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CONTENTS

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Environmental Education and Perception about the Environment by High School Students and Teachers

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Abstract

The philosophies and epistemologies that guide the environmental thought of a certain educational community influences its actions in favor of the environment, including the absences of these actions, thus the political-pedagogical propositions that guide the environmental education actions are also strongly affected. In this context, the actions in environmental education in the town of Presidente Kennedy (Brazil) are analyzed as well as the perceptions/actions regarding environment, considering specifically the high school students of the town. The analysis will occur from semi structured interviews with two important professionals that act in the field and also from a questionnaire with open-ended questions applied to a group of second year students. The data were analyzed from Bardin (2010) content analysis. The project indicates that the way of thinking the environment, represented by conservatism, and the traditional perspective of environmental education maintain the actions and can contribute to the maintenance of indifference to the theme that addresses what is broadcasted by the media in a superficial, uncritical and little contextualized way.

Introduction

The main restlessness is regarding men's relation with nature and has its origin bounded by modern ideas of absolute domination of nature by men, this restlessness is not restrict in biophysical or territorial aspects of the biological systems, it's included here a degeneration of men and their ethical, philosophical, cultural, aesthetic aspects (Barcelos, 1988). The men/nature dichotomy emerged with greater prominence in the scientific revolution, being enhanced in the industrial revolution in which a nature utilitarian version stands out, these perspectives were and are still supported as an important view point in society (Naves & Bernandes, 2014). The evidences that can be understood with the change in the manner of thinking and being in the environment are in the main conditions that impregnate the human life in current times that originate from the technological advances and the more we approximate to this, the more we distance ourselves from ourselves or from our environment, it's in this sense that we can perceive the importance of education for a change in the worrisome scenario (Almeida & Kautzmann, 2011).

It is not intended with the written above to praise the good relationship between society and nature in the periods before the pre-industrial revolution, an important mark of anthropology as described by Faldore and Taks (2004), although having acknowledged the possible impacts of the changes in the way or in proportion of usage of natural resources in posterior societies. The importance of the environment inserts in the debates in the most diverse forms of thought, the Cartesian and disciplinary scientism isn't enough to meet the demands of the environmental problems that countless times receive influence of the looks of the diverse disciplines. Morin (1991, apud Barros, 2013) argues that the understanding of ecology by society will require innumerable competences, which goes against the hyper-specialization, typical of the philosophy of modern science. The debates and actions of society in the environmental field occur within conflicts and disputes between the different entities (state, NGOs, parties, academia, among others) (Barros, 2013). The author is also aware that, however diffuse the rise of environmental debates and conflicts may be, there is a tendency to increase the structuring and centralization of power of these actors, but the interdisciplinarity and complex nature of environmental thinking is evident.

The educational paradigms that guide environmental education are strongly influenced by the way the world and the environment are perceived (Guimarães, 2004), as well as environmental policies and environmental education policies themselves. However, it cannot be stated categorically that this is a unilateral aspect, especially when we consider the complexity of environmentalism, in this sense it is recognized that

environmental education can interfere in the way a community can perceive the environment. Understanding the thoughts that influence practices and possibly educational policies for the environment and environmental education in general, both in the formal and informal fields of the educational process, allows us to rethink our actions in this important area and may even affect our action in the world. Hence, the present work intends to reflect on the actions in environmental education and how these activities impact the view of high school students about the environment in the municipality of Presidente Kennedy, returning to the discussions for the Public Policies that seek to promote Environmental Education in the town.

Method

Sample and Date Collection

The research is characterized as qualitative, exploratorily. In the Escola Estadual de Ensino Fundamental e Médio Presidente Kennedy (EEEFM Presidente Kennedy), located in the town of Presidente Kennedy, south coast of the state of Espírito Santo, Brazil, in the only high school of the town, during the research it also included final grades of middle school and Educação de Jovens e Adultos (EJA, a modality of school for adults). According to the Brazilian Institute of Geography and Statistic (IBGE,2019) the municipality had an estimated population of 11.488 inhabitants in 2018, however, according to the TSE (Supreme Electoral Court), the municipality had 12.958 voters in February 2018, the number reduced to 10.482 in the following month, this data already shows the possibility of political and electoral conflicts in the region, this information should be considered when analyzing the socioeconomic and environmental aspects that find in the ballot box an important field of conflict.

IBGE (accessed on 24/01/2019) still states that GDP per capita, at current prices in 2018, was almost three times higher than the state capital's (Vitória), although the IDHM (Municipal Human Development Index) of 2010 was 0.657, while the capital's was 0.845. The 2015 IDEB (Basic Education Development Index) of the municipal network was 6.4 in the initial grades; surpassing the goal postulated by the Ministry of Education, however in the final series it was only 3.4. In the state network, the municipality did not present SDI in 2015 for the initial grades, only for the final grades, which the grade is 2.6, while in the ENEM (National High School Examination) of the same year it presents a mean of 447.1 (INEP, 2017).

The choice of the school in question was due to its representativeness since it comprises the only high school in the municipality. The classes that participated in the activity were selected for the adequacy of the content to the curriculum of the institution according to suggestion and guidance of the technical staff of the school. Initially, semi-structured interviews with local environmental education agents were carried out in order to create a scenario about environmental education in the municipality. The first interview was with a professional of the EEEFM Presidente Kennedy technical team, followed by a teacher of Sciences that was also numerous times in administrative activity in the municipal secretariats (of education and environment). The choice of such professionals occurred at the suggestion of the innumerable actors of education in the school and in the municipality, for recognizing the relation of their professional trajectory with the research questions. The practices in environmental education in the context of formal education in Presidente Kennedy were analyzed from semi-structured interviews conducted with the aforementioned educational professionals, one linked to the Escola Estadual de Ensino Fundamental e Médio Presidente Kennedy (EEEFM President Kennedy), and another connected also to the municipal network, both with more than a decade of professional activity in their respective jobs.

The second year high school students from that school answered a questionnaire that sought to reflect on the main themes approached in the interviews with the environmental education agents of the municipality. The questions focused on the relationship between society and the environment, on the meaning of the environment, and in the reflections and perceptions on local environmental problems. Thirty eight students participated in the research; the choice of the group of students was made by the relationship of the theme with the curriculum of students.

An interview was recorded in audio and transcribed with the appropriate authorization of the interviewee; the other was carried out by e-mail, as requested by the other interviewee. In view of the small number of professionals in the area, which would make it easier to identify, and due to the history of serious electoral conflicts in the municipality, we must faithfully respond to the request of the professionals, describing only what is necessary about their profile, so that they will be here treated by professional A and professional B, even with

variation of the gender to which they will be treated, in this way, either professional A will be treated by the male gender, and occasionally by the female gender, the same will be done with the professional B.

Data Analysis

The interviews carried out had the objective of describing the general situation of environmental education in the town, and also to support subsequent discussions and corroborate, or not, with possible perceptions regarding the speeches of the students of the institution second year of high school, available from the data of an applied questionnaire that were treated by the content analysis in Bardin (2011).

Results and Discussion

The interviewee A affirms that there isn't a specific treatment for the environmental education in the P.P.P. (Political Pedagogical Project) of the institution or in the curriculum planning, also adding that the inclusion of the topic in the curriculum is unnoticeable. According to the professional, the environmental theme occurs according to demand, as exemplified:

> For example, when we had gone through a great drought period, "right?" The water presentation topic was looked upon, as in the waste of it, and how we could avoid, but as I said, only when there's a demand (Professional A).

The approaches in environmental education are linked to demands, in general, to what is evident at a given time, which can be observed countless times in the interview. The project themes cited were: selective collection, waste of water, ecological tracks, tree planting. According to the interviewee, there is little talk or there is not talk about the local ecosystem, such as sandy coastal plains (restinga), or even about social and environmental issues.

In the previous speech, one can perceive specificity in affirming the "waste that one has to avoid" that can serve as an alert for the way in which the water issue is addressed in environmental education. Besides being a constant target of media actions, the issue of wasteful domestic water use is not the only issue about the hydric crisis (Karatas & Karatas, 2016), which may reveal the superficiality with which the theme is treated, carrying the characteristics of conservative environmental education, since when the issue of water as a whole, its use and accessibility, and another dimension are not addressed, the socio-environmental discussions are left in the background.

The influence of mass media approached on environmental issues can be seen as a tool for propagating environmental thinking with a focus on environmental preservation and well-being, but also as a tool for the spread of interests of hegemonic groups that can be disseminated and emphasized. In this sense, Núñez and Moreno (2016) point to the importance and duality in the relationship between mass media and environmental thinking with a focus on preservation, paying attention to the need to reflect on the role of mass media that can be a powerful instrument of environmental education.

The fact that environmental approaches follow the demands demonstrates a certain distance between who designs and who executes the projects; distancing themselves from the reality of the actors involved, and, in reproducing what is in evidence, ends up responding to the logic of dominant interests, characteristic of the traditional perspective of environmental education (Guimarães, 2004). This distance and the pragmatic characteristic of the approaches evidence the reductionism of the paradigm, as well as characteristics of technicism conceptions, when emphasizing the individual changes (Layrargues, 2002).

In the town the environmental education proposals mainly derive from the City Secretary of Environment. The state school usually receives invitation to participate, and participates whenever possible, but, beside the projects not being too common, they occur according to demand as stated in the interview. The participation of the mentioned school has as limitation the curriculum and the calendar, as professional A highlights, so that it participates when possible - it is emphasized that the professional affirms not to remember any environmental education project in the state school, only some individual approaches of teachers, nothing articulated. He also reminds us that the theme of the Environment is present in the curricular proposals of the State Department of Education and in the federal proposals, but it still occurs in a simple manner in the school.

Professional A is unaware of the projects aimed for the community with the participation of the school. He points out that environmental education, when worked on, is centered on the actions of science and biology teachers, which is also observed by McDonald and Dominguez (2010), and yet reports that if there is a need for a multidisciplinary approach, the technical team must constantly demand from teachers:

> If we don't stat there, demanding, right? they procrastinate. We say that we will do it, and we'll do it, and don't do it. (...).The teachers can't perceive that it's a general problem, (...), Therefore they are not able to work together, they separate it by area (...) (professional A).

Professional A, when talking about interdisciplinarity, mentions the work of numerous disciplines on a theme, an approach in fact of multidisciplinary origin, because according to Pires (1998), within the context of teaching, this perspective seeks to treat the same theme in the different disciplines, each one within its strategies and its focuses, different from the interdisciplinary approach that goes beyond the sharing of information, techniques and bibliographies, is proposed in an epistemological reconstruction.

This difficulty in promoting an interdisciplinary approach demonstrates another obstacle to the insertion of environmental education in a critical perspective in the school, corroborating with the Cartesian-mechanistic paradigms typical of a traditional environmental education that ignores the notion of environmental complexity (Guimarães, 2004). A relevant fact described highlighted by professional A is that municipal environmental education projects occur preferably in the three daycare centers of the town and in the four poles schools, those with the largest number of students, even the municipal network having approximately 20 schools, this fact allows questioning the effective objectives of projects in environmental education, especially with regard to the objective of addressing environmental issues and not just to respond to legislation. At the end of the interview, professional A said he believed in the need to approach the subject and that this approach should be worked beyond the walls of the school, starting from generating themes. The perspective followed by the interviewee meets what Caillon et al. (2017), when proposing the need to break the dichotomy between nature and culture, as well as reinforcing the idea that men is part of nature which could influence conservation practices.

Professional B affirms that projects in environmental education emanate, in general, from the Municipal Department of Environment, which develops them in partnership with the Municipal Department of Education, which usually adopts state and federal government projects. According to the interviewee, there is little agreement with the private sector, he said that, in view of the implementation of the port complex of Porto Central, the Municipal Master Plan (PDM), which is still under discussion and undergoing modifications, proposes, in Article 163, ecology as a common discipline in the municipal network.

When asked about the philosophical and theoretical approaches of environmental education projects, the interviewee (professional B) quotes Izabel Carvalho, a researcher who works on environmental education in Brazil, also cited the legislation in force, without necessarily referencing, describing the main ideas or the perception of the author and legislation on the subject. Professional A, claims to believe in the need to work on environmental education in a preventive perspective, in order to avoid environmental problems, without necessarily presenting any basis or reference.

