living species. In his study, it was determined that students have a utilitarian perspective about value, that is, protection of environment for the benefit of people. The study of Yörek (2006) investigated views of secondary school students on how Turkey's biodiversity is determined and how biodiversity is protected in Turkey. He has also researched students' conceptual understanding of biodiversity.

Science is a method of research and thinking that try to explain the world, based on logical thinking and continuous questioning using experimental criteria (Tatar & Bağrıyanık, 2012). One of the main aims of science teaching is to enable students to learn, understand and experience the natural world (MoNE, 2018). Science course is difficult to confine to books and blackboard, it is intertwined with the real life behind the classroom walls (Payne, 1985). To learn science, you need to take advantage of opportunities outside the school environment (Carrier, 2009). Out-of-school learning is a process-based approach that results from the interaction between the student and the environment. In this process, students actively constructed knowledge from first hand. Out-of-school learning aims to gain knowledge in the learning environment as well as to develop social relationships between students (Orion et al., 1997). Out-of-school activities are carried out outside the classroom, class, or school. Generally, classroom, laboratory and out-of-school places are learning environments in which science education is carried out. The learning outcome that the individual will obtain as a result of his life continues beyond the classroom walls. While the classroom and laboratory environment draws a limited learning place for science lessons, it provides students with many learning opportunities in out-of-school places (Sontay et al., 2016).

There are many types of places where out-of-school learning activities can be carried out such as museums, zoos, aquariums, science centers, factories, and botanical gardens. Technical trips are also accepted as out-of-school learning activities. With technical trips, it is possible to teach the subjects that are difficult to learn in the classroom, students gain experience and trips provide enhancement interest in science (Davidson et al., 2010). The importance of using out-of-school learning environments in the educational process emerges especially in science lessons which are all about our surroundings. Because many subjects of science happen in outside of the classroom are related with covering real events and concepts. In this context; any place where human beings interact outside the school to learn science can be used as a resource (Tatar & Bağrıyanık, 2012). As a matter of fact, in the science curriculum updated since 2004 in Turkey, it was stated that science courses should be carried out in student-based learning environments (problem, project, argumentation, collaborative learning etc.) and it was also given more in out-of-school environments. In this way, many points where the classroom environment is insufficient can be completed within the scope of formal education. Therefore, in-school and out-of-school learning environments are designed according to the research-inquiry based learning strategy that forms the basis of the science curriculum which enables students to learn information meaningfully and permanently (MoNE, 2018).

Theoretical Framework of the CKCM

One of the methods used in science teaching in recent years, especially effective in conceptual change and based on phenomenography, is the Common Knowledge Construction Model (CKCM) (Ebenezer & Connor, 1998). The CKCM is based on Marton's variation theory of learning, Bruner's view of language as a part of the

symbolic system of culture, Vygotsky's "zone of proximal development" and Doll's post-modern thinking on scientific discourse and curriculum development (Biernacka, 2006). The CKCM argues that students construct world views as a result of their personal interactions with the natural environment and their social interactions (Biernacka, 2006; Ebenezer et al., 2004). Therefore, for students to interpret scientific ideas and rules that contain common knowledge about their views on the world must first be determined and a connection must then be established between scientific ideas and their personal views (Ebenezer & Fraser, 2001). The CKCM argues that schools should provide students with social skills along with basic skills. Therefore, learning environments should be constructed in a place where students can grow up as individuals who think critically and who have responsibility and awareness towards global problems. The teacher should provide opportunities for his/her students in this direction. If the teacher shows empathy, understanding and sensitivity towards his/her students and interacts positively with them, both the students' learning experiences and the ability to deal with the problems they face effectively increases (Noddings, 2005; Wood, 2012).

The CKCM consists of four phases. The first phase is Exploring and Categorizing, it includes activities which are done to pay the students' attention to the subject and to determine their prior knowledge. Preliminary information is uncovered by classifying students' information without categorizing them as true or false. In the second phase, namely Constructing and Negotiating, teacher-students and peer-peer interaction is carried out in order to obtain new information through the students' preliminary concepts under the guidance of teachers. The teacher is not the one who transfers the knowledge in the classroom, but the one who guides the students and contributes to their development. In the third phase, Translating and Extending, students make activities in order to transfer their knowledge into new context by integrating them with different disciplines. They try to solve problems around them and in the world at local or national level. The fourth phase, Reflecting and Assessing, it is the phase in which the students construct and learn the subject by using alternative assessment techniques. The teacher can use different techniques to measure the level of students' learning the subject (Ebenezer et al., 2010).

Earlier Studies of the CKCM

When earlier studies of the CKCM reviewed, it was determined that CKCM provides a significant increase in students' conceptual understanding and ensures the permanence of knowledge (Bakırcı et al., 2018; Bakırcı et al., 2016; Bakırcı & Ensari, 2018; Bakırcı & Yıldırım, 2017; Caymaz & Aydın, 2018b; İyibil, 2011; Özden, 2019), has positive impacts in attitudes towards chemistry lesson (Demircioğlu & Vural, 2016), has positive impacts in students 'critical thinking skills (Bakırcı, 2014; Bakırcı & Çepni, 2016; Bakırcı et al., 2020; Yıldızbaş, 2017), has positive impacts in students' academic achievement (Akgün et al., 2016; Bakırcı, 2014; Bakırcı et al., 2015; Bakırcı & Ensari, 2018; Bayar, 2019; Benli Özdemir, 2014; Caymaz & Aydin, 2020; Caymaz & Aydın, 2018a; Ebenezer et al., 2010; Ertuğrul, 2015; İyibil, 2011; Yıldızbaş, 2017), has positive impacts in improving nature of science (Bakırcı, 2014; Bakırcı & Çiçek, 2017; Caymaz & Aydin, 2020; Çavuş et al., 2020; Yıldırım, 2018; Yıldızbaş, 2017), positive influence on students' science process skills (Bakırcı et al., 2020; Bayar, 2019), has positive impacts in socio-scientific issues (Bakırcı et al., 2016; Yıldırım, 2018).

One of the important aspects of CKCM is that it provides flexibility to the teacher about the choice of method and technique and many learning theories can be synthesized. In addition, it allows students to transfer the new knowledge what they just learned into similar situations in real life (Biernacka, 2006; Ebenezer et al., 2010; Ebenezer & Connor, 1998). CKCM also helps students to become aware of their prior knowledge, creates a constructive discussion environment in the classroom and in this way, it makes lessons become more funny (Akgün et al., 2016). Further, it was emphasized that CKCM is effective in eliminating alternative concepts and that it is significantly successful in changing scientific language with daily language (Kiryak, 2013); CKCM is more effective than traditional teaching (Ebenezer et al., 2010; Wood, 2012). Moreover, it was concluded that CKCM is a suitable model for science teaching, as the lessons carried out with CKCM contribute greatly to the development of students' scientific literacy skills (Biernacka, 2006).

Plant, animal and microorganism that create biodiversity and their variations and the communities they form have a great impact on the preservation of natural balance. Providing the nutrients we eat, the oxygen we breathe, and many other needs, biosphere render our daily waste harmless (Yüce & Önel, 2015). Despite this, the biosphere is not destroyed in any era as it is today (Aydoğdu & Gezer, 2006), and its species are constantly disappearing (Efe, 2010). The gradual extinction of biodiversity means the extinction of genetic diversity (Aydoğdu & Gezer, 2006). The disappearance of biodiversity has reached danger levels and has become a global problem (Yörek, 2006). At this point, solutions obtained from studies showed that awareness towards protection of environment increases day by day (Yörek, 2006). Turkey has to improve awareness about this

issue by instructing students because it is very important for future generations. However, deficiencies in the clarity and comprehensibility of the issue of biodiversity are also part of education problems. For this reason, biodiversity has become the focus of educational research in recent years (Dikmenli, 2010). This study is important for the universal and national vital importance of biodiversity and for teaching biodiversity at an early age with correct concepts.

There are many studies on biodiversity in the literature (Barker & Elliott, 2000; Bulut, 2019; Demir, 2020; Fıstıkeken, 2017; Gayford, 2000; Keleş & Özenoğlu, 2017; Kibar, 2019; Kurt, 2018; Lindemann-Matthies, 2002; Uzun et al., 2010; Van Weelie & Wals, 2002; Yörek, 2006). However, there is a paucity of studies on biodiversity conceptual changes in the literature. Since CKCM is an effective model in providing conceptual change (Ebenezer et al., 2010), CKCM was used in this study to provide conceptual changes regarding biodiversity.

The Aim of the Study

The aim of this study is to investigate the effects of CKCM on the determination of alternative concepts of 5th grade students on biodiversity and on the changes of alternative concepts.

The following research questions guided the current study:

1. Is there effect of the teaching based on CKCM to promote conceptual change of 5th grade students' in biodiversity subject?
2. Is there effect of the teaching based on CKCM supported out-of-school learning environments to promote conceptual change of 5th grade students' in biodiversity subject?
3. Is there effect of the science curriculum to promote conceptual change of 5th grade students' in biodiversity subject?
4. Is there any significant difference of the academic achievement of 5th grade students amongst experiment 1, 2 and control groups?

Method

Research Design

In the study, a semi-experimental method was used. In this model, two experimental groups experiment 1 and experiment 2 and a control group were selected randomly among the 5th graders. Experiment 1 is exposed to CKCM, experiment 2 is instructed with CKCM supported with out-of-school learning environments; control group is taught curriculum of the ministry of education in Turkey. All three groups were educated by the responsible the first author. In the instruction of the control group, methods and techniques suitable for the constructivist approach (parallel to Turkey science curriculum) were used. Experimental design is used to reveal cause-effect relationships between variables that can be quantitatively measured in a study. In some studies, it may not be possible to randomly distribute individuals into experiment and control groups. In these cases, the quasi-experimental study is used. In terms of scientific value, this method, which follows the actual experimental method, can be applied in different ways, such as post-test to unequal groups, pre-test and post-test to a single group, and pre-test and post-test to unequal groups (Karasar, 1999). In this method, one or more control and experiment groups are selected. One or more of the groups are randomly selected as experiment and control groups. However, participants are considered to have similar characteristics as possible (Çepni, 2010).

Sample

The study group consisted of 5th grade 74 female students studying in a secondary school in Istanbul, during the spring term of 2018-2019 academic year. There are 24 students in experiment group 1 and 25 students in experiment group 2 and 25 students in control group. As a semi experimental study, random assignment was made while determining all three groups, (namely experiment 1, experiment 2 and control). In the determination of the all study group, easily accessible sampling method was used which makes the research safe and practical (Yıldırım & Simşek, 2008).

Data Collection Tools

Biodiversity Conceptual Understanding Test (BCUT) which is composed of two-tier test items was used as a data collection tool. The conceptual understanding test for biodiversity was developed by Treagust (1988). The content of the test was determined primarily and the boundaries of the subjects and concepts in the test were organized. Then, propositions related to biodiversity were written using question banks, textbooks and different sources related to biodiversity. The relationship between related concepts and the subject contents was determined. Information propositions and concepts related to biodiversity were related. In order to ensure the validity of the scope of the test, four science educators and three experienced science teachers who were experts in their fields examined and gave feedbacks. In this way, the scientific accuracy of the propositions was proved and revised. Missing or incorrect sentences and statements were corrected or removed from the test.

Students' alternative concepts of biodiversity in order to develop two-tier test items were gathered via open-ended questions and semi-structured interviews. Also, it was comprehensively examined related literature about biodiversity to develop BCUT. By taking students' alternative concepts-which are collected according to procedure mentioned above- into consideration, 14 two-tier test questions were developed. The first tier of the test requires the selection of True-False classification, and the second tier requires the selection of the reasons related to the first tier. The pilot study of the developed BCUT was applied to 29 fifth grade students and necessary revisions after the implementation were made. As a result of validity, reliability and item analyzes, only one question was removed from the two-tier test. The validity of the BCUT was provided by a group of four science educators and three experienced science teachers. In the preparation of the BCUT, learning outcome related to biodiversity and student levels were taken into consideration. BCUT was applied to the two experiments and one control group as pre-test and post-test before and after the intervention. BCUT item indexes and reliability coefficient are given in Table 1.

Table 1. BCUT item indexes and reliability coefficient

Item	Difficulty index	Category Difficulty	Item Discrimination	Category Discrimination
1	0,828	Very Easy	0,50	Very Good
2	0,828	Very Easy	0,625	Very Good
3	0,552	Moderate	0,875	Very Good
4	0,621	Easy	0,75	Very Good
5	0,379	Difficult	0,875	Very Good
6	0,621	Easy	0,875	Very Good
7	0,621	Easy	0,875	Very Good
8	0,586	Moderate	0,75	Very Good
9	0,655	Easy	0,5	Very Good
10	0,690	Easy	0,875	Very Good
11	0,759	Easy	0,625	Very Good
12	0,448	Moderate	0,625	Very Good
13	0,448	Moderate	1	Very Good
14	0,103	Very Difficult	0,25	Should be Revised
Total test	0,618	Easy	0,749	Very Good

Reliability; 0,891

According to item indexes (Table 1), item 14 was removed from the test because it is a very difficult item and is a substance that should be revised. BCUT has easy test feature in terms of item difficulty and very good test feature in terms of item discrimination. It is also a very good test in terms of BCUT's reliable coefficient. There are few studies to reveal 5th grade students' alternative concepts related to biodiversity. For this reason, the authors of this paper determined 5th grade student's alternative concepts related to biodiversity. Alternative concepts elicited from students are related to the definition of biodiversity, extinct species, endangered creatures and the effects of biodiversity on nature. The sample questions about the BCUT are given in Figure 1.

Data Analysis

BCUT was analyzed through considering two-tier test items. Students' answers in the two-tier test are provided by tabulating the percentages of each tier. In this way, the percentages of the answers given to the pre-test post-test alternative concepts and the percentages of the pre-test post-test changes of the alternative concepts were

measured. Alternative concepts in the second tier that students chose mostly and alternative concepts in the student's mind were the most changed analyzed as a percentage.

In BCUT, the combination of the first tier of student answers and the second tier indicating justification of the first tier were examined (Coştu et al., 2003). As a result of this classification, as indicated in Table 2, a total score is calculated considering the answers given to all tests. A similar study on the analysis of the two- tier tests was utilized Coştu et al., (2007).

Example Question 1.

The only number of plant species living in a region is biodiversity.
I. True II. False

Because;
a. The number of animal species living in a certain region does not affect biodiversity.
b. The richness of all living species in a region express biodiversity.
c. Only the plants determine the richness of the species in a region.
d. …….

Example Question 2.

In our country, Caretta carettas are in danger of extinction. Natural habitats are made for these creatures.
For Caretta Carettas, which are in danger of extinction, the construction of natural habitats causes a decrease in biodiversity.
I. True II. False

Because;
a. *Caretta Carettas* have no role in nature, the establishment of natural habitats does not affect biodiversity.
b. The extinction of *Caretta Caretta* species affects biodiversity as it reduces the number of species. Therefore, living spaces are needed.
c. The extinction of *Caretta Carettas* does not affect other creatures. Therefore, there is no need to establish habitats for Caretta Carettas.
d. …….

Example Question 3.

Partridge is a bird and feeds on ticks. In an area with partridges, the number of partridges decreased as a result of overfishing of hunters.
Accordingly, the decrease in the number of partridges affected biodiversity.
I. True II. False

Because;
a. Biodiversity has increased, as the number of *partridges* has decreased, leading to an increase in the number of ticks.
b. Biodiversity is not affected because the decrease in the number of *partridges* does not affect other species.
c. Decreasing the number and species of living things in a region reduces the richness of biodiversity.
d.……

Figure 1. Sample two-tier test question of BCUT

The categorization of the responses of the two-tier tests is given as follows;

- True Response- True Reason= Sound Understanding (SU)
- True Response - Partially True Reason= Partial Understanding (PU)
- True Response- False Reason= Specific Misconceptions (SM)
- False Response- False Reason= No Understanding
- No Response- No Reason= No Response (NR)

Similar categorization was used in earlier studies (e.g. Coştu and Ayas, 2005). The highest score that the students gain from the BCUT is 39, while the minimum score is 0.

Table 2. Evaluation criteria used to analyze BCUT

Evaluation Criteria		Score
True Response	True Reason	3 Point
True Response	Partially True Reason	2 Point
True Response	False Reason	1 Point
True Response	No Reason	1 Point
False Response	True Reason	2 Point
False Response	Partially True Reason	1 Point
False Response	False Reason	0 Point
False Response	No Reason	0 Point
No Response	True Reason	2 Point
No Response	Partially True Reason	1 Point
No Response	False Reason	0 Point
No Response	No Reason	0 Point

The data obtained from the students' responses to the two-tier BCUT were statistically analyzed with the help of SPSS program. Kruskal Wallis H-Test was utilized for non-parametric tests because the number of students was less than 30 for each group of the study group and the data did not show homogeneous normal distribution. Wilcoxon paired pairs test was used to determine the significant difference between the pre- and post-tests and Tamhane's T2 test was selected from post hoc tests to determine the direction of the difference of biodiversity post-test scores.

Teaching Intervention

All three groups (namely experiment 1, experiment 2 and control) were taught by the responsible the first author of the paper. He has 10 years of teaching experience and recently he taught relevant research concepts to classes of wide variety students. Thus, he has sufficient experience to teach these concepts properly. In addition, he has also sufficient knowledge and experience about the CKCM and out-of-school learning. The studies in the experiment and control groups were applied at different times in the same week

While lessons were based on science curriculum in the control groups, they were based on the CKCM in experimental groups. In experiment 1 teaching was made only with CKCM, and in experiment 2 teaching was made with CKCM supported out-of-school learning environments. In the teaching of the control group, methods and techniques suitable for the constructivist approach (parallel to Turkey science curriculum) were utilized in period of eight hours. The 5th grade regular teacher taught the control groups with science curriculum involving lectures. The principle of teaching adopted in these classes was that knowledge resides with the teacher and that it is the teacher's responsibility to transfer that knowledge as facts to students. The teacher explained the knowledge structures in following the prescribed textbook. At the end of each class, the teacher asked direct questions on important concepts. The teacher dictated notes while the students copied. The experiments were carried out on the subjects of the unit and homework assignments were given.

Instructional materials developed based on CKCM were applied in experiment 1 and experiment 2 groups for 8 hours period. Out-of-school learning activities for experiment 2 were carried out outside of class hours. Experiment 2 completed the instruction in out-of-school learning activities such as zoo, recycling activities, water treatment plant. In addition, experiment 2 students gave information about the importance of recycling to environmental trades.

Exploring and Categorizing

The first phase of the CKCM explored the students' prior knowledge of the biodiversity. In order to attract student's attention to biodiversity in experiment 1 and experiment 2 groups, the teacher aimed to reveal the students' prior knowledge about biodiversity with the brainstorming technique by hanging photographs of all the living species that the students have never met, all fish species and extinct organisms. The worksheet on extinct and endangered life forms was given to the students and the students' prior knowledge of these life forms was revealed. An event called conservation of Caretta caretta, prepared according to the method of Predict-Explain-Observe-Explain (PEOE), was held to reveal the students ' preliminary knowledge. In a similar study, students' alternative concepts were determined with the PEOE method (Bakırcı, 2014). Before the PEOE method was used, students were shown a video that would predict that the generations of Caretta Caretta are in danger. Then,

PEOE worksheet containing the news about the protection of the nests of Caretta Caretta's on the beach in Kas district of Antalya was made. In this way, students were made to guess and observe that the generations of Caretta caretta are in danger. Also, at this stage of the model, Word Association Test (WAT) was used to determine the students' concepts related to biodiversity. Then, two visuals were given to the students to express the importance of biodiversity and the preliminary information about biodiversity was tried to be revealed. At this phase, the students' alternative concepts related to biodiversity were revealed. Alternative concepts have been solved with the help of activities in other stages. As a result of all the studies, the commonalities in the students' thoughts were determined and phenomenographic categories were created.

Constructing and Negotiating

In this phase, teacher-student and peer-peer interaction are implemented. The teacher guides the students and ensures that information is socially structured in the light of scientific discourses (Biernacka, 2006; Duschl & Osborne, 2002). "What is Biodiversity, what are the factors affecting biodiversity, what are the endangered species in our country and in the world, what are the extinct species in our country and in the world? "The subject homework was presented by the students in the classroom. In the experiment 2 where the CKCM supported out-of-school learning environments was conducted the students made their presentations with the help of TV programs and drama activities such as out-of-school learning activities. With the help of out-of-school learning, such as TV presentation and drama production, students learn by structuring their knowledge. In the first phase after the presentations, the observation explanation steps of the worksheet prepared according to the prediction explanation observation explanation method (PEOE), which was filled in the estimation explanation step, were performed at this stage. Before completing the PEOE worksheet, students watched a video about the Caretta caretta and contradictions were found. Those contradictions were resolved by comparing the predictions and observations in the light of this video. Afterwards, students discussed the effectiveness of biodiversity in different ecosystems with group discussions. The activity was held on "human and nature-induced factors that threaten biodiversity". There was an activity about extinct and endangered species in our country and around the world. At this stage, FENVIVOR game was prepared for all groups to learn exactly what was learned and eliminate alternative concepts. This game was created by the researcher in accordance with the lesson outcomes. The letters they wrote to people for the nests of different animals, called sweet creatures ' letters, were read in each group and the nests of animals were drawn by the students. The experiment group 2, the event called "Letters of sweet creatures" was read in each group and students drew animal nests in line with the letters.

Translating and Extending

Students identify and discuss socio-scientific problems related to biodiversity (Ebenezer et al., 2010). In addition, by structuring, students transfer their knowledge to new situations by associating them with different disciplines and concepts. Activities for finding solutions to local or national problems in the environment or around the world are also carried out at this phase (Bakırcı, 2014). At this stage, the activity called "the effects of chemical spraying" was applied to the students in order to draw attention to socioeconomic issues. The aim is to show students that chemical spraying can destroy insects that damage plants, while at the same time damaging bees, flies and spiders that live in that region and negatively affect biodiversity. Then socio-scientific activity related to the effects of an explosion on biodiversity on an offshore platform was applied. With this activity, the students examined the benefits of oil extraction in the seas as well as the negative effects of biodiversity and the effects of living things in danger of extinction. Afterwards, it was ensured that they understood the importance of the issue and offered solutions through group discussions. In order to realize the importance of biodiversity to the experiment 2, they were provided with informal learning through a zoo trip and observed and implemented what they learned in daily life. During the zoo trip, students made observations using the habitats observation form.

Reflecting and Assessing

This is the phase at which students learn the subject by using alternative assessment and evaluation techniques. The teacher can use different techniques to measure the level of students' learning the subject (Biernacka, 2006; Ebenezer et al., 2010). At this phase, students realize that they have experienced meaningful learning according to their behavior at the beginning of the lesson. The word association test applied at the first stage to observe this behavior change was reperformed at this phase. In addition, alternative measurement and evaluation

techniques, structured grid and diagnostic branched tree related work sheets were made at this phase. Finally, in this phase, the game of FENVIVOR, which was prepared for the subject of biodiversity and which we used in the third phase, was played. By implementation of the game what information students learned was determined and at what level they learned the alternative concepts. Figure 2 was created to indicate where the intervention in the experiment 1 and experiment 2 groups differed. As can be seen from the Figure 2, for experiment 2 out-of-school learning were added in stage 1, 2 and 3 to support CKCM.

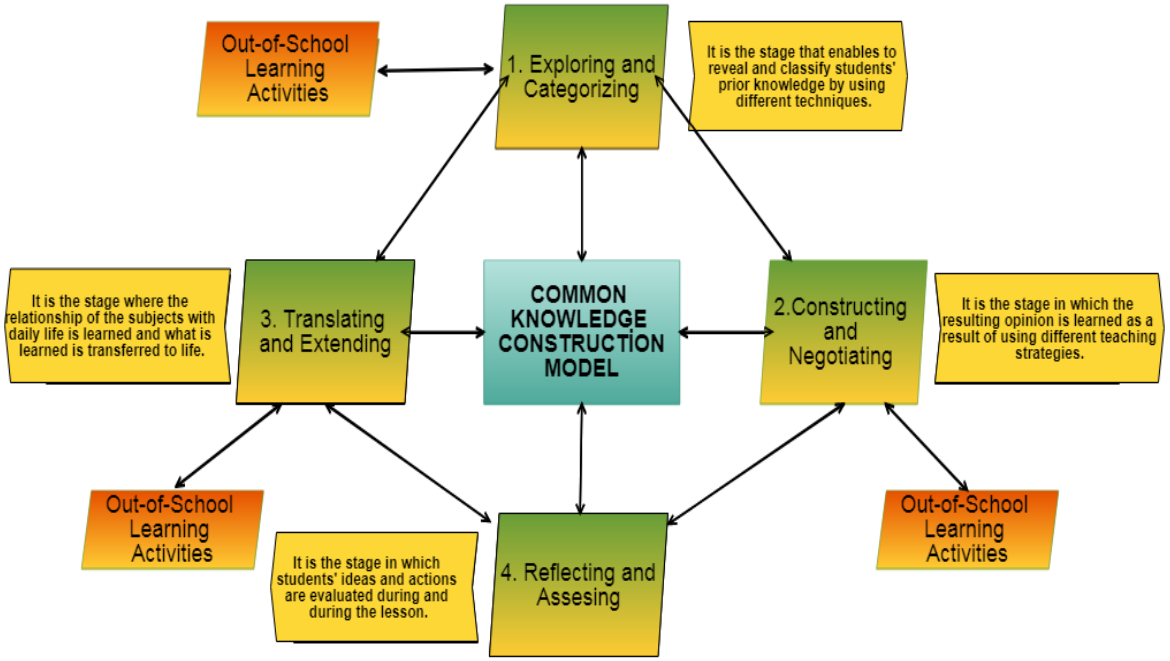

Figure 2. Teaching intervention CKCM and CKCM supported out-of-school learning environments

Findings

As shown in Table 3, when the answers of experiment 1 group to BCUT pre-test questions are analyzed, it is seen that the SU values of all questions are 53%, PU 0%, SM 29%, NU / NR 18%. It is seen that the experiment 1 group students have serious alternative concepts in the questions 1, 2, 3, 4, 5, 6, 7, 9, 12. The answers of experiment group 2 to BCUT pre-test questions are analyzed, it is seen that the SU values of all questions are 73%, PU 0%, SM 19%, NU / NR 8%. It is observed that the experiment 2 group students have serious alternative concepts in the questions 4, 5, 7. The answers of control group to BCUT pre-test questions are analyzed, it is revealed that the SU values of all questions are 53%, PU 0%, SM 30%, NU / NR 17%. It is observed that the control group students have serious alternative concepts in the questions 2, 3, 4, 5, 6, 7, 9, 10, 12. It is observed that the students do not write their own reasons in the justification part of the two-stage test and they choose one of the multiple-choice answers. Partial Understanding percentages are therefore 0%.

As shown in Table 3, when the answers of experiment group 1 to BCUT post-test questions are analyzed, it is seen that the average SU value of all questions is 85%, PU 0%, SM 9%, NU / NR 6%. This value indicates that the alternative concepts of experiment group 1 have been greatly reduced and eliminated. When the answers of the experiment group 2 to the BCUT post-test questions were analyzed, it was seen that the SU values of all questions were 88%, PU 0%, SM 7%, NU / NR 5%. This value shows that the alternative concepts of experiment group 2 are greatly reduced and eliminated. Only in the 10th and 11th questions there was a slight increase in the alternative concepts. It is seen that alternative concepts have decreased in other questions. When the answers of the control group to BCUT post-test questions were analyzed, it was seen that the mean SU values of all questions were 72 percent, PU 0%, SM 16%, NU / NR 12%. It was determined that the alternative concepts of the control group students continued in the questions 3, 5, 6, 12, while there was a slight increase in the alternative concepts only in the 12th question. When Table 3 is analyzed, the group with the least change in alternative concepts is observed as the control group. Table 3 shows the percentages of the BCUT as a pre-test and post-test for the experiments and control groups.

Table 3. Percentage of pre-test and post-test of student responses to items of BCUT

	Response Categorization	Experiment 1 Pre-(%)	Experiment 1 Post-(%)	Experiment 2 Pre (%)	Experiment 2 Post- (%)	Control Pre-(%)	Control Post- (%)
Q 1	SU	50	92	84	100	64	100
	PU	0	0	0	0	0	0
	SM	29	0	12	0	16	0
	NU/NR	21	8	4	0	20	0
Q 2	SU	58	75	92	96	60	88
	PU	0	0	0	0	0	0
	SM	30	17	8	4	24	8
	NU/NR	12	8	0	0	16	4
Q 3	SU	29	63	64	92	36	40
	PU	0	0	0	0	0	0
	SM	58	33	36	4	52	24
	NU/NR	13	4	0	4	12	36
Q 4	SU	46	83	40	68	56	72
	PU	0	0	0	0	0	0
	SM	33	13	56	32	24	20
	NU/NR	21	4	4	0	20	8
Q 5	SU	33	83	44	64	40	56
	PU	0	0	0	0	0	0
	SM	33	8	32	16	36	28
	NU/NR	34	9	24	20	24	16
Q 6	SU	54	88	68	96	44	56
	PU	0	0	0	0	0	0
	SM	46	8	28	4	48	36
	NU/NR	0	4	4	0	8	8
Q 7	SU	50	88	48	76	48	68
	PU	0	0	0	0	0	0
	SM	12	0	16	4	24	4
	NU/NR	38	12	36	20	28	28
Q 8	SU	67	100	80	100	64	72
	PU	0	0	0	0	0	0
	SM	21	0	8	0	20	8
	NU/NR	12	0	12	0	26	20
Q 9	SU	46	79	68	76	28	72
	PU	0	0	0	0	0	0
	SM	38	17	28	20	48	24
	NU/NR	16	4	4	4	24	4
Q 10	SU	71	92	100	92	48	88
	PU	0	0	0	0	0	0
	SM	0	4	0	4	24	12
	NU/NR	29	4	0	4	28	0
Q 11	SU	67	88	100	96	64	80
	PU	0	0	0	0	0	0
	SM	17	4	0	0	28	12
	NU/NR	16	8	0	4	8	8
Q 12	SU	46	83	68	96	52	48
	PU	0	0	0	0	0	0
	SM	38	13	24	0	32	24
	NU/NR	16	4	8	4	16	28
Q 13	SU	75	96	92	92	80	96
	PU	0	0	0	0	0	0
	SM	12	0	4	4	16	4
	NU/NR	13	4	4	4	4	0

SU:Sound Understanding, PU: Partial Understanding, SM:Specific Misconception, NU/NR:No Understanding/No Response

Table 4. Percentages of change in students' alternative concepts from pre-test to post-test in BCUT by groups

		Experiment 1			Experiment 2			Control		
Alternative Concepts	Related Questions	Pre (%)	Post (%)	CC (%)	Pre (%)	Post (%)	CC (%)	Pre (%)	Post (%)	CC (%)
1: The sheer number of living things is called biodiversity.	2, 3, 4	22.2	12.5	+9.7	26.7	12	+14.7	21.3	8	+13.3
2: The habitat differences of living things are called biodiversity.	12	4.2	0	+4.2	12	0	+12	8	16	-8
3: Living together is called biodiversity.	3	29.2	2.5	+26.7	16	4	+12	20	24	-4
4: Only the large number of animal species is called biodiversity.	1,4,	16.7	0	+16.7	0	0	0	4	2	+2
5: Only the excess number of plant species is called biodiversity.	1,2	14.6	0	+14.6	8	0	+8	12	0	+12
6: Decreasing the number of living species, increases the habitats of other living things.	6,8	20.8	8.3	+12.5	8	2	+6	26	16	+10
7: The decrease in the number of species does not affect the lives of other species.	6,7,8	11.1	0	+11.1	8	0	+8	10.7	5.3	+5.4
8: The decrease in the number of species affects only the organisms that feed on it.	9,10	12.5	6.25	+6.25	16	4	+12	16	10	+6
9: Extinct creatures are creatures that have no role left in nature over time.	5,12,13	20.8	6.9	+13.9	12	4	+8	16	14.7	+2.7
10: The extinct life forms are those that stop reproduction over time.	5	12.5	0	+12.5	8	8	0	8	4	+4
11: Endangered organisms die over time because of them cannot meet their nutritional needs.	13	4.2	0	+4.2	4	0	+4	4	0	+4
12: Some living things have no role in nature.	7	4.2	0	+4.2	16	4	+12	8	0	+8
13: Some creatures have no use for nature.	9,10,11	5.6	4.2	+1.4	2.7	6.7	-4	17.3	8	+9.3
14: Some species have only harm to other creatures.	11	12.5	0	+12.5	0	0	0	16	8	+8

CC:Conceptual Change

As a result of BCUT pre-test post-test analysis, SU change was calculated as 32%, PU change as 0%, SM change as 20%, NU / NR change as 12% in experiment group 1. In the Experiment 2, the posttest difference in the pre-test difference was calculated as 15%, PU change 0%, SM change 12%, NU / NR change 3. In the control group the post-test pre-test difference was calculated as SU change 19%, PU change 0%, SM change 14%, NU / NR change 5%. In the groups taught with experiment 1 and experiment 2, it is observed that the alternative concepts are reduced in most of the questions. It is observed that students do not write their own reasons in the questions and choose one of the multiple-choice answers. PU percentages are therefore 0%. Furthermore, when the differences between pre-test and posttest were examined, the difference between the total of SM and NU/NR values was 32 % in experiment 1, 15 % in experiment 2, and 19 % in control group. According to this result, the highest variation between pre-test and posttest alternative concepts was observed in experiment 1. The difference in experiment 2 and the control groups came close to each other. However, this closeness seen in the percentages of concept changes in experiment 2 and control groups is due to low percentage of alternative concepts in pre-test results of experiment 2.

As shown in Table 4, when alternative concepts in BCUT were examined before and after intervention, it was observed that the most significant change was in experiment 1 and then in experiment 2 and control groups. The number of alternative concepts showing more than 10% conceptual change is higher in experiment 1. The change below 10% was considered insignificant. No change was observed for some alternative concepts. Some increase in 14. Alternative concepts were observed in experiment 2. In the control group, a slight increase was observed in alternative concepts 2 and 3. Since some alternative concepts were less in the pre-tests in the experiment 2 than the other groups, the percentage rate of conceptual changes was low. When the changes in alternative concepts were examined, a change of more than 10% was observed only in experiment 1 in 4, 7, 9, 10, 14 alternative concepts. When comparing the academic achievement of the BCUT of the experiment and control groups, analysis revealed that BCUT does not fit into the normal distribution. Kruskal Wallis H-Test was used for independent samples to test whether there was a significant difference between the pre-test and post-test averages of experiment 1, experiment 2 and control groups. In addition, Wilcoxon paired pairs test was used to determine the significant difference between the pre and posttests. Tamhane's T2 test was selected from post hoc tests to determine the direction of the difference in BCUT post-test scores.

Table 5. Pre-test and post-test academic achievement points of the groups

TEST	GROUP	N	X	sd
Pre-Test	Experiment 1	24	26.21	9.146
	Experiment 2	25	27.84	4.368
	Control	25	26.88	5.872
Post-Test	Experiment 1	24	35.46	2.904
	Experiment 2	25	36.32	1.701
	Control	25	31.44	6.063

As shown in Table 5, the mean BCUT pre-test scores and standard deviation of the groups are similar. Kruskal Wallis H-Test was used for independent samples in BCUT to determine whether the differences between the students' pre-test and post-test mean were significant. Table 6 shows the Kruskal Wallis H-Test results of BCUT pre-test and post-tests scores.

Table 6. Kruskal Wallis H-Test results of BCUT pre-test and post-test scores

Group	N	p (pretest)	p (posttest)
Experiment 1	24		
Experiment 2	25	.730	.001
Control	25		

According to Table 6, the results of the analysis show that there is no significant difference between the scores of the classes taken from the biodiversity conceptual understanding pre-test. X^2 (sd=2, n=74) = 0.628, p >.05. This shows that the academic achievement levels of the students participating in the study are close to each other. According to Table 6, the Kruskal Wallis H-Test analysis results of BCUT post-test scores show that there is a significant difference between the scores obtained from the post-test of academic achievement. X^2 (sd=2, n=74) = 14.709, p<.05. In order to reveal the source of the differences, Tamhane's T2 Test was selected from multiple comparison (post-hoc) tests (recommended for unevenness of group variances). Tamhane's T2 Test results are shown in Table 7.

According to Table 7, the mean differences of the experiment 1 in which CKCM was applied as a result of multiple comparisons of BCUT post-test results differ significantly from the mean differences of the control

group was conducted ($p<0.05$). Similarly, the mean differences of experiment 2 differ significantly from the mean differences of the control group ($p<0.05$). There was no significant difference between the mean differences of BCUT post-test results of experiment 1 and experiment 2 groups ($p>0.05$). Biodiversity post-test scores which were obtained from CKCM supported out-of-school learning environments did not differ significantly regarding academic achievement post-test scores obtained from teaching conducted with CKCM.

Table 7. BCUT posttest Tamhane's T2 test results

(I) Class	(J) Class	Mean Differences (I-J)	p
Experiment 1	Experiment 2	-0.862	0.517
	Control	4.018*	0.016
Experiment 2	Experiment 1	0.862	0.517
	Control	4.880*	0.002
Control	Experiment 1	-4.018*	0.016
	Experiment 2	-4.880*	0.002

Note: * Mean difference is significant at 0.05 levels.

Discussion and Conclusion

The main aim of this study is to investigate the impact of CKCM on the changes of alternative concepts on biodiversity. When examining students' answers to the alternative concepts in Table 3, it showed that the alternative concepts of all groups decreased from pre-test to post-test and alternative concepts were replaced with the correct concepts. It was observed that CKCM supported out-of-school learning did not have more effect in eliminating alternative concepts compared to the use of CKCM alone. Furthermore, it was observed that there were differences between BCUT pre-test and post-test changes in experiment and control groups of 5th grade students. It was also observed that most of the alternative concepts were eliminated in both experimental groups. In the control group, it was shown that alternative concepts mostly continued to use before and after the intervention. In BCUT, Sound Understanding (SU), Specific Misconceptions (SM), No Understanding/No Response (NU/NR) were the highest change in the experiment 1 and the lowest in the experiment 2. The reason for the lowest change in the experiment 2 may be that students have fewer alternative concepts in the pre-test than the other groups. As shown in Table 3, PU values were not formed because the students did not write their own reasons as answers to BCUT questions.

When the answers of experiment 1 students to the questions of 1, 2, 3, 4, 5, 6, 7, 9, 12 were examined in the BCUT pre-test, it was observed that students' alternative concepts were 40 % and above. It was observed that the answers of the experiment 1 students to BCUT post-test greatly decreased their alternative concepts in these questions and did not have alternative concepts of 40% or more. When the answers of the experiment 2 students to the questions of 4, 5, 7 were examined in the BCUT pre-test, it was observed that the given answers had 40% and more alternative concepts. It was observed that alternative concepts decreased by 40% or more in the responses of the students of experiment 2 to the BCUT post-test. When the answers of the control group students to the questions of 2, 3, 4, 5, 6, 7, 9, 10, 12 were examined in the BCUT pre-test, it was observed that the given answers had 40% and more alternative concepts. The control group students' answers to the 3,5, 6 questions of BCUT post-test, showed that alternative concepts resist to change, and that there were no alternative concepts by 40% decreasing the alternative concepts in other questions.

When the difference between BCUT pre-test and post-test conceptual changes is examined, the highest conceptual changes in experiment 1 are 3, 4, 5, 6, 7, 9, 10, and 14, and the most conceptual changes in experiment 2 are 1, 2, 3, 8, and 12, the highest conceptual changes were observed in alternative concepts 1, 5 and 6 in the control group. When alternative concepts are examined, the 2nd alternative concepts in the Table 3 "biodiversity differences of living things" are called as biodiversity and the 8th alternative concepts the decrease in the number of species, affect only the creatures fed with it" have experienced a change of more than 10% in experiment 2. The reason for this change can be explained by taking students to the zoo to learn outside of school. This situation shows that teaching with method of CKCM leads to a significant difference in students' understanding of biodiversity. The literature results regarding the effect of CKCM on alternative concepts are as follows; It shows that CKCM is an effective model for eliminating alternative concepts by showing similarities such as greenhouse effect (Bakırcı & Yıldırım, 2017), urinary system (Ebenezer et al., 2010), energy issue (İyibil, 2011), acids and bases (Vural et al., 2012; Wood, 2012) and water pollution (Kiryak, 2013). Following the teaching of biodiversity that is based on CKCM, it is understood that the existing alternative concepts that the students have learned about the subject have been largely eliminated in a comparison to control group

(Ebenezer et al., 2010). This can be explained by the effectiveness of the activities in the first phase of the CKCM, Exploring and Categorizing. Furthermore, the use of different techniques with CKCM may have played an important role in eliminating alternative concepts. Which techniques on the other hand, in the last phase of the model, Reflection and Assessing, it may be due to the application of different alternative assessment and evaluation techniques (structured grid, word association test, diagnostic branched tree) and process-oriented.

According to the results of statistical analysis, BCUT pre-test results were similar and there was no significant difference between academic achievement pre-test results of both groups. BCUT pre-test results showed that the academic achievement levels of the experiment and control groups are similar. When the analysis of BCUT post-test academic achievement results was examined, it was concluded that the groups differed significantly from each other. When the related literature is analyzed, it is seen that there is a limited number of studies on the effects of CKCM on academic achievement supporting this study. (Atayeter, 2019; Bakırcı, 2014; Bayar, 2019; Caymaz & Aydin, 2018a, 2020; Ebenezer et al., 2010; Ertuğrul, 2015; Uzunkaya, 2019; Yıldızbaş, 2017). Post-test BCUT academic achievement results of the experiment 1 and experiment 2 who participated in the study significantly differed from the control group post-test BCUT. According to the results of Tamhane's T2 Test which is one of the post-hoc techniques to determine significant differences among groups, it is concluded that there is a significant difference between experiment 1 and control groups in favor of experiment 1 and experiment 2 and control groups in favor of experiment 2. It was concluded that there was no significant difference in BCUT post-test between experiments 1 and experiment 2 groups. This showed that teaching with CKCM is more effective in terms of academic achievement of biodiversity. According to the study Bakırcı, Artun, Kutlu, et al. (2018) CKCM is effective on students' academic achievement in the human and environmental unit where it is involved in biodiversity.

The use of CKCM supported out-of-school learning did not differ in terms of the academic achievement of biodiversity only from the group taught with CKCM. That is, the inclusion of out-of-school learning in the CKCM did not make a difference in academic achievement of biodiversity from the group taught with CKCM. This may be because experiment 1 and experiment 2 groups provide effective teaching with CKCM. When studies on the effects of CKCM on academic achievement are examined, it was seen that CKCM has a positive effect on academic achievement (Atayeter, 2019; Bakırcı, 2014; Bakırcı et al., 2018; Bakırcı et al., 2015; Bakırcı & Ensari, 2018; Bayar, 2019; Caymaz & Aydin, 2018a, 2020; Ertuğrul, 2015; İyibil, 2011; Sütlüoğlu Dursun, 2019; Wood, 2012; Yıldızbaş, 2017). In addition, the fact that the academic achievement levels of the experiment 1 and experiment 2 groups were close to each other before the education may have resulted in no significant difference between the experiment groups. Moreover, it can be said that the application of worksheets and FENVIVOR game prepared according to CKCM in both experiment 1 and experiment 2 groups for a period of time does not make a significant difference in terms of academic achievement. When the related literature is examined, a study involving out-of-school learning has not been found in CKCM. For this reason, this was the first study to investigate the effect of CKCM supported out-of-school learning environments.

The present study claimed that CKCM will be effective in achieving conceptual understanding and improving conceptual change in other subjects of science courses given the level of progress of conceptual understanding of fifth grade students in biodiversity (Coştu et al., 2012; İyibil, 2011; Kiryak, 2013). It was concluded that the studies about CKCM are related to science and chemistry courses (Bakırcı & Çepni, 2016). In this study, the CKCM-based instruction was observed whether it has a positive effect on students' academic achievements and conceptual change on biodiversity. As relevant studies increase, common inferences can be formed concerning the common impact of the model. Besides, future studies can examine the effects of the CKCM-based instruction can be investigated at different grade levels, such as pre-school and primary school. Moreover, in order to understand comprehensively the effects of using CKCM and out-of-school learning together, different researches can be conducted at different class levels

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Scientific Ethics Declaration

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

References

Akgün, A., Duruk, Ü., & Güngörmez, H. G. (2016). Sixth grade students' views on the common knowledge construction model. *Journal of Amasya University Faculty of Education, 5*(1), 184-203.

Atayeter, M. (2019).*The effect of common knowledge construction model on 4th grade secondary school students' attitudes towards academic success and science within the unit of "structure and properties of matter" in science course* (Master's thesis). Muğla Sıtkı Koçman University, Institute of Educational Sciences, Muğla, Turkey

Aydoğdu, M., & Gezer, K. (2006). *Environmental science*. Anı Publishing, Ankara.