The treatment given by both interviewees to the theoretical and philosophical discussions inherent in environmental issues corroborates with the characteristics of the thought that deals with environmental education in a preventive perspective, because according to the interviewee A it should be practiced in order to avoid environmental problems of seeking the support of results that are still to come, avoiding theoretical and philosophical deepening, which hinders the planning of possible actions and decision-making on broader and more comprehensive issues. The preventive perspective shows that the objective of projects in environmental education are aimed by those who project them, focused on the interests of hegemonic groups, pragmatic projects with the purpose of modifying individual behavior, that would occur to avoid problems, showing that critical debates and complex projects inserted in socio-environmental issues and with a prospect of changing socio-environmental reality are seconded.

In proposing typologies for environmental education, Silva and Campina (2011) present three proposals: traditional and critical, as well as Guimarães (2004), and add the pragmatics, which according to the authors "presents a focus on action, in search of solutions for the environmental problems and the proposal of norms to be followed "(Silva & Campina, 2011). This perspective of environmental education contrasts with criticism because it fails to emphasize the complexity of the human-nature relationship, the political dimension and the questioning of the current productive and economic model.

The pragmatic perspective of environmental education seems to fit into the activities described by the interviewees, because they assume the need for individual change, focusing on practical activities designed and idealized by others, such as ecological walk and separation of waste in selective collection, activities in environmental education that were most cited.

Environmental education in the town of Presidente Kennedy is far from the critical perspective, starting from the analysis of the data obtained in the interviews, especially when it is not observed to seek to transform the reality of the students and the community. The legislation assists in order to impose a minimum of involvement and relationship between the government and the community in the ambit of the environment, however, actions occur unilaterally, without the quest to awaken in citizens the need to get involved with environmental issues, hindering the sense of belonging and participation, which is sometimes confined to associations that end up seeking only economic improvements, as the interviewees report.

The students participating in the research answered a questionnaire with open questions that addressed their respective perceptions about the socioenvironment. The responses were treated by the content analysis in Bardin (2011) as described in the method. The issues specifically addressed: i. The relationship between society and the environment, ii. The meaning of the environment, iii. Identification of environmental problems, iv. Resolution of environmental conflicts. The figure1 presents the categories and frequencies of the answers regarding the students' understanding of the relation between environment and society.

Table 1. Frequency of the answer categories of the students about the questioning of the relations between the society and the environment.

Answer Categories	**Frequency**
The society depends on nature (focus on economical development).	4
Dificulty in collective thinking (focus on individual actions).	6
Constant harmful relationship to the environment	12
Necessity of research and studies.	1
Didn't answer.	7

The idea that the relationship between society and nature has always been harmful to the environment, representing the idea of the need to promote environmental conservation without human presence, presents a tendency towards conservative perspectives of the environment. Loureiro (2004) presents the environmental conservation paradigm that, among others, has the characteristics of biodiversity preservation and intact areas, thus establishing a dissociation between men and nature. The association between the conservationist idea of nature, described in the previous paragraph, added the idea that society depends fundamentally on access to natural resources. For example, as seen in the category "society depends on nature"; exposes the mercantilist and exploratory view of the world. Leff (2006) demonstrates the relationship between the conservation paradigm and the capitalization of the environment:

> [...] the nature ceases to be an object of te work process to be codificated in terms of capital. But this relationship does not return the being to the nature, but it transmutes in a form of capital – natural capital -, generalizing and amplifying the forms of economical value of nature. In this sense, along with the forms of intensive exploration, it promotes in a "conservationist" of nature. The biodiversity appears not only as a multiple forms of life, but as "natural reserves"- territories and biological diversity and cultural habitats – that are being valued for its genetic wealth, its ecotourism resources and its functions as carbon collectors" (Leff, 2006, pg. 146).

Table 2. Frequency of the answer categories of the students about the meaning of environment.

Answer categories	**Frequency**
Importance of the environment for mankind	9
Nature (biological and/or biophisical, without human insersion).	7
Environment (Society, men/environment, etc.).	5
Natural beauty, tranquility, etc.	3
Life.	2
Unanswerd.	7

The perception regarding the relationship between the environment and society of students go through the meaning of environment for them, in this sense, the figure 2 presents the categories of the answers and its

frequencies. The category natural beauties, etc. can represent to some extent the students' romantic perception about the environment. In this category, answers are classified as;

> a quiet place where we can live (student A),

or even

> life, clean air, health... (student B).

Considering that the concept of nature is essentially political and historical, the romantic vision of the environment that exalts nature and its wonders, can also be perceived as a utilitarian perspective that sees the environment as an instrument or space used for leisure and relaxation (Tamaio, 2002). When seeking to describe environmental problems experienced by the family members or the students themselves, the answers were categorized and the frequency is presented in figure 3.

Table 3. Frequencies of the experiences with environmental problems that the student has faced.

Answers	**Frequency**	**Percentage (%)**
Water supplying, droughts, floods in the city	4	14
Deforestation in the city	7	23
Out of town topics or without specific location (garbage on the streets, global warming, etc.)	10	33
Unanswered	9	30
Total	30	100

The question of water resources presented by the students is directly related to the daily life of the Kentish community, which can be observed in the speech of the professional A when interviewed, as well as the issue of deforestation that sometimes appears implied in the speeches. However, important data refers to the high number of approaches to problems outside the community of these students, major environmental disasters that have won the media, such as the pollution of the Tietê River (SP), the rupture of the dam in Mariana City (MG), among others. The observation also corroborates with the speech of the Professional A who points out the media as the main provider of themes for the work on environmental education in the school. In this sense, students were asked about the ways to resolve possible conflicts arising from environmental disputes, The figure 4 shows the frequency of categories.

Table 4. Answers about the forms of resolution to environmental issues

Answers	**Frequency**
Individual actions, ex.: (each doing their own part)	6
“Avoid being selfish”	5
Council meetings, dialogues, respecting opinion, etc.	3
Without answer or lacking examples of conflicts	11
Population awareness	5
Studies and researches about the environment	1
Rules, laws, etc.	1

Non-individualized approaches were mentioned only 8 times (category that addressed council meetings and awareness), affirming dialogue and awareness, and the resolution of conflicts that was presented by most responses highlights an individualistic perspective, where self and other have difficulties in coexisting, further deepening the dissociation between men and nature and men to men, making it difficult to act in favor of the environment, since for most of the students the other is the egoistic, which damages the environment, etc. In summary, the environmental perspectives pointed out in the students' discourses are consistent with the practices of the Policies and with the vision of environment and environmental education that prevails in the town. At this point, one can direct thought to a political-philosophical system fed by traditional environmental education, which in turn feeds the political-philosophical system in question, as in a vicious cycle at the local level that needs to be broken.

However, it is also known that the school paradigm, alien to society, is no longer viable in the face of social changes, especially with the new technologies of learning and communication (Baladeli et al. 2012), so it would

be naive to expect that what would be a cycle indefinite duration, or that it actually constitutes a cycle. In treating the relationship between the praxis of public policies in environmental education and the perception of the environment of the students in this research, we open the way to the recognition of the complexity and importance of the topic for the maintenance of human life on earth, making it necessary, in this sense, (re) thinking about the discourse of financial systems regarding the role of the State and consequently its size.

The neoliberal perspectives in which financial systems are immersed recognize and implore a minimal state, however we must turn our attention to the direction of this minimum state. For Loureiro and Ribeiro (2010), the minimum state in the neoliberal perspective turns to its public character, while for its character of maintainer and guarantor of the capital expansion, a maximum state must be assumed (Netto, 2012), acting on incentives, financial aid, credit programs, etc. In this sense, the role of the State on the environmental issue, especially in its exploration and degradation must be at the service of society and not the financial system, since it comprises fundamental aspects for the maintenance of life on Earth. ORyan and Ibarra (2016) state that in the 2000s, changes in Latin America's perceptions of the environment also stimulated changes in environmental policies, including greater state intervention in the activities of companies that may harm the environment. However, the regulatory mechanisms need always be reviewed, that the polluting agents not may seek loopholes or even compensations that may circumvent such mechanisms, once again the promot environmental education can stimulates thinking and feeling about environment, local or not, it emerges as an important tool for promoting and maintaining the development of practices that seek environmental preservation.

Although we can consider a myth as the idea that education should save humanity, we can not deny what Freire (2001) affirms: "not being able to do all, the educational practice can do something" (p. 47), in this sense, we need to highlight that although public policies in environmental education can not be immersed in a naive optimism, we need, above all, to recognize their role in the face of public and popular education practices, since it is within the individual existence inserted in a collective society that promotes environmental awareness. Schild (2016) in discussing environmental citizenship reminds us of Tbilisi's 1977 declaration, recognizing environmental citizenship as fundamental to the transition to sustainability, also raising discussions on the important notion that environmental citizenship sought in education, is directed beyond specific knowledge and mental habits, it is necessarily oriented towards practice, behavior and attitudes in which the individual is (re) constructively collective.

> (...) The role of the environmental education in this project is to be able to offer students the opportunity to learn as active citizens within their communities through the participation and civic engagement, and at the same time, helping students to understand the root structures and systematics of the social and environmental problems (Schild, 2016, p. 31).

The author also cites the relevance of local environments in environmental education that seeks the development of literacy / environmental literacy and, above all, for the much-desired environmental citizenship. In this sense, Leme, Noronha and Viana (2009) leads us to reflect on an important tool that is the youth protagonism applied to environmental education showing us the importance of considering and exploring the characteristics of different stages of human development for practices, especially referring to environmental education in formal teaching environments.

Final Considerations

Environmental education in the town of Presidente Kennedy-ES is shown to be inserted in the context of traditional environmental education, as well as in the significant distance between the Policies focused on environmental education and local socio-environmental reality. The rise of large port commerce is a significant argument for greater attention to environmental aspects, which also include environmental education, to include the community in the debates on existing environmental conflicts and, above all, those that are yet to come. so that lives are not subjugated to economic dependence. The close relationship between environmental education policies and the perception of the participating students shown in this research demonstrates the need for greater participation of the various sectors of society as a community association, NGOs, environmentalists, education professionals, among others, in debates about the challenges of the future. Finally, it is emphasized here that the school can be the *locus* of discussions about the environment, especially in places with the characteristics described here, since there are those who need each time more to be aware of aspects regarding youth protagonism. The approximation between school and society can be a factor for strengthening the discourses of different citizens, the approach of men / nature, and the struggle for a future different from that projected to the planet.

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The Effect of Problem-based Learning on 7th-grade Students' Environmental Knowledge, Attitudes, and Reflective Thinking Skills in Environmental Education

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Abstract

The study aimed to investigate the effect of authentic problem-based learning (PBL) activities in the unit of "Human and Environment" on 7th graders' environmental information, their reflective thinking skills and their environmental attitudes. The sample of the study consisted of 53 7th grade students from two different classes attending Science and Technology Course at a government school in Turkey. One of the groups was attended as control group the other one was attended as experimental groups. Reflective Thinking Skills Scale, Environmental Knowledge Test, and Environmental Attitude Scale were used as data collection tools. The research design of the study was quasi experimental pre-test post-test control group design. The experimental group was taught by PBL and the control group was taught by didactic teaching method. The results of the study displayed that PBL had significant effect on 7th graders' environmental knowledge; environmental attitudes but it had no significant effect on students' reflective thinking skills.

Introduction

The number and variety of environmental problems are increasing day by day. Urgent environmental problems such as global warming, food scarcity, and destruction of biodiversity are very complex problems, and they concern both science and society (Wals, Brody, Dillon, & Stevenson, 2014).Although the existence of these problems is noticeable, individuals continue to behave environmentally unfriendly at the individual, governmental, and societal levels. The rapid growth of environmental problems leads to the extinction of many species, and this leads to the deterioration of the ecological balance. Although a human being is not independent of its environment and the ecosystem, individuals continue to pollute the environment as if they were living out of this system. The increase of ecological problems threats not only other living bodies they also threat humans' wellbeing. As stated by UNESCO-UNEP (1991), Environmental education aims to make students environmentally literate individuals who play an active role in protecting the environment by making decisions and behaving environmentally-friendly (Makki, Abd-El-Khalick, &Boujaoude, 2003). Environmental awareness, knowledge, and attitude play an important role while protecting the environment (Lahiri, 2011). When individuals increase their knowledge related to environmental issues, they will be more aware of environmental problems and increases their environmental responsibility (Aminrad, Zakariya, Hadi, &Sakari, 2013; Palmberg& Kuru, 2000). Chapman and Sharma (2001), Salequzzman and Stocker (2001), Bradley, Waliczek, and Zajicek (1999) stated that environmental education fosters environmental awareness, environmental understanding, and environmental skills through increasing environmental knowledge. Through environmental education, individuals can understand environmental issues and become a part of the solution to environmental problems. Environmental education helps people to understand the relationship between environmental and their lives (Hafezi, Shobiri, Sarmadi, &Abass, 2013). Lieflander, Föhlich, Bogner, and Schultz (2013) stated that individuals should have a positive relationship with their environments to cope with environmental problems.Makki et al. (2003) stated that environmental knowledge and attitudes affect individuals' environmental decisions and behaviors. Today, in environmental education, the focus is on the development of students' critical thinking and problem-solving skills through working on environmental issues and problems (Kwan & So, 2008).