Bakırcı, H. (2014).*The study on evaluation of designing, implementing, and investigating the effects of teaching material based on common knowledge construction model: Light and voice unit sample* (Doctoral thesis). Karadeniz Technical University, Institute of Educational Sciences, Trabzon, Turkey.

Bakırcı, H., Artun, H., Kırıcı, M. G., & Kutlu, E. (2018).The effect of the learning environment designed according to the common knowledge constructuring model on the academic achievement of fifth grade students: "Example of human and environmental unit". *International Symposium on Social Studies and Behavioral Sciences, 21-23 October 2018, Antalya.*

Bakırcı, H., Artun, H., Kutlu, E., & Kırıcı, M. G. (2018). The effect of the common knowledge constructuring model used in teaching the human and environmental unit on the conceptual understanding and permanence of fifth grade students. *International Symposium on Social Studies and Behavioral Sciences, 21-23 October 2018, Antalya.*

Bakırcı, H., Artun, H., & Şenel, S. (2016). The effect of science teaching based on the common knowledge constructuring model on the conceptual comprehension of seventh grade students in secondary school (let's get to know the celestial bodies). *Yüzüncü Yıl University Journal of the Faculty of Education, 13*(1), 514-543.

Bakırcı, H., & Çepni, S. (2016). The effect of the common knowledge constructuring model on the critical thinking skills of the sixth grade students of secondary school: Example of light and sound unit. *Journal of Inönü University Faculty of Education, 17*(3), 185-202.

Bakırcı, H., Çepni, S., & Yıldız, M. (2015). The effect of the common knowledge construction model on sixth grade students' academic achievement: light and sound unit. *Dicle University Journal of Ziya Gökalp Faculty of Education, 26*, 182-204.

Bakırcı, H., & Çiçek, S. (2017). The effect of the learning environment designed according to the common knowledge constructuring model on the nature of science of 5th grade students. *Journal of Social and Humanities Sciences Research, 4(15)*, 1960-1974.

Bakırcı, H., & Ensari, Ö. (2018). The Effect of common knowledge construction model on high school students' academic achievement and conceptual understanding on heat and temperature. *Education and Science, 43*(196), 171-188.

Bakırcı, H., Kahraman, F., & Artun, H. (2020). The effect of the common knowledge construction model on fifth grade students' scientific process skills and critical thinking skills on biodiversity. *Journal of Science, Mathematics, Entrepreneurship and Technology Education, 3*(1), 51-64.

Bakırcı, H., & Yıldırım, İ. (2017). The effect of common knowledge construction model on conceptual understanding of students and greenhouse effect. *Kirsehir University Journal of the Faculty of Education, 18*(1), 45-63.

Barker, S., & Elliott, P. (2000). Planning a skills-based resource for biodiversity education. *Journal of Biological Education, 34*(3), 123-127.

Bayar, M. F. (2019). The effect of common knowledge Cconstruction model on science process skills and academic achievement of secondary school students on solar system and eclipse. *Online Journal of Science Education, 4*(1), 4-19.

Benli Özdemir, E. (2014). *The study on impact of common knowledge construction model on the cognitive and affective learning of primary education students in science education* (Doctoral dissertation). Gazi University, Institute of Educational Sciences,Ankara, Turkey.

Biernacka, B. (2006). *Developing scientific literacy of grade five students: A teacher-researcher collaborative effort.* (Doctoral dissertation), University of Manitoba, Canada.

Braund, M. (1991). Children's ideas in classifying animals. *Journal of Biological Education, 25*(2), 103-110.

Braund, M. (1998). Trends in children's concepts of vertebrate and invertebrate. *Journal of Biological Education, 32*(2), 112-118.

Bulut, M. (2019). *The views of science, biology, geography and social studies teachers on biodiversity and the levels of processing in biodiversity courses in the region where they work* (Master's thesis). Sakarya University, Institute of Educational Sciences, Sakarya, Turkey.

Cardak, O. (2002). *Identification of misconceptions in high school first year students' diversity and classification of living things and elimination with concept maps* (Doctoral dissertation). Selcuk University, Institute of Educational Sciences, Konya, Turkey.

Carrier, S. J. (2009). The effects of outdoor science lessons with elementary school students on preservice teachers' self-efficacy. *Journal of Elementary Science Education, 21*(2), 35-48.

Caymaz, B., & Aydın, A. (2018a). Investigation of the effect of common knowledge constructuring model on 7th grade students' science achievement. *V. International Eurasian Educational Research Congress, 2-5 May, 2018, Akdeniz University, Antalya.*

Caymaz, B., & Aydın, A. (2018b). Examining the effect of the common knowledge constructuring model on students' conceptual understanding. *V. International Eurasian Educational Research Congress, 2-5 May, 2018, Akdeniz University, Antalya.*

Caymaz, B., & Aydin, A. (2020). The effect of common knowledge construction model-based instruction on 7th grade students' academic achievement and their views about the nature of science in the electrical energy unit at schools of different socio-economic levels. *International Journal of Science and Mathematics Education*, 1-33. https://doi.org/10.1007/s10763-020-10054-0

Chi, M. T., & Roscoe, R. D. (2002). The processes and challenges of conceptual change *Reconsidering conceptual change: Issues in theory and practice* (pp. 3-27): Springer

Coştu, B., & Ayas, A. (2005). Evaporation in different liquids: Secondary students' conceptions. *Research in Science & Technological Education, 23*(1), 75-97.

Coştu, B., Ayas, A., & Niaz, M. (2012). Investigating the effectiveness of a POE-based teaching activity on students' understanding of condensation. *Instructional Science, 40*(1), 47-67.

Coştu, B., Ayas, A., Niaz, M., Ünal, S., & Calik, M. (2007). Facilitating conceptual change in students' understanding of boiling concept. *Journal of Science Education and Technology, 16*(6), 524-536.

Coştu, B., Karataş, F. Ö., & Ayas, A. (2003). Using worksheets in concept teaching. *Pamukkale University Faculty of Education Journal, 14*(14), 33-48.

Çavuş-Güngören, S., & Hamzaoğlu, E. (2020). Science teacher candidates' opinions about the common knowledge constrution model]. *Kastamonu Journal of Education, 28*(1), 107-124.

Çepni, S. (2010). *Introduction to research and project studies*, Trabzon: Celepler Publishing.

Davidson, S. K., Passmore, C., & Anderson, D. (2010). Learning on zoo field trips: The interaction of the agendas and practices of students, teachers, and zoo educators. *Science Education, 94*(1), 122-141.

Demir, E. (2020). *Analyzing of effects of flipped classroom practices on environmental consciousness in the fifth grade sciences lesson human and environment unit* (Doctoral dissertation), Kastamonu University, Institute of Educational Sciences, Kastamonu, Turkey.

Demircioğlu, H., & Vural, S. (2016). The effect of the common knowledge construction model (CKCM) on the attitudes of gifted students at the eighth grade level towards the chemistry course. *Journal of Hasan Ali Yücel Faculty of Education, 13*(1), 49-60.

Dervişoğlu, S. (2010). Value orientations of university students towards living species. *Journal of Hacettepe University Faculty of Education, 39*, 132-141.

Dikmenli, M. (2010). Biology student teachers' conceptual frameworks regarding biodiversity. *Education, 130*(3), 479-489.

Doran, R. L. (1972). Misconceptions of selected science concepts held by elementary school students. *Journal of Research in Science Teaching, 9*(2), 127-137.

Driver, R., & Easley, J. (1978). Pupils and paradigms: A review of literature related to concept development in adolescent science students. *Studies in Science Education, 5*(1), 61-84.

Duschl, R. A., & Osborne, J. (2002). Supporting and promoting argumentation discourse in science education. *Studies in Science Education, 38*(1), 39-72.

Ebenezer, J., Chacko, S., & Immanuel, N. (2004). Common knowledge construction model for teaching and learning science: Application in the Indian context. Paper presented at the *An international conference to review research on Science, Technology and Mathematics Education International Centre (epiSTEME-1)*, Dona Paula, Goa, India.

Ebenezer, J., Chacko, S., Kaya, O. N., Koya, S. K., & Ebenezer, D. L. (2010). The effects of common knowledge construction model sequence of lessons on science achievement and relational conceptual change. *Journal of Research in Science Teaching, 47*(1), 25-46.

Ebenezer, J. V., & Connor, S. (1998). *Learning to teach science: A model for the 21st century*: Upper Saddle River, New Jersey: Prentice-Hall, Inc., Simon and Schuster/A. Viacom Company.

Ebenezer, J. V., & Fraser, D. M. (2001). First year chemical engineering students' conceptions of energy in solution processes: Phenomenographic categories for common knowledge construction. *Science Education, 85*(5), 509-535.

Efe, R. (2010). *Biogeography* (2nd edition). Bursa: Marmara Book Center.

Ertuğrul, N. (2015). *The effect of common knowledge construction model on learning products in science teaching* (Master's thesis). Kırıkkale University, Institute of Educational Sciences, Kırıkkale, Turkey.

Fıstıkeken, N. (2017). *Investigation of attitudes of secondary school students towards decrease of biodiversity and the importance of biodiversity education* (master's thesis), Akdeniz University, Institute of Educational Sciences, Antalya, Turkey.

Gayford, C. (2000). Biodiversity education: a teacher's perspective. *Environmental Education Research, 6*(4), 347-361.

Hewson, M. G., & Hewson, P. W. (1983). Effect of instruction using students' prior knowledge and conceptual change strategies on science learning. *Journal of Research in Science Teaching, 20*(8), 731-743.

İyibil, Ü. (2011). A new approach for teachıng energy concept: the common knowledge constructıon model *World Conference on New Trends in Science Education (WCNTSE), Kuşadası, Turkey*.

Karasar, N. (1999). *Scientific research metho],* Nobel Publishing, 9th Edition, Ankara.

Keating, M. (1993). The Earth Summit's agenda for change: a plain language version of Agenda 21 and the other Rio agreements. *Centre for Our Common Future*.

Keleş, F., & Özenoğlu, H. (2017). Designing a lesson plan on biodiversity for secondary school students. *Adnan Menderes University Faculty of Education Journal of Educational Sciences, 8*(2), 41-65.

Kellert, S. R. (1985). Attitudes toward animals: Age-related development among children *In Fox M.W. & Mickley, L.D (Eds.) Advances in animal welfare science 1984* (pp. 43-60): Springer.

Kibar, H. (2019). *Analyzing effects of the argument-based inquiry approach on teaching the subject of heredity and bio-diversity to 10th grade students*. (Doctoral dissertation). Marmara University, Institute of Educational Sciences, Istanbul, Turkey.

Kiryak, Z. (2013). *The effect of common knowledge construction model on grade 7 students conceptual understanding of water pollution subject* (Master's thesis). Karadeniz Technical University, Faculty of Educational Sciences, Trabzon, Turkey.

Kuhn, T. S. (1962). *The structure of scientific revolutions*. Chicago (University of Chicago Press).

Kurt, Ü. G. (2018). *Investigation of the awarness of the secondary students on biodiversity* (Master's thesis). Akdeniz University, Institute of Educational Sciences, Antalya, Turkey.

Lindemann-Matthies, P. (2002). The influence of an educational program on children's perception of biodiversity. *The Journal of Environmental Education, 33*(2), 22-31.

Marton, F. (1981). Phenomenography—describing conceptions of the world around us. *Instructional Science, 10*(2), 177-200.

Ministry of National Education [MoNE]. (2018). *Elementary education institutions (primary and secondary schools) science courses (3, 4, 5, 6, 7 and 8 grades) curriculum*. Ankara, Turkey.

Noddings, N. (2005). What does it mean to educate the whole child? *Educational Leadership, 63*(1), 8-31.

Nussbaum, J., & Novick, S. (1982). Alternative frameworks, conceptual conflict and accommodation: Toward a principled teaching strategy. *Instructional Science, 11*(3), 183-200.

Orion, N., Hofstein, A., Tamir, P., & Giddings, G. J. (1997). Development and validation of an instrument for assessing the learning environment of outdoor science activities. *Science Education, 81*(2), 161-171.

Osborne, R., & Freyberg, P. (1985). *Learning in science. The implications of children's science*. Published by Heinnemann Education.

Öner, C. (2011). *Genetic concepts* (8th Edition). Ankara: Palme Publishing.

Özden, B. (2019). *The effect of science teaching based on common knowledge construction model on cognitive, affective and psychomotor learning of seventh grade students* (Master's thesis). Aydın Adnan Menderes University, Institute of Science, Aydın, Turkey.

Payne, M. R. (1985). *Using the outdoors to teach science: a resource guide for elementary and middle school teachers*: Educational Resources Information Center, Clearinghouse on Rural Education and Small Schools, New Mexico State University.

Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. *Science Education, 66*(2), 211-227.

Schulte, P. (2001). *Pre Service primary teacher alternative conceptions in science and attitudes toward teaching science*. Unpublished Doctoral Dissertation, New Orleans Üniversity, New Orleans.

Sontay, G., Tutar, M., & Karamustafaoğlu, O. (2016). "Student opinions about "teaching science with out of school learning environments": Planetarium trip. *Journal of Research in Informal Environments, 1*(1), 1-24.

Sütlüoğlu Dursun, R. (2019). *Developing and evaulating a teaching material based on common knowledge construction model for 5th grade on sun, earth and moon* (master's thesis). Recep Tayyip Erdoğan University, Institute of Science, Rize, Turkey.

Tatar, N., & Bağrıyanık, K. E. (2012). Science and technology teachers' views on out-of-school education. *Elementary Education Online, 11*(4), 882-896.

Treagust, D. F. (1988). Development and use of diagnostic tests to evaluate students' misconceptions in science. *International Journal of Science Education, 10*(2), 159-169.

Treagust, D. F., & Mann, M. (1998). A pencil and paper instrument to diagnose students' conceptions of breathing, gas exchange and respiration. *Australian Science Teachers Journal, 44*(2), 55-59.

Trowbridge, J. E., & Mintzes, J. J. (1985). Students' alternative conceptions of animals and animal classification. *School Science and Mathematics, 85*(4), 304-316.

Uzun, N., Özsoy, S., & Keleş, Ö. (2010). Pre-service teachers' views on the concept of biological diversity. *Journal of Biological Sciences Research, 3*(1), 85-91.

Uzunkaya, M. (2019). *The influence effect of the common knowledge construction model basic teaching students' academic success: A case of sound unit* (Master's thesis). Necmettin Erbakan University, Institute of Educational Sciences, Konya, Turkey.

Van Weelie, D., & Wals, A. (2002). Making biodiversity meaningful through environmental education. *International Journal of Science Education, 24*(11), 1143-1156.

Vural, S., Demircioğlu, H., & Demircioğlu, G. (2012). The effect of a teaching material developed in accordance with the general knowledge constructuring model on the understanding of acid base concepts of gifted students]. *Oral presentation, IV. Turkey International Educational Research Congress. Ankara university, Ankara.*

Walsh, L. (2009). *A phenomenographic study of introductory physics students: approaches to problem solving and conceptualisation of knowledge.* (Doctoral dissertation), Dublin Institute of Technology, Ireland.

Wood, L. C. (2012). *Conceptual change and science achievement related to a lesson sequence on acids and bases among african american alternative high school students': ateacher's practical arguments and the voice of the" other".* (Doctoral dissertation), Wayne State University, Michigan.

Yıldırım, A., & Şimşek, H. (2008). *Qualitative research methods in the social sciences*. Ankara: Seçkin Publishing.

Yıldırım, İ. (2018). *Determining the effect of science teaching based on common knowledge construction model on eightg grade students: structure and properties of matter unit sample* (Master's thesis). Yüzüncü yıl University, Institute of Educational Sciences, Van, Turkey.

Yıldızbaş, H. (2017). *The effect of education based on common knowledge construction model on students' academical success and critical thinking skills* (Master's thesis). Necmettin Erbakan University, Institute of Educational Sciences, Konya, Turkey.

Yörek, N. (2006). *Investigation of secondary school students' conceptual understanding of the topic of biological diversity (biodiversity)* (Master's thesis). Dokuz Eylül University, Institute of Educational Sciences, İzmir, Turkey.

Yüce, Z., & Önel, A. (2015). Conceptual association levels of science teacher candidates regarding biodiversity. *Abant İzzet Baysal University Journal of the Faculty of Education, 15*(1), 326-341.

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Perception of Preschool Children about Environmental Pollution

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Abstract

The purpose of this study is to determine the perceptions of preschool children on environmental pollution. A qualitative research method was employed in the current research. The data of the study were collected by semi-structured interview and drawing techniques and the obtained data were analyzed with a descriptive analysis method. The sample consisted of 67 children between 3 and 6 years of age, attending the kindergarten of different schools located in Giresun city center. It was observed that the 3-year-old group emphasized germs and 4 and 6-year old groups emphasized air and sea pollution. When asked about the prevention of environmental pollution, the younger age groups generally stated as "we should throw the garbage into the trashcan", and the group of 6-year-olds stated as "we should not cut the trees". In terms of information sources, the 3-year-old group usually stated their mother, while the groups of 4, 5, and 6-year-olds stated both their mothers and fathers. The children had difficulty in expressing the factors that cause air pollution verbally in the interviews, but in their drawings, they were able to reveal their air pollution perceptions more easily and concretely.

Introduction

It is a fact that environmental problems have increased in recent years and became an important problem worldwide. One of the crucial factors that have an impact on environmental pollution is human beings. It is thought that individuals' awareness of the environment and conscious behavior against environmental problems is the most important step in preventing environmental pollution. To prevent environmental pollution individuals must know throwing trash into such an environment (sea, soil, etc.) is wrong, they must be able to warn others to not use environmental polluters or not to purchase those. For preventing or reducing industrial air pollution, ensuring social awareness is important. To leave a healthier and safer environment for future generations; to prevent the factors that cause environmental pollution, all people, especially students, should be made aware of these issues (Uyanık, 2017).

One of these environmental problems threatening the world is environmental pollution. Environmental pollution, "Is the event of intense mixing of foreign substances with air, water, and soil that adversely affects the health of all living things, that cause material damage on inanimate environmental assets and spoils their qualities." (Çepel, 2003). On the other hand, the use of fossil fuels (coal and crude oil), together with toxic gas emissions into the atmosphere has played a negative role in the increase of the Earth's temperatures (Broadstock et al., 2018). Hence, it is necessary to reduce toxic emissions and leave fuels like coal behind and start using renewable energies (Carvalho et al., 2016).

Especially since the second half of the 20th century, the sensitivity is shown towards environmental problems and the approaches to be applied to solve these problems have gained increasing importance (Kışoğlu et al., 2010). Today, countries allocate budget to solve these problems to cope with the changing environmental conditions and environmental problems. But this solution is the easiest way; raising environmentally conscious individuals. Environmental education plays a vital role in achieving this responsibility (Erol & Gezer, 2006).

The attitudes and behaviors acquired in pre-school education at an early age turn into a permanent identity structure when set as a model. Learning these conversations enables them to develop environmental awareness and a positive lookout towards the future environment (Koçak et al., 2018). A systematic environmental education given starting from the pre-school period is highly effective in gaining a response from the environment and developing positive behavior and attitude towards the environment (Basile, 2000). In this context, environmental education, given starting with the pre-school period, aims to increase the awareness of individuals about the environment and environmental problems.

It is a known fact that preschool children are prone to examine the novelties around them and try to understand the physical world with their natural sense of curiosity and interest. (Mantzicopoulos et al., 2008). A growing literature shows that active care for the environment in adulthood is frequently associated with positive experiences of nature in childhood or adolescence, along with childhood role models who gave the natural world appreciative attention (Chawla, 2007). Preschool children are curious, investigative, and they have strong imaginations and questioning personalities. To support their development, they should be given opportunities so, they can investigate, and satisfy their curiosity, see the cause, and effect relationships, and make various predictions (Arnas, 2002). Their educational environments should be prepared in this direction as well. The introduction of science at an early age allows children to develop insights regarding natural phenomena and to experience basic scientific processing skills, such as observing data, collecting and recording data, making syllogisms, and doing research (Saçkes et al., 2011). For this, it can be said that implementing well-prepared environmental education programs from an early age is important.

The international field of research on environmental and sustainability education is defined in several research overviews (e.g. Reid & Scott 2006). This field of research has its roots going back more than 30 years, to the Tbilisi Declaration in 1977. (Scott, 2009; as cited in, Ärlemalm-Hagsér & Sandberg (2011). From the early 70's, the world's leading leaders in politics, education, and science began to recognize the increasing environmental pollution and its consequences. The International Environmental Education Program – IEEP, in collaboration with UNESCO and the United Nations Environmental Program - UNEP, was launched in 1975. Following the conferences and seminars organized by IEEP, the Intergovernmental Conference on Environmental Education, the first of its kind in the world, gathered in Tbilisi in 1977 with the cooperation of UNESCO and UNEP. The declaration and recommendations of the Tbilisi Conference constitute a turning point for environmental education. Thanks to the conference, environmental education has a place in international education. Education programs currently in curriculum around the world using these programs:

(Classified, general)
• Conscious: To raise the awareness of individuals and societies, all environments, and sections;
• Knowledge: To ensure that individuals and societies have basic knowledge and experience about the environment and issues;
• Attitude: To ensure that individuals and societies gain certain value judgments and sensitivity for the environment, and the desire to participate actively in environmental protection and improvement activities;
• Skills: To enable individuals and communities to gain skills to identify and analyze major systems;
• Participation: To ensure the active participation of individuals and societies at all levels in solving environmental problems (Hungerford et al., 1980:42).

The concept of environmental education in preschool period was first used by Jaus in 1982 (Russo, 2001). Environmental education might be defined as educational efforts exerted to improve individuals' knowledge and awareness of the environment they live in (Gülay & Önder, 2011). Dinçer (2005) emphasizes that the environment is a natural classroom that supports children's cognitive, physical, and social development with rich stimuli. In many studies, the importance of preschool education in the development of children's positive attitudes towards the environment and the importance of environmental education in creating a positive outlook towards the environment is emphasized (Domka, 2004). According to the booklet titled "The Turkish Ministry of National Education, Early Childhood Education Curriculum" (MONE, 2006), prepared by the Directorate General of Preschool Education, meticulously planned educational environments, and is of great importance for the implementation of preschool education programs. According to the booklet, well-planned educational environments should have the following characteristics: (1) They should be relevant to children's developmental characteristics, (2) be safe, (3) be multi-purpose, (4) improve problem-solving skills, and (5) support creativity (Gezgin, 2009).

Children learn by creating and living with science studies in preschool education. Science studies allow children to recognize their environment, conduct experiments and discuss the same, develop manual skills, learn about scientific methods such as observing, testing, and measuring their ideas, and actively participate in the research process. Active learning by these will make the information children receive more permanent. Besides, children can transfer this information to other areas they study (Poyraz & Dere, 2001).

Preschool education is a period in which scientific skills and basic science concepts that a child may need throughout his life are developed. In this period, it is important to teach these subjects to children, similar to how science activities are conducted, and note the problems faced by teachers (Karamustafaoğlu & Kandaz, 2006). Experiencing, exploring, and learning about nature and its diversity is in the framework plan, and is seen as important aspects in developing respect for nature, encouraging environmental awareness, and contributing to

sustainable development. The kindergarten staff is expected to use nature as an arena for play and learning and together with children and reflect on natural phenomena as well as workings of nature (Skarstein & Skarstein, 2020).

The researches indicate that people who cared about plants and animals in their childhood and who have had childhood experiences in nature are more sensitive to environmental problems in their future lives than those who do not perform these behaviors in their childhood (Erten, 2004). To maximize the natural potential of a human being, it is necessary to offer him/her various opportunities at an early age. Therefore, education is given to children at an early age and the role of the physical and social environment of the children is especially important in terms of their development (Oktay, 1999).

It is revealed in various studies that children who learn about their environment and who are sensitive to their environment in the early years of life maintain their attitudes in the later years as well (Robertson, 2008; Orr, 2002). Considering that it is required that children recognize the fact that we are part of nature and they should not harm the living spaces of other living beings and they should be environmentally sensitive and at peace with nature, it will be possible by developing awareness and perception regarding environmental pollution at a young age. In this context, it is important to reveal the perceptions and information sources of the preschool children towards environmental pollution to prepare the educational environment. As a result of the literature review, on the other hand, finding out a study examining the pictures of preschool children regarding environmental problems (Özkul, 2018) indicates that even though environmental education for children in the preschool period has been increased in recent years in Turkey, the desired level is not yet reached. Our study, unlike previous research, is aimed to investigate the perception of environmental pollution as well as information sources. Data collection is conducted with both interview and picture analysis to increase the specificity of the research.

It is a well-accepted fact that children's attitudes and habits concerning the environment are shaped in early ages (Poyraz & Dere, 2001; Aral et al., 2001; Kınık et al., 2016). Attitudes and behaviors towards the environment and nature are acquired in this critical period, affect other steps of life, and become more inflexible in future ages (Palmer, 1995; Horwitz, 1996; Smith, 2001; Domka, 2004; Taşkın & Şahin, 2008). In the related literature, Yağcı (2016) highlights that nature - and environment-related activities are influential on the development of preschool children's scientific process skills, and Uslucan (2016) reports that preschool children's attitudes towards the environment are changed for the better with the implemented environmental education program. Besides, it is possible to think that environmental education given to children at an early age is influential in the prevention of environmental pollution as it increases environmental awareness. In Turkey, this may be possible by giving more coverage to subjects associated with environmental education in preschool education curriculum, expanding subjects, and including projects regarding environmental education or pollution, thereby enhancing environmental perception.

Initial research on the concept of the environment generally focused on the perception of this concept and environmental attitude (Payne, 1998; Rickinson, 2001; Abd El-Salam, et al. 2009; Alp et al. 2006; Aminrand, et al. 2010; Anderson, et al. 2007; Astalin, 2011; Chapman & Sharma, 2001; Harun, Hock, & Othman, 2011; Huang, & Yore, 2005; De la Vega, 2006; Makki et al., 2003; Olufemi, 2012; Özsoy & Ahi, 2014; Loughland et al., 2002; Uyanık, 2017; Olufemi et al., 2017; Saz et al., 2020; Gädicke et al., 2017; Doğan & Simsar, 2019; Aznar-Díaz et al., 2019). Looking at other studies in the literature, The effect of culture on environmental perspective (Liu & Lin, 2014), cognitive perceptions of pre-service science teachers for environmental pollution (Kalaycı, 2020) and children's thoughts on environmental problems (Boyes & Stanisstreet, 1994, 1997, 1998; Jeffries et al., 2001), studies have been found. However, looking at previous studies, it is seen that there is little work done in the preschool period on environmental pollution. In their few studies, it was observed that they use drawings to collect data. Unlike these studies, this study aimed to provide more in-depth information about environmental pollution in the preschool period by collecting data with both drawings and interviews. On the other hand, there is no study on information sources on preschool writing environmental pollution. The purpose of this study is to determine the perceptions of preschool children on environmental pollution. In line with this purpose, this study, it was aimed to reveal what the environmental pollution perception is, whether this perception differs according to age (3, 4, 5, and 6 years) and what the sources of this perception are.

Therefore, in this study, it has been tried to determine the sources of information by focusing on whether children's perceptions of environmental pollution differ according to their age levels during the preschool period. Determining whether perceptions differ will contribute to the literature by providing an insight into the content of environmental education that is to be provided based on age levels. In line with these objectives, the attention of the researchers can be drawn to environmental education in early childhood, and the results obtained from the study are valuable since it can guide future studies about environmental perceptions perceived by

children and sources of information. Also, it is considered to be a model in determining the thoughts on the environmental pollution of students that are in primary schools within Turkey.

Method

Research Design

The purpose of this study is to determine the perceptions of preschool children on environmental pollution. To this end, the preschool children were requested to make drawings that could reveal their perceptions of environmental pollution instead of employing just one source of information (interview). In this regard, the study employed the case study design, which is a qualitative research design, to study and describe the existing situation in-depth. According to Creswell (2007), the case study is a qualitative research approach in which the researcher explores in-depth one or several situations limited in time by using data collection tools including multiple sources (observations, interviews, visuals-audios, documents, reports) and describes situations and themes based on situations. Student drawings, one of the qualitative data collection techniques, have been quite popular with the studies in science education since 2000 (Patrick & Tunnicliffe, 2010).

The most basic feature in the case study pattern in qualitative researches is the in-depth investigation of one or more subjects. Factors related to a situation (individuals, environment, process, etc.) are investigated through a holistic approach and focused on how they affect the situation or how they are affected by the situation. It is not possible to generalize the results as the cases to be researched in qualitative case studies are different from each other. The results obtained regarding a situation constitute examples of similar situations (Yıldırım & Şimşek, 2011).

Study Group

The sample consisted of 67 children between 3 and 6 years of age, attending the kindergarten of different schools located in Giresun in the 2016-2017 Academic Year. Appropriate sampling and purposeful sampling method were used to determine the sample. The children "who participated "in the study were determined by using a convenience sampling method, primarily from each age group. Sample children, usually live in a small developing city by the sea and in the city center or neighborhoods close to the city center, where traffic is not heavy, greenery is abundant and industrial facilities are generally outside of residential areas, with a medium economic class and small nuclear families. The characteristics of the sample are given in Table 1. In our province, there is no intense noise pollution since industrial facilities are located outside of residential areas. The most important cause of air pollution in the province, especially in winter, is the polluting elements originating from heating and the polluting elements from vehicles (ÇED Report, 2018). According to the report, it is stated that soil and water pollution is minimal, there is no noise pollution, and air pollution occurs in winter.

Table 1**.** Characteristics of the sample

Age	Gender	n
Age 3	Female	9
	Male	10
	Total	19
Age 4	Female	7
	Male	6
	Total	13
Age 5	Female	15
	Male	8
	Total	23
Age 6	Female	4
	Male	8
	Total	12

Data Collection Tool

The research data were collected from the children through drawings and semi-structured interviews. Drawings are important tools for preschool children to reflect on their inner world and for obtaining information about

such a world as these children cannot express themselves verbally (Halmatov, 2017). To children, drawing pictures is one of the reliable and valid projective techniques. Small children in particular have a smaller vocabulary (Ryan Wenger, 2001). However, children can express themselves more easily and with words through pictures than words (Skybo et al., 2007). Previous research (Barraza, 1999; Dove et al., 1999) indicates that it is both easy and informative that children express their emotions by drawing pictures during scientific research, and children establish easy communication with the researcher without feeling any pressure. Drawing has been used in research with enthusiasm for 50 years (Mosseley et al., 2010). In the present study, the students were requested to draw a picture of environmental pollution to reveal their perceptions of environmental pollution. Such drawings were scanned and saved in the computer environment.

Having children draw pictures is one of the valid and trusted projective techniques. Small children, especially, have limited vocabulary (Ryan Wenger, 2001) and can withdraw themselves during a conversation. The children can express themselves by paintings easier, and in a more fun way compared to words (Aral & Metin, 2012; Skybo, 2007). To obtain children's opinions, 4 open-ended questions were created, and the interview form was drawn up by the researcher. The first question was "What do you understand from the word environment?" and it was asked for examining the environmental perception in the general sense, and then 4 questions were asked in total which are "What is environmental pollution?", "How is environmental pollution occur?", "What can be done to reduce environmental pollution?", and "Where did you learn those?". The data of the study were collected by using a semi-structured interview regarding "environmental pollution" and the obtained data were analyzed. The opinions of a field specialist and a science education specialist were taken about the validity of the open-ended interview form. In terms of the credibility of the research, interviews were conducted after ensuring that children could not hear each other.

Procedures

In the data collection process, the children were firstly requested to draw pictures about environmental pollution. The researchers entered the classes with the teachers and met with the children, and after greeting them, they said that they would interview the children one by one. In the drawing process, it was ensured that the children made individual drawings at separate times so that they would not be affected by each other. What they would do was explained to them, and they were asked whether they wanted to go to the desk that had been prepared for the study in advance. A4 papers, crayons, and color pencils allowing them to use any color were put on the desks beforehand.

The question "Would you like to draw a picture of environmental pollution?" was addressed to the children. The drawing was not started until it was ensured that each child understood it. Then the children were requested to draw by choosing the crayons and colored pencils they wanted. An attempt was made to assure that the children did not interact with each other during drawing. No intervention was made, and no time limitation was applied when the children were drawing. When a child said that s/he had completed his/her drawing, the question "Could you explain your picture to me?" was addressed to him/her. The children's comments on their drawings were written on a separate paper. The figures they drew were asked one by one, and what they drew was noted. Then the pictures were interpreted and analyzed. The pictures they draw were used to support their interviews. Interview questions were asked at the end of the drawing process. Children were interviewed individually, and their answers were recorded in writing. Also, demographic information of children was obtained from the children's files through their teachers and recorded in the demographic information form.

Researcher's Role

In qualitative research, a researcher is a person who spends time in the field, knows it well, interacts with the individuals in the field, and may affect the research result with his/her interpretation. Hence, s/he should explain his/her role in the study (Yıldırım & Şimşek, 2008). The researcher of the present study has a Ph.D. in science education. Her research interests include scientific process skills, teaching science and environment concepts, inquiry-based teaching, learning-teaching processes, and critical thinking. She actively participated in planning the research, developing data collection tools, analyzing the data, and writing the research report. In qualitative research, the researcher closely monitors events or phenomena with a participatory attitude. On the other hand, the researchers' observation and literature knowledge were used only in the data interpretation stage (Miles & Huberman, 1994).

Data Analysis

The qualitative content analysis method was used as a data analysis method. According to Cohen et al. (2004), content analysis is also defined as the process of summarizing and specifying the basic contents of the written information and the messages they contain. In this research, thematic analysis, among the content analysis methods, was used. The thematic analysis involves the stages of creating a thematic framework, analyzing data based on this framework, and interpreting the findings. Within the framework of the thematic analysis, the data obtained are described, and the data described are interpreted. The results obtained are interpreted by the researcher looking for a cause-effect relationship (Yıldırım & Şimşek, 2006). The interviews were transcribed, and the frequency values were calculated and they were given under the findings section by indicating the different age groups (in the form of C 3, C 4, C 5, and C 6). Also, the children were asked to draw pictures to support the interview questions regarding their perceptions of environmental pollution. Furthermore, the drawings are an alternative way for us to understand them for the children who cannot express themselves verbally (Rennie & Jarvis, 1995). To this end, the draw-and-tell technique has been used (Shepardson, 2005). This technique includes the drawings of students and explanations of these drawings. The draw-and-tell technique is a diagnostic method used to understand how children construct thoughts and concepts (McWhirter et al., 2000). In practice, children were asked to draw a picture of environmental pollution and explain their drawings. The drawings of the students were interpreted and supported with their opinions regarding the concepts.

Ethics in Research

Considering the ethical issues, the required verbal permissions were obtained from the school principals and it was promised that the results of the study would not be used in a situation that would violate research ethics. Voluntary participation was provided by asking the children whether they wanted to engage in interviews and drawings. The interviews and drawings were conducted in the children's classes in their schools. While these children were attending the interviews and drawings, other children continued their activities under the supervision of preschool teachers. The students completing the interviews and drawings returned to the activities conducted by their teachers again. It was stated that the research data would only be read and evaluated by the researchers, and the participants' real names and identities would be kept confidential. The teacher was informed about the ethical principles adopted in the study. Furthermore, code names were used for each student (e.g. Ayşe, Ali) per ethical principles.

Validity and Reliability

To ensure validity and reliability, the study employed qualitative data triangulation, which refers to using multiple data for helping to understand a phenomenon, and analyzer triangulation, which is defined as the analysis of the same qualitative data by two or more people (Jhonson & Christensen, 2014; Patton, 2014). In this regard, the data in written reports were separately coded by two independent coders (one coder was one of the researchers, and the other was a researcher in the same field) to determine the relevance of the codes arranged under categories. The reliability of the data analysis made in this way was calculated by using the formula [Agreements / (Agreements + Disagreements) x 100] (Miles & Huberman, 2015). Average intercoder reliability was found to be 88%.

The Validity and Reliability of the Study

To ensure the credibility of the study, the obtained results were compared by experts, and expert opinions were used in the research process. The themes coming out of the raw data were presented with directly quoted participants' views to assure transferability. For confirmability, the interview notes and drawings were saved in the first place. To provide consistency, the themes were reviewed by an external expert who criticized and provided feedbacks in the entire process from constructing the research problem to preparing the research report. Separate researchers examined all such documents.

FINDINGS

In this section, the findings are presented according to the themes.

The meaning of the concept of environment

As a result of the analysis of the data obtained from the study, a total of 5 themes (Environment, Animal, Human, Buildings/Vehicles, Abiotic Elements) were obtained. It is observed that the children in the 3, 4, and 5-year-old groups stated a clean environment (f=6) under the theme of the environment, whereas 6-year-old groups (f=1) stated a dirty environment. In their interviews, children talked about people, various plants and animals, structures such as houses and factories, the sun, forest, cloud, sea, sky, nature, and natural events, elements such as air and smoke. The most commonly used among these elements is the flower (f=8) and tree (f=8). Under the theme of Human, the 3-year-old group mostly stated family (f=2), 4-year-old group (f=1), and 6-year-old group (f=1) stated people as of damaging nature. Under the theme of buildings/vehicles, it is seen that the 3-year-old group (f=3) indicated a car, park, and house, while the 6-year-old group (f=1) indicated a factory. Under the abiotic theme, it was observed that they were mostly stating sea (f=5).

Examining the perception of the environment in terms of age groups; while 3-year-old age group answered for the term "environment" as rain, sun, and mother, father, sibling, it is observed that 4-year-old age group answered it as sea, sun, cloud, and animals, 5-year-old age group answered it as tree, flower, animals and keeping the environment clean, and the 6-year-olds answered it as polluted environment, forest, tree flowers and sea, and smoke. It can be said that the perception of the polluted environment in the age groups of 3, 4, and 5 is not yet developed and that 6-year-olds have a perception of a "polluted environment". The items frequently mentioned in the interviews with the children are given in Table 2.

Table 2. Frequency table about the meaning of the concept of environment

Themes	*Sub-themes*	*Age 3* (f)	*Age 4* (f)	*Age 5* (f)	*Age 6* (f)
Stated	Dirty				1
	Clean	1	1	4	
Plant	Flower	1	1	3	3
	Tree			5	3
	Grass				1
Animal	Caterpillar, Dog, etc.		2	3	
Human	Human			1	
	Family	2			
	Pit boiler people		1		
	Woodcutting people				1
Building/tools	Factory				
	Car	1			1
	Home	1			
	Park	1			
Abiotic items	Sun	2	3		
	Forest			1	3
	Cloud		2		
	Sea	1	3		2
	Sky		1		
	Nature and nature events	3		1	1
	Air				
	Smoke				1
					1
No information	No information	4		5	

When we take a look at the answers of the children, it is seen that they give the following answers:

C 3: Chips were thrown on the ground
C 3: Trash, rain, fire, storm, sun
C 4: The mud pollutes the environment and the smoke coming from the stove at the house pollutes the environment
C 4: Sea rabbits birds butterflies
C 5: Not polluting the environment
C 5: Many animals or trees in our world
C 6: I understand like forest and city, I think that one of the countries of the world is a forest
C 6: I understand the air. People in the car are coming and they are driving cars.

The occurrence of environmental pollution

In terms of the pollution forming around us, they generally stated as "by throwing garbage on the ground" (f=41) under the theme of behavioral factors, and as for the other factors they stated germs (f=6) in the first rank. Regarding the formation of environmental pollution; while the 3-year-old group responded as "when we throw garbage on the ground and by the germs", it is seen that the 4-year-old group answered as "when we throw garbage on the ground", "from the air" and "by throwing bottles into the sea" the 5-year-old group answered as "when we throw garbage on the ground" and "when we throw fruit/banana skin on the ground and the 6-year-old group responded as "when we throw garbage on the ground" and other than these as "not cutting the trees" and "smoke from the factories". Table 3 shows the answers given for the occurrence of environmental pollution as a frequency table.

Table 3. Frequency table about the occurrence of environmental pollution

Themes	*Sub-themes*	*Age 3* (f)	*Age 4* (f)	*Age 5* (f)	*Age 6* (f)
Behavioral factors	Throwing the trash on the ground	7	7	20	7
	Battery			1	
	Paper		1	1	
	Bottles		2		1
	Banana peel/Ice cream / chips			2	
	Dirty water	1	2		
Other factors	Air		2		1
	Microbe	5		1	
	Smoke		2		
	Coal	1			
	Mud		1		1
No information	No information	3			

When we take a look at the answers of the children, it is seen that they give the following answers:

C 3: When we throw litter and throw the food.
C 3: When we throw the chocolate packages on the ground.
C 4: Smoke comes out of the pipe behind the cars and outside becomes dirty. It gets dirty with the smoke of the garbage truck.
C 4: It is composed of air and because the garbage is thrown into the street.
C 5: If we throw garbage around, our world will be very bad.
C 5: It occurs when the garbage is thrown and when our hands are dirty, and we rub them onto something.
C 6: It is polluted with the factory fumes and they are throwing bottles into the sea
C 6: We can warn people we can tell them about pollution through the writings we can say "boo" to those who pollute the environment.
C 6: We should not cut down the trees.

Reducing environmental pollution

As to how we prevent or reduce environmental pollution, the majority of children stated that "by throwing the garbage in the trash can" (f = 31). While the 3-year-old group answered as "we should throw the garbage in the trashcan or we clean them", it is observed that the 4-year-old group answered as "we should throw the garbage in the trashcan", "we do not throw garbage on the ground", "not throwing bottles into the sea" and 5-year-old group answered as "we should throw garbage in the trashcan and collect all the garbage" and 6-year-old group answered as "we should throw garbage in the trashcan and should not cut the trees". Table 4 shows what needs to be done to reduce environmental pollution as a frequency table.

When we take a look at the answers of the children, it is seen that they give the following answers:

C 3: We do not throw the garbage on the ground and do not throw the sugar bag as well.
C 3: When our environment is dirty, we clean dirty waters.
C 3: We place the soap in our hands, we make it wet and the germs go away.
C 4: The things we throw on the ground will create evil, by throwing them in the trash we can avoid it.
C 4: Construction machinery comes and tidies the roads. Garbage men collect trash

C 4: We spray pleasant odors into the air. We should not pollute our air.
C 5: We have to collect the garbage and throw them in the trashcan.
C 5: When people do not throw garbage
C 5: If we keep our surroundings clean, the animals can play happily.
C 5: Because of toys, messiness, we should not throw the shells on the ground
C 5: We say to them "throw the garbage in the trashcan". We throw the plastic waste into the plastic waste box.
C 6: We should throw the garbage in the bin and we will not draw pictures and use the drawing paper.
C 6: By not throwing the garbage on the ground. By throwing trash into the recycling bin, not cutting down the trees
C 6: If we collect garbage, environmental pollution will be removed. If we collect the garbage, the air will recover, and pollution will decrease.

Table 4. Frequency table for reducing environmental pollution

Themes	Sub-Themes	Age 3 (f)	Age 4 (f)	Age 5 (f)	Age 6 (f)
Cleaning the garbage	Throwing garbage in trash/ trolley /container	8	6	9	8
	Clearing	5	1	7	2
Air cleaning	Filter	1			
	Squeezing nice smells into the air		1		
Sea cleaning	Not throwing bottles		2		
Nature protection	Not cutting a tree				2
	Stop smoking		1		
	Protect			1	
Personal hygiene	Washing hands	1		1	

Source of information on environmental pollution

When the sources of information on environmental pollution are examined, it is seen that the children are usually stated their mothers (f = 16). While the 3-year-old group usually answered as a mother, it is seen that 4-year-old group answered as mother and father (f=5) 5-year-old group answered as mother-father, sister and brother (f=3) 6-year-old group answered as mother-father (f=3) in addition to tablet/computer (f=1). Table 5 shows the frequencies of environmental pollution information sources.

Table 5. Frequency table of information source about environmental pollution

Themes	Sub-themes	Age 3 (f)	Age 4 (f)	Age 5 (f)	Age 6 (f)
Family	Mom	12		2	2
	Father	3		1	
	Mother father		5	3	3
	Sister / Brother	2		3	
	Grandmother	1			
Environmental	Teacher	1	3	1	2
	School	2		1	1
	Scavenger				1
	Friend		3		1
Digital environment	Television		3	2	2
	Tablet / Computer				1
Self-knowledge	to know / to learn	1	2	1	2

When we take a look at the answers of the children, it is seen that they give the following answers:

C 3: From my mother; my mother always cleans and washes the house, and I clean my room.
C 4: I know it myself and sometimes I saw on TV
C 4: My friend Furkan told me
C 5: I know it because in our new neighborhood there is always garbage
C 5: I learned myself, I watched cartoons
C 6: I learned from my mother and from the garbage man
C 6: I learned it from TV, from computer, from phone

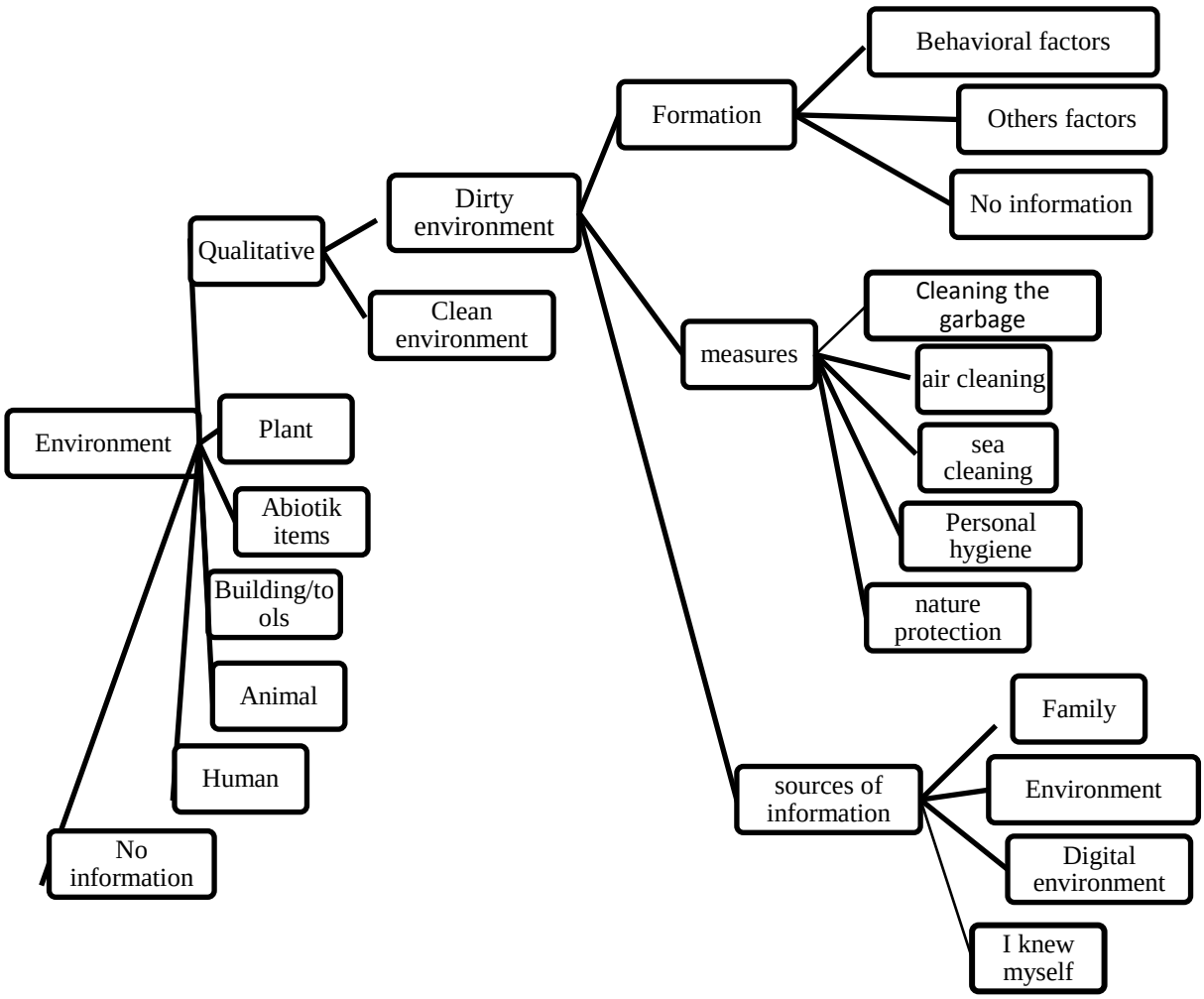


Figure 1. A model with the findings obtained from the study

Findings Related to the Perception of Environmental Pollution

Findings derived from the pictures of 3 to 6-year-olds regarding their environmental pollution perception:

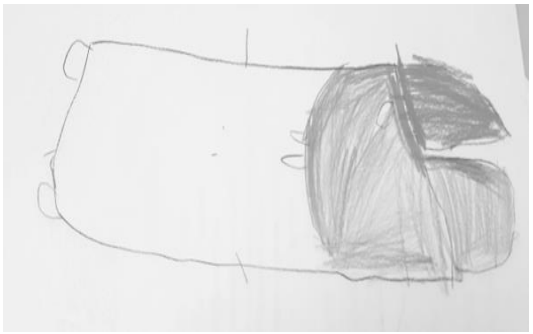
When examining the drawings of the children it is seen that they drew garbage, smoke, and people collecting garbage. When we take a look at the pictures of the children within the 3-year-old age group regarding environmental pollution, it is seen that they primarily drew clean hand and germ, smoke, and cloud pollution. As for the children within the 4-year-old group, they highlighted the types of garbage (paper, beverage, apple litter, etc.), marine pollution, and air pollution in their drawings and they diversely drew recycle bins as well. When the pictures of the children from the 5-year-old group are examined, it is seen that they draw trashcan, garbage truck, garbage collection rocket, and they draw stuff regarding garbage collection. When the pictures of the children from the 6-year-old group are examined, it is seen that they drew garbage truck, garbage men, and also smoke from factories and cutting trees as the causes of pollution, and unlike other age groups, their causes of pollution (smoke from the car or house, the cutting of trees) were diverse.

The use of children's drawings as a systematic measure to evaluate children's perceptions and attitudes towards the environment is still in the process of development. Children's drawings have been used as emotional indicators for specific environmental problems, and to determine the attitudes children have towards different environmental situations (Barraza, 1999). Children were asked what they drew in their pictures and requested to interpret their pictures. Comments of the children regarding their pictures are as follows (Figure 2).

1. Ayşe (3-year-old): Environment is polluted because of dirty water. Cloud is dirty.

2. Ali (3-year-old): I drew a house and smoke coming out of the chimney. I drew a garbage collector robot

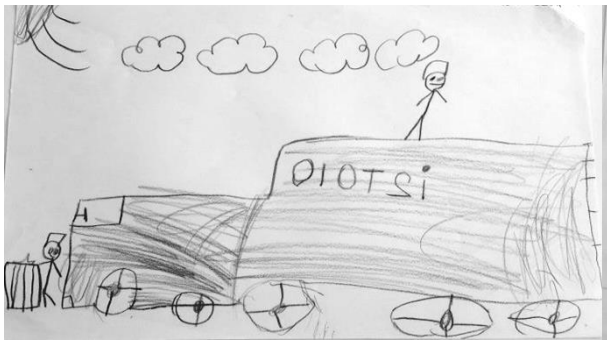
3. Melek (4-year-old): I drew the wind paper and I drew the rain. I drew drinks and apple garbage



4. Sevgi (4-year-old): I drew a big fish in the picture. The head of the fish is dirty because the sea was dirty

5. Büşra (5-year-old): Man throws garbage in the trashcan

6. Ahmet (5-year-old): The garbage truck is cleaning the surroundings. There is a trashcan. There is a parking area under the house.



7. Burak (6-year-old): The garbage man is picking up the trashcan and will be throwing it into the garbage, and he has a helper

8. Müge (6-year-old): Cutting trees is environmental pollution. When hunters cut the trees, it causes environmental pollution. Smoke from cars pollutes the environment. Smoke from the chimney of the houses pollutes our environment

Figure 2: The pictures of 3 to 6-year-old groups regarding their environmental pollution perception

The themes and sub-themes resulting from the analysis of the pictures are shown in Figure 3 as a model.

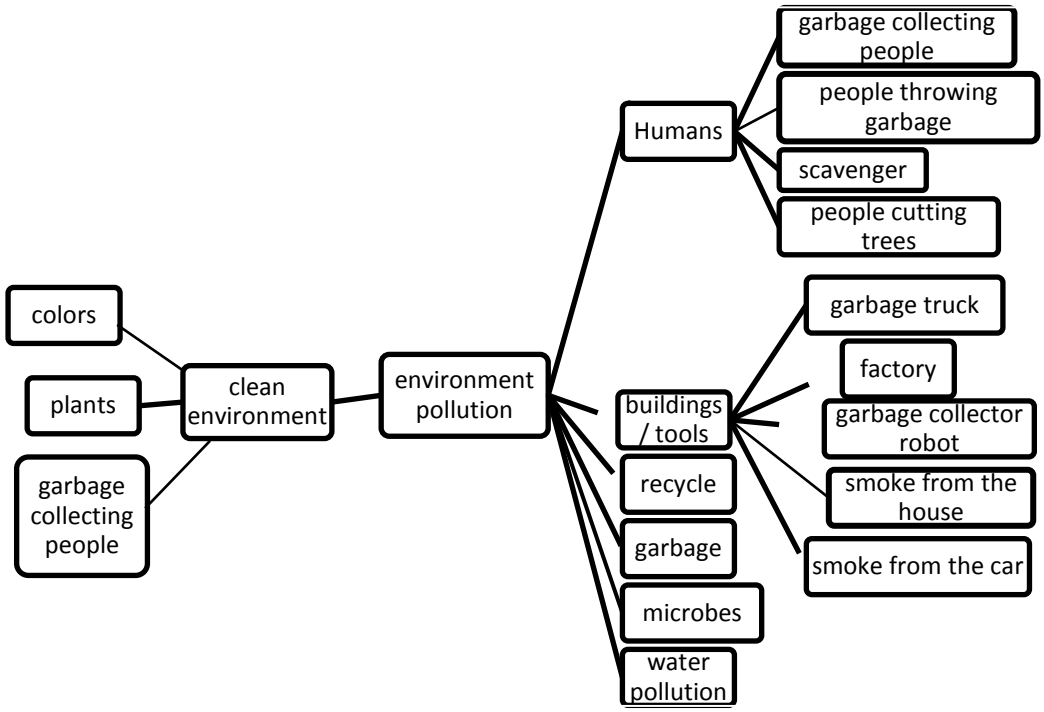


Figure 3. Model created with the findings derived from the drawings

Discussion and Conclusions

According to the results of the interview about environmental perception, it is observed that while the environmental perceptions at 3-4 years of age are rain, sun, cloud, and animals, at 5 to 6 years of age it is changed as keeping the environment clean, smoke out from the factory and cutting the trees. The reason for the change in children's environmental perceptions as they grow can be thought to be the effect of the school. While the environmental perceptions of the children at the ages of 3-4 were about the living and non-living elements they observe in their environment, they were seen to have no perceptions of pollution. Kahraman et al. (2019), states in their study that children's understanding of the environment is limited to which living organisms and tangible objects they explore in their daily lives. Shepardson et al. (2007), analyzed students' cognitive schemas regarding the word "environment" and divided their perceptions into four categories. In the first category, the environment was presented as a place where only plants and animals live. In the second category, the environment was defined as a place where human beings meet their physical needs. In the third category, the environment was seen as a place where human beings interact. In the fourth category, the environment was started as a place where all living beings collectively live in peace. Likewise, Loughland et al. (2002, 2003), discuss that there are six distinct categories in which students perceive the concept of environment, based on the variables mentioned above; these categories are, respectively, the place that includes living organisms; the place that includes living organisms and humans; the place is for humans; humans are part of the environment and are responsible for it; humans and environment are in a mutual relationship and they have an effect on each other. As a result of another study by Shepardson (2005), exploring children's attitudes towards the environment, reports that children perceive the environment as a place where they meet their needs and interact. Children define the environment as the place where they meet their physical needs (eating, drinking water), play games, and spend time with animals. Loughland et al. (2002), argue that children's understanding of the environment in early childhood is that environment is a place; however, after this period, their perception is that environment is a place in which living organisms and nonliving things interact with each other. In this study, it is seen that the environment is perceived as a place where living things live, interact and meet their physical needs, rather than environmental pollution.

On the other hand, in this study, as a striking result, it was observed that while 3-year-old children included mothers, fathers, and siblings in their environmental definitions, children aged 4-5 and 6 did not include their mothers, fathers, and siblings as environmental factors. The reason for this can be said to be that the 3-year-old

family attachment is higher than the other groups. The fact that the children gave examples of environmental pollution at the ages of 5 and 6 shows that the perception of environmental pollution came out at these ages. Although they are in the same development period in terms of age, it is possible to say that they first think more concrete (microbes) about environmental pollution, and they can think in a versatile way as human activity towards the age of 6. One of the common points of all the studies on environmental perception is that the participants associate environment with environmental problems (Barrazza, 1999; Özsoy, 2012; Shepardson et al., 2007; Yardımcı & Bağcı Kılıç, 2010). In terms of studies in primary school, Ertürk, (2017), as a result of the study in which primary school students determined their perceptions of environmental problems and environmental education, students expressed the concept of the environment as a friend, home, oxygen, life, living space, tree, earth, and nature. Students stated that garbage wastes, destruction of trees, soil pollution, garbage disposal in water, disposal of waste batteries, air and sound pollution, forest fires as environmental problems. It is seen that the answers given in 5-6 age groups and in primary school are similar, differently, it is said that waste batteries should be disposed in primary school.

In literature, there are studies showing that the variables affecting the preschool children's understanding of the environment include other factors such as age, gender, socioeconomic status, and the area where they live. Loughland et al. (2002) and Barraza (1999) emphasize that there are a wide variety of variables affecting environmental perception. According to these authors, age and gender are important variables associated with the concept of the environment. This study also indicates, regarding the age groups, that the concept of environment for children at the ages of 5-6 is the environmental pollution and protecting the environment while for the children at the ages of 3-4, this concept is that environment is a place in which living organisms and nonliving things interact with each other.

Same way, in the literature, it is apparent that the environment is perceived as an object or place which living beings inhabit (Barraza, 1999; Shepardson et al., 2007; Yardımcı & Bağcı Kılıç, 2010; Yavetz et al., 2014). Littledyke (2004), expresses that the students at young ages do not hear anything about the concept of environment, and even if it is heard, they don't know what it means and that age is an important variable indirectly perceiving the concept of environment, supporting this result.. On the other hand, according to Basile (2000), the formation of environmental knowledge and attitude towards the environment begins to take shape in the preschool environment. On the other hand, another study reveals that children perceive the concept of environment differently depending on where they live and their socio-economic level (Halmatov et. al.,2012; Taşkın, 2008).

As the factors causing environmental pollution, the children did not specify the smoke coming from the house or the factories that much, but they mostly drew the smoke in their paintings. The participating children had difficulty in verbally expressing the factors causing air pollution, which is a sub-dimension of environmental pollution, during the interviews, but were able to manifest their perceptions of air pollution more easily and concretely through drawings. On the other hand, as a different result, Saz et al. (2020) stated that, as a result of the drawings they made regarding environmental pollution in the age group of 5, they mostly show environmental pollution through plastic, packaging packages, papers, glass waste, metal waste, waste bins, recycling bins, and nutrients. While 1 of the children draws on water pollution; 15 of them made drawings on land pollution. A child deals with both water and land pollution in his painting. Also, for air pollution, no drawings were found. The fact that children see concrete examples in the area they live in and information resources are insufficient could be the reason why perceptions about the type of pollution vary within the same age groups. Likewise, Paraskevopoulos and Zafiropoulos (1998), state that students' understanding of the concepts of environment and the environmental issues is defined by their experiences (facts they face in their lives, for example, regional pollution). Similarly, the environmental perception of children varies according to the areas in which they live (Shepardson, 2005; Paraskevopoulos et al., 1998; Basile, 2000).

When they are asked how environmental pollution is occurring, they usually respond as "when we throw garbage on the ground". In this regard, children between the ages of 3-6 have associated the cause of environmental pollution with the cause of soil pollution. It was observed that the 3-year-old group emphasized germs and 4 and 6-year old groups emphasized air and sea pollution. It can be said that 3-year-olds associated microbes with environmental pollution as they saw them as a general cause of pollution. It was determined that 3-year-olds did not have much knowledge about how environmental pollution occurs, but they indicated a variety of factors causing pollution towards the age of 6. When we look at the results of similar studies conducted at primary school levels, in a study conducted by Yardımcı and Kılıç (2010) with elementary school students, it was observed that students also emphasized the environmental pollution caused by garbage and exhaust gases. On the other hand, in the studies of Demirbaş and Pektaş (2009), where they research the recognition levels of elementary school students of the basic concepts of environmental problems, it is observed

that students often respond accurately in terms of environmental problems encountered within the course of their daily lives, however, wrong answers were given regarding certain subjects which are considered among the current problems but probably not much discussed within the teaching environment, such as the greenhouse effect and global warming, etc. Özdemir Özden and Özden (2015), the purpose of their study is to investigate the perceptions of students in 6th, 7th and 8th grades about environmental problems based on their drawings As a result, the students drew more pictures about local environmental problems than global ones. Among local environmental problems, the students drew pictures of air pollution most.

When asked about the prevention of environmental pollution, the age groups generally stated as "we should throw the garbage into the trashcan", and the group of 6-year-olds diversely stated as "we should not cut the trees" and "we should warn people". 6-year-olds were able to infer that harm to the environment could lead to environmental pollution. The fact that the 3-year-old group stated attaching a filter and the 4-year-old group emphasized sea pollution established a remarkable result. Children at the age of 3 have said that they use a filter and children at the age of 4 have emphasized marine pollution while children at the ages of 5-6 have not mentioned those things. And it points out an interesting conclusion. The underlying reasons for this may be that younger children (i.e., ages of 3-4) have a higher level of awareness and each age group has different information resources. It could be suggested that the higher the age is, the more and detailed information learned from experience one has.

Looking at other studies, in the study conducted by Aydın and Aykaç (2016), interviews with the students in the experimental group show that the children have awareness of matters such as liking animals, protecting animals, recognizing and defining the environment, protecting the plants, protecting the environment, beautifying the environment and preventing environmental pollution. As a result of research Çağlar (2017), according to the children participating in the research, the most important factor causing environmental problems is to throw litter and the most important measure is not to throw litter. The fact that children, who consider people's relationship with the environment negatively, perceive the garbage thrown on the ground as an environmental problem is in line with the findings in the literature (Demirbaş and Pektaş, 2009; Yardımcı and Bağcı, 2010). In terms of this study and other studies, it is possible to say that prevention of environmental pollution is perceived as first not throwing garbage and secondly not harming nature and living creatures.

In terms of information sources, the 3-year-old group usually stated their mother, while the groups of 4, 5, and 6-year-olds stated both their mothers and fathers. While 4, 5, and 6-year-olds stated their information sources like television, the 6-year-old group stated tablet/television. While sources of information in younger ages were stated as mothers and fathers, tablets and televisions were indicated towards the age of 6, but teacher and school were not marked. The reason for not stating the school and teacher as the source of information may be because environmental education is less included in preschool education.

Research conducted by Halmatov and Ekin (2017) studies the contribution of parents to the environmental awareness of preschool children at the ages of 5-6 and establishes that parents have an effect on the environmental awareness of their children. As a result of the research, very few children gave the teacher answers in terms of information sources. In this period when the love of the environment develops, each individual in the family, school, and society should act with this awareness and fulfill the duty that falls on it.

According to Uzun and Sağlam (2005), the environmental awareness of students depends on the quality of the education given, the effectiveness of the teachers, and also on the family. In Turkey, training programs that can improve the point of view of the children in the early childhood period aimed at recognizing, protecting, and enhancing the environment based on social interaction should be diversified (Ogelman and Güngör, 2015). At the secondary school level as a source of information, Olufemi et al. (2014), comparing the environmental pollution awareness, knowledge, and attitudes of middle school students from two South African provinces, students from the two provinces found that they see newspapers as the most important source of information on environmental pollution.

In the interviews conducted with 3-year-old children regarding environmental pollution, it is found out that they generally have clear hand and germ perception in this regard but when we take a look at the paintings they drew, it is observed that they also drew smoke and dirty clouds, and as a result, while their air pollution perception did not reveal itself in interviews, it is detected from their drawings that they have such perceptions as well. Pictures were drawn by children's feelings, thoughts, opinions, growth process, and developmental more descriptive information and details about its properties are available (Wesson and Salmon, 2001). The children had difficulty in expressing the factors that cause air pollution verbally in the interviews, but in their drawings, they were able to reveal their air pollution perceptions more easily and concretely. This is an interesting

conclusion from this study that reveals important information about the educational process, with implications for what can be designed for preschool environmental education programs. With this result, it can be said that it would be more appropriate to use paintings as a data collection tool in younger age groups. As for the children within the 4-year-old group, they highlighted marine pollution and air pollution in their drawings and unlike the other age groups, they diversely drew recycle bins as well. When the pictures of the children from the 5-year-old group are examined, it is seen that they draw trashcan, garbage trucks, garbage collection rocket and that they have a perception of preventing pollution. As a result of human activities, this perception that wastes are produced by humans and is about remediation rather than preventing pollution raises awareness about the treatment of residues. When the pictures of the children from the 6-year-old group are examined, it is seen that, unlike other age groups, their causes of pollution (smoke from the car or house, the cutting of trees) were diverse. Özsoy and Ahi (2014), as a result of the study they conducted, found that elementary school students often included elements such as trees, sun, cloud, human, bird, butterfly, house, apartment, car, mountain, sea, river, garbage, garbage bin in their drawings. When the paintings are examined, it is seen that they often include environmental problems that they can observe in their immediate surroundings such as air pollution, soil pollution, unplanned-structuring, and traffic. It is observed that the students have limited awareness about the types of pollution and the living and non-living elements in the environment.

Özsoy (2012), in his study where he examined the environmental perceptions of elementary school students through their drawings, it is found out that students more frequently include the environmental problems. That they can observe in their immediate surroundings such as air pollution, soil pollution, water pollution and unplanned urbanization in their drawings that they see human beings as a part of nature, and that they think that human beings are affected by environmental problems such as other living things and that human are a factor that pollutes the environment. Also, in this study, children have defined people either as polluting the environment or as trying to clean the polluted environment. One might suggest that, according to children, people are both the cause and the effect of environmental pollution.

It is seen that the drawings towards the age of 6 are more evident in the way of protecting nature, not destroying nature in the way of preventing pollution. While there are polluters at younger ages, as age increases, people who protect the environment have been added. It is possible to say that early children cannot establish a relationship between protecting nature and environmental pollution. The reason for this can be explained by the fact that the sources of information at an early age remain verbal with the parents.

As a result, we tell children what to do and what not to do regarding environmental pollution. However, in preschool education, we should ensure that children are aware of the conflicts and issues necessarily arising from the relationship among people, society, and nature. For practical applications in preschool education, it would be more effective to locally conduct face-to-face observations on children at these ages. Later, studies could be performed on applications, discussions, and preventive measures related to this topic.

Suggestions

Providing environmental education to children at an early age ensures that they both become conscious of the environment and gain the behavior of protecting and developing the environment. For this reason, it is especially important to enrich the pre-school education program related to environmental education (Önder & Özkan, 2013). Integrated activities related to environmental and environmental pollution issues, the global consequences of environmental pollution, and measures to eliminate the negative consequences can be included in the preschool curriculum to raise environmental awareness in children.

It is seen that the aims, attainments, and concepts relevant to environmental education in the preschool curriculum are insufficient. Thus, environment-related activities are required for both qualitative and quantitative purposes. Preschool curriculum should be revised and it should be ensured that environmental education activities by age groups are adopted within the scope of science education. It is recommended that teachers be presented with sample activity practices on how they can raise environmental awareness in children within the scope of the preschool education program. Activities planned to increase environmental awareness in pre-school support the development of environmental awareness in children (Koçak Tümer & Temel, 2018). It is recommended that preschool teachers, who play an important role in the development of children's environmental awareness by implementing these activities, should be given in-service training, conferences, and seminars on how to gain their environmental perception of children.

As a result of the research, given the fact that people have been defined either as polluting the environment or as trying to clean the polluted environment, further researches on the relationship between the perception about people either as caring about or polluting the environment, information resources, and age groups can help to expand on this study. In terms of recommendations for other researchers; parents and preschool teachers can also be included in the study group. It should be conducted in preschool education institutions. The results to be obtained can be made available to people interested in environmental education.

Scientific Ethics Declaration

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

References

Abd El-Salam, M. M., El-Naggar, H. M., & Hussein, R. A. (2009). Environmental education and its effect on the knowledge and attitudes of preparatory school students. *J Egypt Public Health Assoc, 84*(3-4), 345-369.

Adler, A. (2000). The education of children. (Translator: Kamuran Şipal), Cem Publishing, İstanbul.

Alp, E., Ertepinar, H., Tekkaya, C., & Yilmaz, A. (2006). A statistical analysis of children's environmental knowledge and attitudes in Turkey. *International Research in Geographical and Environmental Education, 15*(3), 210-223.

Aminrad, Z., Azizi, M., Wahab, M., Huron, R., & Nawawi, M. (2010). Environmental awareness and attitude among Iranian students in Malaysian universities. *Environment Asia, 3*(1), 1-10.

Anderson, B. A., Romani, J. H., Phillips, H., Wentzel, M., & Tlabela, K. (2007). Exploring environmental perceptions, behaviors and awareness: water and water pollution in South Africa. *Population and Environment, 28*(3), 133-161.

Aral, N., Kandır, A. & Can Yaşar, M. (2001). *Okul öncesi eğitim1 [Pre-school education 1]*. İstanbul: Ya- Pa Yayınları.

Arnas, Yaşare A. (2002). Objectives of science education in preschool period. *Journal of Child Development and Education, 6*(7), 1-6.

Astalin, P. K. (2011). A study of environmental awareness among higher secondary students and some educational factors affecting it. *International Journal of Multidisciplinary Research, 1*(7), 90-101.

Aydın, Ö., & Aykaç, N. (2016). The effect of the education implemented by the creative drama method on the environmental awareness of pre-school students. *Journal of Creative Drama, 11*(1), 1-16.

Aznar-Díaz, I., Hinojo-Lucena, F. J., Cáceres-Reche, M. P., Trujillo-Torres, J. M., & Romero-Rodríguez, J. M. (2019). Environmental attitudes in trainee teachers in primary education. the future of biodiversity preservation and environmental pollution. *International Journal of Environmental Research and Public Health,16*(3), 362.

Basile, C. G. (2000). Environmental education as a catalyst for transfer of learning in young children. *The Journal of Environmental Education, 32*(1), 21–27.

Barraza, L. (1999). Children's drawings about the environment. *Environmental Education Research, 5*(1), 49-66.

Boyes, E. & Stanisstreet, M. (1994). Children's ideas about radioactivity and radiation. *Research in Science and Technological Education, 12*(2), 145-160.

Boyes, E. & Stanisstreet, M. (1997). Children's models of understanding of two major global environmental issues (ozone layer and greenhouse effect). *Research in Science and Technological Education, 15*(1), 19-28.

Boyes, E. & Stanisstreet, M. (1998). High school students' perceptions of how major global environmental effects might cause skin cancer. *Journal of Environmental Education, 29*(2), 31-36.

Broadstock, D.C., Collins, A., Hunt, L.C., & Vergos, K. (2018). Voluntary disclosure, greenhouse gas emissions and business performance: Assessing the first decade of reporting. *Br. Account. Rev., 50*, 48–59.

Carvalho, M., Santana, R., & Vieira, A.M. (2016). Promotion of sustainability by quantifying and reducing the carbon footprint: new practices for organizations. In *Energy, Transportation and Global Warming*, 1st ed.; Grammelis, P., Ed.; Springer: Basel, Switzerland, 61–72. ISBN 978-3-319-30127-3.

Chapman, D., & Sharma, K. (2001). Environmental attitudes and behavior of primary and secondary students in Asian cities: An overview strategy for implementing an eco-schools programme. *Environmentalist, 21*(4), 265-272.

Chawla, L. (2007). Childhood experiences associated with care for the natural world: A theoretical framework for empirical results. *Children Youth and Environments, 17*(4), 144–170.

Cohen, L., Manion, L. & Morrison, K. R. B. (2004). *A Guide to Teaching Practice (fifth edition)*. London: Routledge.

Creswell, J. W. (2007). *Qualitative inquiry & research design. Choosing among five approaches, (2nd. Edition).* London: SAGE.

Çağlar, A. (2017). 4th and 5th grade school students' perceptions of environmental problemles. *International Journal of Turkish Education Sciences, 9*, 311-320.

Çepel, N. (2003). *Ekolojik sorunlar ve çözümleri [Ecological problems and solutions], (2. edition)*. TÜBİTAK Popüler Bilim Kitapları, Ankara: Aydoğdu Matbaası.

De la Vega, E. L. (2006). A preliminary evaluation of awareness, knowledge, and attitude in environmental education specialists, instructors, students, and parents in Southwest Florida. *Florida Scientist,* 166-178.

Demirbaş, M., & Pektaş, H. M. (2009). Elementary students' levels of realization of basic concepts related with environment problem. *Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education (EFMED), 3*(2), 195-211.

Dinçer, Ç. (2005). Ways to increase environmental awareness of preschool children. http://www.rehabilitasyon.com.tr. date of access:26 Kasım 2014.

Doğan, Y., & Simsar, A. (2019). Investigation of preservice preschool teachers' views on environmental problems and relevant suggestions of solution. *International Electronic Journal of Elementary Education, 11*(2), 151-159.

Domka, L. (2004). Environmental education at pre-school. *International Research in Geographical and Environmental Education, 13*(3), 258-263.

Dove, J. E., Everett, L. A. & Preece, F. W. (1999). Exploring a hydrological concept through children's drawing". *International Journal of Science Education, 21*(5), 485-497.

Erol, G., & Gezer, K. (2006). Prospective of elementary school teachers' attitudes toward environment and environmental problems. *International Journal of Environmental and Science Education, 1*, 65-77.

Erten, S. (2004). What is environmental education and environmental awareness, how is environmental education must have?, Environment and human magazine, media organ of the ministry of environment and forestry. Issue: 65/66. 2006/25 Ankara.

Ertürk, R . (2017). Environmental problems of the primary school students and perceptions for environmental education. *İnönü University Journal of the Faculty of Education*, *18*(3), 12-24. https://doi.org/10.17679/inuefd. 354142.

Eva Ärlemalm-Hagsér & Anette Sandberg (2011). Sustainable development in early childhood education: In-service students' comprehension of the concept, *Environmental Education Research, 17*(2), 187-200 http://dx.doi.org/10.1080/13504622.2010.522704.

Gädicke, J., Ibarra, P., & Osses, S. (2017). Evaluation of environmental perceptions in high school students of Temucocity, Región de La Araucanía. *Estudios Pedagógicos, 43*, 107–121.

Gezgin, N. (2009). *The classroom management strategies that preschool education teachers use*, Unpublished Master Thesis, Uludağ University, Institute of Social Sciences, Bursa.

Gülay, H. & Önder, A. (2011). *Environmental education in preschool for sustainable development*. Ankara: Nobel Publication Distribution.

Gülay, H., & Ekici, G. (2010). Analysis of MEB pre-school education program in terms of environmental education. *Turkish Journal of Science Education,* 74-84.

Halmatov, M., Sarıçam, H., & Halmatov, S. (2012). Research on 6 ages children' drawing environment pictures and perception on the environment concept while taking pre-school education according to different variables. *International Social Science Education of Journal, 2*(1), 30-44.

Halmatov, M. (2017). *Children's picture analysis and psychological picture tests*. Ankara: Pegem Akademi.

Harun, R., Hock, L. K., & Othman, F. (2011). Environmental knowledge and attitude among students in Sabah. *World Applied Sciences Journal, 14*(11), 83-87.

He, X., Hong, T., Liu, L., & Tiefenbacher, J. (2011). A comparative study of environmental knowledge, attitudes and behaviors among university students in China. *International Research in Geographical and Environmental Education, 20*(2), 91-104.

Horwitz, W. A. (1996). Developmental origins of environmental ethics: The life experiences of activists. *Ethics and Behavior, 6*(1), 29-54.

Huang, H. P., & Yore, L. D. (2005). A comparative study of Canadian and Taiwanese grade 5 children's environmental behaviors, attitudes, concerns, emotional dispositions, and knowledge. *International Journal of Science and Mathematics Education, 1*(4), 419-448.

Hungerford, H. R., Peyton, R. B. & Wilke, R. (1980). Goals for curriculum development in environmental education. *The Journal of Environmental Education, 11*(3), 42.

Jeffries, H., Stanisstreet, M. & Boyes, E. (2001). Knowledge about the "greenhouse effect": Have college students improved? *Research in Science and Technological Education, 19*(2), 205-221.

Jhonson, B., & Christensen, L. (2014). *Educational research: quantitative, qualitative and mixed approaches (4th Edition)*. Sage publications.

Kalaycı, S. (2020). Cognitive perceptions of pre-service science teacher for environmental pollution. *Journal of Baltic Science Education, 19*(3), 415-428.

Kahraman, P. B., Yılmaz, S. N., & İlyas, G. (2019). The views of the preschool children in the countryside and city zones regarding environmental pollution. *Bartın Üniversitesi Eğitim Fakültesi Dergisi*, *8*(3), 783-810.

Karamustafaoğlu, S. & Kandaz, U. (2006). Using teaching methods in the science activities and difficulties encountered in pre-school education. *Journal of Gazi Education Faculty*, *26*(1), 65-81.

Kınık, B. Okyay, Ö. & Aydoğan, Y. (2016). Analyzing the effects of environment education on language development on 24-36 month old children with parent involved. *Kastamonu Journal of Education, 24*(5), 2143-2156.

Kışoğlu M., Gürbüz H., Sülün A., Alaş A. & Erkol M. (2010). Environmental literacy and evaluation of studies conducted on environmental literacy in Turkey. *International Online Journal of Educational Sciences, 2*(3), 772-791.

Koçak Tümer, B. & Temel, F. (2018). Investigatıon the effects of environmental education program on children' attitudes toward the environment. *Middle East Journal of Education (MEJE), 4*(2), 1-11.

Littledyke, M. (2004). Primary children's views on science and environmental issues: examples of environmental cognitive and moral development. *Environmental Education Research, 10*(2), 217–235.

Liu, S. C..& Lin, H. (2014). Undergraduate students' ideas about nature and human-nature relationships: An empirical analysis of environmental worldviews. *Environmental Education Research, 20*(3), 412-429.

Loughland, T.& Reid, A.-Petocz, P. (2002). Young people's conceptions of environment: a phenomenographic analysis. *Environmental Education Research, 8*(2), 187-197.

Loughland, T., Reid, A., Walker, K. & Petocz, P. (2003). Factors influencing young people's conceptions of environment. *Environmental Education Research, 9*(1), 3–20.

Makki, M. H., Abd-El-Khalick, F., & BouJaoude, S. (2003). Lebanese secondary school students' environmental knowledge and attitudes. *Environmental Education Research, 9*(1), 21-33.

Mantzicopoulos, P., Patrick, H., & Samarapungavan, A. (2008). Young children's motivational beliefs about learning science. *Early Childhood Research Quarterly*, *23*, 378-394.

McWhirter, J. M., Collins, M., Bryant, I., Wetton, N. M., & Bishop, J. N. (2000). Evaluating 'safe in the sun', a curriculum programme for primary schools. *Health Education Research, 15*(2), 203-217.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis*. USA: Sage Publication.

Miles, M. B., & Huberman, A. M. (2015*). Qualitative data analysis (S. A. Altun & A. Ersoy, trans.)*. Pegem Akademi, Ankara.

Ministry of National Education (MONE), (2006). *Pre-school education program for 36-72 months old children and regulation of pre-school education institutions. The curricula and regulation for early childhood education.* İstanbul: Morpa Kültür Publishing.

Moseley, C., Desjean,-Perrotta, B. & Utley, J. (2010). The draw-an-environment test rubric (DALET-R): Exploring pre-service teachers' mental models of the environment. *Journal of Environmental Education Research*, *16*(2), 189–208. https://doi.org/10.1080/13504620903548674

Ogelman, H., & Güngör, H. (2015). Investigating the studies on environmental education in preschool period in Turkey: Investigating the articles and dissertations between 2000-2014. *Mustafa Kemal University Journal of Social Sciences Institute, 12*,(32) 180-194.

Oktay, A, (1999). *Magic years of life: preschool period*. Epilson Publishing, İstanbul.

Olufemi, A. C. (2012). *Assessing the levels of awareness, knowledge and attitude about environmental pollution as well as the presence of pollutants in the vicinity of schools in a coal mining area*.Doctoral dissertation. Tshwane University of Technology.

Olufemi A. C., Mji A. & Mukhola, M.S. (2014). Assessment of secondary school students' awareness, knowledge and attitudes to environmental pollution issues in the mining regions of South Africa: implications for instruction and learning. *Environmental Education Research, 22*(1), 43-61, https://doi.org/10.1080/13504622.2014.984162

Adejoke, O. C., Mji, A., & Mukhola, M. S. (2017). Students' and teachers' awareness of and attitude towards environmental pollution: A multivariate analysis using biographical variables. *Journal of Human Ecology, 45*(2), 167-175. https://doi.org/10.1080/09709274.2014.11906690.

Orr, D.W. (2002). Politics economy and the ecology of childhood. In P.H. Kahn & S.R. Kellert (Eds.), *Children and Nature: Psychological, Sociocultural and Evulutionary Investigations* (pp. 279-304). Cambridge, M.A.: MIT Press.

Özdemir Özden D., & Özden M. (2015). Investigation of children's drawings about environmental issues. *Pamukkale University Faculty of Education Journal, 37*, 1-20.

Önder, A. & Özkan, B. (2013). *Sustainable child development: Environmental education with preschool activities.* Anı Publishing. Ankara.

Özkul B. (2018). The investıgatıon of children' perceptions environmental issues in early childhood period. *ULEAD 2018 Annual Congress: ICRE*. 9-11 Mayıs 2018-Manisa.

Özsoy, S. (2012). Investigating elementary school students' perceptions about environment through their drawings. *Educational Sciences: Theory & Practice, 12*(2), 1117-1139.

Özsoy, S., & Ahi, B. (2014). Determining primary school students' perceptions of the future of the environment through the pictures they draw. *Educational Sciences: Theory & Practice, 14*(4), 1557-1582.

Palmer, J. A. (1995). Environmental thinking in the early years: Understanding and misunderstanding of concepts related to waste management. *Environmental Education Research. 1*(1), 35-45.

Paraskevopoulos, S., Padeliadu, S. & Zafiropoulos, K. (1998). Environmental knowledge of elementary school students in Greece. *The Journal of Environmental Education, 29*(3), 55-60.

Patrick, P. G. & Tunnicliffe, S. D. (2010). Science teachers' drawings of what is inside the human body. *Journal of Biological Education, 44*(2), 81–87.

Payne, P. (1998). Childrens' conception of nature. *Australian Journal of Environmental Education, 14*, 19-26.

Poyraz, H. & Dere, H., (2001). *Principles and methods of preschool education*. Anı Publishing, Ankara.

Rickinson, M. (2001). Leaners and learning in environmental education: A critical review of evidence. *Environmental Education Research, 7*(3), 207-320.

Rennie, L. J., & Jarvis, T. (1995). Children's choice of drawings to communicate their ideas about technology. *Research in Science Education, 25*, 239-252.

Robertson, J. S. (2008). *Forming preeschoolers' environmental attitude: lasting effects of early childhood environmental education*. Unpublished Master's Thesis. Royal Roads University, Canada.

Russo, S. (2001). Promoting attitudes towards environmental education depends on early childhood education. *Australian Primary and Junior Science Journal, 17*(4), 34-36.

Ryan-Wenger, N. (2001). Use of children's drawings for measurement of developmental level an emotional status. *Journal of Child and Family Nursing, 4*, 139-149.

Saçkes, M., Trundle, K. C., Bell, R. L., & O'Connell A. A. (2011). The influence of early science experience in kindergarten on children's immediate and later science achievement: Evidence from the early childhood longitudinal study. *Journal of Research in Science Teaching, 48*(2), 217-235.

Saz, B., Osmanpehlivan, E., Demir, İ. & Bay, D. N. (2020). The analysis of preschool children's of environmental pollution perception. *Journal of Anadolu University Faculty of Education,(AUJEF), 4*(3), 191-215.

Shepardson, D. P. (2005). Student's ideas: What is an environment? *Journal of Environmental Education, 36* (4), 49-58.

Shepardson, D.P., Wee, B., Priddy, M., & Harbor, J. (2007). Students' mental models of the environment, *Journal of Research in Science Teaching, 44*, 327–348.

Skarstein, T. H. & Skarstein, F. (2020). Curious children and knowledgeable adults - early childhood student-teachers' species identification skills and their views on the importance of species knowledge. *International Journal of Science Education, 42*(2), 310-328. https://doi.org/10.1080/09500693.2019.1710782.

Skypo, T., Ryan-Wengwe, N. & Su, Y. (2007). Human figure drawings as a measure of children's emotional status: Critical review for practice. *Journal of Pediatric Nursing, 22*(1), 15-28.

Smith, A. (2001). Early childhood a wonderful time for science learning. *Australian Primary and Junior Science Journal, 17*(2), 18-20.

Soga, M., Gaston, K.J., Yamaura, Y., Kurisu, K., & Hanaki, K. (2016). Both direct and vicarious experiences of nature affect children's willingness to conserve biodiversity. *Int. J. Environ. Res. Public Health, 13*, 529.

Taşkın Ö., & Şahin, B. (2008). The term "environment" and six years old kindergarten children. *Pamukkale University Faculty of Education Journal, 23(*1), 1-12.

Uslucan, S. (2016). *The effect of environmental education program on the attitudes of preschool children (60-72 months) towards the environment (Çanakkale Province Example).* Unpublished Master Thesis. Çanakkale Onsekiz Mart University, Institute of Education Sciences, Çanakkale.

Uyanık, G. (2017). Opinions towards environmental pollution of primary school students. *Van Yuzuncu Yil University Journal of Education, 14*(1), 1574-1600. http://doi.org/10.23891/ efdyyu.2017.56

Uzun, N., & Sağlam, N. (2005). Effect of socio-economic status on environmental awareness and environmental academic success. *Hacettepe University Faculty of Education Journal, 29*, 194-202.

Üstünoğlu, Ü. (1991). *Different approaches in family education, family education*. *T.R. Prime Ministry Family Research Institution Publications*. Ankara, 80-89.

Wesson, M. & Salmon, K (2001). Drawing and showing: Helping children to report emotionally laden events. *Applied Cognitive Psychology, 15*, 301-320.

Yagci, M. (2016). *Examination of nature and environmental practices in the development of scientific process skills of preschool children*. Unpublished Master Thesis. Abant İzzet Baysal University, Institute of Educational Sciences, Bolu.

Yardımcı, E. & Bağcı-Kılıç, G. (2010). Environment and environmental problems through the eyes of children. *Elementary Online, 9*(3), 1122-1136.

Yavetz, B., Goldman, D., & Pe'er, S. (2014). How do preservice teachers perceive 'environment' and its relevance to their area of teaching?. *Environmental Education Research, 20*(3), 354-371.

Yıldırım, A. & Şimşek, H. (2006). *Qualitative research methods in the social sciences*. Seçkin Publishing. Ankara.

Yıldırım A. & Şimşek, H. (2008). *Qualitative research methods in social sciences (6th Edition)*, Seçkin Publishing. Ankara.

Yıldırım, A., & Şimşek, H. (2011). *Qualitative research methods in social sciences (8th Edition)*. Seçkin Publishing, Ankara.

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Effects of Place-Based Socioscientific Issues on Rising Middle School Students' Evidence-Based Reasoning and Critical Thinking on Hydraulic Fracking

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Abstract

This study investigated the implementation of a place-based socioscientific issue curricular unit designed to improve rising middle school students' abilities to think critically about the pros and cons of hydraulic fracturing and engage in evidence-based reasoning on whether the practice should be banned in Massachusetts. Forty-three rising middle school students from a summer enrichment program for science, mathematics, reading and writing operated by a non-profit organization in the northeastern United States participated in this study. The instructional unit exposed the students to information and activities on hydraulic fracturing for five consecutive days (50 minutes each day). The findings from this study showed that through productive socioscientific issues pedagogy, the students used the evidence collected from their investigation to engage in evidence-based reasoning about the cost and benefits of hydraulic fracturing on the public health, economy, and the environment. The students used their understanding of the science and engineering practices to construct valid arguments on whether or not hydraulic fracturing should be allowed in their state. The results further indicate that the use of socioscientific issues as a critical pedagogical strategy can equip students with the skills necessary for them to become better advocates for themselves and their communities.

Introduction

It has been nearly three decades since the first reported study on environmental racism in the United States (Bryant & Mohai, 1992). Since this first study was done, numerous policy makers from the local, state, and federal government across the United States have condemned the practice of environmental racism. Yet, many minority communities are still experiencing daily health-related risks due to living in polluted environments. While proactive governmental policies are required to address these environmental inequities, one question remains: how can education in general, and science education in particular, help to bring about much-needed changes to the environmental racism that are constantly perpetuated on marginalized communities? One train of thought lies in the necessity to implement socioscientific issues (SSI) pedagogy in the K-12 curricula to expose students to place-based education. The SSI framework seeks to provide opportunities for students to develop competencies engaging in discourse on scientific issues impacting their communities. The purpose of this study is to describe the effects of a place-based socioscientific issues instructional unit of instruction on rising middle school students' abilities to engage in evidence-based reasoning and to think critically about hydraulic fracking as they determine whether to ban fracking in Massachusetts. Outlined below is an SSI unit on hydraulic fracking, the teaching strategies adapted, and the results obtained from a group of rising middle school students in the northeastern United States. The issue of hydraulic fracturing was used as a place-based educational opportunity to engage the students in evidence-based reasoning on the effects of hydraulic fracking on the environment.