In line with the goals of environmental education, students need to work on real-life problems to develop their critical thinking, problem-solving, and decision-making skills (Stevenson, 2007). In this context, problem-based learning (PBL) is appropriate for environmental education since it encourages students to express ideas, develop their cognitive and affective skills, direct their learning through analyzing real-life problems (Said, Yahaya,

&Ahmadun, 2007). Vasconcelos (2012) evaluated the success of a PBL intervention program in environmental education and stated that it had positive effects on students' learning of environmental subjects.Meaningful learning occurs when students learn through concrete experiences such as real-life experiences. Therefore, students need to participate in the activities in which they gain first-hand experience, work on real-life and real issues (Chang, Chen, & Hsu, 2011). PBL connects real-world and classroom requirements. PBL focuses on knowledge construction and interaction with real-life problems (Reynolds & Hancock, 2010).In various studies, the researchers stated the positive effects of PBL on students' learning and some effective factors (such as attitude, motivation.9. For example, Etherington (2011) stated that PBL had positive contributions on pre-service teachers' motivation to teach science. Similarly Gorghiu, Draghicescu, Critea, Petrescu and Gorghiu (2015), Jansson, Söderström, Andersson, and Nording (2015), Senocak, Taskesenligil, and Sözbilir (2007) expressed that PBL increased students' understanding of some science concepts.

Albanese and Mitchell (1993) stated that PBL has similar views with Plato and Socrates who want students to think, ask questions, produce new ideas and discuss different ideas. PBL is also similar to the ideas of John Dewey's and Jerome Bruner's about the learning environment (Schmidt, 1993). In PBL students discover and construct their knowledge. In PBL, a loosely constructed real-life problem stands in the center (Reynolds & Hancock, 2010). The teacher encourages the students to participate in the learning process to try to develop solutions for loosely structured problems. In this method, students reach the necessary information while trying to solve the problem. PBL has been applied in various ways, but Reynold and Hancock (2010) summarized the PBL process by reviewing the literature as below:

- A real-world problem is presented to the students. The students work in groups and analyzed the problem by using their previously acquired knowledge;
- The students determine the issues related to the problem and define the sub-problems.
- The students determine the priority of the issues, organize the issue, and prepare a working plan.
- The students try to solve the problem, explore the previous learning, try to put new ideas to solve the problem
- Students discuss their ideas, solutions, and decide which one is the best solution for the problem.
- Following the PBL process, the students evaluate themselves, their group mates, and the process.

Individuals must learn the basic concepts related to ecology and be aware of ecological problems at an early stage in their lives. Within the scope of this study, the effect of the authentic problem-based learning method which will be used in the 7th grade "Human and Environment Relationships" unit on the students' reflective thinking skill based on problem-solving, environmental knowledge (academic success) and attitude towards the environment. Students need to develop reflection skills for deep and meaningful learning (Xie, Ke, & Sharma, 2008). Reflection is a process of inquiry in which students try to find a solution to a problem. Therefore, it was considered that the process of problem-based learning would develop the students' reflective thinking skills.

In this study, dealing with authentic learning and problem-based learning methods together and also working on environmental subjects displays the difference and importance of this study compared to other studies. In reflective thinking, since the student is allowed to learn through his/her own experiences, he/she is given a chance to be aware of what he/she is doing, think about his/her activities, correct mistakes if there are any, do critical thinking about himself/herself, solve problems and do research to solve problems. Due to these characteristics, it is considered that analyzing the skill of reflective thinking will contribute to the science lessons' learning-teaching process.

The aim of the Study

The study aimed to investigate the effect of authentic PBL activities in the unit of "Human and Environment" on 7th graders' environmental information, their reflective thinking skills, and their environmental attitudes. By this aim, the following research questions were prepared:

- Do authentic problem-based learning activities make significant differences in students' environmental information?
- Do authentic problem-based learning activities make significant differences in students' reflective thinking skills?
- Do authentic problem-based learning activities make significant differences in students' environmental attitudes?

Method

In the study, the effect of authentic PBL activities on 7th-grade students' reflective thinking skills, environmental knowledge, and environmental attitudes was investigated in the context of the "Human and environmental relations" unit in science class.

Samples

The sample of the study consisted of 53 7th grade students from two different classes (Number of students in experimental group 26, number of students in control group is 27) attending Science and Technology Course at a government school in Turkey. The sample was selected by incidental sampling method. The first unit related to the environment in the middle-school science program is the "Human and environmental relations" unit. Therefore, this sample group was used in line with the goals of the study. The study was conducted in the 2015-2016 Academic Year.

Research design

The quasi-experimental research design, which is one of the quantitative research designs, was used in the content of the study. The information about the experimental and control groups, teaching approach and data collection tools are given in Table 1.

Table 1. Research model

Groups	Pre-tests	Method	Post-tests	App. period
Control Group	EKT	Didactic teaching	EKT	6 Weeks
N=27	EAS		EAS	
	RTSS		RTSS	
Experimental	EKT	Authentic PBL	EKT	6 Weeks
Group	EAS		EAS	
N=26	RTSS		RTSS	

Data collection tools were administered as pre-test in the previous week of the application process, and data collection tools were administered as post-test in the following week of the application process. PBL activities continued for four weeks. The process was completed in 6 weeks, included with the pre and posttest applications. In the control group, the teacher followed the activities in the coursebook and used didactic teaching method, in the experimental group, the teacher taught with the PBL method. The application was carried out in the Human and Environmental Relations Unit in the 7th Grade science class curriculum.

Data collection tools

Reflective thinking skills scale

Reflective Thinking Skills Scale was used to identify students' reflective thinking skills level. The scale was developed by Kızılkaya and Aşkar (2009).The items in the scale are related to how the students manage the problem solving process. In the problem solving process, there are items which are related to whether the students are aware of the steps they follow. It was considered that the scale was suitable for observing reflective thinking skills in the problem solving process.The scale was composed of 14 items, and it is a 5 point Likert type scale. The statements in the scale were coded as "Always=5", "Usually=4", "Sometimes=3", "Seldom=2", "Never=1". Kızılkaya and Aşkar (2009) calculated the Cronbach Alpha reliability coefficient of the scale as (Kızılkaya&Aşkar, 2009). The examples of the items are given below:

> When I can't solve a problem, I ask myself questions to understand why I can't solve the problem.
>
> When I'm solving a problem, I think about the stages I follow and think about why I follow these stages.

Environmental knowledge test

Environmental Knowledge Test (EKT) developed by Bildik (2009) was used to evaluate students' environmental knowledge level. The test was developed by considering the learning gains in the "Human and environmental relations" unit. It consisted of 24 items. Bildik (2009) calculated the Cronbach Alpha Reliability Coefficient of the scale as 0,762; the KR-20 coefficient as 0,761 and the difficulty index of the test as 0,60. The examples of the items are given below:

1. In an ecosystem, when we kill all predators like lion, fox, and eagle, which one of the following results occurs?
    a. People get rid of these predators, wild animals, and feel comfortable.
    b. Other animals living in the ecosystem are not affected by this situation.
    c. No change in the food chain
    d. Deterioration of natural balance in the ecosystem and increase in the number of some animal species

2. If all plant species in the world are destroyed as a result of an environmental disaster, which of the following is not expected?
    a. The increase in the amount of oxygen in the atmosphere
    b. Damage in all ecosystems
    c. The destruction of animals that eat plants
    d. Degradation of ecological balance

Environmental attitude scale

Environmental Attitude Scale (EAS) developed by Bildik (2009) was used to evaluate students' attitudes towards the environment.The items in the scale aim at identifying the students' attitudes towards environmental problems. The scale was chosen with the view that it is suitable for the purpose of the study. The scale consisted of 20 items, 10 of which are positive, and ten are negative. It was a 3-point Likert type scale, and the positive statements were coded as "Agree=3", "undecided=2," and "disagree=1". Negative statements were coded in reverse. The Cronbach Alpha reliability of the scale was 0,718. The examples of the items were given below:

    1) I feel safe when our country signs agreements to protect the environment.
    11) The balance of nature is very sensitive and can be easily broken, so I need to take various precautions to protect the environment.

The process

Before the application, data collection tools (RTSS, EKT, and EAS) were administered to the students as pre-test. The students who participated in the study were attending two different classes. One of the classes was attended as experimental group, and the other one was attended as control group randomly. The same teacher taught both of the groups to prevent the possible effect of the teacher on the groups.The teacher has 5 years of experience.

The teaching process in the control group

The teacher taught through the didactic teaching method considering the activities given in the textbook. The applications were carried out within four weeks as 4 lesson hours per week. In the applications carried out in the control group, the science education program was taken as the basis. Therefore, the students used only the textbook. The activities in the mentioned source and suggested activities were carried out and the evaluation questions and exercises were completed. The teacher started each lesson by giving a summary of the previous lesson. The teacher asked the students to take notes when it was necessary. The teacher explained the subjects in the textbook and did the exercises at the end of the subjects together with the students. In this process, the teacher played a more active role and taught the lesson using question-answer and discussion techniques.

The teaching process in the experimental group

Preparing authentic problem scenarios

The PBL activities were carried out in the Human and Environmental Relations Unit in the 7th Grade science class curriculum. In the unit mentioned, it was targeted for the students to explain the ecosystem and the related concepts, question the reasons and consequences of environmental problems, acquire knowledge and skills about bio-diversity, extinct beings, and beings under the threat of extinction and what needs to be done to protect these species. A total of 5 authentic problem scenarios were prepared related to the "Human and Environmental Relations" unit to be used in PBL. In this respect, it was aimed to reach the subjects and concepts given in Table 2 in the study.

Table 2.Authentic problem scenarios and related concepts

The title of the scenario	Related concepts
Report Card Gift (Pilot study)	Ecosystem, Habitat, Population, Species
Salep (Anatolian Orchid)	Biodiversity, Local and global environmental problems, Endangered species, Overhunting, Conservation of species
Museum visit	Biodiversity, Local and global environmental problems, Extinct species, Conservation of species
Which decision is better for us?	Biodiversity, Local and global environmental problems, Conservation of species
The Massacre of Nature: Look at the garbage in the stomachs of the dying albatrosses!	Biodiversity, Local and global environmental problems, Endangered species, Conservation of species

When Table 2 was analyzed, it was seen that each scenario is related to more than one concept. Each scenario is related to more than one subject and the concept is due to these problems being authentic. Because in authentic learning, learning must take place through problems that mostly display correlations and are in complex contexts. The information which will be acq1uired through an authentic problem must be able to carry real-life complexity. In the preparation of the scenario texts, the researchers used the textbook, supplementary sources, scientific publications, and current events. In this process, the views of two science teachers, one science education associate professor and a chemistry education professor were made use of, the necessary corrections were made and the final version was achieved for the authentic problem scenarios. The scenarios consist of problems that the students are familiar with in daily life, situations that attract their interest and attention and related to social problems. In the preparation of the selected problem situations, a path towards pieces to the whole was followed and these were expressed in an open and simple language that the students can easily understand. Under the scenarios, a few questions which helped the students find the problem were included and it was aimed for the students to find the details about the identification and solution of the problems on their own.