Literature Review

There are no secrets that racial minority and low-income communities across the United States are disproportionally impacted by environmental risks associated with pollutants (Powell & Fuchs, 2020, Cutter, 1995, USEPA, 1992a). Studies have shown that it is quite common that waste disposal sites are often located in minority communities, away from individuals who receive the majority of the benefits that are associated with the events that generate the waste (Griffith et al., 1989, Norton, 2007, Lowman, 2013, Johnson, 2016). Throughout the United States, waste disposal facilities are disproportionally located in communities of color

(Bullard, 2008, Bryant, 1992, Powell & Fuchs, 2019). This unequal pattern of distributing waste treatment facilities in marginalized communities comes with a price, as residents who live in these areas often bear the brunt of health-related illnesses that are caused by the pollutants from these industries (Davis, 2018; Singer, 2011). For example, in the Standard Heights community of Louisiana, an area of the state called "Cancer Alley" because of the pollutants from the petroleum industries in the area, studies have reported that residents often developed strange sores on their feet that don't heal, sinus infections, odor smelling air, and deposits on everything that is outdoors (Keehan, 2018). Studies have reported that it is a common occurrence for residents who live along the Mississippi River to die at a young age from cancer and lung disease (Keehan, 2018).

Other studies have also reported that petrochemical accidents that results in spillage into the environment is not new (Allen, 2003, Louisiana Department of Environmental Quality 1997).). For example, in 2012, the Exxon plant bordering Standard Heights in Louisiana spilled 31,000 pounds of cancer-causing benzene into the air. After this event many residents of the community became ill. While this was the case, this accident was not reported to the Environmental Protection Agency (EPA). These practices often resulted in great fear among people who live in marginalized communities where petrochemical industries are constructed, whether these industries are conventional or unconventional oil and gas industries. For example, unconventional oil and gas technique such as hydraulic fracturing that combines horizontal drilling with pressurized high-volume injection of fluids to fracture underground shale rocks to release trapped oil or gas is practiced in many regions of the United States. This practice is a subject of contention among the two political parties in the 2020 presidential election in the United States. While both political parties debate the issue of hydraulic fracturing, this practice is on the increase throughout the United States. For example, it was estimated that as of 2012, the United States has approximately 100,000 unconventional oil and gas wells in several states (Ellsworth, 2012). Each of these wells requires 11 to 19 million liters of water for drilling (US Environmental Protection Agency, 2015). In each well, sand and other additives that are known to have adverse health risks are also injected (Colborn, et al., 2011). An estimated 5.2 million liters of fracking fluid returns to the surface from each well as waste water (Lutz, et al., 2013; Ferrar et al., 2013). One can expect that the management of this waste water pose significant threats to drinking water resources, and ultimately public health (Vengosh et al., 2014; Yuan et al., 2013). The events of Cancer Ally, and the impact of the health of the residents who live in these eighty-five miles stretch of land that borders the Mississippi River from Baton Rouge to New Orleans should create enough cause for concerns about hydraulic fracturing. Therefore, it is imperative that school science develop generations who can ask the right questions of their elected officials, to analyze the data associated with hydraulic fracturing, and make inform decisions on the issue, requires an educational system that utilizes place-base education as a key instructional strategy. The use of the SSI in the K-12 science education curriculum is poised to enhance students' abilities to engage in these actions.

Socioscientific Issues and its Impact on Place-Based Education

Whether we are talking about the disproportionate numbers of waste treatment facilities in communities of color (Bullard, 2008, Bryant, 1992, Powell & Fuchs, 2019), health-related illnesses that are caused by the pollutants from these industries (Davis, 2018; Singer, 2011), or America's quest for energy independence, these scientific issues make it is quite clear that school science must provide the framework on which youth can take civic actions that are aimed at protecting their communities from the fallout that may result from these industries. This is needed in order to preserve the health of the residents who live in marginalized communities throughout the United States and other parts of the world. One way to accomplish this goal is for school administrators, science supervisors, and science teachers to make SSI part and parcel of the school science curriculum. SSI are scientific issues that are typically contentious issues, can be considered from a variety of perspectives, do not possess simple conclusions, and frequently involve morality and ethics (Zeidler & Kahn, 2014). Examples of SSI include, but are not limited to a range of dilemmas such as hydraulic fracking, biotechnology, health effects of diets, as well as genetic engineering (Sadler & Murakami, 2014; Zeidler & Kahn, 2014). The SSI framework seeks to involve students in decision making regarding everyday social issues with moral or ethical implications embedded within scientific contexts (Yap, 2014). Hydraulic fracturing practices in the United States have garner supports because of its potential of helping the United States to wean itself off of foreign oil. While this is the train of thoughts by supporters of hydraulic fracturing, others are vehemently opposed to the practice because of the potential risks it poses to the environment and public health. Introducing students to scientific issues, such as hydraulic fracturing that lacks clear cut solutions has the potential to enhance their ability to analyze, synthesize and evaluate information, develop their moral reasoning and ethical decision-making skills, in addition to improving students' content knowledge and argumentation abilities (Dawson & Venville, 2010; Klosterman & Sadler, 2010; Sadler, Klosterman, & Topcu, 2011). These skills are critical in promoting civic engagement among students. Currently, our science education policy promotes the idea that scientific

understanding is all students need to make informed scientific decisions (e.g., AAAS, 1989; NRC, 2012). However, studies have shown that scientific understanding is not enough to impact the decisions people make on civic engagement (Allum et al., 2008; Sadler, 2004). For example, studies that have investigated secondary school students' willingness to act to reduce climate change have reported that while students are willing to turn off lights and unplug electrical appliances when not in use (Chokker et al., 2010; Hermans & Korhonen, 2017; Skamp et al., 2009), they are less likely to less likely to purchase used items to preserve natural resources, or to reduce their carbon footprints by walking moderate distances (Hermans & Korhonen, 2017). Therefore, students in the K-12 system need more opportunities that promote civic engagement aimed at protecting the environment should be explicitly taught in the school settings. The use of SSI in the science classroom is position to promote more civic engagement among students.

In a recent study, Birmingham and Barton (2014) engaged youth from underrepresented backgrounds in an after-school science program in the Great Lake City area of Michigan that was designed so that the youth could examine SSI as they took educated action in science. As a culminating activity, the youth hosted parents, peers, and other community members at a "green carnival" who were interested in learning more about green energy. The youth wanted to educate their community members about green energy, why it matters, and what community members can do at home to be green. Based in the research the youth did prior to the carnival, they felt that they had become "experts" on these topics, and had ideas they wanted to share with community members. At the "green carnival," the youth messages to their community members include information on energy efficiency and technological advances, energy and the environment, and renewable energy technology. The youth conveyed information, showcase exhibits, and demonstrated experiments to their community members who attended the green carnival specific practices they hoped community members would enact at their home. For example, in teaching their community members about energy efficiency and technological advancements, the youth created a Light Bulb Efficiency exhibit that provided opportunities for community members to interact. The community members were able to speculate which light bulb is more efficient, and determine which light bulb is better for home use. This exhibit was designed to teach community members about energy efficiency. The three girls who led this exhibit used their scientific knowledge about how light bulbs work, energy usage, how energy usage is measured, and energy transformation to community concerns, and potential actions that community members can take to enhance their energy efficiency at home.

Birmingham and Barton (2014) reported that the youth effectively engaged their community members on other exhibits that included renewable energy technology, energy and the environment (for more details see Birmingham and Barton, 2014 study). These researchers reported that:

> … we argue that the specific design of the carnival itself was intended to make green energy issues accessible, salient, and interesting to the community in response to how they understood their community's knowledge of green energy. We believe that these forms of educated action allowed the green carnival to open dialog and foster interaction within science among community members. (p. 306).

The finding from Birmingham and Barton, (2014) highlight the potential impact of using SSI to educate students and community members on actions that can be taken to preserve natural resources and the environment in which one live. The ill-structured nature of hydraulic fracturing is a great SSI activity that can be used to enhance students' argumentation quality, decision-making skills, and civic engagement. This is because the issue of on hydraulic fracturing is ill-structured in nature, as a result it presents numerous pros and cons on which students can engage in meaningful discourse on whether the practice should be banned. This is a place-based issue that is concerning for residents who get their potable water from aquifers in and around areas where hydraulic fracturing is occurring or is slated to occur. For example, several bills have been proposed in Massachusetts House to ban hydraulic fracturing in the Commonwealth. In 2016, Massachusetts Senate approved Senate, No. 2309, that place a ten-year moratorium on fracking and the disposal of fracking wastewater in the Commonwealth. While this is the case, there are other areas of the United States where hydraulic fracturing is occurring un-impeded. One of the main reasons is that the link between direct contamination to drinking water resources as a result of hydraulic fracturing activities is still being investigated. For example, Barth-Naftilana, Sohnga, & Saiersa (2018) conducted a 2-year prospective study of groundwater quality within the Marcellus Shale. This study installed eight multilevel monitoring wells within bedrock aquifers of a 25-kilometers square area targeted for shale gas development. The study reports that twenty-four isolated intervals within these wells were sampled monthly over two years, and groundwater pressures were recorded before, during, and after seven shale gas wells were drilled, hydraulically fractured, and placed into production. This study found no lasting impact on groundwater quality from hydraulic fracturing. While this is the case, residents are still on edge about hydraulic fracturing.

One of the chief concerns from citizens is that groundwater wells located closer to hydraulically fractured sites are more likely to be exposed to contamination. Jasechko and Perrone (2017) conducted a study that analyzed the distance between domestic groundwater wells (public and self-supply) constructed between 2000 and 2014 and hydraulically fractured wells stimulated in 2014 in 14 states. They reported that 37% of all recorded hydraulically fractured wells stimulated during 2014 exist within 2 km of at least one recently constructed (2000–2014) domestic groundwater well. These findings create cause among residents in communities where hydraulic fracturing is occurring because studies have found methane in drinking water wells in regions where hydraulic fracturing occurs. For example, Osborna et al. (2011) conducted a study investigating methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing. This study reports that methane concentrations were generally detected in 51 of 60 drinking-water wells (85%) in the region where the Marcellus and Utica shale formations of northeastern Pennsylvania and upstate New York. The study reports that methane was detected in drinking water wells regardless of gas industry operations, but concentrations were substantially higher closer to natural-gas wells. The study also notes that methane concentrations were 17-times higher on average in shallow wells from active drilling and extraction areas than in wells from nonactive areas.

In this study, Osborna et al. (2011) also reported that they found no evidence for contamination of drinking-water samples with deep saline brines or fracturing fluids. These researchers conclude that greater stewardship, data, and—possibly—regulation are needed to ensure the sustainable future of shale-gas extraction and to improve public confidence in its use (Osborna et al., 2011, p. 8172).

Knowing that hydraulic fracturing is currently occurring in many established oil and gas producing regions of the United States makes it an essential place-based educational issues that school science education curriculum should address. This will undoubtedly add opportunities for school science to engage K-12 students in real world scientific discourse, which can potentially impact students' evidence-based decision-making skills.

What is Place-Based Education?

Many have argued that place-based education enhanced students' understanding of the interdependent relationship between their lives and the various systems within their communities (Lewicki, 1998; Howley & Howley, 2010; Theobald, 1997). While place-based education has a long history in rural schools and communities (Howley & Harmon, 2000; Howley et al., 2008; Jennings et al., 2005), it is important to point out that threats to the public drinking water resources as well as health-related dangers to the environment are concerns that are shared by citizens from all locations, both urban and rural. Therefore, the use of place-based education in the K-12 curricula should be a point of interest for all because of its potential in providing students with opportunities for learning in authentic ways (Sarkar & Frazier, 2008). It also has the potential to enhance students' argumentation quality, decision-making skills, and civic engagement

But what exactly is place-based education, and is it appropriate for the science classroom? David Sobel (2004) reported that:

> Placed-based education is the process of using the local community and environment as a starting point to teach concepts in language arts, mathematics, social studies, science, and other subjects across the curriculum. Emphasizing hands-on, real-world learning experiences this approach to education increases academic achievement, helps students develop stronger ties to their community, enhances students' appreciation for the natural world, and creates a heightened commitment to serving as active, contributing citizens. Community vitality and environmental quality are improved through the active engagement of local citizens, community organizations, and environmental resources in the life of the school. (p. 7).

Based on Sobel's (2004) definition, it is clear that place-based education has the potential to immerse students into community issues that can be tied to all school subjects. Such teaching approach is paramount in facilitating the creation of engaged students, better future citizens, improved communities, awareness of preserving the natural environment, and higher academic achievement (2010).

As educators think about how to make science curriculum relevant to students' lives, connecting the school science curriculum to scientific issues that plague the communities in which students live presents students with opportunities to think fruitfully about how their actions or inactions may impact their communities. Place-Based Education in the school science curriculum can provide a set of circumstances for students to examine data, reason, make conclusions, and think critically to challenge injustices perpetrated on their communities by

powerful others. However, instituting place-based Education in the school science curriculum will require teachers to put away the science textbook as the communities' scientific problems are not often represented in the textbooks students are asked to read. Instead, teachers must align the place-based education topics they want to discuss in their classroom to their state curriculum standards. Doing so will provide opportunities for teachers to integrate science education with other disciplines that will (re)consider new politico-ethical directions (Carter 2011).

The SSI unit on hydraulic fracturing described in this article presented the opportunity for these students who are from a major metropolitan area in Massachusetts to engage evidence-based discourse on a place-based education topic that creates contention in many communities throughout the United States. The students' abilities to navigate this issue may impact their skills to make evidence-based reasoning central to their decision on whether hydraulic fracturing should be banned in Massachusetts.

Method

The framework for K-12 science education sets a very ambitious goal for all students within the system. The overarching goal of the framework states:

> By the end of 12th grade, all students are to have some appreciation of the beauty and wonder of science; possess sufficient knowledge of science and engineering to engage in public discussions on related issues; are careful consumers of scientific and technological information related to their everyday lives; are able to continue to learn about science outside school; and have the skills to enter careers of their choice, including (but not limited to) careers in science, engineering, and technology (National Research Council [NRC], 2012).

One way of facilitating the overarching goal of the framework is to provide opportunities for K-12 students to connect events of their communities to the school curriculum authentically. Doing so will enable students to make a more meaningful connection between the things they learn in school and the events that are happening in their communities. Therefore, in an attempt to satisfy the framework's goal, the following questions and corresponding rationales were used to guide this investigation.

Research Question 1

What relationships, if any, exist between place-based education on students' abilities to engage in evidence-based reasoning?

Rationale 1

Advocates of the SSI framework have argued that such pedagogy has the potential to develop students' competencies in making evidence-based decisions on sustainable environmental practices (Bencze et al., 2012, Mueller et al., 2011, Powell & Fuchs, 2019). The potential scientific problems that stem from hydraulic fracturing pose a serious threat to the health and survival of the citizens who live within communities where hydraulic fracturing is conducted. Determining the cause and effects relationships between hydraulic fracturing on public health will require a generation who can engage in the cause and effects investigation of hydraulic fracturing in addition to critically think about the potential ramification of such practice. Sound pedagogy is a requirement for students to determine potential relationships between hydraulic fracturing and the health of the environment. SSI as a pedagogical strategy is poised to enhance students' abilities to think critically as they determine cause and effects relationships and engage in evidence-based reasoning on science issues such as energy consumption and production that relates to their everyday lives.

Research Question 2

How might middle school students' abilities to think critically about hydraulic fracking impact their decision-making on whether to ban fracking in Massachusetts?

Rationale 2

Enhancing students' critical thinking abilities requires an extensive, deliberate practice that involves the use of argument mapping (Mulnix, 2010). Such beliefs are aligned with the vision for K-12 science education advocated by the NRC (2012). For students to become the critical consumer of science, they must get opportunities to use critique and evaluation to judge the merits of any scientifically based argument (NRC, 2012). However, achieving this goal is only possible if teachers adapt and use sound pedagogical practices in the classroom settings that foster the development of students' abilities to use critique and evaluation to judge the merit of an argument (Powell & Fuchs, 2019). The use of SSI as a key pedagogical strategy has the potential to enhance students' critical thinking abilities as they engage in argumentation exercises on scientific issues that are personally relevant and meaningful to their daily lives.

Study Participants and Context

The participants of this study were 43 rising middle school students (11–12-years-old; 20 males, 23 females) who participated in a summer enrichment program for science, mathematics, reading, and writing operated by a non-profit organization in the northeastern United States. The goal of the organization is to develop and implement programs that prepare underserved students in the northeastern United States for educational opportunities that lead to college success. The program remediates achievement gaps and prepares students for acceptance to and success at top independent, Catholic, and public exam schools in the Northeastern United States. The students are generally referred to the program by their teachers from the public-school system, and they are admitted in the spring before their fifth or sixth-grade year. The racial breakdown of the students is as follows: 19% Asian, 37% Black, 21% Hispanic, 10% Multiracial, 4% White, and 9% other. These students were from 40 distinct feeder schools. Seventy-seven percent of the students attended public schools, nineteen percent attended charter schools, and four percent attended parochial schools. The average family income was $41,735, and fifty-one percent of the students qualify for free and reduced meals.

Data Generation and Implementation Process

The instructional unit was done over six consecutive class periods. Each class period lasted for 55 minutes. Students' written artifacts were collected each day and analyzed. Below is a description of the day's events:

Day 1:

The Center for Local, State, and Urban Policy at the University of Michigan conducts, supports and fosters applied academic research to inform local, state, and urban policy issues. Questions 3, 14, 15, 17, and 25 from the center's survey on the public perceptions of shale gas extraction and hydraulic fracturing in New York and Pennsylvania (Borick, Rabe, & Lachapelle, 2014) were used to create pre/posttest surveys for this unit. The pretest was administered at the beginning of the unit of study, while the post test was administered at the end.

After administering the pretest, a brief YouTube video, "The Frack Attack" was used to introduce the students to the term fracking (https://www.youtube.com/watch?v=iILUxumUu40). The idea behind this was to show the pros and cons of hydraulic fracturing and to see if the students could pick up on any bias of this particular news coverage. After the students watched the video, the *See-Think-Wonder* technique (Harvard Graduate School of Education, 2009) was used to engage students in inquiry-based thinking through close observation (Powell & Fuchs, 2019). The students' prior knowledge on the topic as well as any misconceptions, feelings, fears, or ideas regarding the topic were gathered by this technique. The students were then asked to determine if hydraulic fracturing should be allowed in Massachusetts and to give their initial reasons for their stance. This was done so that the students could generate their own claims on hydraulic fracturing. This initial stance taking was used as a starting point which the students revisit throughout the unit as they gain further knowledge on the topic.

To introduce the students to the topic of hydraulic fracturing in greater depth, they were assigned an article that tells what is fracking, where fracking is taking place internationally, how the process is done, and the cost and benefits of fracking (http://www.bbc.com/news/uk-14432401). The 'Jig-saw' technique (Slavin, 1990) was used for this reading activity. The students were divided into small groups. Each student was assigned a task. They searched for these words/phrases in the article. Under "Context", write the sentence in which the word appears. Under "Definition", provide the meaning of the word.

The students were also required to identify the pros and cons of fracking that were discussed in the article. They identified the pros and cons in the graphic organizer below. Representing the pros and cons in the graphic organizer allowed the students to organize their thoughts in a cohesive way and help them distinguish the different sides presented in the article.

The students were asked to deconstruct the shale gas extraction picture in the article and to highlight the steps taken in the fracking process based on the item and the image. The students were asked to use the picture to help remind them of the fracking process in addition to helping the students to understand the process visually. This enhanced their abilities to break down the steps from the article; they could use the illustration as a guiding point.

Day 2:

The students were asked to respond to the following questions:

a) What is fracking?
b) What is the purpose of fracking?

After answering these questions, the students were provided with a video that shows the steps of fracking (https://www.nationalgeographic.org/media/how-hydraulic-fracturing-works/). Based on the information provided in the video, the students were asked to determine the risks that are associated with each step. Finally, the students were asked to respond to the following questions:

a) What potential impact does fracking have on the environment?
b) Did your opinion on fracking change after this activity?

Day 3:

The students were assigned the Newsela article titled, "Issue Overview: Fracking" (https://newsela.com/read/overview-fracking/id/21698/). This article was assigned to reinforce the students' reading comprehension and point of view for the pros and cons of fracking. This was done so that the students could better solidify their stance on fracking. The students were asked to read and take note of the various positions on fracking and then come up with their lists in groups. This allows them to organize better the information that is presented to them in the article.

The students were then presented with a unique way to share their thoughts on the article. They were asked to use Twitter-style (280 characters) response to summarize the main point of the article. The students were very engaged in this activity to the point where they calculated the number of characters in their summary to ensure they were able to express their view accurately with no fewer characters.

Day 4:

The students responded to the question, should fracking be outlawed in Massachusetts? The students were asked to record their responses to the above question in the graphic organizer below. This graphic organizer allowed the students to build upon the previous day's work by requiring them to pick a stance on fracking, use reasons, provide evidence from their research, and record these in the graphic organizer below. Having this graphic organizer allows the students to organize their point of view in a meaningful way.

Day 5:

The students engaged in a whole class debate on whether fracking should be banned in Massachusetts. This place-based education assignment is meant to be a formative assessment of the students' knowledge of the process of fracking. This allowed the students to further elaborate on the evidence they have gathered. Students had already gathered evidence over the past few lessons, formed opinions/claims based on evidence and reasoning, and now have the chance to pick a side and debate with their peers whether or not fracking should be

allowed in their local region. This was done so that students have a closer connection to the topic—if the topic is close to home, it will be more meaningful to the students.

Day 6:

For a final reflection on hydraulic fracturing, the students were assigned the following questions:

a) What was your position on fracking at the beginning of the unit (day 1)?
b) Did your position change? Why or why not?
c) Was your opinion swayed by any of the information that your peers presented in the debates or posters? Why or why not?
d) What is the purpose of fracking?

These questions were used as a summative assessment of the unit to gauge how effective the unit was as a whole. It tells whether or not the misconceptions of the students changed based on the research they've conducted as well as how much of an impact the SSI topic of fracking had on the students overall.

Study Design/Procedure

This study employed the use of a critical ethnography design. The use of this design allowed for a more extensive examination of the political, social, and economic issues that focus on oppression, conflict, struggle, power, and praxis (Schwandt, 1997, p. 22). Based on the research literature, critical ethnography is rooted in research which recognizes that some with power dominate and exploit the less powerful either overtly or covertly, and rather than identifying the imbalance, seek to create fundamental social change through power (Ross et al., 2016; Carspecken, 1996; Denzin & Lincoln, 2011; LeCompte & Schensul, 1999; Smyth & Holmes, 2005). The potential fallout from hydraulic fracturing on peoples' health, the environment, and the economy provided us with the opportunity to use this study to examine the students' abilities to engage in evidence-based reasoning, to think critically about hydraulic fracking as they determine whether to ban fracking in Massachusetts.

The data gathered presents an in-depth understanding of the students' abilities to think critically about whether hydraulic fracturing should be banned in Massachusetts because of the potential detrimental health effects on drinking water resources and the environment, as well as the students' abilities use evidence-based decision reasoning to substantiate their claim. The senior director of teaching and learning for the non-profit organization randomly assigned three classes to the SSI curriculum. The author taught all three classes. The students in these classes were given the pre-test questionnaire, exposed to the SSI instructional unit and activities, and then given the post-test questionnaire.

Data Analysis-Use Critical Thinking Tenets from Diversity Work

The students' responses to the pretest and posttest were tabulated to identify changes in the students' exposure to and beliefs about the impact of hydraulic fracturing on the economy, public health, and the environment. A constant comparative method of analysis (Glaser & Strauss, 1967) on the students' suggested course of actions and justifications were conducted to identify emergent themes. The author and the two post-baccalaureate teacher candidates with qualitative data analysis experience were involved in the data analysis process. The data analysis process was divided into three phases. The first phase of the analysis examined themes apparent in days 1-6 artifacts generated from the students' responses to various items and activities. We identified segments of the data from the various days that included information on the students' prior knowledge about hydraulic fracturing, potential misconceptions of the practice, the pros and cons of hydraulic fracturing, and the students' feelings and fears regarding the effects of hydraulic fracturing on the economy, public health, and the environment. These segments were then coded with respect to themes such as premise, claim, rules, evidence, and data. This analysis allowed us to elaborate on how the students' abilities to engaged in evidence-based reasoning.

In the second phase of the analysis, we examined the students' determination on whether fracking should be banned in Massachusetts. This analysis allowed us to examine the students' abilities to gather complete information about hydraulic fracturing and question the conclusions drawn by their peers. The analysis further

allowed us to determine the students' abilities to think about the issue, examine the big picture of hydraulic fracturing, consider the cause and effect of fracturing, understand their own bias on the issues, consider others' views, and question the sources of data. The analysis allowed us to elaborate on the students' abilities to think critically about hydraulic fracking as they weigh their decision-making on whether to ban fracking in Massachusetts.

Results and Discussion

The findings demonstrated how the rising middle students in this study engaged in evidence-based reasoning as they think critically about the pros and cons that are associated with hydraulic fracking as they determine whether to ban fracking in the state of Massachusetts. Details below are the two main areas of findings that are aligned to the two research questions: (1) Relationships between place-based education on students' abilities to engage in evidence-based reasoning, (2) students' abilities to think critically about hydraulic fracking and their decision-making on whether to ban fracking in Massachusetts.

Relationships between Place-Based Education on Students' Abilities to Engage in Evidence-Based Reasoning

Day 1: Pretest/Posttest

The issue of hydraulic fracturing has been a hot-button issue in Massachusetts for the last decade. However, it is often common for students in this age group to not follow up or keep abreast of new reports on their local news outlet. Therefore, it is crucial to determine the potential impact that the instructional unit had on the students' level of familiarity with the practice of hydraulic fracturing before and after the instruction unit. As a result, the students were asked to share how much they have heard about the practice of hydraulic fracturing. Figure 1 below shows the question and the pre/posttests results of the students' knowledge of oil and natural gas development through hydraulic fracturing.

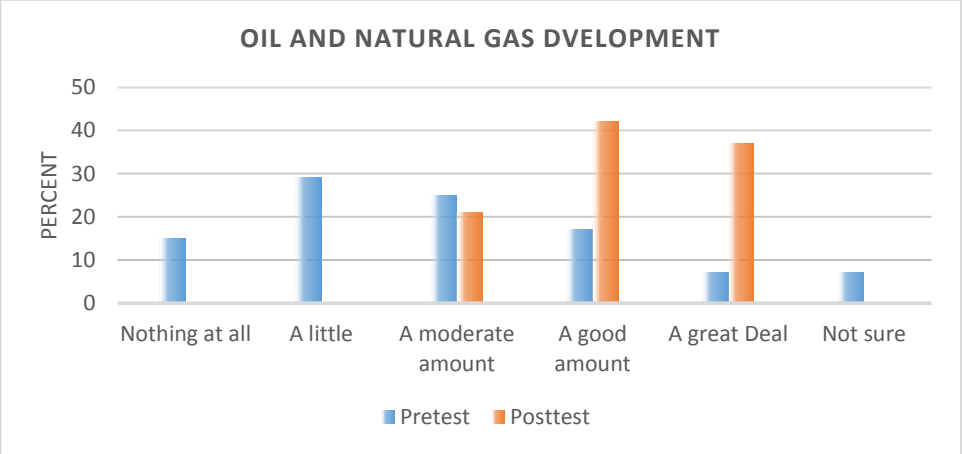

Figure 1. Oil and natural gas development through hydraulic fracturing

The students started the unit not knowing much about oil and natural gas development through the use of hydraulic fracturing. When asked how much they have heard about oil and natural gas development through the use of hydraulic fracturing in the pretest, 28% of the students stated that they know little, while 15% stated they know nothing at all. Only, 17% stated that they know a good amount, while 7% stated they know a great deal. However, after the student engaged in the instructional unit and conducted their research on hydraulic fracturing, the students improved their knowledge. In the post-test, no students stated that they knew nothing at all or very little about hydraulic fracturing to produce oil and natural gas. In fact, 42% of the students stated that they know a good amount about hydraulic fracturing, while 37% stated they know a great amount. It is interesting to note that while some students in the pretest stated that they knew nothing at all about fracking (15%), and other stating that they know a little about the practice (27%), the subject has been a contentious issue in Massachusetts to the point where the state has already banned hydraulic fracturing since 2013. Additionally, there have been several protest, rallies, and news articles about banning hydraulic

fracturing in the commonwealth of Massachusetts (Cooney, 2019; Annear, 2014; Weiskel & Green-Weiskel, 2017). Exposing the students to the contentious issue of hydraulic fracturing that has been debated and legislated in their states was used to get the students excited to the extent that they would add to the conversation as they make important decisions whether to ban hydraulic fracturing in Massachusetts.

During some of the rallies in opposition to hydraulic fracturing nationwide, people often consider the harmful effects at the expense of thinking about their local economy's potential benefits. Therefore, the students were asked to indicate if they believe the use of hydraulic fracturing has a positive effect, adverse effect, or no effect on the economy. Figure 2 below shows the pre/posttests results of the students' beliefs of hydraulic fracturing on the economy.

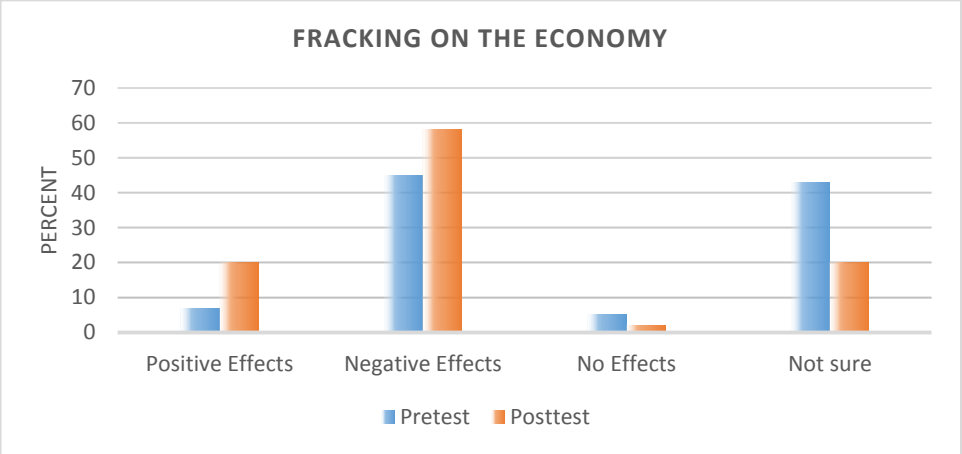

Figure 2. Hydraulic fracturing effects on the economy

When asked in the pretest to indicate if the use of hydraulic fracturing is having a positive effect, negative effect, or no effect on the economy, 42% of the students in the pretest were unsure of the impact of hydraulic fracturing on the economy while 45% stated that hydraulic fracturing will have a negative effect on the economy. In the post-test, 20% of the students were uncertain of the impact of hydraulic fracturing on the economy. This indicate a 22% reduction between pre and post test results/. However, more student (58%) stated that hydraulic fracturing would harm the economy. To further measure the impact of the instructional unit on the students' abilities to critically think about the effects of hydraulic fracturing on their communities, they were asked to indicate their beliefs of hydraulic fracturing on public health. Figure 3 below shows the students' pre/posttests thoughts regarding the impact of fracking on public health.

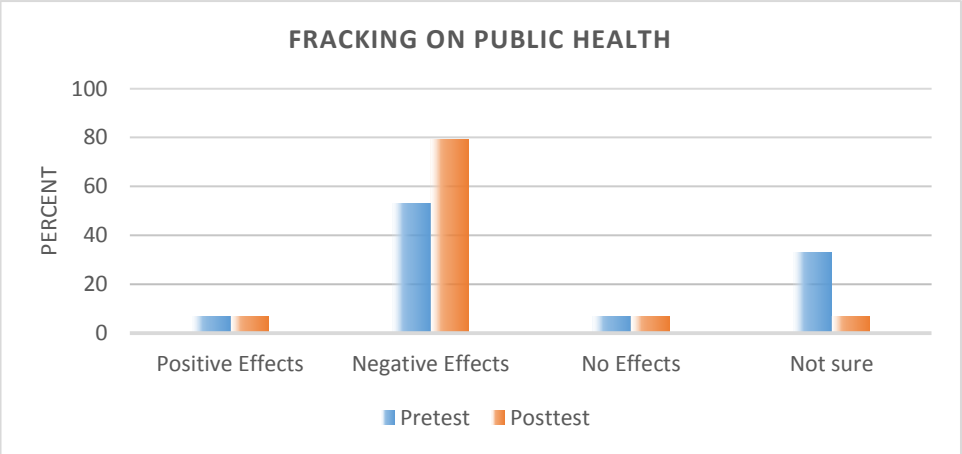

Figure 3: Hydraulic fracturing effects on public health

When asked in the pretest to indicate if the use of hydraulic fracturing is having a positive effect, adverse effect, or no effect on public health, 53% of the students stated the process will have adverse effects, while 33% of the students were unsure of the impact. In the posttest, there was a drastic change in the students' belief, as 79% of the students stated that hydraulic fracturing harm public health. Interestingly, only 8% of the students were

unsure of the impact after the exposure to the unit. Figure 4 below shows the students' pre/posttests thoughts regarding the impact of hydraulic fracturing on the environment.

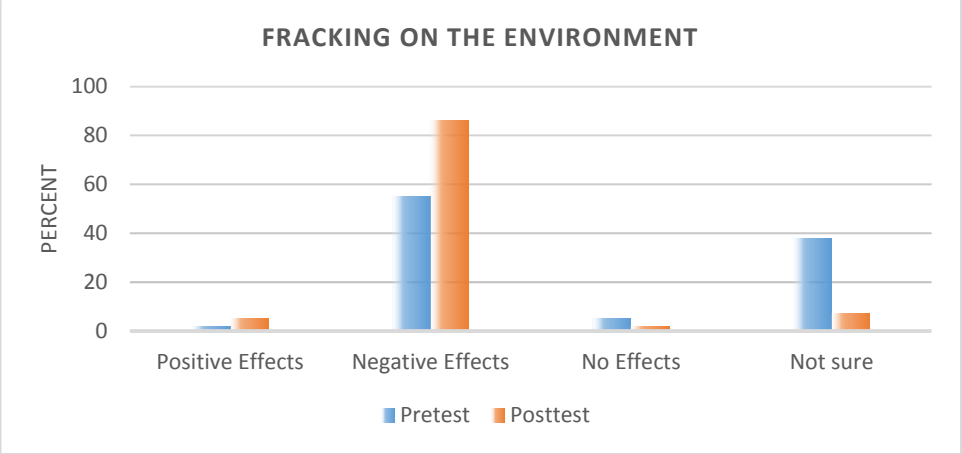

Figure 4. Hydraulic fracturing effects on the environment

When asked in the pretest to indicate if the use of hydraulic fracturing is having a positive effect, adverse effect, or no effect on the environment, 55% of the students stated hydraulic fracturing harmed the environment. Approximately, 38% of the students were unsure of the impact that hydraulic fracturing has on the environment. However, after exposure to the unit on fracking, 84% of the students stated that hydraulic fracturing would hurt the environment. Only 7% of the students were unsure of its effects on the situation after exposure to the unit on fracking. Figure 5 below shows the students' thoughts when they hear the term fracking.

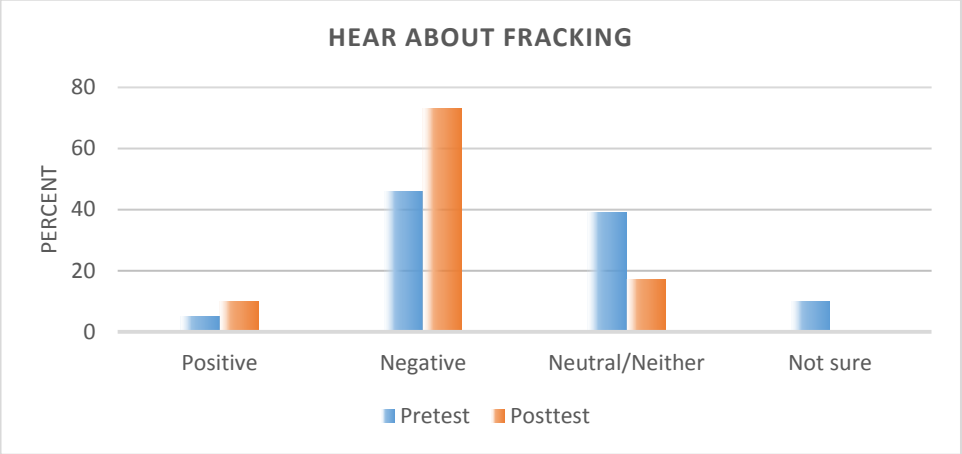

Figure 5. Consideration of fracking

In the pretest, 46% of the students stated that when they hear the word "fracking," they consider it a negative term. Also, in the pretest, 39% of the students indicated they neither consider it positive or negative when they hear the word fracking. However, in the posttest, 73% of the students stated they believe the term fracking is negative. Approximately, 17% of the students indicated they neither consider the term positive or negative when they hear it. While 49 % of the students stated in the pretest that they were neutral or not sure if they felt positive or negative, only 17% of the students retained these thoughts after exposure to the unit on fracking.

Although the students started off the instructional unit not knowing much about hydraulic fracturing, it seems as if their review of literature from the research they conducted provided more information on the dangers to hydraulic fracturing. The students talked about the potential of hydraulic fracturing rendering the United States in becoming energy independent. They also stated that the process will create good paying jobs. However, when they read about the potential of hydraulic fracturing contaminating drinking water resources, they stated that the risk far outweighed the benefits. As a result, a greater percentage of the students were opposed to hydraulic fracturing, although the percentage of students those who supported the practice increase slightly by the end of the instructional unit.

The Controversies of Fracking on Students' Abilities to Engage in Evidence-Based Reasoning

After administering the pretest, a brief YouTube video, "The Frack Attack" was used to introduce the students to the term fracking (https://www.youtube.com/watch?v=iILUxumUu40). The idea behind this was to show the pros and cons of hydraulic fracturing and to see if the students could pick up on any bias of this particular news coverage. After the students watched the video, the *See-Think-Wonder* technique (Harvard Graduate School, 2009) was used to engage students in inquiry-based thinking through close observation (Powell & Fuchs, 2019). The students' prior knowledge of hydraulic fracturing, and thoughts regarding the impact of hydraulic fracturing on the economy, public health, and the environment, were gathered by the see-think-wonder technique. The students then determined if hydraulic fracturing should be allowed in Massachusetts and gave their initial reasons for their stance.

This was done so that the students could generate their claims on hydraulic fracturing and think about the potential ramifications of the practice as they use evidence to determine whether Massachusetts should ban hydraulic fracturing. This initial stance-taking was used as a starting point for the students revisit and gain further knowledge on the topic. The students' written responses were read and re-read to identify instances where the students identify the impact of hydraulic fracturing on the economy, public health, and the environment. Approximately 20% of the students initially supported hydraulic fracturing in Massachusetts compared to the 80% who were opposed to the practice. However, by the end of the instructional unit 38% supported the practice while 62% opposed. Table 1 below illustrates some of the common reasons the students gave.

Table 1. See-think-wonder about hydraulic fracturing

	Supported Fracking	Opposed to Fracking
What did you see?	There are economic advantages of fracking	There are health problems that are associated with fracking. Fracking has the potential to contaminate water with dangerous chemical and methane. Fracking can cause earthquakes
What do you think?	Fracking is useful to the economy Fracking gives us more source of energy	Fracking has the potential to cause health problems among people Fracking may cause natural disasters such as earthquakes
What do you wonder?	How to increase safety of fracking Why blame these problems (earthquakes and methane in drinking water) on fracking?	Why is fracking so dangerous?

These statements were generated from the student's response on the *See-Think-Wonder* activity they were assigned after they watched the "Frack Attack" video. The students' written responses were read and re-read to identify statements relating to the economy, public health, and the environment. This was done to further align the students' thought process on the hydraulic fracturing pre/post-test items. The students who supported hydraulic fracking identified benefits that fracking will have in the economy and the environment. They stated that it will help the economy because the practice will lead to job creation and more energy. However, these students understood that there is the possibility that fracking might results in contamination to surrounding drinking water resources and inquired about how to conduct the fracturing more safely. They were also skeptical on whether or not hydraulic fracturing results in Earthquakes.

The students who were opposed to hydraulic fracturing stated that it might affect peoples' health, contaminate drinking water sources, and caused Earthquakes. The view hydraulic fracturing as too dangerous and stated that fracking should not be allowed to happen.

Table 2. Vocabulary role understanding the words you read

Word	Context	Definition
Hydraulic fracturing/fracking	Refers to how the rock is fractured apart by high pressure mixture	It's a technique to recover gas and oil from shale rock
Shale Gas	Drilling for shale gas is only at an exploratory phase in the U.K.	Natural gas occurring within or extracted from shale
Shale Rock	Shale is a fine-grained clastic sedimentary rock composed of mud that is a mixture of flakes of clay minerals	It is a type of rock
Tremor	A subsequent study found it was "highly probable" that shale gas test drilling triggered the tremors	A slight earthquake
Energy	We need 21st century energy revolution based on efficiency and renewable	Power derived from the utilization of physical or chemical resources, especially to provide light and heat or to work machines
Carcinogenic	Environmentalists say potentially carcinogenic chemical used may escape and contaminate ground water around the fracking site	Having the potential to cause cancer
Fossil Fuels	Not more fossil fuels that will add for climate change	A natural fuel such as coal or gas formed in the geological past from the remains of living things

To introduce the students to the topic of hydraulic fracturing in greater depth, they were assigned an article that tells what is fracking, where fracking is taking place internationally, how the process is done, and the cost and benefits of fracking (http://www.bbc.com/news/uk-14432401). The 'Jig-saw' technique (Slavin, 1990) was used for this reading activity. For the activity, the students were divided into seven groups. This was done to ensure that at least one student who opposed hydraulic fracturing was in each group. Groups 1-6 consisted had 6 students each, and group had 7 students. The groups assignments are shown below:

Group 1: Hydraulic fracturing/fracking
Group 2: Shale Gas
Group 3: Shale Rock
Group 4: Tremor
Group 5: Energy
Group 6: Carcinogenic
Group 7: Fossil Fuels

Each group read the article and searched for their assigned words/phrases in the article. Under "Context", they write the sentence in which the word/phrase appears. Under "Definition", they provided their meaning of the word/phrase. After 15 minutes reading and discussing the article among themselves, and responding to the task, the groups came together as one group and discuss their groups answers to assigned topic in a whole group setting. Table 2 below shows some common description of the students' thoughts.

The students were clearly able to present definitions of the key words that are associated with fracking in the articles. For example, the students were able to correctly state that hydraulic fracturing is the process of drilling into the earth and injecting high pressure water to get natural gas and oil. They were also able to correctly state what are fossil fuels and the sources of fossil fuels. The students were also required to identify the pros and cons

of fracking that were discussed in the article. They identified the pros and cons in the graphic organizer below. Representing the pros and cons in the graphic organizer allowed the students to organize their thoughts in a cohesive way and help them distinguish the different sides presented in the article. Table 3 below is a typical example of what one student was able to identify as the pros and cons associated with fracking according to the article.

Table 3. Pros and cons of fracking

Pros	Cons
• Energy independence	• General risks and dangers
• Increase land value	• May explode
• Job creation	• Water pollution
• No evidence or record of negative environmental effects	• Decrease land value
• Lower fuel price	• Cause earthquakes
• Help local economies	• Air pollution
• Cleaner energy than coal	• Global warming
• Reuse water	• Methane gas release
• Replace coal and other fossil fuels	• Delays green energy
• Produce needed energy	• Produce fossil fuel
	• Harm to the environment

In the pros section, the students made the case that the use of fracking will reduce the need to burn so much gas, oil and coal. This they believe will reduce the amount of nitrogen, sulfur, and carbon dioxide in the air, which will make the air cleaner. The students believed that hydraulic fracturing will render the United States to become energy independent, as a constant source of natural gas will reduce the need to rely on foreign oil and gas. Additionally, the students stated that fracking will result in an economic boom as it will create more high paying jobs. As cons, the students stated that fracking might cause tremors which could potentially result in earthquakes. They also voiced their concerns for the leakage of chemicals into the drinking water resources resulting in contamination of drinking water.

Steps in the Fracking Process

The students were asked to deconstruct the shale gas extraction picture in the article and to highlight the steps taken in the fracking process based on the item and the image. The students were asked to use the picture to help remind them of the fracking process in addition to helping the students to understand the process visually. This enhanced their abilities to break down the steps from the article; they could use the illustration as a guiding point. The students' abilities to break down the steps of hydraulic fracturing from the article were assessed by their abilities to correctly identify the steps in the fracking process. Their written response was assessed for statements relating to the drilling of wells, the injection of high-pressure fracking fluid in the drilled wells, the fracturing of the shale rocks as a result of the injected high-pressure fluid, the fracking proponents that wedge between the fractured shale, and the extraction and storage of the natural gas. All of the students (100%) were able to identify these basic steps in the fracking process. The students were able to use the picture in the article to recognize that the well is drilled in the shale region before the fracking fluid is pumped into the well. The students were also able to identify the importance of fracturing the shale to extract the gas. The steps the students were able to identify indicated that they were able to use the readings from the article along with the picture to enhance their understanding of how natural gas is extracted in the fracking process.

Day 2. How to Better Understand Fracking

The students were asked to respond to the following questions:

c) What is fracking?
d) What is the purpose of fracking?

All of the students (100%) stated in their written responses that fracking is the process of drilling into shale rocks and injecting high pressured water to extract gas and oil. All of the students (100%) also stated that

fracking provides access to hard to reach oil and natural gas. After answering these questions, the students were provided with a video that shows the steps of fracking (https://www.nationalgeographic.org/media/how-hydraulic-fracturing-works/). Based on the information provided in the video, the students were asked to determine the risks that are associated with each step. Finally, the students were asked to respond to the following questions:

c) What potential impact does fracking have on the environment?
d) Did your opinion on fracking change after this activity?

Below is a list of responses to question C generated by the students (80%) who were opposed fracking:

1. Fracking affects air quality
2. Fracking might cause chemicals to leak in the drinking water causing pollution
3. Fracking could potentially cause human death
4. Fracking cause earthquakes
5. Fracking use a large amount of water
6. Fracking can cause energy independence

The listed items above indicate the students' concerns about fracking. They believe the fracking has the potential to cause harm to the environment as well as human health. In response to the question asking if the activity change opinions, the data shows that students changed their position in supporting or opposing fracking by the end of the unit. The majority of the students, who were opposed to fracking before (80%) and after the unit (62%), stated that the practice has the potential to cause damage to the environment as well as drinking water resources. By the end of the unit, 18% of these students switched their position to support fracking. These students stated that there is not enough evidence to support the notion that fracking causes harm to the environment. The students who supported fracking initially (20%) held firm to their beliefs that it will allows the United States to become energy independent and provide high paying jobs for people. The students who switched their position and supported fracking (18%) also supported the idea that the fracking will lead to energy independence and jobs that will bring need income and support to the economy.

Day 3: Review the Pros and Cons of Fracking

The students were assigned the Newsela article titled, "Issue Overview: Fracking" (https://newsela.com/read/overview-fracking/id/21698/). This article was assigned to reinforce the students' reading comprehension and point of view for the pros and cons of fracking. This was done so that the students could better solidify their stance on fracking. The students were asked to read and take note of the various positions on fracking and then come up with their lists in groups. This allows them to organize better the information that is presented to them in the article.

The students were then presented with a unique way to share their thoughts on the article. They were asked to use Twitter-style (280 characters) response to summarize the main point of the article. The students were very engaged in this activity to the point where they calculated the number of characters in their summary to ensure they were able to express their view accurately with no fewer characters. The students written responses were assessed for the following:

a. Evidence in their written statements on what the article was about
b. Evidence of pros and cons used in the article
c. Students' abilities to generate their own conclusion from the article

Below are two examples of Twitter-style group responses from students who support and oppose fracking.

Student 1:

> The article was about how fracking might be good or bad. It's bad because it speeds up global warming, it's like coal mining, and dangerous. But, it could be good since it potentially may create lots of jobs and lead to energy independence. There are no signs of pollution from fracking. These things are important, so I support fracking.

Student 2:

> Overall, the main idea of the article was about whether fracking is good or not. There were many, many reasons why or why not, but there are more reasons why fracking should be allowed. But in my personal opinion on this topic, I would say that there shouldn't be any fracking allowed.

Table 4. Advertise fracking

Position: For (Advertise) or Against (Outlaw) Fracking?	
I am for fracking (Advertise)	
Supporting Statements	Supporting Evidence (from your research)
Reason 1: It can create many jobs for the US and UK.	Evidence: For the USA, it has already created many jobs. For the UK, research has proven that it will most likely create more jobs.
Reason 2: It has created and will create enough energy for the future.	Evidence: For the USA, it has already created enough energy so that we don't have to import. For the UK, it will create a lot of energy and economic boom.
Reason 3: All of the effects that fracking cause can be reduced.	Evidence: It has already reduced carbon emissions as fuel like coal is rarely used and natural gas produces less carbon dioxide than other fossil fuels. We can prevent methane leaks by testing and repairing valves. We can reduce risks of small earthquakes by mapping deep rock formation and avoiding where tremors could happen.
Conclusion*:* Even though it can harm the environment, those risks can be reduced, and it is better than coal mining.	
Reference: http://www.bbc.com/news/uk-14432401 (Adapted from Bloomberg)	

Though they were asked to summarize the main points of the article using 280 characters, the students (100%) ensured they included their beliefs about fracking. The purpose of the Twitter style activity was to allow the students to practice their reading comprehension and writing skills in a social media type atmosphere. Such approach caters to the young learners because it will enable them to be creative in a format that they understand (Twitter) that practices concise expression of their thoughts in words. The exemplar above shows that this student was able to write concisely about what the article was about. The student correctly stated that the article was about the pros and cons of fracking and the associated reasons for both sides of whether to allow fracking.

Day 4: Should Fracking be outlawed in Massachusetts?

The students were asked to record their responses to the above question in the graphic organizer below. This graphic organizer allowed the students to build upon the previous day's work by requiring them to pick a stance on fracking, use reasons, provide evidence from their research, and record these in the graphic organizer below. Having this graphic organizer allows the students to organize their point of view in a meaningful way. Table 4 below is a common exemplar of a completed organizer from a student who supported fracking. In the above exemplar, this student gave three good reasons with supporting evidence to strengthen his position that fracking should be allowed in the United States. For example, one of the reasons this student gave for supporting fracking is that it can create many jobs. To substantiate this reason, the student used text-based evidence to support his stance on fracking. Table 5 below is a typical example of a student who was opposed to hydraulic fracturing in Massachusetts.

In the below exemplar, this student was able to use text-based evidence to support her stance against fracking. For example, the student stated that from her research, she learned that methane emission, as well as other greenhouse gas emissions, can release into the environment and cause potential problems. The responses from these students clearly show that when students are exposed to a well-planned curriculum, they garner the abilities to enhance their argumentation skills by using evidence to substantiate claims. These students were able to use what they learned from the article they read and the activities they engaged in to provide evidence to support their stance on fracking.

Table 5. Outlaw fracking

Position: For (Advertise) or Against (Outlaw) Fracking?	
I am against fracking in Massachusetts	
Supporting Statements	Supporting Evidence (from your research)
Reason 1: The gas could be leaked into our drinking water supply.	Evidence: Toxic chemicals could leak into the aquifers. According to my past research, a risk from the 2nd part of fracking that pumped high pressured water, the water is mixed with chemicals that could leak into our drinking water.
Reason 2: Fracking uses high-pressured water to break apart the shale rocks.	Evidence: From the fracking worksheet, each fracking phase requires 15,000 cubic meters of water, which is mixed with sand and toxic chemicals.
Reason 3: Fracking can cause many damaging things such as natural disasters.	Evidence: Based on the research, when the high-pressured water breaks apart the shale rocks, this can cause things like earthquakes and other natural disasters.
Conclusion: Although, I'm sure you probably don't know what fracking is, I can assure you that it is not a good thing. Fracking causes leaks into our water supply, uses high pressured water, it can cause natural disasters.	
Reference https://www.wired.com/2015/06/frackings-problems-go-deeper-water-pollution/	

Day 5: The Great Fracking Debate

This place-based education assignment is meant to be a formative assessment of the students' knowledge of the process of fracking. This allowed the students to further elaborate on the evidence they have gathered. Students had already gathered evidence over the past few lessons, formed opinions/claims based on evidence and reasoning, and now have the chance to pick a side and debate with their peers whether or not fracking should be allowed in their local region. This was done so that students have a closer connection to the topic—if the topic is close to home, it will be more meaningful to the students. Table 6 below shows the outline of the class debate questionnaire that students who typically were opposed to fracking (62%) used as they engaged in debates of whether hydraulic fracturing should be banned in Massachusetts.

Table 6. Class debate questionnaire: Students against fracking

I am in favor of: No fracking
Write 5 valid scientific reasons that support your opinion: 1. Each fracturing well requires 1-8 million gallons of water 2. Contaminate water system in area where fracking is done 3. The potential to release methane into the air 4. Link to Earthquakes or tremors near fracking site 5. Uses hazardous chemicals
Anticipate 5 arguments from the opposing side: 1. Cheaper energy 2. Less carbon emission 3. Create jobs 4. Provide a source of natural gas 5. Lower the value of surrounding land value
Notes: Fracking poses a lot of risk to peoples' health.
Write a least 3 sources you used to support your argument • https://www.nytimes.com/topic/subject/natural-gas-fracking • https://www.wired.com/2015/06/frackings-problems-go-deeper-water-pollution/ • https://www.scientificamerican.com/article/fracking-can-contaminate-drinking-water/ • https://www.youtube.com/watch?v=LAxsTJd7VCA

Table 7 below shows the outline of the class debate questionnaire that students who typically were supportive of fracking (38%) used as they engaged in debates of whether hydraulic fracturing should be banned in Massachusetts.

Table 7. Class debate questionnaire: Students who support fracking

I am in favor of: Fracking

Write 5 valid scientific reasons that support your opinion:

1. It can lead to our nation becoming energy independent
2. We are not aware of major geologic or environmental impact
3. Fracking offers the potential for major job creation
4. It will provide an enormous boost to our state and local economies
5. There is no record of these activities causing pollution of any kind

Anticipate 5 arguments from the opposing side:

1. We don't yet know for sure what impact fracking has on the movement of the earth
2. Fracking activities drive land values down
3. Similar to drilling for oil or mining for coal
4. It's another example of a means to an end

Fracking contaminate water

Notes: Fracking is good for a lot of reasons

Write a least 3 sources you used to support your argument

- https://www.youtube.com/watch?v=oMboTKOWeAs&feature=youtu.be
- https://www.youtube.com/watch?v=LAxsTJd7VCA
- https://www.youtube.com/watch?v=Uti2niW2BRA

Final Reflection on Hydraulic Fracturing

The questions below were used as a summative assessment of the unit to gauge how effective the unit was as a whole. It tells whether or not the misconceptions of the students changed based on the research they've conducted as well as how much of an impact the SSI topic of fracking had on the students overall. Below are some typical arguments given by students who did not support fracking at the beginning of the unit of study.

Typical questions from the researcher and responses from the students who were swayed

a) What was your position on fracking at the beginning of the unit (day 1)?
   - *Fracking should be outlawed because it is bad*

b) Did your position change? Why or why not?
   - *Yes, because when I saw how much more evidence to support fracking, I changed my mind.*

c) Was your opinion swayed by any of the information that your peers presented in the debates or posters? Why or why not?
   - *Yes, because using natural gas is healthier than burning coal.*

d) What is the purpose of fracking?
   - *To extract natural gas from shale rocks.*

The students who supported fracking generally made the case that it has the potential to promote energy independence and create high paying jobs for people.

The use of socioscientific issues as a critical pedagogy strategy can enhance students' conceptual understanding of scientific phenomena affecting their daily lives (Powell & Fuchs, 21019). This study investigated the effects of a place-based socioscientific issues curricular unit of instruction on rising middle school students' abilities to engage in evidence-based reasoning as they critically think about whether or not hydraulic fracturing should be banned in Massachusetts. Throughout this investigation, we saw students shared strong support or opposition to the process of hydraulic fracturing. At the start of the instructional unit, most students (80%) were opposed to the practice. The students stated that the hydraulic fracturing process could contaminate drinking water resources, resulting in health problems for people who drink the contaminated water. These students also noted that hydraulic fracturing contributes to Earthquakes. By the end of the instructional unit, there was a slight shift in the percentages (62%) of students initially opposed to hydraulic fracturing. The 18% of students who initially opposed fracking explained that they changed their thoughts from opposing hydraulic fracturing to supporting the practice because the benefits far outweighed the risks. They joined with the group of students who supported

fracking from the start (20%) and gave a compelling argument that the practice will generate need gas and oil to make the United States energy independent. These students also stated that jobs generated from hydraulic fracturing would help stimulate the economy since it will provide a livable income for people who work in the industry. These students also stated that there is no real evidence to suggest that the hydraulic fracturing causes Earthquakes or other adverse environmental consequences. These students also indicate that, if anything, hydraulic fracturing will be of benefit to the environment because natural gas burns cleaner than coal.

Both groups of students understood the steps involved in hydraulic fracturing to raise essential arguments about the pros and cons and whether the process should be banned in Massachusetts. The students' statements in support or opposition to hydraulic fracturing are aligned with what of children of similar age and adults. For example, Sarge et al. (2015) conducted a study investigating the public perceptions of hydraulic fracturing and found similar results. In their study, Sarge et al. (2015) had 250 adult participants responded to items asking about their pre-existing attitudes and beliefs regarding hydraulic fracturing.

After responding to these items, the participants then evaluated a series of news photos coded as either presenting the issue's economic benefits or environmental costs. This study found that support for hydraulic fracturing was positively associated with beliefs that it is primarily an economic issue and negatively related to beliefs that it is an environmental issue (Sarge et al., 2015). These results indicate that students and adults hold similar views pertaining to the impact of hydraulic fracturing on the environment, public health, and the environment. While approximately 44% of the students stated in the pretest that they know very little or nothing at all about oil and natural gas development through the use of hydraulic fracturing, by the end of the instructional unit, 100% of the students stated fracking is the process of drilling into shale rocks and injecting high pressured water to extract gas and oil. All of the students (100%) also stated that fracking provides hard-to-reach oil and natural gas. The students who opposed hydraulic fracturing noted that the process poses significant risks to human health because of the potential to pollute the air and drinking water resources. Interestingly, these students who were opposed to hydraulic fracturing also acknowledge that the process could allow the United States to become energy independent. However, these students believe the risks associated with the practice outweigh the benefits of becoming energy independent, and as a result, the practice should be banned in Massachusetts. The students who supported hydraulic fracturing believe the opportunity to be energy independent is of paramount importance as this will create well-paying jobs that will ultimately improve the economy.

These views on hydraulic fracturing are similar to what Thomas et al. (2016) have reported. In trying to determine the public perceptions of hydraulic fracturing for shale gas and oil in the United States and Canada, Thomas et al. (2016) reviewed 58 articles on perceptions of hydraulic fracturing published between 2009 and 2015. They reported that individuals tend to have negative associations with the term fracking. The students in the current investigation expressed a similar attitude whenever they heard the word fracking. Thomas et al. (2016) reported that the perceived benefits tend to be economical (e.g., job creation, boosts to local economies) and risks more commonly environmental and social (e.g., impacts on water, increased traffic).

These findings are similar to what was discovered in this study. The instructional unit positively impacted the students' abilities to succinctly identify the pros and cons of hydraulic fracturing, as they use the pros and cons as evidence to reasoned and think critically about whether the process should be banned in Massachusetts. The students identified their position in support or opposition to hydraulic fracturing and provided reasons and evidence to strengthen their conclusion.

The students who supported hydraulic fracturing discussed how the practice is already creating jobs and providing clean energy in the United States. These students believe proper mitigation strategies should be implemented to prevent fracturing adverse effects because the benefits are so crucial to the economy and the environment. The students used what they learned from the instructional unit to effectively used evidence-based reasoning as they critically think and debated debate if hydraulic fracturing should be banned in Massachusetts. The students used information learned from the articles they read to inform their decision on fracking in Massachusetts. They used scientific reasons from the articles they read to support their stance on hydraulic fracturing. They also anticipated counterarguments that their peers with different beliefs would use to contradict their arguments. This allowed the students to engage in substantive discussions that showcase their ability to engage in evidence-based reasoning and critical thinking about hydraulic fracking and whether the practice should be banned in Massachusetts. For example, the student who supported hydraulic discussed that although we are not aware of any significant geologic or environmental impact due to hydraulic fracturing, we don't yet know what impact fracking has on the movement of the earth. As a result, more studies are needed to learn more about the process. However, they believe that the process should still be allowed to continue with caution. The

students (18%) who were opposed to hydraulic fracturing but changed their position talked about how much more evidence is there to support fracking. They talked about how natural gas harvested from hydraulic fracturing is better for the environment as it much cleaner type of fossil fuel.

While many people in society may think rising middle school students are not equipped with the technical knowledge to debate scientific issues that affect their communities, the finding from this investigation proved otherwise. The facts are, if students are exposed to proper guidance to conduct research and are taught how to summarize their conclusions, then they can learn to express themselves in productive ways. The students in this investigation were able to engage in the research on hydraulic fracturing and present compelling arguments supporting their views. The use of SSI to engage students in place-based education can enlighten students on scientific topics that affect their communities. Such pedagogy has the potential of equipping students with the skills necessary for them to become better advocates for themselves and their communities.

Conclusion

The results obtained from this investigation are very encouraging considering the study was done with rising middle school students who are 11-12 years old. This suggested that SSI when implemented effectively in the curriculum, such pedagogical strategy has the potential to enhance students' abilities to engage in meaningful discourse on scientific issues impacting their communities. The results indicate that students are able to use their understanding of the science and engineering practices to construct valid arguments on whether or not fracking should be allowed in Massachusetts. While many students did not necessarily change their initial thoughts on whether fracking should be banned in Massachusetts, all the students were able to generate arguments from evidence.

Scientific Ethics Declaration

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

References

Allen, B. (2003). *Uneasy alchemy: Citizens and experts in Louisiana's chemical corridor dispute*. Cambridge: MIT Press.

American Association for the Advancement of Science. (1989). *Science for all Americans*. Washington, DC: American Association for the Advancement of Science.

Annear, S. (2014). Environmentalists: Stay the 'frack' out of Massachusetts health advocates are continuing their fight to ban fracking in the Bay State. *City Life.* https://www.bostonmagazine.com/news/ 2014/02/20/fracking-massachusetts-protest-letters/

Barth-Naftilan E, Sohng J, &Saiers J.E. (2018). Methane in groundwater before, during, and after hydraulic fracturing of the Marcellus Shale. *Proc Natl Acad. Sci USA*, *115*:6970–6975.

Bencze, L., Sperling, E., & Carter, L. (2012). Students' research-informed socio-scientific activism: Re/ visions for a sustainable future. *Research in Science Education, 42*, 129–148.

Birmingham, D., & Barton, A. C. (2014). Putting on a green carnival: Youth taking educated action on socioscientifc issues. *Journal of Research in Science Teaching, 51*(3), 286–314.

Bryant, B.I. & Mohai, P. (1992). *Race and the incidence of environmental hazards*. Boulder, CO: Westview Press

Bullard, R.D., Mohai, P., Saha, R., & Wright, B. (2008). Toxic wastes and race at twenty: why race still matters after all of these years. *Environmental Learning. 38*(2):371–411.

Carspecken, P. F. (1996). *Critical ethnography in educational research*. New York: Routledge.

Carter, L. (2011). Gathering in threads in the insensible global world: The wicked problem of globalization and science education [Editorial]. *Cultural Studies of Science Education, 6*(1), 1–12.

Chokker, K., Dua, S., Taylor, N., Boyes, E., & Stanisstreet, M. (2011). Indian secondary students' views about global warming: Beliefs about the usefulness of actions and willingness to act. *International Journal of Science and Mathematics Education, 9*(5), 1167–1188. https://doi.org/10.100710763-010-9254-z

Colborn, T., Kwiatkowski, C., Schultz, K., & Bachran, M. (2011). Natural gas operations from a public health perspective. *Hum Ecol. Risk Assess.,17*(5):1039–1056.

Cooney, A. (01/13/2019). Protesting the pipeline: In Weymouth, the fight continues. *The Patriot Ledger.*

https://www.patriotledger.com/news/20190112/protesting-pipeline-in-weymouth-fight-continues
Cutter, S. (1995). Race, class and environmental justice. *Progress in Human Geography*. *19*, 107-18.
Davis, T. (2018). Toxic space and time: Slow violence, necropolitics, and petrochemical pollution. *Annals of the American Association of Geographers*, *108*(6), 1537–1553.
Dawson, V. M., & Venville, G. (2010). Teaching strategies for developing students' argumentation skills about socio-scientific issues in high school genetics. *Research in Science Education*, *40*(2), 133–148.
Denzin, N., & Lincoln, Y. (2011). *The Sage handbook of qualitative research*. Thousand Oaks California: SAGE Publications, Inc.
Ellsworth, W. L. (2013). Injection-induced earthquakes. *Science, 341*, 1225924, https://doi.org/10.1126/science.1225942.
Environmental Protection Agency (2016*). Hydraulic fracturing for oil and gas: Impacts from the hydraulic fracturing water cycle on drinking water resources in the United States*. Environmental Protection Agency, Washington, DC, Report EPA/600/R-16/236F.
Ferrar, K.J, Michanowicz, D.R, Christen, CL, Mulcahy, N., Malone, S.L., & Sharma, R.K. (2013). Assessment of effluent contaminants from three facilities discharging Marcellus Shale wastewater to surface waters in Pennsylvania. *Environmental Science Technology, 47*(7):3472–3481.
Glaser, B., & Strauss, A. (1967). *The discovery of grounded theory*. Chicago: Aldine.
Griffith, J., Duncan, R.C., Riggan, W.B., &Pellom, A.C. (1989). Cancer mortality in US counties with hazardous waste sites and ground water pollution. *Arch Environ Health, 44*(2):69–74.
Harvard Graduate School of Education. (2009). *Visible thinking resource book*. Downloaded on May 11, 2020 http://www.pz.harvard.edu/vt/
Hermans, M., & Korhonen, J. (2017). Ninth graders and climate change: Attitudes towards consequences, views on mitigation, and predictors of willingness to act. *International Research in Geographical and Environmental Education*, *26*(3), 223–239. https://doi.org/10.1080/10382046.2017.1330035
Howley, C., & Harmon, H. (2000). Community as tacit curriculum. In C. Howley & H. Harmon (Eds.), *Small high schools that flourish: Rural cases and resources* (pp. 61–88). Charleston, WV: AEL, Inc. (ERIC Document Reproduction Service No. 447 998).
Howley, A., Howley, C., Burgess, L., & Pusateri, D. (2008). Social class, Amish culture, and an egalitarian ethos: Case study from a rural school serving Amish children. *Journal of Research in Rural Education, 23*(3), 1–12. http://www.jrre.psu.edu/.
Howley, C., & Howley, A. (2010). Poverty and school achievement in rural communities: A social class interpretation. In K. Schafft & A. Jackson (Eds.), *Rural education for the twenty-first century: Identity, place, and community in a globalizing world* (pp. 34–50). University Park, PA: Pennsylvania State University Press.
Jasechko, S., & Perrone, D. (2017). Hydraulic fracturing near domestic groundwater wells. *Proceedings of the National Academy of Sciences of the United States of America*, *114*(50), 13,138–13,143.
Jennings, N., Swidler, S., & Koliba, C. (2005). Place-based education in the standards-based reform-era: Conflict or complement? *American Journal of Education*, *112*(1), 44–65.
Johnston, J.E, Werder, E, & Sebastian, D. (2016). Wastewater disposal wells, fracking, and environmental injustice in Southern Texas. *Am J Public Health, 106*(3):550– 556, PMID: 26794166, https://doi.org/10.2105/AJPH.2015.303000.
Keehan, C.J. (2018). Lessons from cancer alley: How the clean air act has failed to protect public health in Southern Louisiana. *Colo. Nat. Resources, Energy & Envtl. L. Rev. 29*(2): 341-371
Klosterman, M.L. & Sadler, T.D. (2010). Multi-level assessment of scientific content knowledge gains associated with socioscientific issues-based instruction. *International Journal of Science Education*, *32*(8), 1017-1043, https://doi.org/10.1080/09500690902894512
LeCompte, M., & Schensul, J. (1999). *Designing & conducting ethnographic research* (Vol. 1). Rowman Altamira, London.
Lewicki, J. (1998). Cooperative ecology and place: Development of a pedagogy of place curriculum. http://www.eric.ed.gov/PDFS/ED461461.pdf
Louisiana Department of Environmental Quality (1997). *Louisiana toxics release inventory report 1997*. Baton Rouge: LEDQ.
Lowman, A, McDonald, MA, Wing, S, & Muhammad, N. (2013). Land application of treated sewage sludge: community health and environmental justice. *Environ Health Perspect. 121*(5):537–542.
Lutz, B.D., Lewis, A.N., & Doyle, M.W. (2013). Generation, transport, and disposal of wastewater associated with Marcellus Shale gas development. *Water Resour. Res. 49*(2):647–656.
Mueller, M.P., Zeidler, D.L., & Jenkins, L.L. (2011). Earth's role in moral reasoning and functional scientific literacy. In J. L. DeVitis & T. Yu (Eds.), *Character and moral education: a reader* (pp. 382–391). New York: Peter Lang.

Mulnix, J.W. & Mulnix, M. J. (2010). Using a writing portfolio project to teach critical thinking skills. *Teaching Philosophy, 33*(1), 27–54.

National Research Council (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas. Committee on conceptual framework for the new K-12 science education standards*, Board on Science Education, National Research Council. Washington, DC: National Academies Press.

Norton, J.M., Wing, S., Lipscomb, H.J., Kaufman, J.S., Marshall, S.W., & Cravey, A.J. (2007). Race, wealth, and solid waste facilities in North Carolina. *Environ Health Perspect. 115*(9):1344–1350.

Osborn, S.G., Vengosh, A., Warner, N.R., & Jackson, R.B. (2011). Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing. *Proc Natl Acad Sci USA 108*(20):8172–8176.

Powell, W.A., & Fuchs, D. (2019). Using socioscientific issues to enhance evidence-based reasoning among middle school students. In S. Robinson & V. Knight (Eds.), *Handbook of Research on Critical Thinking and Teacher Education Pedagogy (pp. 150-176).* IGI Global.

Ross, C, Rogers, C, & Duff, D. (2016). Critical ethnography: An under used research methodology in neuroscience nursing. *Canadian Journal of Neuroscience Nursing, 38*, 1, 4-7.

Sadler, T. D. (2004). Informal reasoning regarding socioscientific issues: A critical review of research. *Journal of Research in Science Teaching, 41,* 513–536.

Sadler, T. D., Klosterman, M. L., & Topcu, M. S. (2011). Learning science content and socioscientific reasoning through classroom explorations of global climate change. In T. D. Sadler (Ed.), *Socio-scientific issues in science classrooms: Teaching, learning and research* (pp. 45–77). The Netherlands: Springer.

Sadler, T. D., & Murakami, C. D. (2014). Socio-scientific issues-based teaching and learning: Hydrofracturing as an illustrative context of a framework for implementation and research. *Brazilian Journal of Research in Science Education, 14*(2), 331-342.

Sarge, M.A., VanDyke, M.S., King, A.J.,& White, S.R. (2015). Selective perceptions of hydraulic fracturing: The role of issue support in the evaluation of visual frames. *Politics and the Life Sciences*, *34* (1), 57-72.

Sarkar, S., & Frazier, R. (2008). Place-based investigations and authentic inquiry. *The Science Teacher, 75*, 29–33.

Schwandt, T. A. (1997*). Qualitative inquiry: A dictionary of terms*. Thousand Oaks, CA: Sage.

Singer, M. (2011). Down cancer alley: The lived experience of health and environmental suffering in Louisiana's chemical corridor. *Medical Anthropology Quarterly 25* (2):141–63. https://doi. org/10.1111/j.1548-1387.2011.01154.x

Skamp, K., Boyes, E., & Stanisstreet, M. (2013). Beliefs and willingness to act about global warming: Where to focus science pedagogy? *Science Education, 97,* 191–217.

Slavin R. E., & Sharan S. (1990). *Comprehensive cooperative learning methods: Embedding cooperative learning in the curriculum and school. Cooperative learning: Theory and research*. New York: Preston Press.

Smyth, W., & Holmes, C. (2005). Using Carspecken's critical ethnography in nursing research. *Contemporary Nurse*, *19*(1-2), 65–74.

Sobel, D. (2004). Place-based education: Connecting classrooms and community. *Nature and listening, 4(*1), 1-7.

Stossel, J. (2014, October 1). The Frack Attack [Video]. YouTube. https://www.youtube.com/watch?v=iILUxumUu40

Theobald, P. (1997). *Teaching the commons: Place, pride, and the renewal of community*. Boulder, CO: Westview Press.

Thomas, M.J., Pidgeon, N.F., Evensen, D.T., Partridge, T., Hasell, A., Enders, C., & Herr-Harthorn, B. (2016). *Public perceptions of shale gas operations in the USA and Canada: A review of evidence*. M4 ShaleGas Consortium: Utrecht, The Netherlands.

Environmental Protection Agency (1992a). *Environmental equity: reducing risk for all communities*. Washington, DC: Government Printing Office. *EPA Journal,18*, 1-64.

Vengosh, A, Jackson, R.B., Warner, N., Darrah, T.H., & Kondash, A. (2014). Acritical review of the risks to water resources from unconventional shale gas development and hydraulic fracturing in the United States. *Environ Sci Technol. 48*(15):8334–8348.

Weiskel, P. W. & Green-Weiskel, L. (2017). Protecting Western Massachusetts farms: Down with fracking and the kinder morgan pipeline. *HUFFPOST.* https://www.huffpost.com/entry/kinder-morgan-gas-pipeline-fracking_b_5592574

What is fracking and why is it controversial? (2018). Downloaded on January 5, 2019 http://www.bbc.com/news/uk-14432401.

Yap, S. F. (2014). Beliefs, values, ethics and moral reasoning in socio-scientific education. *Issues in Educational Research, 24* (3), 299-319.

Yuan, Z., Gardoni, P., Schubert, J.,& Teodoriu, C. (2013). Cement failure probability analysis in water injection well. *J Petrol Sci Eng*. *107*, 45–49.

Zeidler, D.L. & Kahn, S. (2014). *It's debatable! Using socioscientific issues to develop scientific literacy, K-12*. Arlington, VA: NSTA Press.

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A Bibliometrical Analysis of the Articles on Environmental Education Published between 1973 and 2019

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Abstract

The aim of the study is to conduct bibliometrical analysis of the published articles on environmental education. With this aim, 3979 articles published between 1973 and 2019 were reached as a result of scanning Scopus database and they were bibliometrically analyzed so that research tendencies in the last 46 years were determined. The database was scanned using "environment/environmental education" keywords and results regarding the annual distributions of the articles; the journals and the authors with the highest number of related articles; h-index scores of the authors; research collaboration networks; the articles that were cited at the highest rates; the average annual citation scores; the citation burst scores of the authors; the results for word cloud and the conceptual mapping patterns obtained were analyzed. The findings reveal that the issue started to gain popularity among scientific researchers after 2008. The journal publishing the highest number of articles on the topic is found to be *Environmental Education Research* while the researchers with the highest number of published articles belong to Kopnina, H., Bogner, F. X., and Thiengkamol, N. The researchers from Netherlands, Mexico and Israel have the highest rates of research collaborations. The related articles are found to focus mostly on sustainability education, climate change, teacher education, student's or teacher's attitudes toward environment, the level of knowledge and consciousness on environment and environmental issues. The most frequently used concept in the keywords sections of published articles is determined to be "environmental education". The findings of the study are meant to guide researchers planning to conduct further research on the issue.

Introduction

Human beings have been in interaction with the environments since their existence on earth began. While this relationship was at first aimed using the environment for their benefit, it evolved, in time, towards trying to control and dominate it parallel to the advancement in science. As humanbeings started to exploit the environment freely, the destructive effects of these human activities started to cause serious environmental problems. When humanbeings questioned how these destructive results could be overcome, they realized that human activities were responsible for these results and that such activities needed to be controlled and prevented. Scientists working on environment education emphasize the need to raise awareness on environment and environmental issues. Environmental consciousness encompasses individuals' obtaining sufficient information on and acquiring the necessary attitudes and behaviors towards environment (Erten, 2004). In a broader sense, environmental consciousness includes individuals' thoughts, attitudes and behaviors toward environment; their level of awareness on environmental issues; perceptions of and interaction with their environment; ability to understand, know and feel their environment; and their level of knowing and internalizing ethical and scientific norms that regulate the environment (Atasoy, 2006). Thus, the ultimate aim of environmental education is to be able to raise individuals with high consciousness and knowledge levels on environment and environmental issues.

Environmental education is a process where individuals obtain the required values and main concepts related to environment by acquiring the required abilities and attitudes while acknowledging the relationship of humanbeings with their biophysical and cultural environment (IUCN, 1972). For Grodziéska-Jurczak et al. (2006), environmental education is a long-term process where the skills and the behaviors necessary to understand and accept the relationships between people, culture and the natural environment are developed. Environmental education was first mentioned in IUCN Conference held in Paris in 1948 (Palmer, 1998). After

many years of this first mention, in 1972 at Human and Environment Conference organized in Stockholm by United Nation, a general consensus was reached on the approaches towards and the aims of environmental education, and a declaration document was published stating that adults and new generations need to be provided with environmental education (IUCN, 1972). In 1977, Tbilisi Conference was organized by UNESCO – UNEP collaboration. The Proceedings and Implications of this conference contained national and international frameworks for environmental education as well as the content, the aims, and the pedagogical principles of education on environment. In the Proceeding of Tbilisi Conference, the aims of environmental education were presented five main headings: environmental education, consciousness, knowledge, abilities, attitudes, and participation related to environmental education. Accordingly, environmental education aims for all individuals and nations: I) to gain consciousness and awareness on environment and environmental issues; II) to acquire knowledge and experiences on them; III) to develop adopt the appropriate values, awareness and willingness to actively participate in activities for protecting and recovering the environment; IV) to attain the necessary abilities in order to describe, research, and to solve environmental issues; V) to provide opportunities to actively participate in the activities and events that aim to find solutions to environmental issues (ICEE, 1977).

In this respect, there have been plenty of training programs and courses provided to adults and new generations in addition to the social responsibility projects and the scientific research carried out. The aim is to define individuals' environmental consciousness and to help them to acknowledge the existing environmental problems and to guide and equip them with necessary skills and knowledge to solve these problems. Almost every nation has integrated environmental education to their curricula for learners at all ages and has accelerated research on the issue. Grodziéska-Jurczak et al. (2006) conducted a study in 30 pre-school institutions in Poland to determine the learners' (n=674 aged 6) and their parents' (n=686) knowledge and skills levels on environment. Their findings revealed that the majority of the young learners had high levels of environmental consciousness. The participants were found to recognize main concepts related to environment and to distinguish between environmentally-friendly and not friendly behaviors. The findings showed that the participants were environmentally-friendly, acknowledged the value of nature, respected animals and plants, and cared about maintaining cleanliness in their immediate environment. The researchers' state that the parents had significant effects on their children's attitudes and that the attitudes of both the parents and the children were similar regarding using and maintaining natural resources. Liarakou et al. (2011), aimed to explore secondary-school learners' opinions on the causes, the effects, and the potential solutions for global warming. Working with 626 Greek learners (grades 8-11), they found that the learners at 11th grades were more acknowledged on the topics related to global warming such as greenhouse effect or ozone layer depletion compared to younger learners. Also, the learners were found to have clear ideas on the effects of environmental problems while being rather confused about the causes and possible solutions. The researchers concluded that environmental education has a critical role in raising consciousness of learners on environmental issues and in having them actively participate in the related processes. Studies on environmental education have also focused on teachers, who have a significant role in raising consciousness among learners. In their study with 186 teachers in Taiwan, Liu et al. (2015) found that the participant teachers had sufficient levels of knowledge and desired attitudes towards environmental issues; however, they had low levels of participation in related activities. They also indicate that primary school teachers had better performances on the issue compared with high school teachers, which, for them, could only be explained by teacher education policies. Therefore, they suggest that educational programs for professional development of teachers and the policies of school-environment education should be improved. There are also studies conducted to investigate opinions on environmental issues from the perspective of other professions in addition to learners and teachers. For example, Ziadat (2010) conducted a study in Jordan with 2000 participants living in 59 villages and five big cities. Analyzing the collected data based on variables such as gender, age, and educational background, Ziadat (2010) found that women had higher levels of consciousness on environmental issues compared with men and that age and educational background had positive relationship with environmental consciousness. There are numerous studies focusing on investigating environmental consciousness (e.g. Yavetz et al., 2009; Esa, 2010; Yingchao et al., 2011; Arslan et al., 2012; Sammons et al., 2015; Zachariou et al., 2017; Türkoğlu, 2019; Sanchez-Llorens et al., 2019) and almost all of them suggest providing education to increase individuals' consciousness on environment and environmental issues.

There are also studies in which educational programs aiming to improve environmental consciousness of adults and young generations have been developed and the results of such educational programs on environment and environmental issues are presented (Santos et al., 2011; Stanišić & Maksić, 2014; Green & Smorville, 2015; Nxumalo, 2018; Huang et al., 2020; Kuvac & Koc, 2019; Wu et al., 2020; Edsand & Broich, 2020).This line of research aimed to raise awareness on environmental issues, to equip individuals with necessary knowledge and skills to recognise environmental problems and to be part of the solution process. The major problems focused on in these studies are global warming and climate change (Cantell et al., 2019; Ho & Seow, 2015), sustainable development (Kopnina, 2012; Lükö & Kollarikcs, 2013; Halbe et al., 2015), environmental protection (Araghieh

et al., 2012; Heidari & Heidari, 2015), pollution (Aydın, 2015; Radanov, 2016), renewable energy (Taleghani et al., 2010; Mälkki & Alanne, 2017), ecological footprints (Gottlieb et al., 2012; Karaarslan-Semiz & Çakır-Yıldırım, 2018). In these studies, the results of the educational programs given to individuals from different ages and professional groups are discussed while the majority of them included samples of students or teachers. Some of these studies aimed to provide training programs on environment to teachers using different teaching methods, tasks and activities. Glasson et al. (2006) conducted a big scale study in Malawi (a developing country in Africa) and investigated teachers' perspectives and attitudes towards teaching the concepts related to ecological sustainability. They introduced teachers with research based education method in order to overcome ecological deterioration in Malawi. The results of the study indicate that the participant teachers adopted research based education to equip their students with research skills such as investigation, decision-making, and taking responsibility. A similar study was conducted by Shareef (2010) in Maldives. The study revealed that the teachers, who provide environmental education through research based education method could create environments for productive class discussions, easily motivate their learners to become more attentive to environmental issues by learning from different sources. There have been other studies aiming to raise consciousness of students on environmental issues adopting different teaching methods. These studies used student-centered methods such as virtual reality (Horne & Thompson, 2008), educational games (Lin et al., 2011), argumentation (Faize & Akhtar, 2020), collaborative- project based learning (Baser et al., 2017), outdoor education (Higgins & Kirk, 2006). Utilizing various teaching methods, these studies aimed to enable learners and adults to gain environmental literacy and to develop desired attitudes, beliefs, and awareness towards environmental issues (Otto & Pensini, 2017; Erhabor & Don, 2016; McGuire, 2015; Mobley et al., 2010). Today, it is vital that individuals get environmental education in order to become active and conscious agents against increasing environmental problems. Consequently, there is an increase in the number of educational programs, projects and scientific research focusing on environmental issues. The literature in the field reflects the importance attached to the issue. Therefore, it is important for researchers to be given scope for recent research on the topic, to become familiar with and analyse the work of leading researchers.

Researchers can benefit from bibliometrical studies by obtaining accumulated data on the publications related to their research areas (Al et al., 2010). Bibliometrical analysis is an efficient method in identifying the research areas of countries, institutions, and of journals as well as evaluating them in terms of the related area of research (Huang et al., 2006). As bibliometrical research has been attracting researchers, a significant amount of research with bibliometrical analyses have been published on topics such as STEM education, scientific literacy, astronomy, science misconceptions using various programs (e.g., CiteSpace, Vosviewer, R-Studio, etc.) (Effendi et al., 2020; Doğru et al., 2019; Syahmani et al., 2021; Kurtuluş & Tatar, 2021). Doğru et al. (2019) have conducted a bibliometrical analysis of the studies on astronomy education using Citespace. The researchers have analyzed 55 graduate theses published in WoS, Turkish National Center of Higher Education Theses, and ProQuest Dissertations & Theses data bases between 2004 and 2018. Kurtuluş & Tatar (2021) have analyzed the studies on science misconceptions in science education and conducted a bibliometrical analysis of the articles published in Web of Science Core Collection data base using R-Studio program. Analyzing 859 articles published in the last 33 years on the topic, the study has revealed the research tendencies on the topic. Syahmani et al. (2021) have conducted a bibliometrical analysis utilizing Vosviewer program and used "environmental literacy", "STEAM" and "waste management" keywords to scan the articles published in Google Scholar between 1969 and 2020. There are also bibliometrical analysis studies conducted on environmental education on topics such as solid waste, water footprint, carbon education, atmospheric pollution, climate change (Fu et al., 2010; Zhang et al., 2017; Hudha et al., 2020; Li et al., 2017). Doğru et al. (2019) have analyzed 7000 studies published between 2009 and 2018 on "Sustainable Development and Education". Xianchun et al. (2021) have conducted a bibliometrical analysis with 21.225 studies published between 2003 and 2018 using key words related to climate change. Environmental education is among the important topics for researchers. It is quite common to develop and deliver education on environment in order to raise awareness of learners on environment and environmental issues. In this respect, the present study aims to introduce the leading researchers in the field and their work, the journals that publish articles on the issue, and the most frequent keywords used when researching related literature on databases. It is believed that the findings of this study can guide researchers interested in this line of research.

Method

Designed following descriptive research method, the study aims to describe the biometrical characteristics of the articles published in educational journals reached through using "environment/environmental education" keywords in Scopus database. Bibliometrical studies guide journals to improve their publication policies by enabling them to perform internal evaluation. Researchers can also benefit from bibliometrical studies by

obtaining accumulated data on the publications related to their research areas (Al et al., 2010). Bibliometrical analysis is an efficient method in identifying the research areas of countries, institutions, and of journals as well as evaluating them in terms of the related area of research (Huang et al., 2006).

Bibliometric analysis is an analysis method different from meta-analysis. While meta-analysis research aims to arrive at a single general conclusion by bringing the conclusions of different studies together and analyzing them systematically (Dinçer, 2014), bibliometric research is based on analyzing different studies bibliographically. Bibliometric analysis is a method that helps to summarize and to interpret existing information. Literature presents a good number of bibliometric studies (Hernandez-Torrano & Ibrayeva, 2020; Jimenez et al., 2019; Özkaya, 2019; Doğru et al., 2019; Tang et al., 2019; Ye et al., 2019; Jho, 2018; Khodabandelou et al., 2018; Altınpulluk, 2018; Lopes et al., 2017).

Sampling

The data for the study consisted of the articles reached through Scopus database published between 1973 and 2019using "environment/environmental education" keywords. As a result of the initial scanning, the first article on the subject matter was found to be published in 1973; and therefore, 1973 is considered to be the starting date for this line of research. As 2020 has not finished yet, the articles published in 2020 so far were also excluded from the sample of the study since they could affect the results of the analyses. Science Citation Index (SCI), Social Science Citation Index (SSCI) and Art & Humanities Citation Index (A&HCI) international citation indexes are regarded to be the most important sources in bibliometrical analyses. Since these indexes could be accessed through Scopus database (Güzeller & Çeliker, 2017), which is compatible with the bibliometrical analysis system run through R-Studio program, Scopus was chosen as the database to carry out the present research.

It should be noted that the sampling of the study has some limitations. Firstly, the sample did not involve of all the publications on environmental education in the related literature. All of the published articles in Scopus database emerging as a result of the search with "environment/environmental education" key words were included in the analyses of the study. However, the scope of the study is limited to related published work only in article format and does not cover conference papers, reviews, editorials, notes, letters, short surveys, book chapters, books and reports published on the topic. It is also important to note the limitation related to subject area. Subject areas of biological sciences, earth and planetary sciences, physic and astronomy and chemistry were counted in, as they comprise fields of environmental science, social sciences and science. In addition, year of publication was also set to be another limitation for the reasons mentioned earlier. There was no limitation regarding the publication language, and thus, articles published in any language were included in the analyses.

Data Collection

As a result of the scanning conducted in Scopus, 5547 publications in total were reached. For the aim of the study, search limitations such as publication type (i.e., journal article) and time period were set and 3979 articles were obtained and included in the analyses. The analyses results for this sample of 3979 articles revealed the findings related to the annual distributions of the articles; the average citation scores; the journals and the authors with the highest number of related articles; the citation burst scores and h-index of the authors; the scientific productivity of the countries of the authors; the articles that were cited at the highest rates; collaboration networks; and their patterns that were obtained through text mining methods of word cloud and conceptual structure mapping.