One of these scenarios titled "Salep (Anatolian Orchid)" is given below. The city of Kahramanmaraş, where the study was carried out, is famous for its ice-cream. This type of ice-cream produced in Kahramanmaraş is called Maraş ice-cream in Turkey. In the production of Maraş ice-cream, the root of the salep plant which is a type of orchid, is used. After the roots of the salep plant whose pictures are given below are processed, they are used to give taste and consistency to the ice-cream. The salep plant grew naturally in the mountains and picked up in the mountains. It is a plant the students are familiar with and ice-cream production is important for the city's economy. Also, salep is a plant species whose numbers are decreasing due to not being grown in culture environments and the increasing ice-cream production. This plant is authentic and directly related to the daily lives of the students, the subject being interesting and the extinction of various orchid types were the reasons why it was selected as the subject of the scenario. The example scenario titled "Salep" and the learning gains related to the scenario are given in Appendix 1.

PBL activity

After the pre-tests were done, a pre-study consisting of 4 lesson hours was carried out to give information about the method to be used with the experiment group students. In this study, five groups consisting of 5-6 students and have different characteristics in terms of learning levels were formed which were heterogeneous within themselves and homogeneous between the groups. An example scenario was studied with the groups and the students were given information about how the lessons were to be taught. Information related to the steps of solving the current problem, selection of sources to be made use of, doing research, preparing reports, teamwork, etc. were given through the scenario. The sitting places of the groups in the experiment group were determined and each group was asked to select a president, clerk and speaker and to find a name for the group. In the experiment group, the lessons were taught in the following manner using the authentic PBL method:

- For each séance, a different authentic problem scenario was prepared, and the students were asked to read these at the beginning of each séance. Also, a few questions were added under the scenarios to help the students find the problem and it was aimed for the students to find the details about the identification and solution of the problem and the sub-problems themselves through these questions.
- The students who were separated into small groups consisting of 5-6 people in the first lesson hour were given some time to identify the problem or problems in the scenarios, to discuss these in their groups and to exchange ideas.
- After the given time was over, the groups announced their ideas, and as a result of the discussions both within the groups and between the groups, the problems in the scenarios were identified. Then, the students seeking for the answers to the following questions:
  What do I know about the problems?
  What are my guesses about the problems?
  What do I need to research on?
  What have I learned?
- To identify the current knowledge of the students, they were asked to find the answer to the question "What do I know?" related to the problem and the situation indicated in the scenario. Thus, the students listed their guesses under the "What are my guesses?" title.
- In the following lesson hour, the students were asked what information they need to solve the problem and they were expected to form sub-problems about the problem they identified. Therefore, the students tried to find the answer to the question, "What do I need to research on?" They were asked to research with their group members on the problem, sub-problem and the subjects. In this process, the students made use of different supplementary sources. In this step, the students were able to bring supplementary sources to class and they were allowed to research on the Internet through the interactive board as well.
- The students were asked to find solutions to the problem in the light of the research they carried out on the sub-problem and subjects which they identified through group discussion.
- The students obtained the materials they needed until the next lesson, shared the information they prepared by getting together before the lesson and then wrote reports or created a product related to the solution to the problem. They presented their reports and products to their classmates for 5 minutes each. They were asked to have discussions with each other within the class environments and it was made possible for them to share suggestions for a solution which they identified for the solution of the problem among the groups.
- The assisting questions in the scenarios were asked a final time to the students and each question was answered through the discussion of the whole class. The erroneous or incomplete parts in the reports were observed during the presentations and corrected. Therefore, the subject was summarized and the problem was solved under the guidance of the researcher.
- At the end of the lesson, the students filled out the "peer evaluation form" and "self-evaluation form" to evaluate themselves, the method, their friends and teamwork. Also, in the 2nd and 4th weeks of the application, student exercise pages were given to consolidating their knowledge and for the students to review what they have learned. A sample of the exercise pages is given in Appendix 1. The authentic problem scenario which included the gains of the following weeks were distributed to the students in a written form and the necessary explanations were given. In the application, the same method was followed for the other problem situations.

In the PBL method, since the students reach information by doing research, questioning, and having discussions among themselves, they take responsibility for their own learning. In this process, the guidance of the teacher for the students is helpful in terms of having students reach information and learning to take place. Therefore, the researcher guided the students by asking questions during the experimental activity, tried to prevent students from getting off the track by interfering when necessary and guided them to make up their deficiencies. The lesson plan used in the experiment group is given below. A few photos from the PBL activity are given in Appendix 3.

Findings

The data, obtained from the pre-post test results of the experimental and control group were analyzed, and the following findings were obtained. The quantitative data obtained within the scope of the study showed normal distribution, and the required statistical analyses were made accordingly. The students who participated in the study were attending two different classes. One of the classes called Group 1 and the other one was called Group 2 at the beginning of the study. The data collection tools (EKT, EAS, and RTSS) were administered to

the students of Group 1 and Group 2 as pre-test before the application. The pre-test scores of Group 1 and Group 2 students were compared with the help of independent samples t-test to determine whether there was a difference between pre-test scores of the groups. The findings of the independent samples t-test were displayed in Table 3.

Table 3. Comparison of the pre-test scores of the groups with independent samples t-test

Tool	Groups	N	$\bar{X}$	SD	df	t	p
EKT Pre-test	Group 1	26	12,08	3,38	51	0,223	0,824
	Group 2	27	11,85	3,91			
EAS Pre-test	Group 1	26	50,85	3,90	51	1,913	0,061
	Group 2	27	48,52	4,87			
RTSS Pre-test	Group 1	26	54,38	9,03	51	1,540	0,130
	Group 2	27	50,56	9,06			

The findings displayed that there was no significant difference between the pre-test EKT scores of Group 1 and Group 2 students (t=0,223; p=0,824>0,05); there was no significant difference between the pre-test EAS scores of Group 1 and Group 2 students (t=1,913; p=0,061>0,05); there was no significant difference between the pre-test RTSS scores of Group 1 and Group 2 students (t=1,540; p=0,130>0,05). The comparison of the pre-test scores displayed that the groups displayed similar characteristics, and Group 1 was attended as experimental group, and the Group 2 was attended as control group randomly. Paired samples t-test was carried out to identify whether there were significant differences among EKT, EAS, and RTSS pre and post-test scores of the experimental group and the findings are presented in Table 4.

Table 4.Comparison of the pre and post-test scores of the experimental group

Tool	N	$\bar{X}$	SD	df	t	p
EKT Pre-test	26	12,08	0,66	25	-8,728	0,000
EKT Post-test	26	17,27	0,89			
EAS Pre-test	26	50,85	0,76	25	-2,560	0,017
EAS Post-test	26	53,23	0,71			
RTSS Pre-test	26	54,38	1,77	25	-,293	0,772
RTSS Post-test	26	54,69	2,01			

Table 4 displays that there is a significant difference between the EKT pre-test and post-test mean scores of the experiment group in favor of the post-test (t(25)= -8,728,p= 0,000 < 0,05). This result reveals that in the experimental group, authentic PBL had a significant effect on students' academic achievement. Paired sample t-test results displayed that there is a significant difference between the EAS pre-test and post-test mean scores of the experimental group in favor of the post-test (t(25)= -2,560, p= 0,017 < 0,05). This result reveals that in the experimental group, authentic PBL had a significant effect on students' environmental attitudes. The results displayed that there is no significant difference between the RTSS pre-test and post-test mean scores of the experimental group following the PBL (t(25)= -0,293, p= 0,772 > 0,05). This result displays that in the experimental group, the authentic PBL activities had no significant effect on students' reflective thinking skills. Paired samples t-test was carried out to identify whether there were significant differences among EKT, EAS, and RTSS pre and post-test scores of the control group and the findings are presented in Table 5.

Table 5. Comparison of the pre and post-test scores of the control group

Tool	N	$\bar{X}$	SD	df	t	p
EKT Pre-test	27	11,85	0,75	26	-3,228	0,003
EKT Post-test	27	14,07	0,89			
EAS Pre-test	27	48,52	0,94	26	-1,599	0,122
EAS Post-test	27	50,11	1,26			
RTSS Pre-test	27	50,56	1,74	26	-1,354	0,187
RTSS Post-test	27	52,00	1,68			

Table 5 displays that there is a significant difference between the EKT pre-test and post-test mean scores of the control group in favor of the post-test (t(26)= -3,228, p= 0,003 < 0,05). This finding displays that the didactic teaching method had a significant effect on students' learning in the control group. Paired sample t-test results displayed that there is no significant difference between the EAS pre-test and post-test mean scores of the control group (t (26) = -1,599, p= 0,122 > 0, 05). This result reveals that the didactic teaching method had no significant effect on students' environmental attitudes in the control group.

The results displayed that there is no significant difference between the RTSS pre-test and post-test mean scores of the control group following the PBL (t(26)= -1,354, p= 0,187 > 0,05). This result reveals that the didactic teaching method had no significant effect on students' reflective thinking skills in the control group. EKT, EAS, and RTSS post-test scores of the experimental and control group students were compared by using independent samples t-test, and the findings are displayed in Table 6.

Table 6. Comparison of the post-test scores of the experimental and control group

Tool	Groups	N	$\bar{X}$	SD	df	t	p
EKT Post-test	Experiment Group	26	17,27	4,52	51	2,545	0,014
	Control Group	27	14,07	4,62			
EAS Post-test	Experiment Group	26	53,23	3,61	51	2,156	0,037
	Control Group	27	50,11	6,55			
RTSS Post-test	Experiment Group	26	54,69	10,24	51	1,029	0,309
	Control Group	27	52,00	8,72			

Independent samples t-test results displayed that post-test EKT scores of the experimental group (M=17,27) was higher than those of the control group (M=14,07) and the difference was significant (t(51)= 2,545, p= 0,014 < 0,05). This result reveals that authentic PBL activities were more effective on students' academic achievement than traditional teaching. Similarly, post-test EAS scores of the experimental group (M=53,23) were higher than those of the control group (M=50,11) and the difference is significant (t(51)= 2,156, p= 0,037 < 0,05). This result revealed that authentic PBL activities were more effective on students' environmental attitudes than traditional teaching. No meaningful differences were detected between post-test RTSS scores of the experimental group (M=54,69) and the post-test RTSS scores of the control group (M=52,00) (t(51)= 1,029, p= 0,309 > 0,05).This result displays that the authentic PBL and the didactic teaching method had similar effects on students' reflective thinking skills. Covariance analysis (ANCOVA) was implemented on data to determine whether statistically meaningful differences existed between experimental and control groups' post-test EKT scores when pre-test EKT, EAS, and RTSS scores were controlled. The findings are presented in Table 7.

Table 7. ANCOVA analysis results when pre-test scores are controlled*

Source of Data	$\bar{X}$	df	F	p
Model	186,107	3	14,207	0,000
EKTpretest**	341,510	1	32,280	0,000
EASpretest**	42,670	1	4,033	0,050
RTSSpretest**	2,783	1	0,263	0,610
group	75,050	1	7,094	0,010
ERROR	10,580	48		
Total	14167,000	53		

* R^2= 0,577; ** Controlled variables

According to Table 7, the implemented model is meaningful (for the model p= 0,000 < 0, 05). The model explains 58 % of the academic achievement in the "Human and Environmental relations Unit (R^2= 0,577). The results of the ANCOVA analysis display that the PBL had a meaningful effect on the experimental group students' academic achievement when pre-test scores were controlled.

Results and Discussion

In the content of the study, data collection tools (EKT, EAS, and RTSS) were administered to the student groups as pre-test before the study. The pre-test scores of the groups were compared by using independent samples t-test. When the pre-test scores of the groups were analyzed, it was seen that the EAS pre-test average of group 1 was 50,85, while the EAS pre-test average of group 2 was 48,52. In addition, the RTSS pre-test average of the experimental group was 54,58, while RTSS pre-test average of group 2 was 50,56. When the averages were analyzed, although it was seen that the averages of both tests were higher in group 1, the results of the independent samples t-test showed that the difference is not statistically significant.The findings displayed that there was no significant difference between the pre-test scores of the EKT, EAS, and RTSS. The comparison of the pre-test scores displayed that the groups displayed similar characteristics and one of the groups was attended as experimental group, and the other one was attended as control group randomly. The experimental group was taught through the PBL, and the control group was taught through didactic teaching method.

Following the application, data collection tools were administered to the groups as post-test. The pre-test and post-test scores of each group were compared by implementing paired samples t-test. The paired sample t-test results displayed that there was a significant difference between the EKT post-test scores of the experimental group in favor of the post-test. Similarly, the paired samples t-test results displayed that there was a significant difference between the EKT post-test scores of the control group in favor of the post-test. Independent samples t-test was carried out to determine whether there was a significant difference between post-test scores of the experimental and control group. The results displayed that there was a significant difference between EKT post-test scores of the experimental and control group in favor of the experimental group. This finding revealed that authentic PBL activities had a significant effect on students' academic achievement when compared with the didactic teaching method.