Data Analysis

The sample of the articles was analyzed using R-Studio program accessed at https://cran.r-project.org/, which is the official storage website of many bibliometric analysis packages. For bibliometrical analyses in quantitative research, these package programs are considered to be effective (Aria & Cuccurullo, 2017). The rationale behind chosing R program for the bibliometric analyses conducted is that it provides more variety of results with enriched details. After forming the data file for the study through Scopus database based on the criteria identified for the research, the first step was to select "All" in the file. Then, the options "export", "bibtex", "citation information, bibliographical information, abstract & keywords, funding details, other information" were selected and finally "exported. Since the data file after the selection had 3979 articles, the articles were

saved in two separate files as the system allows downloading maximum 2000 articles at a time. Then, these two files were combined before downloading "bibliometrix" package in R program and activating it for the analyses. Next, R-Studio program directed to bibliometric analysis page through a web address. At this step, the "bibtex" file was saved into data segment and the analyses of the study were conducted. Figure 1 displays the flow of the actions taken during the analysis process.

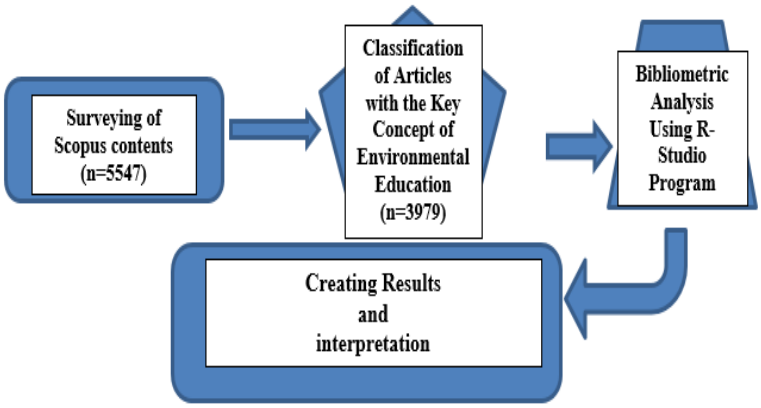


Figure 1. Actions conducted during data analysis

Bibliometrical laws and models are the rules established based on various statistical calculations and distributions in order to evaluate research processes of authors. These laws are generally simple mathematical and statistical functions that analyze the correlation of a variable with another variable (Karaboğa, 2019). In bibliometrical science, there are five laws to determine the bibliometrical productivity. These are Lotka law, Bradford law, Zipf law, Price law and Pareto law. In the present study, Bradford law was evaluated in terms of compatibility. The reason for excluding the evaluation of the other laws is that all laws have the same focus, and also, that R-Studio program provides statistical information with visuals on Bradford law. Bradford law, which is also referred to as the distribution law, is considered in the study. In one of his studies in the field of geophysics, Bradford reached to 326 journals in total. Bradford tried to explain the correlation for his study by using 1:n:n2 equation. The first group includes the smallest number of related journals but with the most important ones that are considered "core sources". While the second group covers a higher number of journals, the third group includes the journals with the lowest impact rates (Bookstein, 1980). In our study, the first group consisted of 21 journals considered to be core sources with 1314 articles on environment/environmental education. The second group had 140 journals with 1333 articles whereas the third group included 827 journals with 1323 articles in total. It is believed that the study conducted by scanning with the key concept of "environment/environmental education" complies with Bradford law.

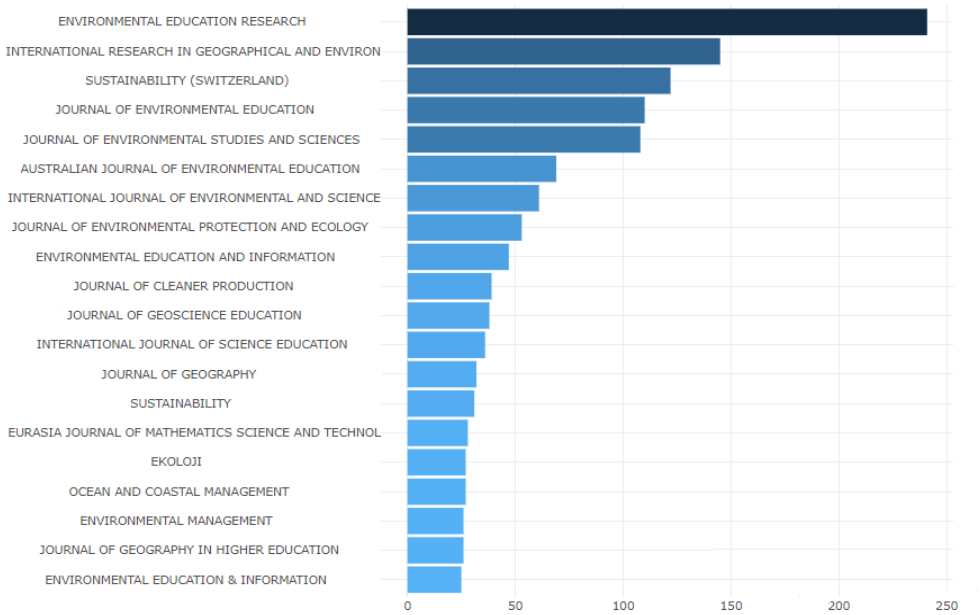
Results

As a result of the bibliometrical analysis conducted on environment education, 3979 articles published in the span of 46 years were obtained. The distribution of the articles by time periods is shown in Table 1.

Table 1.The distribution of the articles by time periods

Year	Number of Articles (f)	Percentage (%)
1973-1978	5	0.13
1979-1984	31	0.78
1985-1990	54	1.36
1991-1996	154	3.89
1997-2002	306	7.69
2003-2008	499	12.56
2009-2014	1437	36.14
2015-2019	1490	37.45

Table 1 indicates that the relevant articles started to be published in 1973 and the highest frequency was reached between 2015 and 2019 (f=1490). The articles on the topic published after 2008 make up for 73.59% of the total articles. Graph 1 displays the top 20 journals in the rank of the publications.



Graph 1.Journals with the highest number of published articles on environment/environmental education science misconception

As a result of the scanning conducted using "environment/environmental education" keywords, the obtained articles were found to have been published in 988 different journals. The highest numbers of the accessed articles were published in *Environmental Education Research* (f = 241), *International Research in Geographical and Environmental Education* (f = 145) and *Sustainability (Switzerland)* (f = 122). Table 2 presents authors' number of articles on the subject matter and the information regarding the h index scores.

Table 2. Number of articles and h-index information of the authors based on the topic

Author	h-index	Total Citations	Number of Article	Start Date for Publishing
Kopnina H.	11	445	18	2011
Bogner F. X.	10	417	15	1998
Krasny M. E.	10	334	12	2009
Boyes E.	8	230	13	1994
Stanisstreet M.	8	230	13	1994
Ballantyne R.	8	406	11	1995
Jacobson S.K.	8	234	10	1991
Jickling B.	7	422	11	1996
Ardoin N. M.	6	178	10	2008
Ertepinar H.	6	186	8	2006
Tal T.	6	78	8	2010
Powell R.B.	6	286	7	2008
Lundholm C.	6	135	6	2008
Thiengkamol N.	5	80	15	2011
Goldman D.	5	206	8	2006
Gough A.	5	58	8	2004
Skanavis C.	5	43	7	2004
Monroe M. C.	5	286	6	2010
Stern M. J.	5	246	6	2008
Tilbury D.	5	103	6	1994

When the authors who published the most articles on the subject are examined, it could be seen that the authors with the highest number of articles are Helen Kopnina (f = 18), who is from The Hague University of Applied Sciences in Holland, Franz X. Bogner (f = 15), who is from University of Bayreuth in Germany, and Nongnapas Thiengkamol (f = 15), who is from Mahasarakham University in Thailand. It has been found that 8810 articles in total have been published on the topic by one author or in collaboration of multiple authors. The number of published articles per author 0.451, while the number of authors per article is 2.22. The top 20 authors

depending on their h-index information are in Table 2. h-index enables evaluations on the quality of published work by the researchers. The h-index number of a researcher is determined by the number and the distribution of the citations to their published articles. As Hirsch (2005) explains, if a researcher has h number of articles each of which receive h number of citations; and if his or her other articles have received h number of citations, then this researcher's index value is accepted to be According to Table 2, the researcher with the earliest published article on the topic started in 1991, and the latest researcher started the first publication on the topic in 2011. The researchers in listed in Table 2 mostly started publishing their articles before 2000, except the two researchers in the first eight. Table 3 displays the countries of the corresponding authors, the number of articles, and SCP and MCP values.

Table 3.The number of articles per country and SCP and MCP values

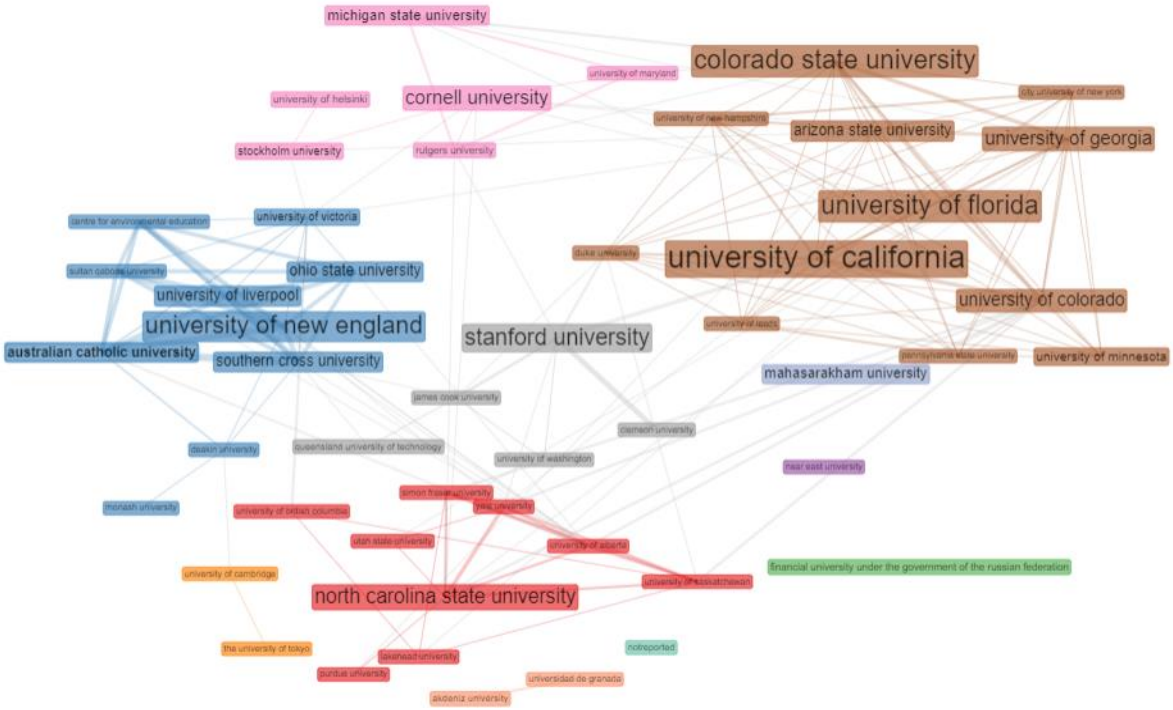
Country	Number of Article	Frequency	SCP	MCP	MCP Ratio
USA	769	0.273958	703	66	0.0858
United Kingdom	205	0.073032	183	22	0.1073
Brazil	182	0.064838	164	18	0.0989
Australia	166	0.059138	140	26	0.1566
Canada	120	0.04275	101	19	0.1583
Spain	117	0.041682	99	18	0.1538
Germany	96	0.0342	76	20	0.2083
Turkey	93	0.033131	82	11	0.1183
Greece	65	0.023156	57	8	0.1231
Japan	57	0.020306	50	7	0.1228
China	51	0.018169	41	10	0.1961
South Africa	47	0.016744	40	7	0.1489
Italy	42	0.014963	35	7	0.1667
Netherlands	38	0.013538	28	10	0.2632
Taiwan	36	0.012825	31	5	0.1389
Mexico	35	0.012469	26	9	0.2571
New Zealand	34	0.012113	30	4	0.1176
Thailand	34	0.012113	31	3	0.0882
Israel	32	0.0114	25	7	0.2188
Portugal	32	0.0114	26	6	0.1875

As can be seen in Table 3, the top three countries are the USA (SCP: 703, MCP:66) with 769 articles in total, United Kingdom (SCP:183, MCP:22) with 205 articles, and Brazil (SCP: 164, MCP: 18) with 182 articles. Out of 3979 published articles, 1270 of them had a single author whereas the rest were written by multiple researchers' collaboration. Therefore, it is seen that the majority of the articles were written in collaboration of the researchers. The Single Country Publications (SCP) values refers to the number of published articles by the researchers from the same country and the Multiple Country Publications (MCP) values represent the number of the articles by the researchers from different countries. While the USA ranks the first among the countries with the highest number of articles on the topic, it has one of the lowest values of MCP among 20 countries. In other words, the researchers in the USA conducted their research in collaboration with the researchers in the same country. Although Netherlands ranks as the 14th among the 20 countries in terms of the number of published articles, it has the highest MCP value. This indicates that the researchers in Netherlands, Mexico and Israel are more open to international collaborative studies. Table 4 displays the researchers and the collaboration clusters.

Table 4. Co-citation networks author-cluster-centrality values

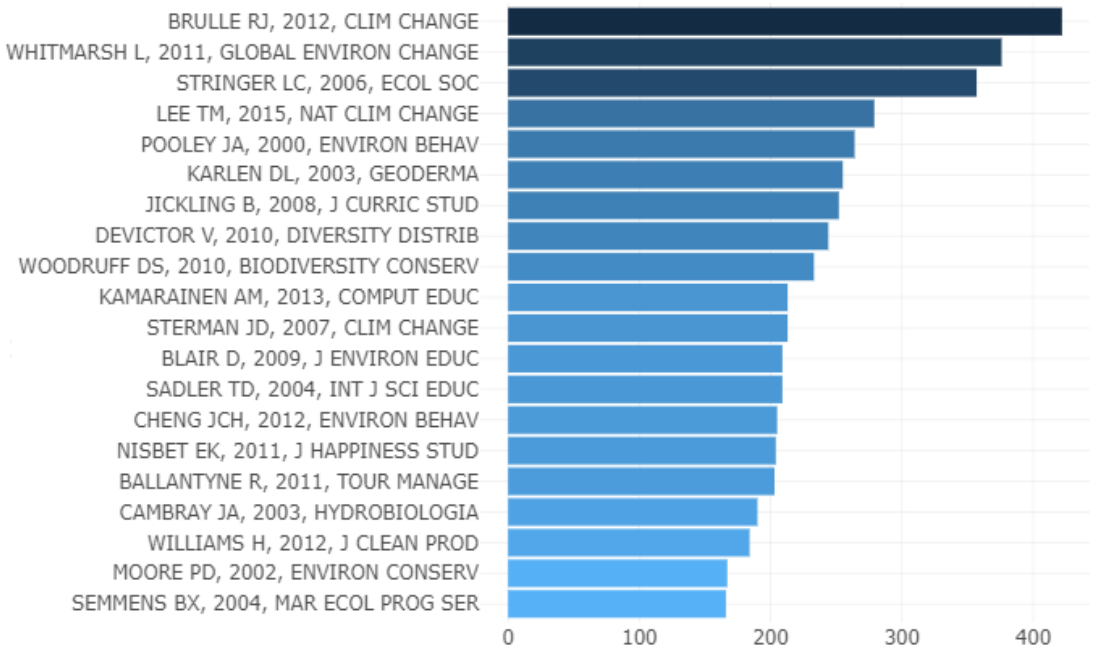
Author	Cluster	Author	Cluster	Author	Cluster
Kim M.	1	Ardoin N.M.	4	Davies K.	8
Skamp K.	1	Uak M.	5	Bhattacharyya R.	8
Boyes E.	1	Pruneau D.	6	Kugan R.	8
Stanisstreet M.	1	Thiengkamol N.	7	Luckhurst D.A.	8
Taylor N.	1	Fullen M.A.	8	Chan K.	8
Ambusaidi A.	1	Subedi M.	8	Black A.W.	8
Bogner F.X.	2	Booth C.A.	8	Townrow D.	8
Groffman P.M.	3	Sarsby R.W.	8	James T.	8
				Poesen J.	8

According to Table 4, it can be stated that the authors in the same cluster publish articles on similar topics in collaboration with other authors. For example, when the authors in the eighth cluster are analyzed, it can be seen that their research areas are similar and that they have co-authored many publications. Graph 2 shows the collaboration network of universities.



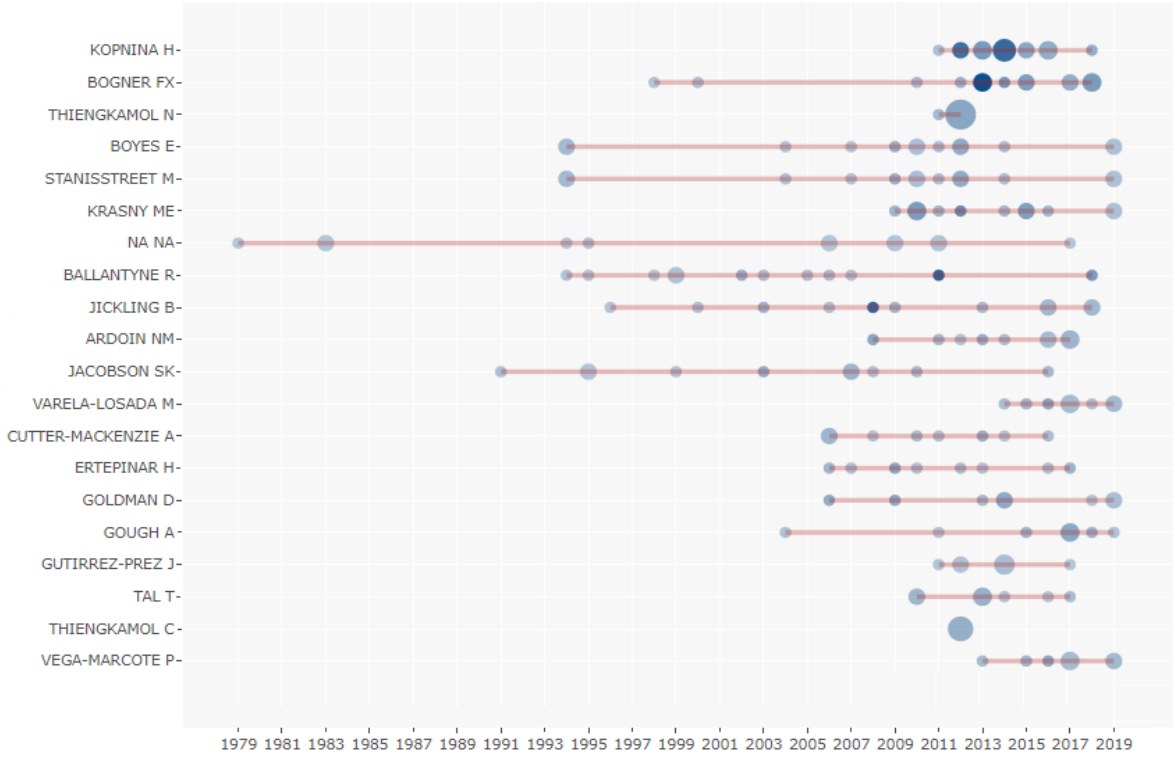
Graph 2. Collaboration network of universities based on research areas

As the results displayed in Graph 2 indicate, collaboration groups form mainly five clusters. The highest collaboration rates among the institutions are found in University of California, University of Florida, University of England, North Carolina State University, Stanford University and Cornell University. Researchers tend to cite the previous work conducted on the same topic. Graph 3 shows the articles with the highest citation rates.



Graph 3. The articles with the highest citation rates

Analyzing Graph 3, it can be seen that among the published articles on "environment/environmental education" key concepts, the highest citation scores belong to Brulle et al. (2012) with 422 citations in total, followed by Whitmarsh (2011) with 376 citations and Stringer et al. (2006) with 357 citations. Graph 4 displays citation burst scores of the published articles on the topic.



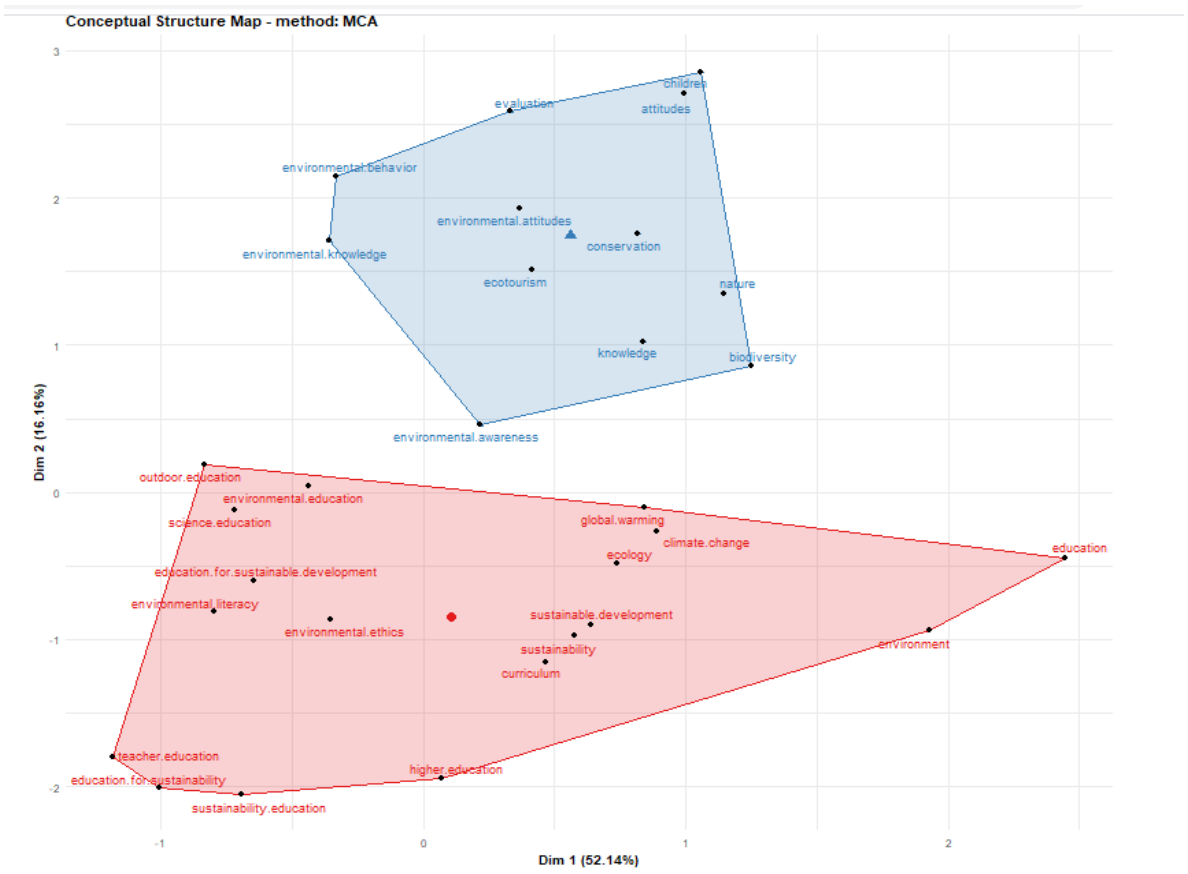
Graph 4.Authors' citation burst scores

Considering citation burst scores of the authors, F. X. Bogner (24.50) had the highest score between 1998 and 2018. However, this does not indicate that Bogner is the author with the highest number of citations; rather, it implies that Bogner had the highest number of citations when the citation burst occurred. M.Varela-Losado and P. Vega-Marcote have been among the frequently cited authors in recent years as they were cited between 2013 and 2019. F.X. Bogner (24.50), R. Ballantyne (20.30), B. Jickling (19.38) and H. Kopnina (18.85) are the leading researchers that have been working on the topic for many years. Figure 2 presents the Word cloud for the most frequently used keywords in the articles published on environment and environmental education.

Figure 2.Word clouds of the keywords

As one of the data mining methods, word clouds method enables researchers to reveal the most frequently used words in a paragraph or a text. The most frequently used word in the topic is shown in the center. The sizes of the words and their relative closeness to the central word reflect how frequently have been used. The further the word is located from the center and the smaller the size gets, the less commonly the word is used. The keywords of the articles were scanned with the word clouds. Figure 2 indicates that the keywords with the highest frequencies are education (f=490), student (f=465), sustainable development (f=346), environmental protection (f=322), and teaching (f=313).

One of the important analyses conducted within biometrical analyses is conceptual structure mapping of the publications. As a result of the factor analysis of the concepts, the dynamics of the conceptual structure and the conceptual milestones in the related literature could be revealed by analyzing the keywords used by the authors. Graph 5 presents conceptual structure mapping on the topic.



Graph 5. Conceptual structure mapping

As a result of the factor analysis, the clusters displayed in Graph 5 were formed. The bigger group represented in red includes articles related to educational topics and concepts focusing on issues such as teacher education, sustainability education, science education, climate change, and ecology. The blue cluster on the top is found to cover learning areas such as environmental knowledge, attitudes or awareness.

Conclusion and Discussion

The study scanned the articles accessed using “environment/environmental education” keywords in Scopus database, which provides access to international publications and citations. The scanning resulted in 5547 publications in total. Having set limitations such as publication type and date, the sample consisted of 3979 articles, which were then analyzed bibliometrically using R-Studio program. As a result of the analyses carried out, findings regarding the annual distributions of the articles; the average citation scores; the journals that published the highest number of related articles; the authors that had published the highest number of related articles and their h-index information; the citation burst scores of the authors; the scientific productivity of the

countries of the authors; the articles that were cited at the highest rates; collaboration networks; and their patterns that were obtained through text mining methods of Word cloud and conceptual structure maps.

The findings show that the oldest article on the topic was published in 1973 in "*Journal of the Air Pollution Control Association*" by L.D. Kornreich et al. and was titled "*University Consortia: A Unique Approach to Environmental Education and Research*". The number of the published articles on the topic was found to increase after 2008 and reached its peak between 2015 and 2019 (f=331). In the 21st century, sensitivity towards environmental issues is observed to increase while efforts to provide effective approaches and methods for these problems started to gain more importance. The need to acknowledge environmental problems and finding measures against these problems have led scientists to focus more on the topic. The annual article publication on the topic is found to be 14.39%. Considering annual growth rate, it is expected that there will be an increase in the number of articles on the topic in 2020. It is also estimated that environment and environmental education will be the most studied topic among the published articles in 2020.

The articles on the subject matter have been published in 988 different journals. This suggests that a good number of journals place importance to the topic. The journal having published the highest number of articles on the subject matter is determined to be "*Environmental Education Research*" (f=241). The other journals on the list are prestigious journals in the field. It has been also identified that 8810 authors in total have worked on the subject matter either individually or in collaboration with other researchers. The author with the highest number of articles on the topic and the highest h-index score is identified to be H. Kopnina. According to the data in Scopus, the researcher has 18 published articles on the topic and has received 445 citations. These articles are usually on sustainability. The second author on the list is F.X. Bogner with 15 articles, mostly focusing on sustainable development and environmental education. He is found to have received 417 citations in total with 10 h-index score. The researchers who started to publish articles on the subject matter in earlier dates are more likely to have further articles on the topic as, compared to the authors who started to focus on the topic recently, they are more likely to work on research projects with young researchers they may have trained on the topic or with the research groups they have worked with previously. Yet, the authors who have recently started to produce articles on the topic are also expected to have higher rates of citations in time and attain higher h-index scores.

The majority of the published articles on the subject matter are seen to be by researchers from America, the UK, and Brazil. The researchers from Netherlands, Mexico and Israel are shown to be the most collaborative researchers. Researchers from Mexico are found to have worked in collaboration with researchers from America, Canada, the UK, Australia, Italy, and Spain (e.g., Ruiz-Mallen et al., 2010; Mercado-Domenech, et al., 2017). The researchers from Israel, on the other hand, have worked with mostly American colleagues (e.g., Tal & Alkaher, 2010; Brenner et al., 2005). When analyzing collaboration at university level, it is revealed that universities that are more open in terms of location are the ones that have the highest numbers of published articles on the topic.

The highest annual citation rate is found to belong to 2010. According to citation burst scores, F.X. Bogner is shown to receive the highest number of citations for his three articles published in 2013. These articles are "Promoting connectedness with nature through environmental education" (Liefländer et al., 2013) and "Climate change education: quantitatively assessing the impact of a botanical garden as an informal learning environment" published in "*Environmental Education Research*" (Sellmann & Bogner, 2013a); and "Effects of a 1-day environmental education intervention on environmental attitudes and connectedness with nature" published in "*European Journal of Psychology of Education*" (Sellmann & Bogner, 2013b).

Having a citation burst for a publication does not mean to have the highest number of citations, rather this is determined by the density of citations in a specific period. For example, citation burst scores of the scanned 3979 articles in Scopus database are determined based on the citation numbers received in a specific period. As one of the leading researchers on the subject matter, H. Kopnina is seen to have started to publish articles on the subject matter later compared to the other leading authors. Her highest citation burst score belongs to her article titled "Education for sustainable development (ESD): the turn away from 'environment' in environmental education?" published in "*Environmental Education Research*" in 2012. The second and third highest citation burst scores belong to the article titled "Visitors' learning for environmental sustainability: Testing short- and long-term impacts of wildlife tourism experiences using structural equation modelling" published in "*Tourism Management*" (Ballantyne et al., 2011) and "Globalization and environmental education: looking beyond sustainable development" published in "*Journal of Curriculum Studies*" (Jickling & Wals, 2018). However, the citation burst scores of these three researchers are still lower than Bogner's score. The researchers with highest citation scores are found to be from America. The highest number of received citation is found to belong to

Robert J. Brulle, Jason Carmichael and J. Craig Jenkins for their article titled "Shifting public opinion on climate change: an empirical assessment of factors influencing concern over climate change in the U.S., 2002–2010" published in "*Climatic Change"* in 2012.

According to the findings obtained through text mining analyses, the most frequently used keywords by the authors when using keywords for scanning and when writing abstract sections of their articles are "education" and "environmental education". "Sustainability" and "sustainable development" concepts are also found to be frequently used. Another significant finding of Word cloud analyse is that America and China, having high numbers of published articles on the topic, appears in keywords section. This is due to the high numbers of published articles reporting the studies conducted in their specific contexts. These researchers are found to refer to their countries in keywords and abstract sections (e.g., Mitchell, 2009; Chen & Li, 2019). As a result of conceptual structure mapping analysis, two main groups are identified based on the studied topics. One of these two groups is found to focus more on education, sustainability, and climate change topics (e.g., Jickling & Wals, 2008; Whitmarsh, 2011; Pooley & O'Connor, 2000) while the other group consisted of articles related to learning outcomes such as attitudes towards environment, environmental awareness, or biodiversity (e.g., Littledyke, 2008; Özden, 2008; Cambray, 2003; Hostetler et al., 2011).

Suggestions for Future Studies

The overall results of this study clearly show that there is an increasing interest in environmental education. The worsening environmental issues today require raising conscious generations equipped with necessary knowledge and skills to overcome these problems. It is vital to support and to keep up to date with the research on environmental issues in order to be able to educate new generations and improve national and international policies. Several suggestions for the researchers could be made based on the findings of the study.

It has been identified that the majority of the research on environmental education has been conducted with the participation of learners. Further research could be conducted with the participation of different groups of samples considering variables such as profession, educational backgrounds or region of residence. However, it is found that most of the published research is about the outcomes of educational or training programs provided to help individuals become aware of environmental issues and be part of the solution process. Global warming, and climate change, sustainable development, biodiversity, pollution and energy consumption are among these serious environmental problems. It can be suggested that researchers determine their research focus considering these issues. At the same time, it is suggested that longitudinal studies be conducted in order to raise consciousness of individuals on environmental issues and to track retention level of such a consciousness. Bibliometrical analyses could guide researchers in determining research topics and conducting research. Therefore, researchers could run bibliometrical analyses using the keywords related to research areas. This will enable them to gather the leading researchers and read their research. They can also identify the journals that publish articles in these research topics and send their research for publication. Finally, Scopus database was used in the present study. Similar studies could be conducted using databases such as, Web of Science Core Collection or Proquest. In addition to articles, research published as theses, books, or conference proceedings could be included to the sample for the analysis. Different limitations could be set to analyse articles published in a specific range of journals or years.

Scientific Ethics Declaration

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

References

Al, U., Soydal, İ., & Yalçın, H. (2010). An evaluation of the bibliometric features of bilig. *Bilig, Güz, 55*, 1-20.

Altınpulluk, H. (2018). Examination of theses on augmented reality in Turkey through bibliometric analysis method. *Eğitim Teknolojisi Kuram ve Uygulama, 8*(1), 248-272.

Araghieh, A., Inanloo, A., & Farahani, N. (2012). An exploration into environmental protection training methods from students' perspective at primary school. *J. Appl. Environ. Biol. Sci*, *2*(6), 255-259.

Arslan, H. O., Cigdemoglu, C., & Moseley, C. (2012). A three-tier diagnostic test to assess pre-service teachers'

misconceptions about global warming, greenhouse effect, ozone layer depletion, and acid rain. *International Journal of Science Education*, *34*(11), 1667-1686.

Atasoy, E. (2006). *Çevre için eğitim çocuk doğa etkileşimi [Education for environmental, child-nature interaction]*. Bursa: Ezgi Kitabevi.

Aydın, G. (2015). The effects of computer-aided concept cartoons and outdoor science activities on light pollution. *International Electronic Journal of Elementary Education*, *7*(2), 142-156.

Ballantyne, R., Packer, J., & Falk, J. (2011). Visitors' learning for environmental sustainability: Testing short and long-term impacts of wildlife tourism experiences using structural equation modelling. *Tourism management*, *32*(6), 1243-1252.

Baser, D., Ozden, M. Y., & Karaarslan, H. (2017). Collaborative project-based learning: An integrative science and technological education project. *Research in Science & Technological Education*, *35*(2), 131-148.

Bookstein, A. (1980). Explanations of the bibliometric laws. *Collection Management*, *3*(2-3), 151-162.

Brenner, A., Shacham, M., & Cutlip, M. B. (2005). Applications of mathematical software packages for modelling and simulations in environmental engineering education. *Environmental Modelling & Software*, *20*(10), 1307-1313.

Brulle, R. J., Carmichael, J., & Jenkins, J. C. (2012). Shifting public opinion on climate change: an empirical assessment of factors influencing concern over climate change in the US, 2002–2010. *Climatic Change*, *114*(2), 169-188.

Cambray, J. A. (2003). Impact on indigenous species biodiversity caused by the globalisation of alien recreational freshwater fisheries. *Hydrobiologia*, *500*(1-3), 217-230.

Cantell, H., Tolppanen, S., Aarnio-Linnanvuori, E., & Lehtonen, A. (2019). Bicycle model on climate change education: presenting and evaluating a model. *Environmental Education Research*, *25*(5), 717-731.

Chen, W., & Li, J. (2019). Who are the low-carbon activists? Analysis of the influence mechanism and group characteristics of low-carbon behavior in Tianjin, China. *Science of The Total Environment*, *683*, 729-736.

Dinçer, S. (2014). Eğitim bilimlerinde uygulamalı meta-analiz [Applied meta-analysis in educational sciences]. *Pegem Atıf İndeksi*, *2014*(1), 1-133.

Doğru, M., Güzeller, C. O., & Çelik, M. (2019). A bibliometric analysis in the field of sustainable development and education from past to present. *Adıyaman University Journal of Educational Sciences*, *9*(1), 42-68.

Doğru, M., Satar, C., & Çelik, M. (2019). Analysis of the studies on astronomy education. *Avrasya Sosyal ve Ekonomi Araştırmaları Dergisi (ASEAD), 6*(7), 235-251.

Edsand, H. E., & Broich, T. (2020). The impact of environmental education on environmental and renewable energy technology awareness: Empirical evidence from Colombia. *International Journal of Science and Mathematics Education*, *18*(4), 611-634.

Effendi, N. D., Irwandani, Anggraini, W., Jatmiko, A., Rahmayanti, H., Ichsan, Z. I., & Rahman, M. M. (2020). Bibliometric analysis of scientific literacy using VOS viewer: Analysis of science education. Paper presented at 240th ECS Meeting. *Young Scholar Symposium on Science Education and Environment (YSSSEE*), 1796 (2021).https://doi.org/10.1088/1742-6596/1796/1/012096

Erhabor, N. I., & Don, J. U. (2016). Impact of environmental education on the knowledge and attitude of students towards the environment. *International Journal of Environmental and Science Education*, *11*(12), 5367-5375.

Erten, S. (2004). Çevre eğitimi ve çevre bilinci nedir, çevre eğitimi nasıl olmalıdır? [What is environmental education and environmental awareness, how should environmental education be?]. *Çevre ve İnsan Dergisi, Çevre ve Orman Bakanlığı Yayın Organı*, Sayı 65/66.

Esa, N. (2010). Environmental knowledge, attitude and practices of student teachers. *International Research in Geographical and Environmental Education*, *19*(1), 39-50.

Faize, F. A., & Akhtar, M. (2020). Addressing environmental knowledge and environmental attitude in undergraduate students through scientific argumentation. *Journal of Cleaner Production*, *252*, 119928.

Fu, H., Ho, Y., Sui, Y., & Li, Z. (2010). A bibliometric analysis of solid waste research during the period 1993 2008. *Waste Manegement, 20* (12), 2410-2417.

Glasson, G. E., Frykholm, J. A., Mhango, N. A., & Phiri, A. D. (2006). Understanding the earth systems of Malawi: Ecological sustainability, culture, and place-based education. *Science Education, 90*(4), 660-680.

Gottlieb, D., Vigoda-Gadot, E., Haim, A., & Kissinger, M. (2012). The ecological footprint as an educational tool for sustainability: A case study analysis in an Israeli public high school. *International Journal of Educational Development*, *32*(1), 193-200.

Green, M., & Somerville, M. (2015). Sustainability education: Researching practice in primary schools. *Environmental Education Research*, *21*(6), 832-845.

Grodziéska-Jurczak, M., Stepska, A., Nieszporek, K., & Bryda, G. (2006). Perception of environmental problems among pre-school children in Poland. *International Research in Geographical & Environmental Education*, *15*(1), 62-76.

Güzeller, C. O. & Çeliker, N. (2017). Gastronomy from past to today: A bibliometrical analysis. *Journal of Tourism and Gastronomy Studies, 5*/Special Issue2, 88-102.

Halbe, J., Adamowski, J., & Pahl-Wostl, C. (2015). The role of paradigms in engineering practice and education for sustainable development. *Journal of Cleaner Production, 106*, 272-282.

Heidari, F., & Heidari, M. (2015). Effectiveness of management of environmental education on improving knowledge for environmental protection (Case study: Teachers at Tehran's elementary school). *International Journal of Environmental Research*, *9*(4), 1225-1232.

Hernandez-Torrano, D., & Ibrayeva, L. (2020). Creativity and education: A bibliometric mapping of the research literature (1975-2019). *Thinking Skills and Creativity*, *35*, 100625.

Higgins, P., & Kirk, G. (2006). Sustainability education in Scotland: The impact of national and international initiatives on teacher education and outdoor education. *Journal of Geography in Higher Education*, *30*(2), 313-326.

Hirsch, J. E. (2005). An index to quantify an individual's scientific research output. *Proceedings of the National academy of Sciences*, *102*(46), 16569-16572.

Huang Y., Liu J., Wang J., & Xie Y. (2020) How urban wetland-based environmental education activate school children's childhoodnature in anthropocene times: experience from Chinese curriculum reform. In: Cutter-Mackenzie-Knowles A., Malone K., Barratt Hacking E. (eds) *Research handbook on childhoodnature*. Springer international handbooks of education. Springer, Cham. https://doi.org/10.1007/978-3-319-67286-1_42

Huang, Y.L., Ho, Y.S., & Chuang, K.Y. (2006). Bibliometric analysis of nursing research in Taiwan 1991–2004. *Journal of Nursing Research*, *14*, 75–81.

Hudha, M. N., Hamidah, I., Permanasari, A., Abdullah, A. G., Rachman, I. & Matsumoto, T. (2020). Low carbon education: A review and bibliometric analysis. *European Journal of Educational Research, 9*(1), 319-329.

Ho, L. C., & Seow, T. (2015). Teaching controversial issues in geography: Climate change education in Singaporean schools. *Theory & Research in Social Education*, *43*(3), 314-344.

Horne, M., & Thompson, E. M. (2008). The role of virtual reality in built environment education. *Journal for Education in the Built Environment*, *3*(1), 5-24.

Hostetler, M., Allen, W., & Meurk, C. (2011). Conserving urban biodiversity? Creating green infrastructure is only the first step. *Landscape and Urban Planning*, *100*(4), 369-371.

ICEE [Intergovemmental Conference on Environınental Education](1977). *Intergovernmental conference on environmental education, final report, 14-26 October 1977. Tbilisi (USSR),* Georgia: https://unesdoc.unesco.org/ark:/48223/pf0000032763

IUCN [International Union for the Conservation of Nature and Natural Resources](1972). *European working conference on environmental conservation education,15-18 December 1971, Morges, Switzerland*: https://portals.iucn.org/library/sites/library/files/documents/NS-SP-034.pdf

Jho, H. (2018). Trends in research on the nature of science: A bibliometric analysis with R-mapping tool. *Journal of Learner-Centered Curriculum and Instruction, 18*(18), 937-956.

Jickling, B., & Wals, A. E. (2008). Globalization and environmental education: Looking beyond sustainable development. *Journal of Curriculum Studies, 40*(1), 1-21.

Jimenez, C.R., Prieto, M.S., & Garcia, S.A. (2019). Technology and higher education: A bibliometric analysis. *Education Sciences, 9*(3), 169.

Karaarslan-Semiz, G., & Çakır-Yıldırım, B. (2018). Is my footprint too big? Exploring the ecological footprint concept with high school students. *Science Activities, 55*(3-4), 104-114.

Karaboğa, H. A. (2019). *Örgütsel davranış araştırmalarının bibliyometrik analizi [A bibliometric analysis of research on organizational behaviour]*. Master's thesis, Yıldız Teknik Üniversitesi, Sosyal Bilimler Enstitüsü, İstanbul.

Khodabandelou, R., Mehran, G., & Nimehchisalem, V. (2018). A bibliometric analysis of 21st centuryresearch trends in early childhood education. *Revista Publicando, 5*(15), 137-163.

Kopnina, H. (2012). Education for sustainable development (ESD): the turn away from 'environment' in environmental education?. *Environmental Education Research, 18*(5), 699-717.

Kornreich, L. D., Matula, R. A., McGinty, R. T., Rider, T. H., Stukel, J. J., & Worley Jr, F. L. (1973). University consortia: A unique approach to environmental education and research. *Journal of the Air Pollution Control Association*, *23*(9), 755-760.

Kurtuluş, M. A., & Tatar, N. (2021). An analysis of scientific articles on science misconceptions: A bibliometric research. *Elementary Education Online, 20*(1), 192-207.

Kuvac, M., & Koc, I. (2019). The effect of problem-based learning on the environmental attitudes of preservice science teachers. *Educational Studies*, *45*(1), 72-94.

Li, Y., Wang, Y., Rui, X., Li., Y., Wang, H., Zuo, J., & Tong, Y. (2017). Sources of atmospheric pollution: a bibliometric analysis. *Scientometrics, 112*, 1025-1045.

Liefländer, A. K., Fröhlich, G., Bogner, F. X., & Schultz, P. W. (2013). Promoting connectedness with nature through environmental education. *Environmental Education Research*, *19*(3), 370-384.

Liarakou, G., Athanasiadis, I., & Gavrilakis, C. (2011). What Greek secondary school students believe about climate change?. *International Journal of Environmental and Science Education*, *6*(1), 79-98.

Lin, K. Y., Son, J. W., & Rojas, E. M. (2011). A pilot study of a 3D game environment for construction safety education. *Journal of Information Technology in Construction (ITcon)*, *16*(5), 69-84.

Littledyke, M. (2008). Science education for environmental awareness: approaches to integrating cognitive and affective domains. *Environmental Education Research*, *14*(1), 1-17.

Liu, S-Y., Yeh, S-C., Liang, S-W., Fang, W-T., & Tsai, H-M. (2015) A national investigation of teachers' environmental literacy as a reference for promoting environmental education in Taiwan, *The Journal of Environmental Education*, *46*(2), 114-132, https://doi.org/10.1080/00958964.2014.999742.