Additionally, the results of the ANCOVA analysis display that the PBL had a meaningful effect on the experimental group students' academic achievement when pre-test scores were controlled and explained 58 % of the students' achievement in the "Human and Environmental relations Unit. Findings showed that PBL activities using authentic problems were more effective in increasing students' environmental knowledge compared to the traditional method. When the studies in the literature are analyzed, it can be seen that the findings in both studies which make use of the problem-based learning method and authentic learning support the finding that PBL increases the academic success of the students (McParland, Noble, & Livingston, 2004; Kelly & Finlayson, 2009; Wong & Day,2009; Reynolds & Hancock, 2010; Dochy, Segers, Van Der Bossche, &Gijbel, 2003; Albanese & Mitchell, 1993; Vernon & Blake, 1993).

In PBL, students deal with real-life problems. The real-life problems are worthy of solving and interesting and the students' attendance and learning increase in the activity. In PBL, a scenario that is related to a real-life situation is one of the most important components of the method. This scenario provides a meaningful context for the concepts (Dahlgren &Öberg, 2001). Since the scenarios make students focus on their learning process, designing the scenarios is very important (Boudand&Feletti, 1991). The problem scenarios are considered to be effective in the increase of students' learning about the subject.

Similarly, McGibbon and Van Belle (2015) stated that real-life problems enhance students' awareness and increase their participation. In PBL, students try to find solutions for a real-world problem, need collaboration and work in teams (Brundiers&Wiek, 2015). The problems are complex, systemic and cannot be solved easily (Wiek, Ness, Schweizer-Ries, Brand, &Farioli, 2012). In a PBL environment, students direct their learning while trying to solve the problems (Smith, 1995; Hungerford & Volk, 2003). Directing their learning supports the development of students' abilities and provides meaningful learning. Since the real-world problems in PBL are complex and multidimensional, students need to work in teams collaboratively (Stauffacher, Walter, Lang, Wiek, &Scholz, 2006). This situation supports not only the learning of students but also the development of various social skills.

Therefore, the researchers paid attention; that the scenarios used in the study carried a local quality. The events in the scenarios were directly related to the daily lives of the students, and they increased their interest in the problems and their willingness to find solutions. The use of authentic problem scenarios that reflect real-life or taken from real life, the problems in these scenarios having sub-problems and increasingly becoming interesting increased the interest of the students on the subject as well. Also, the students working together and sharing tasks and information in the PBL activities carried out in cooperative activities and being responsible for their learning and their friends' learning is another reason which positively affects the increase in their academic success. The students doing individual research and acquiring wide-scale information by interacting with more than one source to solve the authentic problems can be shown as a reason for the increase in their academic success.

The studies in the literature, in particular, show the efficiency of PBL in education related to environmental issues. For example, Haney, Wang, Keil, and Zoffel (2007) examined teachers' beliefs and practices in a problem-based learning curriculum that focuses on environmental health issues. The results displayed that PBL was an effective method in environmental education. Haney et al. (2007) stated that an integrated EE curriculum increased students' achievement compared with a traditional curriculum. In another study, Keil, Haney, and Zoffel (2009) stated that the proficiency and performance scores increased through using an integrative problem-based environmental health science curriculum. Kwan and So (2008) investigated the environmental learning of students through a PBL program, and the findings revealed that students acquired more in-depth knowledge and developed their critical thinking and problem-solving skills. Due to the complex and multidimensional nature of environmental problems, traditional didactic teaching methods are not sufficient

while teaching these issues (Ashford, 2004). Therefore, as the findings of this study displayed, PBL is one of the effective methods that can be used in environmental education.

Following the application, EAS pre-test and post-test scores of the experimental group were compared by implementing paired samples t-test. The results displayed that there was a significant difference in favor of the post-test. EAS pre-test and post-test scores of the control group were compared by implementing paired samples t-test. The results displayed that there was no significant difference between the pre-test and post-test scores. When the EAS post-test scores of the experimental group and the control group by implementing independent samples t-test, the results displayed that there was a significant difference in favor of the post-test scores of the experimental group. This finding shows that authentic PBL activities had a significant effect on students' environmental attitudes. Similar findings were stated in various studies (Mittelstaedt, Sanker, &VanderVeer, 1999; Waliczek&Zajicek, 1999;Palmberg& Kuru, 2000; Kadji-Beltran, Barker, &Rager, 2001; Bögeholz, 2002; Korhonen&Lappalainen, 2004;Kaplowitz& Levine,2005; Bolin,Khramtsova, &Saarnio, 2005; DiEnno& Hilton, 2005; Carrier, 2009;Ajiboye&Olatundun, 2010; Zembat, 2013; Reynolds & Hancock, 2010).The efficiency of authentic PBL activities in terms of increasing their attitude and awareness towards the environments can be explained by reasons such as the students being busy with authentic problems related to the environment, researching groups in the stage related to solving the authentic problems and their interest and sensitivity increasing due to the increase in their knowledge about the environment as a result of these researches. The problem scenarios being directly related to the lives of the students (for example, Salep-Anatolian Orchid) resulted in students realizing that the current problems might directly affect their own lives. In this respect, environmental problems have become a phenomenon that is not outside of their environment and lives but a phenomenon that directly and negatively affects their lives. It is considered that this increases the students' attitude towards the environment. In the present time, environmental problems have reached a dimensions which cannot be ignored and have gradually become complex. There is no single solution method for these problems. To solve the mentioned problems, individuals need to think, question and do research. Individuals who are faced with numerous news and information each day on the media need to have certain skills to be able to understand this news and distinguish right information from the erroneous ones. The purpose of environmental education is to help students acquire knowledge about the environment and develop their awareness of the environment. The findings of this study and the findings of the other studies indicated above showed that PBL application is an effective method in terms of increasing students' knowledge and awareness about the environment. Therefore, PBL is a method which can be used in environmental education.

Paired sample t-test was carried out to identify whether there was a significant difference between RTSS pre-test and post-test scores of the experimental group. The results displayed that there was no significant difference between RTSS pre and post-test scores of the experimental group. Similarly, when the RTSS pre-test and post-test scores of the control group were compared, the results displayed that there was no significant difference between the pre and post-test scores. When the RTSS post-test scores of the experimental and control group were compared, the results displayed that there was no significant difference between the post-test scores of the groups. However, Preus (2012) in his study, showed that authentic learning activities increase the skills of reflective thinking. This study was carried out in a total of 6 weeks in which pre and posttest applications were done. The PBL application lasted for four weeks. This period may not be sufficient for the development of the students' reflective thinking skills for problem-solving. Another reason is considered to be the young age of the students. Also, since the students met the authentic problem-based learning method for the first time, they may need more time to get used to the method. It is considered that with the process of getting used to the method, the students' giving their interest and attention to the applied method gets ahead of their reflective thinking and therefore, the method is not effective on the skill of reflective thinking.

Conclusion and suggestions

The findings of the study showed that authentic PBL application is an effective method in increasing the students' knowledge of the environment and developing positive attitudes towards the environment. Certain suggestions can be made to make the application more effective. The most important material of learning activities based on authentic problems is the problem scenarios prepared concerning the subject. The problem scenarios should be prepared taking the gains of the unit into consideration, be interesting and taken from real life or be possible to associate them with real life. A pre-study can be carried out and visual materials can be used in the presentation of the scenarios to make them more interesting. When PBL science education subjects are taken into consideration, it can be used in teaching all kinds of subjects, because all science related subjects have a place in daily life. However, the preparation of problem scenarios suitable for each subject can be compelling for teachers. While the teacher prepares problem scenarios suitable for a given subject, he/she can

use news on the media for inspiration, as well as his/her own creativity. Therefore, the preparation stage can be time consuming and difficult for the teachers compared to the traditional method.

One of the most important problems which can be faced with during PBL application is time limitation. The application of learning activities based on authentic problems is a method that requires more time compared to the traditional method. Since the application requires research to be done both in and out of the classroom, time management is extremely important. The teacher needs to plan and manage the process in a very good manner. In this process, problems can be solved with the teacher being familiar with the method and being experienced in the application of the method. The teachers who will be applying the method for the first time can face these mentioned problems in the beginning. In limited class lessons, the planning before the application needs to the done in a very careful manner to use the method productively. Therefore, pilot applications will be beneficial in terms of the identification of the application time and considering possible problems that may take place. Arranging the class in which the learning activities based on authentic problems suitable for group work, the materials to be used in the experiments and activities being easily accessible will make the method more productive. Continuous control and giving feedback during teaching through learning activities based on authentic problems is important for the process to continue productively. Therefore, it is suitable to work in only a few and small groups to increase interest and participation. In this sense, classes that are not too crowded will be more suitable for the use of this method. In teaching applications through learning activities based on authentic problems, the teacher should be competent in using the method. The teacher should create a democratic atmosphere in the class and should give importance to the views of the students on the method, encourage them and keep their motivation high and should guide the students as an expert when necessary. Learning activities based on authentic problems is an approach that aims at learning the subjects in-depth. Therefore, teachers can carry out these applications on subjects and concepts for which students are expected to learn in-depth, can come face to face within real life and wished to create awareness. Therefore, the use of the learning method based on problems in environmental subjects will be extremely suitable.

The habits of students as much as the habits of teachers can make the PBL process difficult. It can be difficult for the students who get used to the learning environmentsin which they are passive,to get used to PBL applications which require them to be active. Therefore, the teacher needs to inform students about the process and their expectations from them. When students know about the application steps and what is expected of them, it will be easier to carry out the PBL application. As a result, the possible problems to be faced during the PBL application can be overcome with the motivation of teachers. It is the teacher who will make the process easier and interesting for students. During the application process, students will become familiar with the process by time, and the problems which can be faced in the application will be reduced to the minimum.

Notes

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Appendix 1: Problem Scenario

Learning gains

1. Questions the importance of bio-diversity for natural life.
2. Discusses the factors which threaten bio-diversity based on research data and produces suggestions for solution.
3. Does research on plant and animal species which are extinct or under the threat of extinction in our country and in the world and gives examples.

Scenario

You graduated from the university as a food engineer. You hear that a food engineer will be hired by a new ice-cream factory in Kahramanmaraş. When you go there to apply for the job, the person in charge tells you that there are many applications for the position and that you need to write a report in which certain criteria should be given place to in order to be able to hire the best food engineer for the factory. He indicates that the food engineer who prepares the best report will be hired. The following criteria are needed:

1) How is salep which is used in ice-cream production obtained?
2) Where should salep be obtained from for the ice-cream not to lose its Maraş ice-cream quality?
3) What needs to be done to find large amounts of salep every time it is required?

Appendix 2: Student worksheet

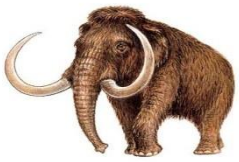
1. Below, photos of some species are presented. Decide whether the photo belongs to a species which is under the danger of extinction or became extinct.




Mediterranean seal Moa Lykia Orchid Dinosaur

……. ……. ……. ……






Bald Ibis Caretta Caretta Mammoth Galanthus

……. ……. ……. ……

2. Consider the following sentences as true (T) or false (F).
   ( ) The diversity and number of living species in a region express the biodiversity in that region.
   ( ) The biodiversity of our country is very poor.
   ( ) Biodiversity is used in the field of agriculture, medicine, pharmacy, forestry, fishing, breeding, and industry.
   ( ) The biodiversity of the desert ecosystem is richer than the biodiversity of the marine ecosystem.
   ( ) Deterioration of ecosystems does not affect biodiversity.
   ( ) The richness of a country's biodiversity supports the economic and cultural development of that country.
   ( ) Both human-induced factors and natural factors are effective in the deterioration of ecosystems.
3. Please match the statements given below.

Environmental problem	**Related Event**
( )Air pollution	a. Polluting the environment by radioactive substances.
( )Snow slide	b. Increasing toxic gases in the air.
( )Forest destruction	c. Combining toxic gases with rain.
( )Nuclear pollution	d. The sliding of a large mass of snow down the side of a mountain or cliff.
( )Soil pollution	e. Increasing waste in the soil.
( )Acid rain	f. Air polluting gases cause the world to overheat.
( )Ozone layer depletion	g. Increasing waste in the water.
( )Greenhouse effect	h. Exposure to the harmful effects of the sun.
( )Water pollution	ı. Reducing the number of plants and animals.

4. Please give five examples for the species which threatened with extinction in our country and the world (Plants/animals).
5. To prevent environmental problems, please write down your suggestions.

Appendix 3: Students'photos in PBL activities

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Preservice Teachers' Knowledge Levels, Risk Perceptions and Intentions to Use Renewable Energy: A Structural Equation Model

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Abstract

In today's world, energy consumption constitutes a topic on countries' main agendas. In parallel with the military, technological and scientific developments associated with the increasing population, countries are generating policies that highlight energy sources that play a part in global competition. As with many innovations, factors such as the public's knowledge levels regarding the innovations, social acceptance, attitudes, intentions and risk perceptions are seen to be directly related to the use of renewable energy. For this reason, the aim of this study was to test the relationships among the knowledge levels, risk perceptions and intentions of preservice teachers regarding renewable energy sources using structural equation model analysis. 642 preservice teachers studying in 3rd and 4th grades, and selected by convenience sampling, participated in the study. According to the results of the structural equation model analysis, the knowledge levels of the preservice teachers related to renewable energy sources negatively predicted their risk perceptions regarding renewable energy sources. Furthermore, while individuals' risk perceptions negatively predicted some of the theory of planned behavior components related to renewable energy sources, the theory of planned behavior components related to attitude, subjective norms and perceived behavioral control positively predicted the intention to use renewable energy sources. These analyses related to the structural equation model findings are discussed in detail.

Introduction

In today's world, energy consumption constitutes a topic on countries' main agendas. In parallel with the military, technological and scientific developments associated with the increasing population, countries are generating policies that highlight energy sources that play a part in global competition. These policies are mainly those that emphasize clean and renewable energy use (Açıkgöz, 2011; Bang, Ellinger, Hadjimarcou, & Traichal, 2000; Karagöl & Kavaz, 2017; Leiserowitz, 2008). However, despite these policies, the superiority of fossil fuels in supplying a large part of the world's energy demands continues. For example, according to the BP Energy Outlook 2035 report, in 2015, %32.8 of the world primary energy consumption met by oil, %29 by coal, and % 24.2 by natural gas (Karagöl & Kavaz, 2017). While fossil fuels continue to supply the energy needs of a growing population, their impact on the environment and their share in global warming have reached serious proportions. Similarly, when IEA (International Energy Agency) data in 2012 was considered, it was stated that around 31.7 million tons of carbon dioxide emissions were released worldwide and that fossil fuels having high carbon emissions played an important role in this (Çoban & Şahbaz Kılınç, 2015).

In this context, countries have organized meetings and signed protocols for controlling the use of fossil fuels and for trying to reduce the effects of greenhouse gases on a global scale. For example, with the meetings held in Rio de Janeiro and Kyoto, certain regulations and requirements related to emissions into the atmosphere and environmental pollution were introduced (Çoban & Şahbaz Kılınç, 2015; Leiserowitz, 2008). The aim of countries is to meet the growing need for energy on the one hand, while increasing the potential of clean and Renewable Energy Sources (RES or RE Sources) on the other (Açıkgöz, 2011). Many countries determine policies that target the meeting of future energy needs through the use of renewable energy sources. Turkey, for example, is one of these countries. The target is for one third of the country's energy needs to be supplied through renewable energy sources by 2023 (Karagöl & Kavaz, 2017; Ministry of Energy and Natural Resources 2014). Although countries and governments have determined investments and policies related to RE sources, the use of these energy resources is related to the public's adoption of RE sources. As with many innovations, factors such as the public's knowledge levels regarding the innovations, social acceptance, attitudes, intentions

and risk perceptions are seen to be directly related to the use of renewable energy (Devine-Wright, 2007; Güven & Sülün, 2017; Halder, Pietarinen, Havu-Nuutinen, Pöllänen, & Pelkonen, 2016).

The public's acceptance of RE sources and their intention to use them result in RE sources being adopted and spread to large populations. In this context, while on the one hand, investment and policies are being determined, on the other hand, revealing and examining the factors that affect public use will give clues to policymakers. For example, when examining the studies related to RE sources, it is seen that factors such as the attitudes (Kaldellis, Kapsali & Katsanou, 2012; Upreti & van der Horst, 2004; Zyadin, Puhakka, Ahponen, Cronberg, & Pelkonen, 2012), awareness and ideas (Altuntaş & Turan, 2018; Kılınç, Stanisstreet & Boyes, 2009), knowledge levels (Güven & Sülün, 2017) and beliefs (Bang et al., 2000; Halder et al., 2016) of individuals affect the use of RE sources. It can be said that all these factors are examined together and that there is no widely accepted psychological model (L'Orange Seigo, Dohle & Siegrist, 2016). However, in this context, it is also true that the Theory of Planned Behavior (TPB) is often adopted by researchers in determining acceptance for environmentally friendly behaviors such as RE sources (Halder et al., 2016).

TPB investigates intentions affecting the behavior of individuals with factors such as attitude (AT), perceived behavioral control (PBC) and subjective norms (Ajzen, 1991). Moreover, the TPB allows for other variables, which can be considered as related to the components it contains, to be tested together with these (Kilinc, Ertmer, Bahcivan, Demirbag, Sonmez, & Ozel, 2016). On the other hand, when individuals encounter innovations, one of the most important factors other than the TPB components that affect the adoption and use of these innovations is risk perceptions (L'Orange Seigo, Dohle & Siegrist, 2016; Visschers, Keller, & Siegrist, 2011; Whitmarsh, 2009). The public's perceptions of risk, particularly in matters they perceive as dangerous such as nuclear power plants and genetically modified organism directly affect social acceptance (Kılınc, Boyes & Stanisstreet, 2013). When risk perceptions are felt, the public may decide with lack of knowledge and limited reasoning. (Kılınç et al., 2013; Upreti & van der Horst, 2004). In this sense, countries and policymakers should demand at least that public awareness is raised regarding risk perceptions that hinder the fair evaluation of evidence and decision-making mechanisms such as logical reasoning (Frewer, 2004; Upreti & van der Horst, 2004). Therefore, in this study, an attempt will be made to model the knowledge, risk perceptions and intentions which, as outlined above, affect the use of RE sources by considering them together. In the study, preservice teachers were selected as the sample group, since preservice teachers, when they themselves undergo training related to the use of RE sources and then begin their careers, play an important role in raising public awareness of RE sources. Therefore, from the perspective of the teachers who assume a leading role in the public's use of RE sources, it is important that the factors regarding the use of RE sources are clarified. For this purpose, the knowledge levels, risk perceptions and intentions of preservice teachers regarding RE sources will be examined with the Structural Equation Model (SEM) model.

Theoretical Framework

Knowledge Levels

Changes in energy policies by countries and their efforts to start looking for new types of energy have led individuals to turn towards formal and informal energy training aimed at increasing their awareness and knowledge of eco-friendly, renewable energy types. In this context, there are studies in the related literature that examine individuals' knowledge levels about RE sources, as well as their attitudes, awareness and risk perceptions regarding RE sources (Altuntaş & Turan, 2018; Güven & Sülün, 2017; L'orange et al., 2014; Upreti & van der Horst, 2004; Wolsink, 2007). Examining the studies conducted, for example, Upreti and Van der Horst (2004) stated in their research that individuals do not know about bioenergy power plants, which are one of the types of RE, and that because of this, they have high levels of risk and anxiety. Moreover, the public's lack of knowledge and misunderstandings regarding bioenergy production, which is one of the RE sources, how it is carried out and its potential impacts on the environment give rise to risk perceptions and cause these to spread in society. In his study, Wolsink (2007) examined the effect of individuals' knowledge levels about RE on the use of RE sources and the changes in their attitudes and behaviors when they were familiarized with this type of energy. In the latest research conducted after wind turbines were established and local people were informed about the subject, it was concluded that individuals' knowledge levels increased and that there were positive changes in their behaviors. In their research, in which the mixed-method design was used, Altuntaş and Turan (2018) investigated the awareness of high school students about RES. As a result of the study, it was determined that the high school students had high awareness levels about RES, that there was a significant relationship between knowledge levels and attitudes, and that students with high levels of knowledge stated that they did not see a risk in the use of RES, that they had a positive attitude towards them, and that they would

prefer them in the future. In their studies, Güven and Sülün (2017) examined the knowledge and awareness levels of preservice teachers regarding RE sources. They utilized knowledge test and awareness scale for RE sources in the data collection process. As a result of the analyses, it was concluded that there was a significant relationship between RE sources knowledge levels and awareness of the preservice teachers and that their knowledge levels were a predictor of their awareness. In their study, in which they investigated the knowledge and perceptions of Finnish high school students regarding RES, Halder et al. (2016) found that the great majority of the students had low levels of knowledge about RE sources and that students living in the city center had more positive perceptions about RE sources than did students living in rural areas. They suggested that students' knowledge about RE sources could be increased through cooperation with policy makers and training programs.

Risk perceptions

One of the most popular concepts in the decision-making mechanism of individuals over the last half century is risk. According to researchers, risk is addressed in two dimensions, namely direct exposure to risk, that is the risk itself, and perception of risk in the individual (Sjöberg, Moen & Rundmao, 2004). In this research, since individuals are not directly at risk from renewable energy, their risk perceptions are discussed in the study. According to risk theorists, risk perceptions are defined as the possibility of there being unwanted events such as accidents (Howard, 2011; Rohrmann & Renn, 2000). Risk perceptions include subjective evaluations of individuals regarding the possibility of there being a specific situation, such as the occurrence of an accident. Besides an evaluation of its probability, perception of the risk also includes its negative consequences (Sjöberg et al., 2004). Furthermore, risk perceptions are related to a specific attitude formed by individuals towards a specific object (a potential hazard) and are intertwined with other psychological factors (Frewer, Lassen, Kettlitz, Scholderer, Beekman, & Berdal, 2004).

Examining risk theory, two dominant theories are revealed in studies related to risk, namely cultural theory and the psychometric paradigm. While the psychometric paradigm is based on psychology and decision-making science, cultural theory has been developed by sociologists and anthropologists (Sjöberg et al., 2004). While cultural theory is limited in terms of empirical studies, the psychometric paradigm is effective in quantifying and measuring factors related to risk with appropriate survey instruments (Sjöberg et al., 2004; Slovic, 1992). In this study, when discussing the perceptions of risk, the psychological paradigm is focused on. The psychometric paradigm assumes that there is no risk perception that is independent from our minds and culture, and includes subjective evaluations. The psychometric paradigm includes risk-related factors such as dread, voluntary risk, catastrophic potential, control, severity of consequences, etc. In many studies, these factors are gathered by researchers under the headings of "dread" and the "unknown" (Kılınc et al., 2016; Slovic, Fischoff, & Lichtenstein, 1982). "Dread" is characterized by a lack of control over the risk, the potential for catastrophic or fatal consequences, and the degree to which distribution of the risk is inequitable. The unknown is characterized by the newness of the hazard, the degree to which its dangers are unobservable, and the delay mechanism of the harm (Sohn, Yang & Kang, 2001, p.555).

Examining the studies on risk perceptions and RE, it is observed that risk perceptions are closely related to attitudes, use behavior and knowledge. For example, in their study, Eltham et al. (2008) examined the attitudes and views of individuals living in coastal regions of Scotland before and after the establishment of wind turbines (a period of 14 years), with regard to energy safety and negative effects. Following the interviews conducted, it was concluded that the residents of the region stated that wind farms were clean, sustainable and environmentally friendly, and even that they had begun to support them after their installation. Moreover, it was determined that their attitudes had changed positively, while their risk perceptions of negative and harmful aspects decreased after installation and use. Again, in other studies (e.g., Upreti & van der Horst, 2004), it was stated the manipulative portrayal of environmental and social risks related to RE sources by the local media had led to a negative attitude towards public and that this negative attitude and risk had been spread by communication among people. Pongiglione (2011) argued that knowledge of the subject, risk perception and individual interests are three important components in individuals' environment-friendly decision-making processes. Previous studies evaluated each of these components independently and therefore were unable to fully ensure that the environment-friendly decision-making process was carried out. For example, Pongiglione (2011) reported that individuals' possession of knowledge about global warming is not directly reflected in behaviors aimed at reducing global warming, that is, it does not lead to effective behavior change. For this reason, Pongiglione (2011) stated that factors such as knowledge, risk perception and self-interest should be evaluated together in environmentally-friendly decision-making processes, and that only in this way can they bring about behavior change by activating deep psychological mechanisms.