Lopes, R. M., Fidalgo-Neto, A. A., & Mota, F. B. (2017). Facebook in educational research: A bibliometric analysis. *Scientometrics*, *111*(3), 1591–1621.

Lükö, I., & Kollarics, T. (2013). The significance of environmental sustainability in adult environmental education. *International Journal of Environmental Protection*, *3*(4), 1-9.

Mälkki, H.,& Alanne, K. (2017). An overview of life cycle assessment (LCA) and research-based teaching in renewable and sustainable energy education. *Renewable and Sustainable Energy Reviews*, *69*, 218-231.

McGuire, N. M. (2015). Environmental education and behavioral change: An identity-based environmental education model. *International Journal of Environmental and Science Education*, *10*(5), 695-715.

Mercado-Doménech, S. J., Carrus, G., Terán-Álvarez-Del-Rey, A., & Pirchio, S. (2017). Valuation theory: an environmental, developmental and evolutionary psychological approach. Implications for the field of environmental education. *Journal of Educational, Cultural and Psychological Studies (ECPS Journal)*, *16*, 77-97.

Mitchell, J. T. (2009). Hazards education and academic standards in the Southeast United States. *International Research in Geographical and Environmental Education*, *18*(2), 134-148.

Mobley, C., Vagias, W. M., & DeWard, S. L. (2010). Exploring additional determinants of environmentally responsible behavior: The influence of environmental literature and environmental attitudes. *Environment and Behavior*, *42*(4), 420-447.

Nxumalo, F. (2018). Stories for living on a damaged planet: Environmental education in a preschool classroom. *Journal of Early Childhood Research*, *16*(2), 148-159.

Otto, S., & Pensini, P. (2017). Nature-based environmental education of children: Environmental knowledge and connectedness to nature, together, are related to ecological behaviour. *Global Environmental Change*, *47*, 88-94.

Özden, M. (2008). Environmental awareness and attitudes of student teachers: An empirical research. *International Research in Geographical and Environmental Education*, *17*(1), 40-55.

Özkaya, A. (2019). Bibliometric analysis of the publications made in STEM education area. *BartınUniversity Journal of Faculty of Education*, *8*(2), 590-628.

Palmer, J. A. (1998). *Environmental education in the 21st century: theory, practice, progress and promise*, Routledge, London.

Pooley, J. A., & O'Connor, M. (2000). Environmental education and attitudes: Emotions and beliefs are what is needed. *Environment and Behavior*, *32*(5), 711-723.

Radanov, P. (2016). Research of awareness of South Banat residents about air, water, land and food pollution ", Environmental awareness as a universal European Value, Monograph, University of Belgrade, Tehnical Faculty in Bor. *Engineering Management Department (EMD)*, 152-167.

Ruiz-Mallen, I., Barraza, L., Bodenhorn, B., Ceja-Adame, M. D. L. P., & Reyes-García, V. (2010). Contextualising learning through the participatory construction of an environmental education programme. *International Journal of Science Education*, *32*(13), 1755-1770.

Sammons, P., Toth, K., Sylva, K., Melhuish, E. C., Iraj, I., & Taggart, B. (2015). Pre-school and early home learning effects on A-level outcomes. *Effective Pre-school, Primary & Secondary Education Project (EPPSE)*. Research Report DFE-RR472A. London:DfE.

Sánchez-Llorens, S., Agulló-Torres, A., Del Campo-Gomis, F. J., & Martinez-Poveda, A. (2019). Environmental consciousness differences between primary and secondary school students. *Journal of Cleaner Production*, *227*, 712-723.

Santos, P. T. A., Dias, J., Lima, V. E., Oliveira, M. J., Neto, L. J. A., & Celestino, V. Q. (2011). Trash and recycling as motivating theme in chemistry teaching [Lixo e reciclagem como tema motivador no ensino de química]. *Ecletica Quimica*, *36*(1), 78–92. https://doi.org/10.1590/s0100-46702011000100006

Sellmann, D., & Bogner, F. X. (2013a). Climate change education: Quantitatively assessing the impact of a botanical garden as an informal learning environment. *Environmental Education Research*, *19*(4), 415-429.

Sellmann, D., & Bogner, F. X. (2013b). Effects of a 1-day environmental education intervention on

environmental attitudes and connectedness with nature. *European Journal of Psychology of Education*, *28*(3), 1077-1086.

Shareef, M. (2010). *Environmental education in the Maldives: The implementation of inquiry-based learning at the primary level* (Master's thesis). Unitec Institute of Technology, New Zeland.

Stanišić, J., & Maksić, S. (2014). Environmental education in Serbian primary schools: Challenges and changes in curriculum, pedagogy, and teacher training. *The Journal of Environmental Education*, *45*(2), 118-131.

Syahmani, S., Hafizah, E., Sauqina, S., Adnan, M. B., & Ibrahim, M. H. (2021). STEAM Approach to improve environmental education innovation and literacy in waste management: Bibliometric research. *Indonesian Journal on Learning and Advanced Education (IJOLAE), 3*(2), 130-141.

Tal, T., & Alkaher, I. (2010). Collaborative environmental projects in a multicultural society: working from within separate or mutual landscapes?. *Cultural Studies of Science Education*, *5*(2), 325-349.

Taleghani, M., Reza Ansari, H., & Jennings, P. (2010). Renewable energy education for architects: lessons from developed and developing countries. *International Journal of Sustainable Development & World Ecology*, *17*(5), 444-450.

Tang, K.Y., Hsiao, C.H., & Su, Y.S. (2019). Networking for educational innovations: A bibliometric survey of international publication patterns. *Sustainability*, *11*, 4608.

Türkoğlu, B. (2019). Opinions of preschool teachers and pre-service teachers on environmental education and environmental awareness for sustainable development in the preschool period. *Sustainability*, *11*(18), 4925.

Whitmarsh, L. (2011). Scepticism and uncertainty about climate change: Dimensions, determinants and change over time. *Global Environmental Change*, *21*(2), 690-700.

Wu, E., Cheng, J. Q., & Zhang, J. B. (2020). Study on the environmental education demand and environmental literacy assessment of citizens in sustainable urban construction in Beijing. *Sustainability*, *12*(1), 241.

Xianchun, T. A. N., Kaiwei, Z. H. U., Yuling, S. U. N., Wangyu, Z. H. A. O., & Fang, C. H. E. N. (2021). Bibliometric research on the development of climate change in the BRI regions. *Advances in Climate Change Research, 12(2), 254-262.* https://doi.org/10.1016/j.accre.2021.03.010

Yavetz, B., Goldman, D., & Pe'er, S. (2009). Environmental literacy of pre-service teachers in Israel: A comparison between students at the onset and end of their studies. *Environmental Education Research*, *15*(4), 393-415.

Ye, J., Chen D., & Kong, L. (2019). Bibliometric analysis of the WoS literature on research of science teacher from 2000 to 2017. *Journal of Baltic Science Education*, *18*(5), 732-747.

Yingchao, L. I. N., Fujii, M., & Peng, W. A. N. G. (2011). Study on comparison of citizens' environmental awareness among four cities in China and Japan. *Management Science and Engineering*, *5*(3), 126-131.

Zachariou, F., Tsami, E., Chalkias, C., & Bersimis, S. (2017). Teachers' attitudes towards the environment and environmental education: An empirical study. *International Journal of Environmental & Science Education*, *12*(7), 1567-1593.

Zhang, Y., Huang, K.Yu, Y., & Yang, B. (2017). Mapping of water footprint research: A bibliometric analysis during 2006–2015. *Journal of Cleaner Production, 149* (15), 70-79.

Ziadat, A. H. (2010). Major factors contributing to environmental awareness among people in a third world country/Jordan. *Environment, Development and Sustainability*, *12*(1), 135-145.

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Exploring Medical Students' Readiness for E-Learning and Knowledge Sharing Behaviors in Emergency Remote Learning Environments during Covid-19

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Abstract

The rapid spread of Covid-19 pandemic has profoundly affected the educational practices all over the world and educational institutions sought ways to adapt to this unprecedented situation. The problem was that most of these institutions, educators and students were not ready for online learning environments and the stakeholders were not yet sure about how to share the knowledge in a better way. This study aims to examine the medical students' readiness for e-learning and knowledge sharing behaviors in online learning environments during Covid-19, and to analyze the relationship between these variables. The study has been designed according to correlational research methodology. The data were collected using "Knowledge Sharing Behavior in Online Learning Environments Scale" and "E-Learning Readiness Self-Assessment Instrument". 725 medical students participated in the study. Students' readiness for e-learning and knowledge sharing behaviors were analyzed using descriptive statistics, and the relationship between the variables was modeled using multivariate regression equation. The results revealed that the students with high ability to use computer, mobile phone and tablet PC have higher readiness level for e-learning in terms of technology access, technical skills, online relationships, motivation, online skills, importance of success. Similarly, they have a higher level of knowledge sharing behaviors in online learning environments.

Introduction

Covid-19 pandemic has had great societal and economic impacts worldwide, and, without doubt, education has been one of the most affected sectors at all levels. Due to the rapid spread of coronavirus, countries had to close down the schools and universities, and had to implement emergency actions to sustain education through digital learning environments. We call these actions "emergency" as it was neither an expected condition to emerge nor an alternative to be chosen, but a challenge to prevent the learning loss of the students and enable the continuity of education. In this respect, the way we consider "education" in online learning environments should be redefined.

The type of education rapidly developed as a response to a crisis situation such as Covid-19 pandemic is called "emergency remote learning", and as a temporary way to educate the students, it differs from the concept of "online learning" which is planned in advance with appropriately chosen resources and infrastructure in a carefully designed virtual environment (Affouneh et al., 2020; Cameron-Standerford et al., 2020; Hodges et al., 2020; Wang et al., 2020). On the contrary, online learning or e-learning refers to careful instructional design and planning, using a systematic model for design and development in the presence of different types of interaction rather than information transmission (Hodges et al., 2020). Within this context, we can understand that "emergency remote learning" and "online learning" are different terms.

Although remote learning has certain advantages in that it has a flexible and comfortable educational environment, it is better for time utilization, the courses can be recorded used again when needed (Shim & Lee, 2020), and it enables self-paced and self-directed learning (Adedoyin & Soykan, 2020; Hodges et al., 2020), it has also some disadvantages for the learners: having difficulty in accessing to digital devices with internet connection (Ferri et al., 2020), not being able to receive instant feedback from instructors as well as their peers, lack of interaction between the learners, poor communication with the instructor as well as inability to collaborate effectively with classmates (Arkorful & Abaidoo, 2015; Shim & Lee, 2020). Similarly, socially disadvantaged groups encounter difficulties in meeting the basic conditions required by online learning (Ferri, Grifoni & Guzzo, 2020). Another problematic issue related to emergency remote learning is that fields that

require hands-on practical experiences may be more difficult to study through e-learning (Arkorful & Abaidoo, 2015) since these fields are based on learning through practical and clinical practice (e.g., medical students, engineering students, etc.).

Readiness for e-learning can be defined as being mentally or physically prepared for online learning experience (Watkins et al., 2004). Therefore, it requires certain abilities that students should develop before engaging with online learning materials (Pillay et al., 2007). Watkins et al. (2004) suggested that these abilities can be grouped under the dimensions of technology access, technology skills, online relationships, motivation, online skills and importance of success. While readiness for e-learning clearly involves the technical skills of computer usage and site navigation, there are also issues that may be related to effective student engagement with online learning (Smith, 2005). Knowledge sharing behavior is one of them. This concept refers to exchanging experiences and knowledge with peers in classes, teams, or communities (Wang & Noe, 2010) and how well team members share information to perform their tasks (Han et al., 2018). In other words, knowledge sharing is a set of behaviors that involve the exchange of information, sharing, and donating task-relevant ideas, and suggestions among a group of people (Elrehail et al., 2018). Ma and Yuen (2011) define this term as the online communication of knowledge so that knowledge is learned and applied by individuals. Chao et al. (2011) suggested that there is a strong relationship between knowledge sharing and online learning interaction. Therefore, online learning environments should be designed to promote student engagement, student-student, student-instructor interactions (Bolliger & Martin, 2018).

Given the potential for more difficult days to come, we can state that emergency remote learning will have an even more critical role for the societies (Korkmaz & Toraman, 2020). This implies that considering this situation as temporary and reckoning that we'll get back to "normal" soon seems to be far away from the reality. So, how well are/were the students prepared to learn online before the pandemic? Are they getting better at learning in digital environments? What is the level of student interaction and engagement in remote learning environments? Do they get enough opportunities to share the knowledge with their peers or engage with others? Are online practices enough to provide medical students with certain professional skills and competences? These questions are still critical as it seems that online learning will remain important in the agenda of many countries for many years. Since there are not many studies regarding students' readiness to emergency remote learning and their knowledge sharing behaviors in online learning environments, there is still a need to focus more on these issues that motivate students to learn collaboratively in a more social environment.

This study aims to examine the medical students' readiness for e-learning and knowledge sharing behaviors in online learning environments during Covid-19, and to analyze the relationship between these variables. The following are the research questions of this study:

(1) How do medical students perceive themselves in terms of knowledge sharing in online learning environments?
(2) How do medical students perceive themselves in terms of readiness for e-learning?
(3) What is the prediction level of readiness for e-learning on knowledge sharing behaviors in online learning environments?
(4) Is there a significant difference between the students' readiness for e-learning and knowledge sharing behaviors in online learning environments according to their computer, mobile phone and tablet PC using skills?
(5) Is there a significant difference between students' e-learning readiness and knowledge sharing levels according to time spent on computer, mobile phones, tablet PC, etc.?

In the following sections, we presented the research design, gave information about the participants, described how we collected the data, and they were analyzed in the method; the results section was structured following the same order with the research questions above and the related findings, and the discussion section focused on the findings regarding the results of the study.

Method

This study has been designed as a correlational research in which the researcher measures two or more variables and assesses the statistical relationship between those variables (Fraenkel et al. 2012). Statistical techniques such as correlation analysis, multivariate regression equation were designed to explore students' e-learning readiness and knowledge sharing levels and the authors investigated the causal relationship among to compare the students' computer, mobile phone and tablet using skills and duration of use. In other words, this descriptive correlational study examines the level of medical students' readiness for e-learning and knowledge sharing

behaviors in emergency remote learning environments by analyzing whether there is any correlation between several variables.

Participants

The research was conducted at Çanakkale Onsekiz Mart University, Faculty of Medicine with the approval of the Scientific Research Ethics Committee, Çanakkale Onsekiz Mart University (18/12/2020-07/16). The data were collected during the COVID-19 pandemic. In this period, medical students (year 1-3) conducted their studies online, 4th and 5th year students through hybrid (online learning-face-to-face) learning, and 6th year students through face-to-face learning environments. Therefore, the Ethics Committee suggested that the data should be collected online, and the data collection form was uploaded to university online platform. In this platform, the students were asked to read the related information about the research and give their consent if they would like to participate in the study. The students who did not accept to participate did not see the scale items related to the study. In this way, data were obtained from 725 students in total out of 994 students (according to 2020-2021 Academic Year) who study at the Faculty of Medicine, Çanakkale Onsekiz Mart University. The participation rate to the study is %73, which indicates that the data could not be obtained from the entire population. Therefore, purposive sampling method was adopted. The researchers, while using purposive sampling, determine the characteristics of the people who will form the research population and they aim to reach the people who have these characteristics. Based on the information about the population, the subjects who can provide the best information for the purpose of the research are selected (Christensen et al., 2014; McMillan & Schumacher, 2014). 398 of the participants (54.9%) are female and 327 (45.1%) are male [173 (23.9%) Year 1, 175 (24.1%) Year 2, 114 (15.7%) Year 3, 112 (15.4%) Year 4, 94 (13%) Year 5 and 57 (7.9%) Year 6 students].

Data Collection Tools

In this study, the data were collected through two different tools described as follows;

Knowledge Sharing Behavior in Online Learning Environments Scale (KSBOLES): The scale developed by Tseng and Kuo (2014) was adapted to Turkish by Avcı Yücel and Ergün (2015). The scale aims to examine how students perceive themselves in terms of knowledge sharing in online learning environments. The adaptation study was carried out with the data collected from university students. The scale consists of two subscales: knowledge receiving (Item 1, 2, 3 and 4) and knowledge giving (Item 5, 6, 7, 8 and 9), and it was designed using 7-point Likert structure. There are no reverse scored items in the scale. In the adaptation of the scale into Turkish culture, the confirmatory factor analysis fit-indexes were determined as X2/df=2.41, RMSEA=.07, SRMR=.03, GFI=.92, CFI=.99, NNFI=.98 and ıfi=.99. The Cronbach Alpha reliability co-efficient of the scale was determined as .90.

E-Learning Readiness Self-Assessment Instrument (ELRSAI): The scale developed by Watkins et al. (2004) was adapted to Turkish by Kalelioğlu and Huri Baturay (2014). The scale aims to assess students' readiness for e-learning. The adaptation was carried out with the data collected from university students. The scale has 6 subscales: technology access (Item 1-3), technical skills (Item 4-7), online relationships (Item 8-12), motivation (Item 17-19), online skills (Item 17-19) and importance of success (Item 20-25). It was designed using 5-point Likert structure. There are no reverse scored items in the scale. The Cronbach Alpha reliability co-efficient of the subscale of the scale was vary between .64 and .84.

Apart from the scales above, the students were also asked four questions about their gender, years of study at the faculty of medicine, ability to use different electronic devices for e-learning (computer, mobile phone, tablet PC, etc.) time spent on the computer, mobile phone and tablet PC per day. However, the gender and years of study variables were not used in any analyses.

Data Analysis

The data were analyzed using R statistical software. Students' e-learning readiness and knowledge sharing behavior levels were analyzed using descriptive statistics (mean, standard deviation, median, etc.). The relationship between the variables was modeled using multivariate regression equation. Students' e-learning readiness and knowledge sharing levels were compared using the MANOVA test according to their computer,

mobile phone and tablet using skills and duration of use. For multivariate regression modeling, the prerequisite for the data to have a normal distribution was ignored.

Tests which focus on normality are hypersensitive tests (Tabachnick & Fidell, 2013). In addition, in many studies, especially in social sciences, the measurement of dependent variables does not correspond to normal distribution (Pallant, 2016). The Central Limit Theorem suggests that if the sample is large enough (n=30+), the sampling distribution of the mean will be normally distributed regardless of the distribution of the variables, and the normal distribution violation will not cause a major problem (Everitt & Howell, 2005; Field, 2018; Pallant, 2016; Tabachnick & Fidell, 2013). In large samples, skewness does not deviate from normal distribution significantly. In other words, if the data set is more than 200, the data is considered normal and parametric tests are applied (Tabachnick and Fidel, 2013). Within this context, multivariate regression analysis and MANOVA were used to analyze the data.

Results

Medical Students' Knowledge Sharing Behaviors in Online Learning Environments

Knowledge Sharing Behavior in Online Learning Environments Scale (KSBOLES) was applied to the participants. The descriptive statistics of the responses given by 725 students (from year 1 to year 6) are shown in Table 1.

Table 1. Medical students' knowledge sharing behaviors in online learning environments

Items of Knowledge Sharing Behavior in Online Learning Environments Scale	Mean (Std. Deviation)	Median (Min-Max)
I read other members' posts in online environments.	4.64 (1.65)	4 (1-7)
I download the educational resources in online environments.	4.76 (1.68)	5 (1-7)
I get other members' learning experiences, knowledge and skills in online environments.	4.61 (1.61)	4 (1-7)
I read other members' sharings in online environments.	4.65 (1.63)	4 (1-7)
I often respond to the topics discussed in online environments.	3.92 (1.62)	4 (1-7)
I often upload educational resources to online environments.	3.75 (1.74)	4 (1-7)
I often share my own learning experience, knowledge and skills in online environments.	3.83 (1.63)	4 (1-7)
I often share my emotion in online environments.	3.64 (1.69)	4 (1-7)
I often express my concerns in online environments.	3.78 (1.70)	4 (1-7)

N=725

"Reading other members' posts", "downloading the educational resources", "getting other members' learning experiences, knowledge and skills" and "reading other members' sharings…" are the items with highest scores in KSBOLES. These items are related to the factor "knowledge receiving" in the scale. The scores of the responses given for the factor "knowledge giving" is lower.

Medical Students' E-learning Readiness Levels

In the study, "E-Learning Readiness Self-Assessment Instrument (ELRSAI)" was also applied to the students. The descriptive statistics of the responses given by 725 students from the year 1-6 are shown in Table 2. The items with highest scores in ELRSAI are:

- Having access to a computer with internet connection
- Having basic skills to operate a computer
- Having basic skills for finding the way around the Internet
- Ability to send an email with a file attached
- Ability to communicate effectively with others using online technologies
- The importance of having regular contact with the instructor
- The importance of quick technical and administrative support to succeed in online coursework,
- The importance of frequent participation throughout the learning process ö
- The ability to immediately apply course materials

Table 2. Medical students' e-learning readiness levels

Items of E-Learning Readiness Self-Assessment Instrument	Mean (Std. Deviation)	Median (Min-Max)
I have access to a computer with an Internet connection.	3.70 (1.19)	4 (1-5)
I have access to a fairly new computer (e.g., enough RAM, speakers, CD-ROM).	3.20 (1.23)	3 (1-5)
I have access to a computer with adequate software (e.g., Microsoft Word, Adobe Acrobat).	3.40 (1.17)	3 (1-5)
I have the basic skills to operate a computer (e.g., saving files, creating folders).	3.74 (1.10)	4 (1-5)
I have the basic skills for finding my way around the Internet (e.g., using search engines, entering passwords).	3.83 (1.08)	4 (1-5)
I can send an email with a file attached.	3.81 (1.08)	4 (1-5)
I think that I would be comfortable using a computer several times a week to participate in a course.	3.47 (1.11)	3 (1-5)
I think that I would be able to communicate effectively with others using online technologies (e.g., email, chat).	3.50 (1.11)	4 (1-5)
I think that I would be able to express myself clearly through my writing (e.g., mood, emotions, and humor).	3.39 (1.12)	3 (1-5)
I think that I would be able to use online tools (e.g., email, chat) to work on assignments with students who are in different time zones.	3.46 (1.11)	3 (1-5)
I think that I would be able to schedule time to provide timely responses to other students and/or the instructor.	3.41 (1.08)	3 (1-5)
I think I am able to chat with others via internet (e.g., Messenger).	3.57 (1.08)	4 (1-5)
I think that I would be able to remain motivated even though the instructor is not online at all times	3.10 (1.12)	3 (1-5)
I think that I would be able to complete my work even when there are online distractions (e.g., friends sending emails or Websites to surf).	3.25 (1.09)	3 (1-5)
I think that I would be able to complete my work even when there are distractions in my home (e.g., television, children, and such).	3.08 (1.14)	3 (1-5)
I think that I would be able to carry on a conversation with others using the Internet (e.g., Internet chat, instant messenger).	3.20 (1.12)	3 (1-5)
I think that I would be able to take notes while watching a video on the computer.	3.32 (1.09)	3 (1-5)
I think that I would be able to understand course related information when it's presented in video formats	3.33 (1.07)	3 (1-5)
I think that I would be comfortable having several discussions taking place in the same online chat even though I may not be participating in all of them.	3.32 (1.05)	3 (1-5)
I sometimes prefer to have more time to prepare responses to a question.	3.62 (1.06)	4 (1-5)
Regular contact with the instructor is important to my success in online coursework.	3.55 (1.08)	4 (1-5)
Quick technical and administrative support is important to my success in online coursework.	3.59 (1.06)	4 (1-5)
Frequent participation throughout the learning process is important to my success in online coursework.	3.51 (1.05)	4 (1-5)
I feel that prior experiences with online technologies (e.g., email, Internet chat, online readings) are important to my success with online course.	3.61 (1.05)	4 (1-5)
The ability to immediately apply course materials is important to my success with online courses.	3.61 (1.05)	4 (1-5)

N=725

The Prediction Level of Readiness for E-Learning on Knowledge Sharing Behaviors in Online Learning Environments

The items with high scores are related to the subscales of "technical skills" and "importance to your success". The impact of medical students' readiness for e-learning on their knowledge sharing behaviors in online learning environments was modeled using multivariate regression analysis. The results are shown in Table 3.

Table 3. The prediction level of readiness for e-learning on knowledge sharing behaviors in online learning environments

Estimated	Predictor	Coefficient	p	95% Confidence Interval		R^2
				Lower	Upper	
Knowledge Giving	Technology Access	0.20	0.081	-0.02	0.43	0.27
	Technical Skills	-0.74	0.0001	-0.99	-0.47	
	Online Relationships	0.46	0.0001	0.26	0.66	
	Motivation	0.59	0.0001	0.39	0.79	
	Online Skills	0.22	0.191	-0.11	0.55	
	Importance of Success	0.13	0.095	-0.02	0.28	
Knowledge Receiving	Technology Access	0.13	0.127	-0.04	0.29	0.46
	Technical Skills	0.25	0.009	0.06	0.44	
	Online Relationships	0.14	0.062	-0.01	0.29	
	Motivation	-0.11	0.118	-0.26	0.03	
	Online Skills	-0.03	0.816	-0.26	0.21	
	Importance of Success	0.47	0.0001	0.36	0.58	

"Online relationships" and "motivation", the subscales of readiness for e-learning scale, are positive predictors for the knowledge giving subscales of knowledge sharing behavior scale ($p<.05$). Therefore, the increase in the readiness levels in terms of "online relationships" and "motivation" will also increase "knowledge giving". "Technical skills", one of the subscales of readiness for e-learning scale, is a negative predictor for the "knowledge giving" subscales of the knowledge sharings behaviors scale ($p<.05$). In other words, the increase in the "technical skills" readiness will decrease the level of knowledge giving. "Technical skills" and "importance of success", the subscales of readiness for e-learning scale, are positive predictors for "knowledge receiving", one of the subscales of knowledge sharing behavior scale ($p<.05$). In other words, the increase in the "technical skills" and "importance of success" readiness levels also increases the level of "knowledge receiving". The exploratory regression percentage for "knowledge receiving" ($R2=0.46$, 46%) is higher than the percentage for "knowledge giving" ($R2=0.27$, 27%).

The Comparison of Students' E-Learning Readiness and Knowledge Sharing Levels in terms of Their Computer, Mobile Phone and Tablet Using Skills and Time Spent on Computer

Students' e-learning readiness and knowledge sharing levels were compared using the MANOVA test according to their computer, mobile phone and tablet using skills and exposure time of use. The results are indicated in Table 4.

Table 4. The comparison of students' e-learning readiness and knowledge sharing levels according to their computer, mobile phone and tablet using skills and time spent on computer, etc. (MANOVA Test)

Effect	Value	F	Hypothesis df	Error df	p	η^2
Computer using skills	0.09	4.02	16	1420	0.000	0.04
Time spent on computer, etc.	0.03	1.35	16	1420	0.158	0.02
Computer using skills *Time spent on computer, etc.	0.05	1.21	32	2848	0.192	0.01

The level of computer, mobile phone and tablet using skills create a significant difference between the students' readiness for e-learning and knowledge sharing behaviors in online learning environments ($F(16\text{-}1420)=4.02$, $p<.05$). this significant difference refers to medium effect size ($\eta2=0.04$) according to the classification proposed by Cohen et al. (2013). According to MANOVA test results, the time spent on computer, mobile phones and tablet PCs do not have a significant effect on the level of students' readiness for e learning and knowledge sharing behaviors in online learning environments ($F(16\text{-}1420)=1.35$, $p>.05$). The interaction of the two main effects (interaction of the ability to use computer, mobile phone, tablet PC and time spent on these devices) does not make a significant difference between the levels of students' readiness for e-learning and knowledge sharing behaviors in online learning environments ($F(32\text{-}2848)=1.21$, $p>.05$). The results of the analysis about which the sub-factors have a significant difference between the levels of students' readiness for e-learning and knowledge sharing behaviors are shown in Table 5.

Table 5. The comparison of students' readiness for e-learning and knowledge sharing behaviors in online learning environments in terms of ability to use computer, mobile phone, tablet PC

Dependent Variable		Sum of Squares	df	Mean Square	F	p	η^2
Knowledge Giving	Contrast	1065.63	2	532.81	9.87	0.000	0.03
	Error	38649.51	716	53.98			
Knowledge Receiving	Contrast	1404.53	2	702.26	19.95	0.000	0.05
	Error	25198.72	716	35.19			
Technology Access	Contrast	296.20	2	148.10	15.26	0.000	0.04
	Error	6948.92	716	9.71			
Technical Skills	Contrast	500.49	2	250.25	17.07	0.000	0.05
	Error	10499.14	716	14.66			
Online Relationships	Contrast	846.93	2	423.46	18.95	0.000	0.05
	Error	15997.89	716	22.34			
Motivation	Contrast	283.59	2	141.79	9.51	0.000	0.03
	Error	10677.44	716	14.91			
Online Skills	Contrast	174.82	2	87.41	11.26	0.000	0.03
	Error	5558.58	716	7.76			
Importance of Success	Contrast	856.16	2	428.08	13.44	0.000	0.04
	Error	22813.18	716	31.86			

According to the analysis, the ability to use computer, mobile phone and tablet PC have a significant difference on all subscales ($p<.05$). All these differences were at medium effect size. According to Bonferroni post-hoc test, which was applied to see if these significant differences are in favor of the students with poor, adequate or high-level ability to use computers, mobile phones and tablet PCs. The results revealed that it is in favor of the students with high level ability to use these devices. To sum up, the students with high ability to use computer, mobile phone and tablet PC have higher readiness level for e-learning in terms of technology access, technical skills, online relationships, motivation, online skills, importance of success. Similarly, they have a higher level of knowledge sharing behaviors in online learning environments.

Discussion

As part of this research, we examined the medical students' readiness for e-learning and knowledge sharing behaviors in online learning environments during Covid-19 and explored the relationship between these variables. First, the responses the students gave for the items in the "knowledge sharing behaviors in online learning environment" scale revealed that they agree more with the items related to knowledge receiving than the items about knowledge giving. This finding is in line with the study conducted by Chao, Hwu and Chang (2011). This may have resulted from the fact that they do not find the online learning environment engaging enough or they feel alone during the online learning practices, and they prefer receiving knowledge more than sharing their own knowledge with others. While we, as educators, aim to develop students skills to be independent and self-directed learners, we should also be careful about the issue that the students may be isolated from each other if they do not interact with each other. This may result in lack of student collaboration, interaction with the instructor and other students, and cause troubles in creating a learning community. In other words, we shouldn't ignore the improvement of social competences while trying to develop their technical or professional competences.

Second, the increase in the readiness level in terms of online relationships and motivation also increases the knowledge giving in online learning environments. This means that when students feel ready for online learning, they are motivated and intend to have more relationship with others in the online learning environments. This finding correlates with the study by Joosten and Cusatis (2020). However, the increase in the readiness level in terms of technical skills has a decreasing role on knowledge giving in online learning environments. But the increase in the readiness level in terms of technical skills and importance of success increases the knowledge receiving behaviors of the students. This reverse affect may have resulted from the idea that the students feel more independent to learn as they have enough technological skills, and therefore, they do not feel the need to give knowledge by engaging with others, but they still intend to receive knowledge in the online environments. Another reason may be the fact that they do not want to share their knowledge as they do not think that the others will be interested in what they share.

Finally, the students with high ability levels to use computer, mobile phone and tablet PC have higher readiness level for e-learning in terms of technology access, technical skills, online relationships, motivation, online skills, importance of success. This finding is in line with the research conducted by Forson and Vuopala (2019) in that students' skills in ICT is an important factor that contributes student readiness. Similarly, it correlates with the findings of the studies by Rahardjo (2018) and Martin, Stamper and Flowers (2020) in that knowledge and ability to use these tools increase student motivation and the expectation of success. However, the time spent on computers, mobile phones or tablet PCs does not affect the level of students' readiness for e-learning and/or knowledge sharing behaviors in online learning environments.

Limitations

This study has a limitation in that the data were obtained from only one medical faculty although there are a lot of medical faculties in Turkey. Therefore, collecting the data from a larger sample could have increased the generalizability of the results. In this context, further research can be conducted with larger samples and can be compared with the findings of our study.

Conclusion

Although the term "emergency" in remote learning sounds "strict" or "rough" at first sight, having experience in digital learning environments will definitely increase students' readiness for e-learning which is quite useful for the educational practices during and possibly after Covid-19 pandemic. This study revealed that medical students' readiness for e-learning is high in terms of knowledge receiving rather than knowledge giving. This shows us that the medical students who participated in this study prefers learning from others rather than sharing the knowledge they have. However, sharing knowledge is a voluntary action and so does their profession; therefore, medical students' knowledge sharing behaviors should also be developed in order to create a sense of learning community. And it is more important for medical students who will work collaboratively in a team to gain such competences as well as learning hands-on clinical skills. Therefore, online learning environments should be designed to promote students' knowledge sharing behaviors. This will not only motivate them learn from each other but also help to get necessary skills (e.g., teamwork, communication, etc.) required for their future profession. To achieve this, medical educators should also be provided with the trainings about how to create a knowledge sharing culture in online learning environments and how to adapt their teaching strategies to enhance knowledge sharing activities more.

We believe that the results of our study will contribute to highlight the essential knowledge and skills that the students should have in order to increase their readiness level for e-learning in terms of technology access, technical skills, online relationships, motivation, online skills, importance of success. In addition, this study reveals original results as it focused on the medical students' readiness for e-learning and knowledge sharing behaviors in emergency remote learning environments during Covid-19. As medical education adopts a more practice or clinical based approach in terms of learning environments, online learning may be considered inadequate for medical students to gain the required knowledge, skills and competences. However, they also need to gain some process skills in addition to technical/clinical skills, and both educators and students should be aware of the fact that, even if it is online, the learning environment should be designed properly to foster these skills. Further research should focus on analyzing the students' e-learning and knowledge sharing behaviors with a larger sample size from different medical faculties and several research can be conducted to investigate about what factors affect the medical students' e-learning readiness and knowledge sharing behaviors.

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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References

Adedoyin, O. B., & Soykan, E. (2020). Covid-19 pandemic and online learning: the challenges and opportunities. *Interactive Learning Environments*, 1-13. https://doi.org/10.1080/10494820.2020.1813180

Affouneh, S., Salha, S., & Khlaif, Z. N. (2020). Designing quality e-learning environments for emergency remote teaching in coronavirus crisis. *Interdisciplinary Journal of Virtual Learning in Medical Sciences, 11*(2), 135-137.

Arkorful, V., & Abaidoo, N. (2015). The role of e-learning, advantages and disadvantages of its adoption in higher education. *International Journal of Instructional Technology and Distance Learning, 12*(1), 29-42.

Avcı Yücel, Ü., & Ergün, E. (2015). Adaptation of the knowledge sharing behavior in online learning environments scale to Turkish: A validity and reliability study, *Başkent University Journal of Education (BUJE), 2*(2), 219-228.

Cameron-Standerford, A., Menard, K., Edge, C. U., Bergh, B., Shayter, A., Smith, K., & VandenAvond, L. (2020). The phenomenon of moving to online/distance delivery as a result of Covid-19: Exploring initial perceptions of higher education faculty at a rural Midwestern university. In *Frontiers in Education, Vol. 5*, p. 203. Frontiers.

Chao, C.-Y., Hwu, S.-L., & Chang, -C.-C. (2011). Supporting interaction among participants of online learning using the knowledge sharing concept. *Turkish Online Journal of Educational Technology, 10*(4), 311–319.

Christensen, L. B., Johnson, R. B. & Turner, L. A. (2014). *Research methods, design, and analysis*. The USA: Pearson Education.

Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2013). *Applied multiple regression/correlation analysis for the behavioral sciences*. Routledge.

Dabbagh, N. (2007). The online learner: characteristics and pedagogical implications. *Contemporary Issues in Technology and Teacher Education, 7*(3), 217-226.

Elrehail, H., Emeagwali, O. L., Alsaad, A., & Alzghoul, A. (2018). The impact of transformational and authentic leadership on innovation in higher education: the contingent role of knowledge sharing. *Telematics and Informatics, 35*(1), 55-67.

Everitt, B. S., & Howell, D. C. (2005). *Encyclopedia of statistics in behavioral science*. The UK: John Willey and Sons.

Ferri, F., Grifoni, P., & Guzzo, T. (2020). Online learning and emergency remote teaching: Opportunities and challenges in emergency situations. *Societies, 10*(4), 1-18.

Field, A. (2018). *Discovering statistics using IBM SPSS Statistics*. The USA: Sage.

Forson, I. K., & Vuopala, E. (2019). Online learning readiness: perspective of students enrolled in distance education in Ghana. *The Online Journal of Distance Education and e-Learning, 7*(4), 277-294.

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2012). *How to design and evaluate research in education*. USA: McGraw Hill.

Han, S.J., Lee, Y., Beyerlein, M. & Kolb, J. (2018). Shared leadership in teams: The role of coordination, goal commitment, and knowledge sharing on perceived team performance. *Team Performance Management, 24*(4), 150-168. https://doi.org/10.1108/TPM-11-2016-0050

Hodges, C., Moore, S., Lockee, B., Trust, T., & Bond, A. (2020). The difference between emergency remote teaching and online learning. Educause Review. https://er.educause.edu/articles/2020/3/thedifference-between-emergency-remote-teaching-and-online-learning

Joosten, T., & Cusatis, R. (2020). Online learning readiness. *American Journal of Distance Education, 34(*3), 180-193.

Kalelioglu, F., & Baturay, M. H. (2014). daptation of e-learning readiness self-assessment instrument to Turkish: The validity and reliability study. *Başkent University Journal of Education (BUJE), 1*(2), 22-30.

Korkmaz, G. & Toraman, Ç. (2020). Are we ready for the post-COVID-19 educational practice? An investigation into what educators think as to online learning. *International Journal of Technology in Education and Science (IJTES), 4*(4), 293-309.

Ma, W. W., & Yuen, A. H. (2011). Understanding online knowledge sharing: An interpersonal relationship perspective. *Computers & Education, 56*(1), 210-219.

Martin, F., Stamper, B., & Flowers, C. (2020). Examining student perception of readiness for online learning: importance and confidence. *Online Learning, 24*(2), 38-58.

McMillan, J., & Schumacher, S. (2014). *Research in education evidence based inquiry.* The UK: Pearson Education.

Pallant, J. (2016). *SPSS survival manual*. The USA: McGraw-Hill Education.

Pillay, H., Irving, K., & Tones, M. (2007). Validation of the diagnostic tool for assessing tertiary students' readiness for online learning. *High Education Research & Development, 26*(2), 217-234.

Rahardjo, D. (2018). E-learning readiness and technology adoption in online tutorial. In *Proceedings of the 32nd Annual Conference of the Asian Association of Open Universities (AAOU) 2018:* Open Education in Human Resource Development in Asia's Period of Integration.

Shim, T. E., & Lee, S. Y. (2020). College students' experience of emergency remote teaching due to COVID-19. *Children and Youth Services Review, 119*, 105578.

Smith, P. J. (2005). Learning preferences and readiness for online learning. *Educational Psychology, 25*(1), 3-12.

Tabachnick, B. G., & Fidell, L. S. (2013). Learning preferences and readiness for online learning. *Educational Psychology, 25*(1), 3-12.

Tseng, F. C. & Kuo, F.Y. (2014). A study of social participation and knowledge sharing in the teachers' online professional community of practice. *Computers & Education, 72*, 37-47.

Wang, S., & Noe, R. A. (2010). Knowledge sharing: A review and directions for future research. *Human Resource Management Review, 20*(2), 115-131.

Wang, G., Zhang, Y., Zhao, J., Zhanh, J., & Jianh, F. (2020). Mitigate the effects of home confinement on children during the COVID-19 outbreak. *The Lancet, 395*(10228), 21–27.

Watkins, R., Leigh, D., & Triner, D. (2004). Assessing readiness for e-learning. *Performance Improvement Quarterly, 17*(4), 66-79. https://doi.org/10.1111/j.1937-8327.2004.tb00321.x

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Are University Students Willing to Participate in Environmental Protection Activities (EPAs)? – Sub-dimensions of Ecological Intelligence as Predictors

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Abstract

Ecological intelligence is a comprehensive understanding that aims to create an awareness regarding how human activities affect ecosystems and to promote preventing unconscious consumption behaviors that would lead to a sustainable life. It enables us to take social, economic and environmental responsibility, also to act cooperatively and sensitively against ecological problems. All this would pave the way for maintaining strong global sustainability in our ecological objectives. This study explores the levels of ecological intelligence (LoEI) of university students; it also investigates the role of the sub-dimensions of ecological intelligence in predicting future participation in environmental protection activities (EPAs). The data were collected via ecological intelligence scale (EIS) and written open-response assessment (WORA) form by using a sample of 179 students. According to the results, the model to predict participation in EPAs indicated that a good discriminative ability with a prediction accuracy of 79.3%. We found that the most significant variables for the prediction of willingness to participate were ecologically conscious purchasing behavior (ECPB), ecological sensitivity (ES), ecological knowledge sharing (EKS) among the sub-dimensions of the EIS. This study is an important contribution to solve environmental problems by developing an ecological intelligence responding to the individual, social and economic needs of the next generation.

Introduction

Due to the many problems such as global climate change, species extinction, pollution of natural resources, ozone layer destruction, our planet and its ecosystems advancing towards a breaking point (Dyment et al., 2014; Foster et al., 2008; Organisation for Economic Co-operation and Development [OECD], 2014). These problems rapidly disrupt the ecological balance of nature and threaten the sustainability of the existence of humanity and other life forms in nature. When the main cause of these ecological problems and ecological destruction that we face today is investigated, it is seen that the major role is human actions (Goleman, 2009; Goleman et al., 2010; McCallum, 2008; Orr, 2004; UN Environment Programme [UNEP], 2006). Miéville (2015, p. 16) emphasizes the impact of human actions in ecological changes by establishing a link between human actions and ecological problems. The idea that human actions lead to ecological destruction has become more evident with the 'mechanical approach' in the enlightenment and the industrial revolution. Although this approach is the understanding of the world that today's modern industrial civilization owes its existence to, it has led to more production and consumption than nature can bear. The unconscious excessive consumption of people with the concern of being able to provide their vital needs has brought about ecological problems that are difficult to compensate until today. Researchers point out that due to excessive consumption, the impact of human actions on the environment has reached a significant extent and we are entering a new geological period called the Anthropocene (Miéville, 2015; Waters et al., 2015). In the emergence of this period, the man on a large scale has a role in determining power on a global scale; he has become a biological, chemical, and geological actor (Crutzen, 2002; Zalasiewicz et al., 2011). Recent years saw such disastrous developments as the rapid melting of polar glaciers, extreme rise of the limit values in climate change, as well as the increase in floods and droughts (Steffen et al., 2007) which are all caused by human actions. It indicates that we need to adopt an ecocentric worldview instead of an anthropocentric one, also that we need to develop a new type of consciousness. At this point, it is very important to solve environmental problems by developing a new ecological consciousness and taking a collective approach. Environmental movements, such as EPAs involving collective action, have emerged in response to such ecological destruction in ecology-based social struggles.

A New Kind of Ecological Paradigm: Let's Explore Our Ecological Intelligence

Sustainability problems are complex and interrelated, specific key abilities are needed to be able to solve these problems (Wiek et al., 2011). Studies in the literature emphasize the need to lay the foundations for a new ecological paradigm for solving sustainability problems (Bowers, 2010; McCallum, 2008; Sterling, 2009). At this point, researchers ground the realization of paradigmatic transformation associated with solving environmental problems on individuals discovering and developing their ecological intelligence. Ecological intelligence, based on how our activities affect the ecosystem, comes across as an understanding that drives us to change our buying behaviors to live a sustainable life. The development of ecological intelligence brings about individual and social responsibility in the face of ecological problems (Goleman, 2009; Shumba, 2011; Sterling, 2009).

McCallum (2008) stated that we are conscious, romantic species and are the guardians of our zoo; however, if we do not accept this, we will continue to be the creators of our disaster. The importance of taking responsibility in the face of ecological problems, as well as the measures taken individually, to play an active role in environmental activities as a collective and especially to take part in various EPAs, cannot be ignored (Kirchain et al., 2017; Wang et al., 2010). Individuals who are aware of the problems related to nature are sensitive to nature, support individual and social developments, are conscious consumers, have environmental concerns, are open to innovation, and are willing to engage in acts against ecological problems on the level of social action. The seeds of ecological intelligence can influence individuals of the natural world and, possibly, actions (Hornbuckle, 2008). The main purpose of this study is to determine whether ecological intelligence has a role in predicting the actuality of an individual's participation in future EPAs.