The Theory of Planned Behavior

The Theory of Planned Behavior (TPB) is one of the most important theories that have pioneered the understanding of human behavior. The TPB is based on "the Theory of Reasoned Action" (Ajzen, 1991; Halder et al., 2016). Theory of Reasoned Action postulates that individuals' own wills and desires guide behavior. However, in his later research, Ajzen (1991) stated that external factors and barriers affect an individual's behavior and that the individual predicts his behavior in his perception of and belief in his control over these external structures (Perceived Behavioral Control), and so he put forward the TPB.

The TPB attempts to explain the factors that guide behavior by centering on individual and social judgements such as belief and attitude (Ajzen, 1991; Halder et al., 2016). In this context, the TPB is established on the trio of attitude (AT), which include individuals' positive and negative judgements regarding behavior, Subjective Norms (SN), which include the effect of other people's discourses and attitudes on behavior, and Perceived Behavioral Control (PBC), which includes individuals' perceptions of their control over the external factors that make their behaviors easier or more difficult. TPB assumes that these factors together form the basis of behavioral intention (I) (Ajzen, 1991). The TPB is a widely accepted and studied theory covering a very wide range from marketing to consumer behavior, from the use of educational technologies to inability to explain health-related behaviors. In recent years, the TPB has also been used to explain the intentions of individuals towards environmentally friendly behaviors (Halder et al., 2016). For example, with the TPB, attempts have been made to explain university students' willingness and behaviors regarding the use of recycling (Chan &Bishop, 2013) and their purchasing of organic foods (Yazdanpanah & Forouzani, 2015) or adults' willingness to use individual vehicles and to reduce their use (Abrahamse, Steg, Gifford & Vlek, 2009) and their choice of public transport types when commuting (Donald, Cooper & Conchie, 2014) and more particularly, individuals' energy conservation behaviors (Wang, Zhang, Yin & Zhang, 2011), their willingness/intention to reduce carbon use (Lin, Wu, Liu, & Lee, 2012), or their intentions related to afforestation efforts and underlying parameters (Karppinen, 2005).

The TPB also functions as an important theoretical framework in determining the intentions for use of RE sources. For example, in Halder et al.'s (2016) study, the tendencies of 9th and 10th grade high school students (n=532) in Finland and India to use bioenergy were investigated. With the structural model they established, they examined the power of the TPB to predict bioenergy use. As a result of the analyses, it was concluded that the attitude component was statistically the strongest and most meaningful predictor of bioenergy use, that the second strongest predictor was the SN component and that the PBC component, however, had a negligible or insignificant effect on the intention dimension. In general, it is emphasized that the model was accepted and that when the model was examined, it predicted the high school students' intentions to use bioenergy.

In their scanning study, Alam and Rashid (2012) examined perceptions regarding the use of RE sources in Malaysia (N=200) by means of the scale they developed. In the analyses of the data obtained, they utilized exploratory factor analysis and multiple regression analysis. As a result of the factor analysis, items were grouped into five dimensions, namely relative advantage, perceived behavioral control, ease of use, awareness and benefit-cost trade-off. As a result of the multiple regression analysis to test the five dimensions, relative advantage and perceived behavioral control positively mediated attitude towards renewable energy, while attitude positively mediated intention to use renewable energy. However, ease of use, benefit-cost trade-off and awareness positively but directly influenced intention to use renewable energy.

Proposed Model

When the literature summarized above is considered, no study related to RE sources has been encountered in which knowledge level, risk perceptions and intentions in the context of the TPB are modelled together. However, when the literature outlined above is examined, it is considered that knowledge, risk perceptions and intentions regarding RE sources may be interrelated. As suggested by Pongiglione (2011) it is aimed to test the structural relationships proposed in Figure 1 by taking into consideration his suggestion that factors such as knowledge and risk perception are examined together with intention when examining environmentally friendly behaviors. Examining Figure 1, paths between knowledge, risk perceptions and the TPB with regard to RE sources are proposed. On the paths suggested, the broken arrowed lines show negative relationships, while the continuous arrowed lines show positive relationships. When these relationships are examined, first of all, the hypothesis that an increase in the knowledge levels of the preservice teachers regarding RE sources "may be a positive predictor of intention to use RE sources" is proposed, in accordance with the literature (Altuntaş & Turan, 2018; Bang et al., 2000).

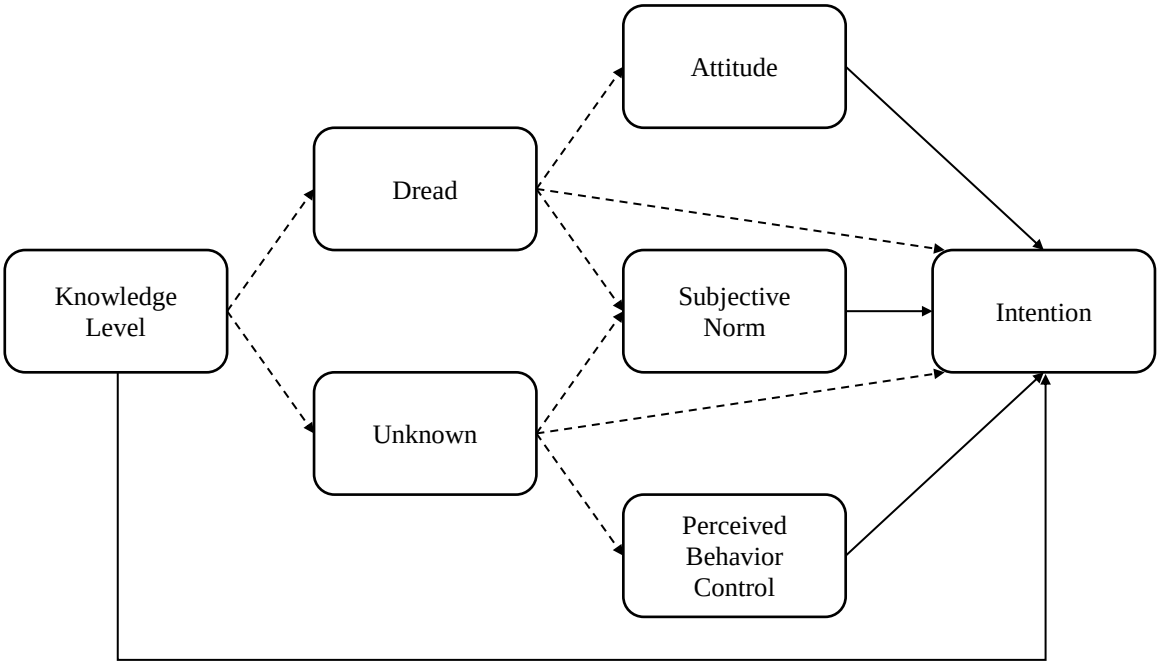

Figure1. Proposed model

On the other hand, considering knowledge levels and risk perceptions regarding RES, it is assumed that risk perceptions (some clues exist) may decrease as knowledge levels increase (Painuly, 2001; Upreti & van der Horst, 2004). Considering another relationship, the one between risk perceptions and the TPB, it is hypothesized that the preservice teachers' risk perceptions regarding RE sources may have a negative effect on the TPB components (AT, SN, PBC and I). Considering the dread and unknown risk factors related to RE sources, it can be expected that the dread factor, which accompanies concerns about the damage that renewable energy sources can cause to nature and living things, and the unknown factor, which includes the possible unknown damage from the risks in the future, will be negative predictors of the intention to use RE sources and of the other factors related to intention (AT, SN and PBC). Indeed, studies exist which show that risk perceptions about the use of RE sources negatively affect factors such as attitudes towards and intention to use RE sources (L'Orange et al., 2014; Wolsink, 2007). With these expectations in mind, answers to the following research question have been sought in the proposed model:

1) What are the relationships among preservice science teachers' knowledge levels, risk perceptions and intentions with regard to RE sources?

Significance of the Study

When the literature is examined, it is seen that especially the variables chosen for this study are generally considered independently. In this study, the first significance of the study is to examine all three variables together and test the relationship between SEM analysis. Secondly, the results of the studies showing how TPB, which is frequently discussed in environmental studies, are diffused with other variables will contribute to the literature. In this sense, considering the risk perceptions and knowledge level together with the TPB reveals the second significance of the study. Finally, the selection of prospective teachers in this study shows another importance of the study, because it is important to clarify the perspectives of future teachers, who play a leading role in the acceptance of the public's use of RE resources.

Methods

Participants

In this study, the relationship between the variables presented in Figure 1 was investigated by SEM analysis. Therefore, the correlational research design was applied in the study (Fraenkel & Wallen 2009). A total of 642

preservice teachers from six different universities, selected by convenience sampling participated in the study. The preservice teachers were selected from preservice teachers attending to the 3rd and 4th grades of the science teaching and classroom teaching departments. Prior to this selection, the researchers examined the courses given and the departments in the faculty of education with regard to RE sources. The reason for the selection of preservice teachers from these grade levels and departments was because courses such as environmental science that include content knowledge related to renewable energy sources are included with priority in the curricula of the science teaching and classroom teaching departments and because these courses are completed by the preservice teachers at these grade levels.

Development and Implementation of Measurement Tools

Development of Risk Perception Scale and Intention Scale

It was aimed to develop scales containing preservice teachers' risk perceptions and intentions with regard to renewable energy sources. For this purpose, firstly, an interview form consisting of open-ended questions was prepared by taking inspiration from studies in the literature (e.g. Ajzen, 1991; Kılınç et al., 2009; Sjöberg et al., 2004). In the interview form, together with questions applying to the TPB and its components, such as Are you planning to use renewable energy sources? (I), Who will support the use of renewable energy sources? (SN), and What can be facilitated by using renewable energy sources, and what will you need? (PBC), questions applying to risk perceptions based on the psychometric paradigm were used, such as Does using renewable energy sources pose a risk to you? Can you explain your answer? (Dread), Can the risks that will be created using RE sources be brought under control? (Control), and Can the use of renewable energy sources cause any damage that we cannot observe today? (Unobserved Effect). The interview form consisted of 22 questions. Secondly, by means of the interview form prepared, focus group interviews were conducted with 16 preservice science teachers and preservice classroom teachers selected from the third and fourth grades. The focus groups were selected separately according to department and grade level and 4 focus groups were thus formed. Each group consisted of 4 preservice teachers, as follows: 4 classroom preservice teachers in third grade (2 low, 2 high), 4 science preservice teachers in third grade (2 low, 2 high), 4 classroom preservice teachers in fourth grade (2 low, 2 high), and 4 science preservice teachers in fourth grade (2 low, 2 high). To provide maximum diversity, the students in each focus group were evaluated according to their final grades in the environmental science course which included content related to renewable energy sources from the previous semester, and were separated into low and high achievement according to a certain pass mark set by the university automation system. Semi-structured interviews conducted with each focus group lasted approximately 45 minutes and were recorded with a voice recorder. With the aid of the transcripts of the data obtained from the interviews, the process of writing the items was begun and the item pool was created. The items created were examined by two academicians who are experts in the field, and the draft versions of the scales were created by making the necessary semantic and linguistic revisions and content control. The risk perception scale for RE sources consisted of 22 items, while the intention scale for use of RE sources consisted of 37 items. The scales were designed as 5-point Likert-type scales.

Risk Perception Scale

Exploratory Factor Analysis (EFA) was applied to the risk perception scale developed as outlined above. Following maximum likelihood and Varimax rotation, factor loads below 0.40 were eliminated. As a result of the first analysis, 5 items with factor loads below 0.40 were removed and a two-dimensional structure was obtained. When the remaining 17 items were analyzed in themselves, it was seen that the two items were collected under a common dimension, these items were also removed. When the two-dimensional factor structure in the remaining 15 items was examined, it was seen that the factors were separated under the headings of "dread" and "unknown", as in previous studies. However, since two items which should, theoretically, have been collected under the title dread, were instead collected under the title unknown, these items were also removed and the analysis was finalized based on the remaining 13 items. Following the analysis, the KMO measure of sampling adequacy was 0.94 and Bartlett's test of sphericity was significant, with chi-square (4552, n=642), $p < 0.0001$. Several verifications (eigenvalue>1, scree plots and communality value > 0.5) were considered during the exploratory factor analysis, which produced a 2-factor solution. The factor loadings were between 0.82 and 0.46. Also, the Cronbach Alpha reliabilities were calculated as 0.85 and 0.90 for the dread and unknown dimensions, respectively. This explains 56% of the total variance.