Based on Howard Gardner's (1983) theory of multiple intelligences, psychologist and science journalist Daniel Goleman describes ecological intelligence as an 'all-encompassing sensibility' (Goleman, 2009, p. 44) that reveals the interconnections between human actions and their impacts on the planet, human health, and social systems. Ecological intelligence embraces the holistic, organismic or ecological worldview and arises in response to the limits of the modernist worldview, which rejects the dominant mechanical approach (Bowers, 2010). It is a more humanistic, relative, and less consumeristic lifestyle based on ecological intelligence. In this context, ecological intelligence is a type of consciousness that guides our behavior to live a sustainable life in our living space, including cognitive and affective components. Regarding the ecological intelligence concept; Goleman (2009), states that the individual can be an environmentally conscious producer and consumer by knowing her/his own impacts, favoring the improvements, and sharing what he/she learns. When the definition of this concept, outlined by Goleman (2009), is examined closely, ecological intelligence leads the individual to evaluate ecological problems in economic, social, and environmental dimensions. So, the ecological intelligence, which has been indispensable for sustainable development in recent years, approaches environmental problems, not from a single point of view, but a variety of dimensions including the above-mentioned ones (Flower, 2006; Lummis, 2002).

Social, economic, and environmental aspects are also the basis of sustainability (Fischer et al., 2020; Purvis et al., 2019). On this basis, ecological intelligence is also a key pathway for strong sustainability in our ecological objectives (Fischer et al., 2020). When approached from all these aspects, ecological intelligence enables us to comprehend systems in all their complexity and to better understand the interaction between what is natural and what is man-made. However, this understanding requires enormous multidisciplinary knowledge, and it is extremely important to have a collective understanding to get ahead in this complexity. As a community, we need to learn on the one hand what dangers we face, what causes them, and how to neutralize them, and on the other hand, we need to move forward by recognizing the new options these solutions offer (Bowers, 2010; Goleman, 2009). It is at this point that the approach to ecological problems with community psychology is a crucial step in the fight for sustainability.

The Role of Ecological Intelligence in Sustainability with Its Various Sub-dimensions

Maintaining strong global sustainability is possible by preventing unconscious consumption behaviors that lead to the extinction of nature (Murphy et al., 2008). This is why it is important to determine the conscious purchasing behavior that constitutes more of the cognitive side of ecological intelligence. Bayazıt Hayta (2009) emphasizes that if our consumption behavior improves, manufacturers would be forced to focus on environmental problems that may occur during the processes of production, transportation, and procurement. At the United Nations Conference on Environment and Development (1992) it is stated that unsustainable consumption and production models are the main cause of environmental degradation (Akenji & Bengtsson,

2014). At this point, our conscious purchasing behavior, which ecological intelligence will bring to us, will contribute to sustainability in terms of both economic and environmental change. On this basis, it is extremely vital to determine individuals' informed purchasing behavior levels and subsequently to establish whether their purchasing behavior has a role in their future actions for sustainability or not.

One of the serious consequences of increasing consumption habits today is the hidden impacts of products on the ecosystem (Tukker & Jansen, 2006). Azapagic (2003) states that the environmental and health impacts of the product must be considered during the entire supply chain within the framework of the life-cycle approach. When we examine the hidden impacts of each product we buy, we encounter problems such as climate changes, greenhouse effects, thinning of the stratospheric ozone layer, and depletion of natural resources (Collins et al., 2006). As the production and consumption forms developed within the framework of the economic competition approach are taken into consideration, it is seen that the products manufactured using cheap raw materials also cause problems that disrupt human psychology and physiology. Besides, the toxic effects that workers are exposed to during the manufacture of products and therefore the working conditions also reveal the importance of the hidden impacts from social and environmental aspects. In this context, knowing the hidden impacts of products will contribute to sustainability in various aspects. This is possible through the identification and development of ecological awareness, i.e. ecological intelligence, regarding the individual, social and economic benefits of the needs of the next generation.

Understanding how nature is sustainable, everything that constitutes life is interconnected, and that it continues in ecological balance include empathy development with all life forms (McCallum, 2008). Therefore, ecological intelligence is also related to the affective domain (Sterling, 2009) and it naturally evolves from the development of social and emotional intelligence (Goleman et al., 2012). Because having ecological intelligence leads the individual to act sensitively at the point of receiving products that are harmful to the ecological balance and to react accordingly when necessary. This enables us to take social and environmental responsibility and act cooperatively against ecological problems. Goleman (2009) emphasizes the importance of collective understanding by stating that when sharing ecological knowledge, we need to think by acting together like insects. Ecological intelligence requires a collective and collaborative effort, as no single mind is able to grasp all the essential knowledge regarding our ecological problems and the countless potential impacts of our actions on the environment (Kirchain et al., 2017). In particular, this collective understanding took its place on the agenda with the period of the Industrial Revolution, when environmental problems became more evident, and with this understanding, many environmental organizations emerged. Today, environmental activities on a global scale are continuing within the scope of this understanding. Individuals who are sensitive to ecological issues become a member of international voluntary environmental organizations such as the 'World Wide Fund for Nature (WWF)', 'Greenpeace' and/or national voluntary environmental organizations in their countries. People are expected to act together in solving environmental issues for a more sustainable world, share ecological knowledge, and take an active part in various activities (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2012). This is especially possible with the ecological consciousness acquired during the education and training process. On this basis, it is predictable that students at the university level who are trained to take on all these responsibilities will also be individuals with a high level of ecological intelligence. Many studies are based on university-level students' awareness of the significance of protecting the environment in a sustainable society and their ability to actively participate in environmental activities to use and develop ecological intelligence (Chili, 2014; Suwandi et al., 2017). From this point of view our research seeks to answer the following questions:

- What are the levels of ecological intelligence of university students?
- What are the university students' average scores and levels concerning the sub-dimensions of ECPB, HEIP, ES, and EKS?
- What are the students' views on the sub-dimensions of ecological intelligence?
- Do the sub-dimensions of ecological intelligence predict their participation in future EPAs?

Method

Research Model

The research was carried out by the synthesis of qualitative and quantitative methods in accordance with a descriptive research model. The synthesis of these two methods by taking into consideration the research problem and its nature together increases the quality of the research by eliminating the shortcomings of using a single method (Greene, 2005).

Sample

The participants of the study consisted of university students (N:179) attending the Primary School Teacher Education Program of the Faculty of Education of a State University in the western part of Turkey. The study group was determined by a purposeful sampling method. Students who took the Environmental Education Course were included in sample group. Participants were informed about the purpose of the study and the data tools. We received consent forms for their voluntary participation. Demographic categories of the students (class, gender, age, etc.) are shown in Table 1.

Table 1. The frequencies and percentages of the sample in three demographic categories

Categories	f	%
Gender		
Female	118	65.9
Male	61	34.1
Age		
18-19	76	42.5
20-21	85	47.4
22-23	12	6.7
24-25	6	3.4
Grade		
1	86	48.0
2	93	52.0

To achieve the fundamental purposes of our survey, we asked the students 1a) whether they were members of environmentalist organizations, 1b) whether they were participating in EPAs, 1c) whether they consider to participate in future EPAs. The distributions of students' answers according to these questions are shown in the Figure 1a, 1b, 1c.

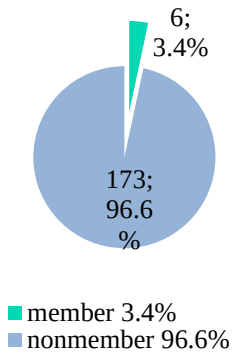

Figure1a. Distribution of membership status

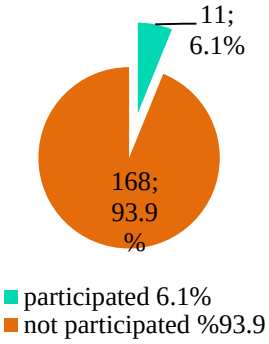

Figure 1b. Distribution of attendance status

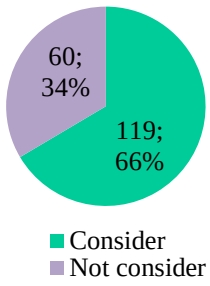

Figure 1c. Considering to attend EPAs

Instruments

Ecological Intelligence Scale (EIS)

The EIS developed by Akkuzu (2016) is a measurement tool aiming to determine LoEI, which is inspired by Goleman's (2009) consumption behavior of individuals. This scale basically enables us to determine our ecological intelligence levels from various perspectives such as purchasing behaviors, hidden impacts of a product, ecological sensitivity, and knowledge sharing. It also facilitates to establish the ecological problems caused by our consumption behavior economic, social, and environmental aspects in terms of reproduction. The EIS, which is valid and reliable with the data obtained from university students studying in various departments of the Faculty of Education, has scale items that can be applied to both university-level students and adults of all ages. On this scale, which is of the 5 point Likert type, frequency categories and scores are 'Always' (5), 'Often' (4), 'Sometimes' (3), 'Rarely' (2), and 'Never' (1). The EIS consists of 41 items and 4 sub-dimensions. One of the

sub-dimensions is ecologically conscious purchasing behavior (ECPB) (14 items) that includes statements about what individuals pay attention to when purchasing products. Another sub-dimension of the scale is hidden ecological impacts of products (HEIP) (12 items) that is related to the hidden impacts that individuals create in the ecosystem during the production and consumption stages of the products they purchase. The third sub-dimension, called ecological sensitivity (ES) (10 items) that reveal individuals' awareness and sensitivity to ecological problems. The fourth sub-dimension of the scale is ecological knowledge sharing (EKS) (5 items), which emphasizes the importance of sharing information about ecology. The reliabilities of the sub-dimensions are respectively .86, .82, .80 and .70. The minimum score that can be taken from the scale is 41, while the maximum score is 205. In our research, the EIS was used to determine the level of ecological intelligence that the students have and to evaluate the average scores obtained from the scale for the students' participation in future EPAs.

The Written Open-Response Assessment (WORA) Form

We prepared the WORA form in order to examine in depth the students' views on the sub-dimensions of ecological intelligence. This form consisted of a total of four open-ended questions and originally prepared by the researchers (Table 2). Two experts were asked their opinions before the questions were applied to the students. One of the experts was environmental science specialist and the other was chemistry education specialist. Students were provided to answer these questions in approximately 30 min.

Table 2. WORA form questions

Sub-dimensions	Questions
ECPB	Please explain the relationship between consumer behavior of people (buying products, etc.) and environmental issues.
HEIP	Do you think that the products you buy have hidden impacts on environment? What do you think the hidden impacts might be?
ES	What kind of responsibilities or precautions do you prefer to take when you consider your role as a consumer in dealing with environmental issues?
EKS	Do you share the information concerning the precautions you take against environmental problems in your social environment (family, relatives, friends, etc.)? How do you share?

Data Analyses

Data collection tools were applied to students during the fall semester of the 2018-2019 school years. The data were scored and coded according to scale characteristics and transferred to computer media. The data for conformance with a normal distribution was tested with the Shapiro-Wilk test and all data were found to show normal distribution ($p>0.05$). Descriptive statistical analysis was used as data analysis to determine the students' LoEI and the mean ($\bar{X}$), standard deviation (S), minimum and maximum values were calculated for each dimension of the scale (Table 3). The dependent variable examined in the research is the willingness of the students to participate in EPAs. Logistic regression analysis was preferred to study the relationship between ecological intelligence sub-dimensions and the categorical dependent variable. Through this analysis, the probability of realization of one of the values (0, 1) that the dependent variable can reach is estimated. In the estimation of parameters in the logistic regression model, the maximum likelihood has been used as one of the most widely preferred techniques in the literature. With this technique, a prediction is made that selects the parameters for which the observed data is most likely to be contained within the regression model (Ward & Ahlquist, 2018).

We utilized content analysis in order to study WORA forms from which the qualitative data of the research was obtained. Based on the qualitative data, themes have been created. Besides, in the results, the students' sentences are quoted one-to-one and the related theme is given with sample expressions (e.g., [S23]). We used the agreement rate formula of Miles and Huberman (1994) and reached a 97%.

Results

The results of the study are discussed in two main topics. First, the scores of the students from the sub-dimensions of the EIS and the overall scale, as well as the content analysis results are presented. Second, the

willingness of the students to participate in EPAs according to their scores on the EIS is estimated with the results of logistic regression analysis.

Students' LoEI

Table 3 indicated that the students' LoEI were a fraction above the average level. We determined that they received slightly above average scores of 3.5 and 3.6, respectively, from the sub-dimensions of HEIP and ECPB, while the rating scores were 3.8 and higher in the sub-dimensions of ES and EKS. The lowest score on the scale appears to belong to the sub-dimension of HEIP.

Table 3. Descriptive statistics on EIS and its sub-dimensions

Sub-dimensions	N	Min	Max	S	$\bar{X}$	Rating scores	Levels
HEIP	179	24	60	6.92	42.4	3.5	Slightly above average
ECPB	179	39	69	5.88	50.2	3.6	Slightly above average
ES	179	25	49	4.50	37.9	3.8	High
EKS	179	9	25	3.14	18.8	3.8	High
Total	179	116	184	14.6	149.3	3.6	Slightly above average

Content Analysis of WORA

The results of content analysis are presented in this section. The percentages of themes are ranked from high to low in Figure 2.

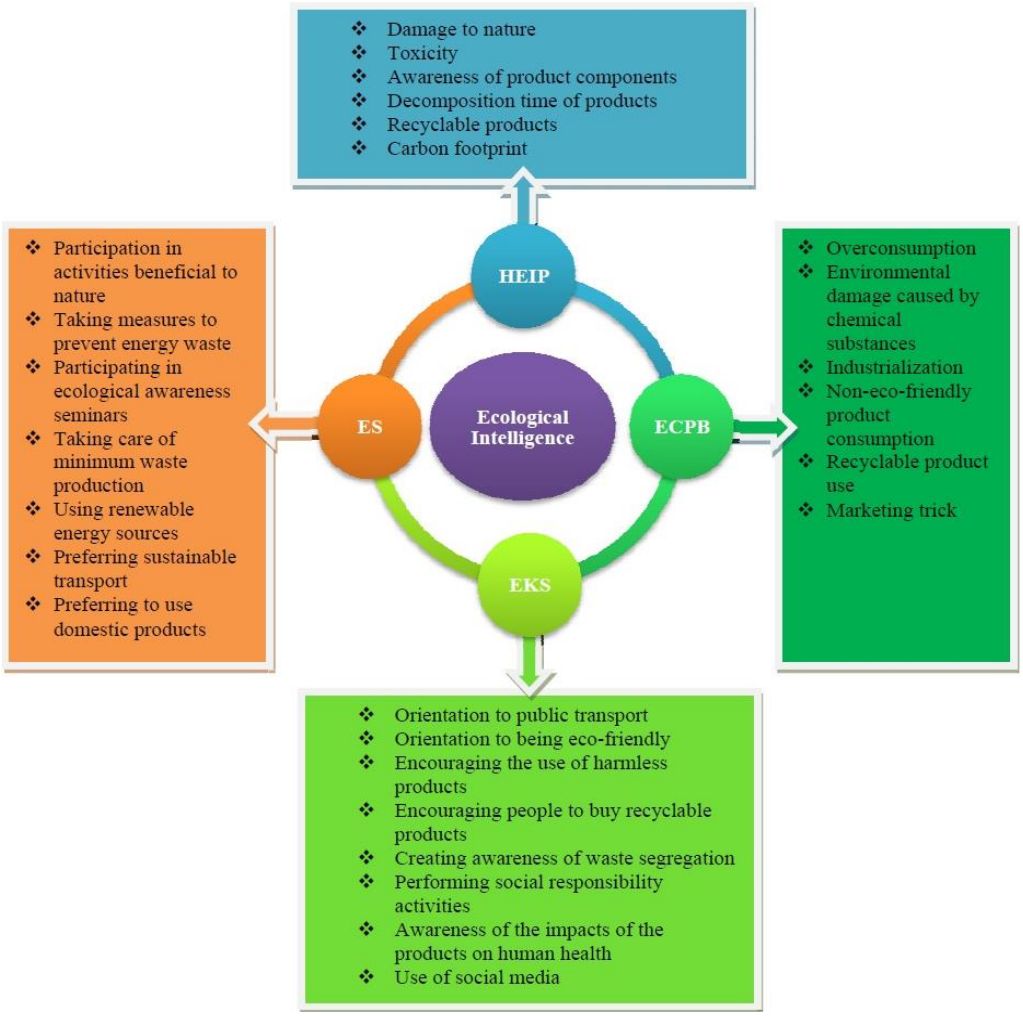

Figure 2. Theme diagram for sub-dimensions of ecological intelligence

Students' Views on the Sub-dimension of ECPB

About conscious purchasing behavior, 40% of the students focused more on 'overconsumption' behavior related to environmental problems and expressed that consumption led to environmental problems on a global scale.

> People always buy more than they need. The especially cheap or falling price of products is very popular. No one thinks about the damage to the environment when buying. For example, when he sees a cheap T-shirt, he buys more than he needs. [S52]

In the study, 20% of the students stated that their purchasing behavior should be changed considering the 'harms that chemical substances cause to the environment' in the contents of the products. 12% of students also expressed their opinion on the preference of 'use of recyclable products' when purchasing products.

> People often buy (plastic) products that are hard to recycle and the production of these plastic products is based on oil and much damage is done to nature during production. [S40]

> Because the products people consume are returned to nature as waste, the soil, the water, everything gets polluted. So the consumer is hurting nature. To give an example of this, if a water bottle we take is thrown into the soil instead of recycling, the soil becomes contaminated. The right thing is recycling. [S150]

Students' Views on the Sub-dimension of HEIP

As seen in Figure 2, views on the hidden ecological impacts of products are summarized in a total of six theme titles. It is observed that the majority of students (45%) pay the most attention to the hidden impacts of the products and what they put forward is 'damage to nature'. It is also understood that the students are careful to pay attention to the content of the products (12%) in the expressions they use, but they do not have sufficient knowledge about the hidden impacts of the products.

> ...for example, roll-on deodorants should be used instead of spray deodorants...Herbal cleaning agents should be preferred instead of hazardous chemical cleaning agents. [S18]

> Although bleach seems to have nothing to do with global warming, bleach affects global warming by polluting the water and then spreading it. [S122]

It is observed that 24% of the students also touched on the theme of 'toxicity' in the hidden impacts of the products.

> The products we buy are necessarily harmful to both the environment and human beings. But I do not know exactly who are hurt by the products in this process, what their toxic effects are. Unfortunately, we are not informed about this. [S8]

> Since we all are a consumer, of course, I think we are affected. Chemical drugs found in the food we eat, GMO foods, artificial fertilizers and heavy metals involved in the soil through the food we eat is disrupting our health. [S34]

In the answers to the question, 7% of students think they do not know enough about recycling.

> We throw the products we buy into the same dustbin, regardless of whether they're recycled or not. We are not conscious of these matters. [S83]

Students' Views on the Sub-dimension of ES

Based on the themes regarding ES, 25% of the students stated that they preferred to 'participate in activities beneficial to nature' in terms of ecological sensitivity. Among these activities, they included the afforestation (planting of seedlings, etc.) studies most in their statements.

> I take care to participate in afforestation...I take care to use public transport. [S59]

> Afforestation is a process where new forests are planted on treeless land. We participate and support such activities. Because green areas are one of the most important investments of cities, accessible green spaces make cities livable. [S45].

Besides, 22% of the students on their sensitivity to environmental problems 'taking measures to prevent energy waste', 17% 'participating in ecological awareness seminars' and 13% 'creating minimum waste' expressions related to the themes are encountered.

> We're participating in environmental awareness seminars and trying to acquire ecological consciousness. [S97]

> We also have a recycling bin in our house. We throw our trash in the trash can. We collect waste oils and batteries and dump them in their boxes. [S83]

> We need to recycle wastes. Thus, there is no need to search for new raw materials for the production of consumables. In this way we can prevent both air and environmental pollution [S78].

Students' Views on the Sub-dimension of EKS

Students shared more information about 'orientation to public transportation' (21.5%), 'orientation to be eco-friendly' (21.5%), 'encouraging to use harmless products' (21.5%) in their social environment for environmental problems.

> ...I'm warning people around me to use public transport. [S59]

> We walk as much as possible instead of using cars. We encourage the people around us to take measures to limit our city's carbon dioxide production. One of the areas where fossil fuel consumption, which directly causes carbon emissions, occurs most in daily life, is transportation. We can make a surprising contribution to nature by renewing our transportation habits [S17].

> We're trying not to throw rubbish around but to use organic matter. We tell the people around us the harm of polluting the land. When a person pollutes the environment, they will both commit suicide and commit murder, so we explain this to them thoroughly. [S62]

Besides, 8% of the students stated that they carried out 'social responsibility activities' on environmental issues.

> ...I buy what I need without brand obsession. I attend awareness conferences and pass it on to my friends. [S24]

In summary, given these views of the students, we are faced with students whose levels of ecological intelligence are not low. These views also support scores from the sub-dimensions of ecological intelligence that emerge as a result of quantitative analyses. Therefore, revealing the willingness of this group of students with a moderate level of ecological intelligence to participate in future environmental activities provides an insight into whether these groups of students at this level will actively participate in EPAs.

Logistic Regression Analysis

Logistic regression analysis was performed to determine the sub-dimensions of the EIS that were effective in the students' willingness to participate in EPAs. The independent variables of the research considered to be effective on the willingness to participate in EPAs are x_1: ECPB, x_2: HEIP, x_3: ES, x_4: EKS. Participation in EPAs was the dependent variable of research (y) and is coded as 0 - I do not consider; 1 - I consider.

The results of the Wald test were used to determine whether the independent variables were significant or not. Besides, Exp (β) values indicate the exponential function of the logistic regression coefficient in other words odds ratios (Field, 2009). The effects of all other sub-dimensions of the EIS except HEIP on the dependent variable were significant at a 95% confidence interval (Table 4). The results indicated positive β coefficients for the independent variables. Since the odds ratios of the independent variables were measured higher than 1, they were in the direction of increase. When we examined the maximum likelihood coefficient estimates which were

calculated after the analysis, ES and EKS variables had a greater impact on the students' willingness to participate in EPAs than other variables. As a whole, the rise in students' LoEI increases their tendency to participate in EPAs.

Table 4. Results of the analysis on sub-dimensions in the logistic regression model

Sub-dimensions	β	S.E	Wald	df	Exp(β)	p
Constant	-14.282	2.542	31.563	1	.000	.000
ECPB	0.094	0.042	5.063	1	1.099	.024
HEIP	0.023	0.033	0.499	1	1.023	.480
ES	0.129	0.057	5.060	1	1.137	.024
EKS	0.244	0.080	9.377	1	1.277	.002

The Regression Model Established as a Result of Logistic Regression Analysis

$$log - odds = ln\left(\frac{p_i}{1-p_i}\right) = 14.282 + 0.094.x_1 + 0.129.x_3 + 0.244.x_4$$

The Goodness of Fit Test for the Logistic Regression Model

The efficiency of explaining the dependent variable of the model in the best way was examined with the goodness of fit of the model. The Hosmer - Lemeshow test was used to evaluate goodness of fit for logistic regression model. The chi-square value for the test was 12.575 with a significance level of .127 ($p>0.05$). The fact that this non-significant p-value indicates that the model has an acceptable alignment, in other words, the model fits the data (Hosmer & Lemeshow, 2000, p. 156).

To test the goodness of fit, the classification table was also used. This table was created by cross-classification of the dependent variable of the research (willingness to participate in EPAs). The classification table presents the observed and the predicted outcomes and the predictive accuracy of the logistic regression model (Table 5).

Table 5. Classification table of the logistic regression model

Participation in EPAs	Observed	Predicted		Percentage correct (%)
		Not consider	Consider	
	Not consider	35	25	58.3
	Consider	12	107	89.9
Overall percentage (%)				79.3

The accuracy percentages in the classification showed that 58.3% of students who did not intend to participate in EPAs and 89.9% of students who did. Regarding the students' willingness to participate in EPAs, we found that 60 students marked 'I do not consider' and 119 marked 'I consider' (Figure 1c.). However, as we can see from the classification table as a result of the data, 25 of the students in the 'not considering' group were actually estimated in the 'considering' group. Similarly, 12 of the 119 students who had selected the first 'I consider' option were again classified in the 'not considering' group. As a result, the findings of a total of 179 students accurately estimated the impact of the sub-dimensions of the EIS on students' participation in EPAs by 79.3%.

Discussion and Conclusion

In our study, we examined the university students' LoEI and their participation in future EPAs regarding ecological intelligence levels by logistic regression. The results from the EIS showed that the students' LoEI were a fraction above the average level. Furthermore, the research results from the logistic regression analysis indicated that the students' LoEI and their willingness to participate in EPAs in the future were related. Increasing the students' levels of knowledge and awareness about environmental issues affects their attitudes and behaviors towards the environment (Akkuzu, 2016; Campbell Bradley et al., 1999). Having ecological intelligence, as it contains cognitive and affective components, drives our behavior to live a sustainable life in our living space (Goleman, 2009; McCallum, 2008). In the struggle for sustainability, students can approach the foundation of environmental problems from various dimensions, including social, economic and environmental, when they acquire this ecological awareness that develops with knowledge and awareness (Fischer et al., 2020).

Bateson (1972) emphasizes that, given the nearly seven billion people who have adopted the individual-centered consumer-dependent lifestyle, if it can slow down the current rate of environmental destruction, it is necessary to learn to use ecological intelligence more in the direction of daily life. Hence, it is predictable that the students who have advanced ecological intelligence will care about environmental issues in their future lives. Consistent with this interpretation, a study conducted in China demonstrated that students with a higher level of environmental knowledge and a more positive attitude towards the environment are more likely to engage in environmentally responsible behavior in the future than other students (He et al., 2011). Wang et al. (2010) asserted that the way to solve environmental problems is to improve and increase public ecological awareness, people's responsibilities to protect the environment, and harmony between human beings' behaviors and the environment through environmental education and training.

Conclusions on the Sub-dimension of ECPB and the Role of ECPB in Participating in EPAs

Results showed that students were engaged in behaviors varying between 'often' and 'sometimes' levels in their consumption habits decisively with an approach to ecological consciousness. In the results of the WORA in which the relationship between purchasing behavior and environmental issues was asked, the students focused more on overconsumption behavior. Students argued that individuals' unconscionable purchasing behavior leads to overconsumption, which in turn is effective in environmental problems. The results of research in accordance with this assertion reveal that consumers do not accept overconsumption as personal responsibility and that many do not perceive that purchasing actions have a significant impact on the environment (Connolly & Prothero, 2003; Pereira Heath & Chatzidakis, 2012). Another theme that emerged within the scope of this dimension was to take into account the chemical hazard in their contents when purchasing products. A significant proportion of the students stated that the products should be purchased by taking into account the damage caused by the chemicals in the contents of the products to the environment. In this context, the students emphasized that individuals had a materialistic conception of consumption. We can deduce from the concept of materialist consumption that its results are a form of behavior without considering its impacts on the environment. Other research that supports this conclusion demonstrates that the understanding of consumption has a negative relationship with individuals' beliefs about environmental responsibility (Kilbourne & Pickett, 2008). The unconscious consumption of people with the concern of being able to provide their vital needs has brought about ecological problems that are difficult to compensate until today. For example, one of the main causes of climate change is the cycle of production and consumption (Goleman, 2009; Steffen et al., 2007). Therefore, the sustainable environment and sustainable development can be mentioned through sustainable production and consumption, which is based on the principle of less waste generation, where less natural resources and energy are used (Knowles et al., 2012).

The results of the sub-dimension of ECPB regarding the participation of students in EPAs revealed that the students would highly likely participate in such activities. Consistent with this conclusion, studies suggest that individuals' purchasing behaviors are related to their environmental attitudes (Chen & Chai, 2010; Mansaray & Abijoye, 1998; Schwepker & Cornwell, 1991). We can infer that individuals who positively exhibit environmental attitudes and behaviors apply these behaviors while consuming. Human beings must acquire such a consciousness of consumption in their early childhood education. Because ecological intelligence includes cognitive and affective components, the development of ecological consciousness and responsibility for the environment, as well as the reflection of behavior, covers a long period (Sterling, 2009).

Conclusions on the Sub-dimension of HEIP and the Role of HEIP in Participating in EPAs

We found that the students participated in behaviors related to this dimension ranging from 'often' to 'sometimes' level. We also determined that the lowest scores belonged to this sub-dimension. We identified that the students focused more on the damage that products cause to nature and their toxic effects on human beings. The students stated that both they and the society did not have sufficient knowledge of this theme and therefore they did not have an awareness of themselves. However, in perceiving future dangers related to the hidden impacts of products, one must exceed the threshold limits of perception and develop the ability to see the uncertain (Goleman, 2009). Another result of this dimension was that very few of the student preferred recyclable products. The reason of this problem may be that recycling is not perceived consciously enough. Additionally, Emanuel and Adams (2011) determined that although college students pay attention to recyclable products in general, a majority of them did not prefer environmentally friendly products in their purchases. In this context, we can infer that environmental awareness and knowledge should be learnt together in order the students to become further conscious of the ecosystem.

The results of the logistic regression analysis of HEIP also showed that it was not an effective variable in the regression model. The reason for this is the lack of knowledge of the students can be considered. Because we may conclude that students do not know about the pollution that occurs in the process of manufacturing, consuming and discarding a product. This indicates that individuals act without considering the environmental effects of the products. On an equal footing with these results, there are numerous studies revealing that even individuals who are environmentally conscious, give priority to secondary factors such as price, brand, and quality, yet they do not attach enough importance to its harmful impacts on the environment while purchasing a product (Othman & Umar, 2000; Said et al., 2003).

Conclusions on the Sub-dimension of ES and the Role of ES in Participating in EPAs

Considering the results, the students opted for 'often' items related to ecological sensitivity. Therefore, this result shows that students are individuals who feel responsible for ecological problems. At the same time, we drew from the statements they used in the themes of the talks such as doing activities beneficial to nature, paying attention to energy saving, taking care of minimum waste production. On the other hand, as the regression analysis results of such a sample group with high ecological sensitivity were examined, we found that the sub-dimension of ES had a predictor effect on the students' participation in future EPAs. In this context, we can assert that the ecological sensitivity of the students is an essential factor in shaping their environmental behavior. Johnson (2004) stated that the philosophy of good living is possible with life where there is sustainability from an environmental standpoint and that ecological sensitivity is a determining component for sustainability. In line with the results of ES in our research is the study of Yılmaz et al.(2009). Their study disclosed that the ecological sensitivity plays an important role in purchasing an ecological product. Similarly, in her study concerning the views of university students, Gheith (2013) reached the conclusion that students had a positive relationship between environmental values and environmental behavior; she emphasized that as the ecocentric perspective increases, the level of pro-environmental behavior will increase as well. A new environmental paradigm understanding arises against the anthropocentric world perspective in the individual with increasing environmental values, and this understanding initiate the environmental ethic, ecological conscience, and ecologically sustainable culture. In this way reflections of personal values trigger alternative perspectives that may stimulate a more flexible viewpoint toward environmental sensitivity (Hart, 2003). From that viewpoint empathy also can be developed through direct contact with other living things. Goleman et al. (2010) stated that we can expand our circles of empathy to consider the quality of life of other life forms, feel genuine concern about their well-being, and act on that concern. Because expanding empathy influences motivation to help by adding to rational cause-and-effect analysis. In this way, individuals with an ecological sensitivity who develop empathy also develop socially and environmentally responsible behaviors for ecological problems, which enable individuals to assume universal responsibility for sustainable development (Dobson, 2007). Therefore, this behavior enables individuals to understand the reasons underlying ecological problems, to conceive potential solutions that can be produced and to play an active role in environmental activities. In our research, we can infer that students with high ecological sensitivity have a sustainable environmental understanding and can take part in future EPAs.

Conclusions on the Sub-dimension of EKS and the Role of EKS in Participating in EPAs

Another results in terms of EKS the students 'often' shared their ecological knowledge about the products they had purchased and the ecological problems caused by the products with their friends and family. Relying upon the results of our study, we further investigated what sort of information the students share with people in their social environment. Considering the results, students encourage people in their social environment to use harmless products, to prefer public transport, to take part in social responsibility activities. Said et al. (2003) emphasized in their study that the development of environmentally responsible behavior can be increased with registering the clubs about nature, environmental seminars, environmental campaigns, and through active participation in outdoor activities. In this context, we can suggest that individuals can develop socially in terms of this behavior by carrying out activities related to environmental protection. This clearly demonstrates that there is a reciprocal relationship between EKS and participation in EPAs. Individuals who promote the spread of ecological knowledge are also individuals who can act cooperatively by adopting collective understanding (Goleman, 2009; Shumba, 2011; Sterling, 2009). In this regard, taking responsibility and reacting to ecological problems as a community forms a social dimension in collective and environmental understanding and encourages individuals to participate together in environmental activities for a sustainable world. At this point, fact that the sub-dimension of EKS in the regression model is encountered as a significant variable also in our study results and thus is a predictor variable, proves that it is a crucial dimension supporting students'

participation in future EPAs and encouraging individuals in this direction. The students' views that came to light within the scope of EKS also confirmed this result with various themes. For example, leading students to be eco-friendly in their social environment is another indicator of ecological knowledge sharing. In the study carried out by Kreis and Rauch (1999) students were trained primarily on production, consumption, and trade in the social responsibility project 'Neighborhood Store'. Afterward, these students visited their neighbors who lived in the neighborhood and discussed their consumption and shopping habits and tried to make changes in their consumption habits over time. The behavior of modeling from interpersonal relationships, especially close environment, can also improve environmental protection awareness among people. In line with our conclusion, Estrada-Vidal and Tójar-Hurtado (2017) have also suggested that we are influenced by the advice and consumption habits of those in our immediate environment and that we can support sustainability by achieving improvements in environmental and social dimensions.

Limitations and Recommendations

We are aware that our findings are still limited, because we examined only a small sample of the university students. To reveal the university students' LoEI and confirm model, further study is needed especially with a broader scope of samples in various universities by using clustering analysis based on the score levels (high, medium, low). In this model, the sub-dimensions of ECPB, ES, and EKS indicate the students' willingness to participate in future EPAs. This result should be discussed again with similar studies on different sample groups to determine whether the predictor variables overlap. At the same time, this study, which reveals the students' thoughts through survey and WORA form, is descriptive, so the levels of development in the sub-dimensions of ECPB, HEIP, ES, and EKS can be revealed in more detail through studies supported by qualitative methods.

Scientific Ethics Declaration

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

References

Akenji, L., & Bengtsson, M. (2014). Making sustainable consumption and production the core of sustainable development goals. *Sustainability*, *6*(2), 513-529.

Akkuzu, N. (2016). Towards a profound ecological understanding: Statistical attempts to measure our ecological intelligence. *International Journal of Social Sciences and Education, 6*(2), 198-216.

Azapagic, A. (2003). Systems approach to corporate sustainability a general management framework. *Process Safety and Environmental Protection, 81*(5), 303-316.

Bateson, G. (1972). *Steps to an ecology of mind: Collected essays in anthropology, psychiatry, evolution, and epistemology*. San Francisco: Chandler.

Bayazıt Hayta, A. (2009). The role of consumer education in achieving sustainable consumption behavior. *Kırsehir Faculty of Education Journal, 10*(3), 143-151.

Bowers, C. A. (2010). Educational reforms that foster ecological intelligence. *Teacher Education Quarterly, 37*(4), 9-31.

Campbell Bradley, J., Waliczek, T. M., & Zajicek, J. M. (1999). Relationship between environmental knowledge and environmental attitude of high school students. *The Journal of Environmental Education, 30*(3), 17-21.

Chen, T. B., & Chai, L. T. (2010). Attitude towards the environment and green products: Consumers perspective. *Management Science and Engineering*, *4*(2), 27-39.

Chili, N. S. (2014). The ecology of teaching: Efficiency, efficacy, and effectiveness of teaching and learning of tourism in township high schools. *Journal of Human Ecology, 48*(2), 299-312.

Collins, A., Flynn, A., Wiedmann, T., & Barrett, J. (2006). The environmental impacts of consumption at a sub-national level: The ecological footprint of Cardiff. *Journal of Industrial Ecology*, *10*(3), 9-24.

Connolly, J., & Prothero, A. (2003). Sustainable consumption: Consumption, consumers and the commodity discourse. *Consumption Markets and Culture*, *6*(4), 275–291.

Crutzen, P. J. (2002). Geology of mankind: The Anthropocene. *Nature*, *415*, 23.

Dobson, A. (2007). Environmental citizenship: Towards sustainable development. *Sustainable Development, 15*(5), 276–285.

Dyment, J. E., Davis, J. M., Nailon, D., Emery, S., Getenet, S., McCrea, N., & Hill, A. (2014). The impact of professional development on early childhood educators' confidence, understanding and knowledge of education for sustainability. *Environmental Education Research, 20*(5), 660-679.

Emanuel, R., & Adams, J. N. (2011). College students' perceptions of campus sustainability. *International Journal of Sustainability in Higher Education*, *12*(1), 79-92.

Estrada-Vidal, L. I., & Tójar-Hurtado, J. C. (2017). College student knowledge and attitudes related to Sustainability education and environmental health. *Procedia - Social and Behavioral Sciences*, *237*, 386–392.

Field, A. (2009). *Discovering statistics using SPSS* (3rd ed.). London: Sage.

Fischer, D., Brettel, M., & Mauer, R. (2020). The three dimensions of sustainability: A delicate balancing act for entrepreneurs made more complex by stakeholder expectations. *Journal of Business Ethics*, *163*, 87-106.

Flower, L. (2006). Environmental challenges in the 21st century. *Assumption University Journal of Technology*, *9*(4), 248-252.

Foster, J. B., Clark, B., & York, R. (2008). Ecology: The moment of truth-an introduction. *Monthly Review*, *60*(3), 1-11.

Gheith, E. (2013). Environmental value orientations and its relation to pro-environmental behavior among Petra University students in Jordan. *Journal of Education and Practice, 4*(22), 61-72.

Goleman, D. (2009). *Ecological intelligence: How knowing the hidden impacts of what we buy can change everything*. New York: Broadway Books.

Goleman, D., Barlow, Z., & Bennet, L. (2010). Forging new norms in New Orleans: From emotional to ecological intelligence. *Teacher Education Quarterly*, *37*(4), 87-98.

Goleman, D., Bennett, L., & Barlow, Z. (2012). *Ecoliterate: How educators are cultivating emotional, social, and ecological intelligence*. San Francisco, CA: Jossey-Bass.

Greene, J. C. (2005). The generative potential of mixed methods inquiry. *International Journal of Research & Method in Education*, *28*(2), 207-211.

Hart, P. (2003). *Teachers' thinking in environmental education.* New York: Peter Lang.

He, X. E., Hong, T., Liu, L., & Tiefenbacher, J. (2011). A comparative study of environmental knowledge, attitudes and behaviors among university students in China. *International Research in Geographical and Environmental Education*, *20*(2), 91–104.

Hornbuckle, C. A. (2008). *Ecological intelligence: British women writers and the environmental tradition* (Unpublished PhD thesis). University of South Carolina, Columbia.

Hosmer, D. W., & Lemeshow, S. (2000). *Applied logistic regression*. New York: John Wiley and Sons.

Johnson, B. (2004). Simply identity work? The voluntary simplicity movement. *Qualitative Sociology*, *27*(4), 527-530.

Kilbourne, W., & Pickett, G. (2008). How materialism affects environmental beliefs, concern, and environmentally responsible behavior. *Journal of Business Research, 61*(9), 885-893.

Kirchain, R. E. Jr., Gregory, J. R., & Olivetti, E. A. (2017). Environmental life-cycle assessment. *Nature Materials*, *16*(7), 693–697.

Knowles, V., Henningsson, S., Youngman, R., & Faulkner, A. (2012). *Coming clean: The global cleantech innovation index 2012*. http://info.cleantech.com/2012InnovationIndex.html

Kreis, I., & Rauch, F. (1999). *Joint learning and research of educational organisations and local communities*. *A report of international workshop of innovations in teacher education through environmental education.* https://docplayer.net/11309557-International-workshop-11nnovations-in-teacher-education-through-environmental-education.html.

Lummis, G. (2002). Globalisation: Building a partnership ethic for an ecopedagogy in Western Australia. *Australian Journal of Teacher Education*, *27*(1), 9-18.

Mansaray, A., & Abijoye, J. O. (1998). Environmental knowledge, attitudes and behavior in Dutch secondary school. *The Journal of Environmental Education*, *30*(2), 4-11.

McCallum, I. (2008). *Ecological intelligence: Rediscovering ourselves in nature.* United States: Fulcrum.

Miéville, C. (2015, August 1). *The limits of Utopia*. Salvage. https://salvage.zone/in-print/the-limits-of-utopia/

Miles, M. B., & Huberman, M. (1994). *Qualitative data analysis: A sourcebook of new methods*. London: Sage.

Murphy, E. R., Illes, J., & Reiner, P. B. (2008). Neuroethics of neuromarketing. *Journal of Consumer Behaviour*, *7*, 293– 302.

OECD (2014). *OECD work on biodiversity and ecosystems*. OECD Publishing. http://www.oecd.org/env/resources/OECD-work-on-biodiversity-and-ecosystems.pdf

Orr, D. W. (2004). *Earth in mind: On education, environment, and the human prospect* (2nd ed.). Earth Island Press.

Othman, M. N., & Umar, S. M. (2000). Kesedaran terhadap alam sekitar: Kajian perbandingan di antara pengguna Melayu dan Cina di Bandar. *Malaysian Journal of Consumer and Family Economics*, *3*(1), 42-50.

Pereira Heath, M. T., & Chatzidakis, A. (2012). 'Blame it on marketing': Consumers' views on unsustainable consumption. *International Journal of Consumer Studies*, *36*(6), 656-667.

Purvis, B., Mao, Y., & Robinson, D. (2019). Three pillars of sustainability: In search of conceptual origins. *Sustainability Science, 14*, 681–695.

Said, A. M., Ahmadun, F., Paim, L. H., & Masud, J. (2003). Environmental concerns, knowledge and practices gap among Malaysian teachers. *International Journal of Sustainability in Higher Education*, *4*(4), 305-313.

Schwepker, C. H., & Cornwell, T. B. (1991). An examination of ecologically concerned consumers and their intention to purchase ecologically packaged products. *Journal of Public Policy & Marketing, 10*(2), 77-101.

Shumba, O. (2011). Commons thinking, ecological intelligence and the ethical and moral framework of Ubuntu: An imperative for sustainable development. *Journal of Media and Communication Studies*,*3*(3), 84-96.

Steffen, W., Crutzen, P. J., & McNeill, J. R. (2007). The Anthropocene: Are humans now overwhelming the great forces of nature? *Ambio*, *36*(8), 614-621. https://doi.org/10.1579/0044-7447(2007)36[614:TAAHNO]2.0.CO;2.

Sterling, S. (2009). Ecological intelligence: Viewing the world relationally. In A. Stibbe (Ed.), *The handbook of sustainability literacy: Skills for a changing world* (pp. 76-83). Totnes, UK: Green Books.

Suwandi, S., Yunus, A., & Rahmawati, L. E. (2017). The effectiveness of ecological intelligence-based Indonesian language textbooks on the environmentally friendly behaviors of state junior high school students in Surakarta. In *Proceedings of the 1st International Seminar on Language, Literature and Education Conference (ISLLE 2017)* (pp. 261-267).Jakarta, Indonesia: KnE.

Tukker, A., & Jansen, B. (2006). Environmental impacts of products: A detailed review of studies. *Journal of Industrial Ecology, 10* (3), 159-182.

UNEP (2006). *Annual evaluation report 2005*. https://wedocs.unep.org/bitstream/handle/20.500.11822/183/UNEP_Anual_Evaluation_Report_2005.pdf?sequence=1&isAllowed=y%2C%20https

UNESCO (2012). *Shaping the education of tomorrow: 2012 report on the UN decade of education for sustainable development, abridged*. UNESCO. https://sustainabledevelopment.un.org/content/documents/919unesco1.pdf

Wang, J., Zhu, M., Tang, X., He, M., Xu, S., Gao, Y., & Gu, J. (2010). Opportunities and challenges for environmental education at Yunnan's institutions of higher learning. *Chinese Education & Society, 43*(2), 82–93.

Ward, M. D., & Ahlquist, J. S. (2018). *Maximum likelihood for social science: Strategies for analysis.* New York: Cambridge University Press.

Waters, C. N., Zalasiewicz, J., Summerhayes, C., Barnosky, A. D., Poirier, C., Galuszka, A.,… Wolfe, A. P. (2016). The Anthropocene is functionally and stratigraphically distinct from the Holocene. *Science, 351*(6269), 138-147.

Wiek, A., Withycombe, L., & Redman, C. L. (2011). Key competencies in sustainability: A reference framework for academic program development. *Sustainability Science, 6*, 203-218.

Yılmaz, V., Çelik, H. E., & Yağızer, C. (2009). Investigating the effects of environmental sensitivity and environmental behavior on ecological product buying behavior through structural equation modeling. *Anadolu University Journal of Social Sciences*, *9*(2), 1-14.

Zalasiewicz, J., Williams, M., Haywood, A., & Ellis, M. (2011). The Anthropocene: A new epoch of geological time? *Philosophical Transactions of the Royal Society A, 369*(1938), 835-841.

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