Intention Scale for Renewable Energy

To ensure validity of the intention scale for RE sources, EFA was performed using maximum (n=642) likelihood analysis with direct oblimin rotation. It was observed that the factors were distributed according to the Theory of Planned Behavior (TPB). Factors were divided into the PBC, SN, I and AT dimensions. However, it was seen that there were some problems in the attitude and intention dimensions. Firstly, considering the problem related to the attitude dimension, the analysis revealed that the items were collected in a fifth dimension outside the TPB components. When the items in this scale were examined, it was seen that although the items could be named in the attitude sub-dimension, they had shifted to a different dimension. Interestingly, when these items were examined in detail, it was seen that they consisted of negative attitude items. Although these items were recoded prior to analysis, the fact that they were placed in a separate dimension posed a problem. In order to solve this problem, first-order analysis was performed with AMOS software, and since a high degree of correlation was observed between items in the two dimensions, these were combined into a single dimension. After an item which reduced the estimated factor load had been removed from these combined items, the attitude dimension was finalized. As for the problem with the intention dimension, it was determined that some items of the intention dimension contained self-efficacy items. The analysis was finalized by removing these 3 items. Following the analysis, the KMO measure of sampling adequacy was 0.89 and Bartlett's test of sphericity was significant, with chi-square (4883, n=642), $p < 0.0001$. Several verifications (eigenvalue > 1, scree plots and communality value > 0.5) were considered during the exploratory factor analysis, which produced a 5-factor solution. The factor loadings were between 0.84 and 0.41. Also, the Cronbach Alpha reliabilities were calculated as 0.66 for SN, 0.86 for PBC, 0.86 for I, and 0.75 for A, respectively. This explains 47% of the total variance.

Knowledge Level Test

The knowledge test for RE sources was previously developed by Güven and Sülün (2017). The knowledge test used has a 3-point Likert-type ("correct", "wrong ", and "don't know") structure consisting of 12 items. A reliability coefficient of KR20 = 0.84 was obtained by the researchers. Item difficulties for each item ranged from 0.39 to 0.65, and discrimination indices ranged from 0.32 to 0.58. In this study, while using the test, correct answers were awarded a score of 1 point, while wrong and "don't know" answers were given a score of 0. The test was subjected to structural equation modelling and evaluated on the basis of total score, and the total reliability coefficient of the test was determined as Cronbach's alpha = 0.72.

Procedure and Analysis

The scale, which consists of the developed risk perceptions and intention scales and knowledge level test, was applied to 642 preservice teachers studying in the science teaching and classroom teaching departments of six different state universities. The reason for applying the scale to preservice teachers in these departments was because the curricula of these departments include content related to RE. Before the implementation, brief information about the purpose of the study was given to the participants and it was stated that since personal data would not be shared in any way, they should not specify their identity on the questionnaire. The data, collected using SPSS 25 software, were checked for missing values after the application. The explanatory factor analysis (EFA) of the developed risk perception and intention scales and the reliability analysis of the knowledge test were performed using SPSS 25 software. After the necessary analyses were performed and the scales were verified, Structural Equation Model (SEM) analysis was performed with the aid of AMOS software.

Results

Descriptive Results

The descriptive analysis shows that the mean scores of the preservice teachers related to renewable energy sources is 9.40. Considering that the maximum score that could be obtained from the knowledge test was 12 points, it can be said that according to their mean scores, the preservice science teachers had high levels of knowledge about RE sources. According to the results of the analysis, it can be said that the prospective teachers' risk perceptions with regard to RE sources were not very high. When the Table1 is examined, it is seen that the items related to risk perceptions are below the mean value.

Table 1. Descriptive and factor analysis results for risk perception

Dread	Mean	SD	Fac.
To what extent can renewable energy sources harm the lives of plants?	2.05	1.03	0.82
To what extent can renewable energy sources harm the lives of animals?	2.13	1.04	0.87
To what extent can renewable energy sources harm the lives of humans?	1.98	1.05	0.85
To what extent can renewable energy sources harm the lives of future generations?	2.09	1.12	0.78
To what extent do you worry about using renewable energy sources for the first time?	2.40	1.15	0.46
To what extent does using renewable energy sources mean disrupting the natural world?	2.14	1.06	0.56
Unknown			
To what extent may renewable energy sources contain risks which are invisible now, but which are potential risks in the future?	2.60	1.07	0.53
How worrying is the fact that renewable energy sources are new?	2.39	1.10	0.47
To what extent can the risks of renewable energy sources have a knock-on effect on other living things?	2.44	1.06	0.54
To what extent can scientists manipulate the risks of renewable energy sources for commercial purposes?	2.96	1.17	0.48
To what extent can a harmful effect of renewable energy sources created in one region impact other regions?	2.76	1.12	0.69
To what extent will the risks created by renewable energy sources increase in time?	2.63	1.03	0.76
To what extent can renewable energy sources cause unknown negative results today?	2.55	0.97	0.62

Table 2. Descriptive and factor analysis results for TPB dimensions

Attitude	Mean	SD	Fac.
Renewable energy sources provide an inexhaustible energy supply.	3.67	0.96	0.59
Using renewable energy sources reduces dependence on foreign resources.	4.03	0.90	0.62
The use of renewable energy sources can provide sustainable development.	3.84	0.87	0.71
Using renewable energy sources is environmentally friendly.	3.90	0.99	0.63
Renewable energy sources can increase global warming.	3.47	1.06	0.69
The technological infrastructure of renewable energy sources may disrupt nature.	3.12	1.01	0.67
Renewable energy sources can cause climate change.	3.23	1.06	0.71
Renewable energy sources may not replace fossil fuels for the consumer.	3.10	1.00	0.44
The use of renewable energy sources creates aesthetic pollution.	3.52	1.05	0.59
Renewable energy sources may not be able to meet the supply-demand balance.	3.03	0.98	0.43
Perceived Behavioral Control			
If the tools and equipment used for working with renewable energy sources ensure ease of use, I will choose them.	3.92	0.93	0.70
If renewable energy sources are safe, I will use them.	4.08	0.90	0.75
If the necessary infrastructure is provided to suit regional and climatic conditions, I will use renewable energy sources.	3.95	0.93	0.71
I will use renewable energy sources if they can meet our basic needs as much as fossil fuels.	3.79	0.95	0.61
If the use of renewable energy sources is tested in a region and the results are seen, I will use them.	3.83	0.90	0.66
If renewable energy sources ensure energy continuity, I will use them.	3.89	0.89	0.73
If technical support is provided for problems related to renewable energy sources, I will use them.	3.89	0,84	0.68
It is necessary to have sufficient knowledge in order to use renewable energy sources.	3.95	0.97	0.48
Subjective Norms			
If politicians and government officials approve my use of renewable energy sources, I can use them.	3.31	1.07	0.65
If the use of renewable energy sources is supported by the media, I can use them.	3.29	1.02	0.76
Intention			
I plan to use renewable energy sources in the future.	3.69	0.90	0.83
I am considering obtaining the necessary energy from renewable energy sources.	3.58	0.94	0.84
I am willing to use renewable energy sources.	3.83	0.95	0.80

However, when the mean values of the items under the dread heading and the items under the unknown heading are compared, it can be stated that with regard to RE sources, the unknown dimension was a more important parameter for creating risk than the dread dimension for the preservice teachers. For example, under the heading

of unknown, the preservice teachers agreed more strongly with the risks that "scientists may manipulate the risks of renewable energy sources for commercial purposes" and "a harmful effect created in one region may also impact other regions" than they agreed with other items. On the other hand, under the unknown title, the preservice teachers showed less agreement with the items related to the risks of newness of renewable energy sources. When the items under the dread heading are examined, however, the preservice teachers showed a high level of agreement with the point regarding using RE sources for the first time, while they showed low agreement with the point stating that renewable energy sources harm people's lives. Considering each of the sub-dimensions of the TPB including the factors related to intention (Table 2), it can be said that attitude towards RE use, SN, PBC and intention have high mean values. For example, when the AT sub-dimension is examined, it can be stated that a large percentage of the preservice teachers considered renewable energy sources to be an important factor in reducing dependence on foreign sources. Again, while the preservice teachers accepted RE sources as environmentally friendly, they had a less positive attitude towards RE sources replacing fossil fuels for the consumer and towards RE sources meeting the supply-demand balance. When examining the SN of the preservice teachers, both items appear to have similar mean agreement values. The preservice teachers stated that with the approval of politicians and government officials and with the support of the media for the use of RE sources, then they could use RE sources. Examining another factor, that of PBC, the preservice teachers indicated that they gave more importance to safety, infrastructure and knowledge levels as facilitators for using RE sources and that they planned to use them after they were controlled. Although the PBC item for the ability of RE sources to meet basic needs as much as fossil fuels has a high mean score when considering the scale in general, it can be said to be a weaker facilitator in comparison with the other items in this dimension.

SEM Results

Structural equation modelling analysis was conducted to investigate the relationships among preservice teachers' knowledge levels, risk perceptions and intention of using renewable energy. The statistical model has an acceptable fit index ($\chi 2/df=2.82$, CFI=0.90, TLI=0.89 and RMSEA=0.037). The structural relationships are displayed in Figure 2.

AT: Attitude, SN: Subjective Norms, INTENT: Intention

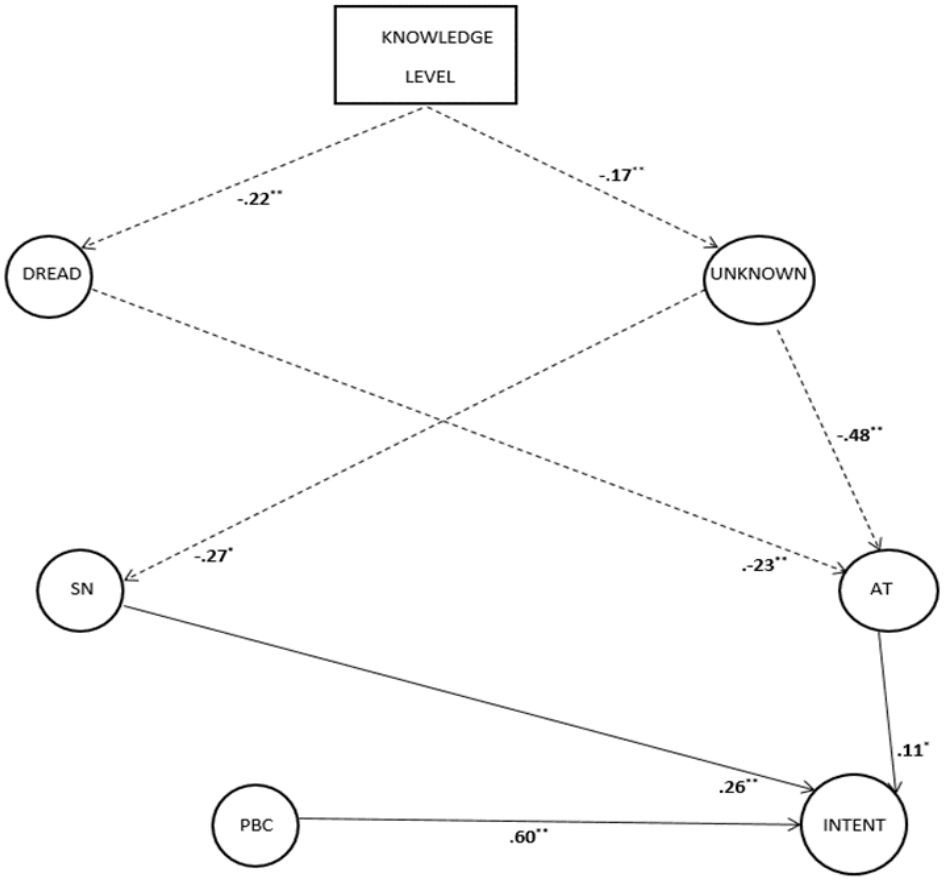

Figure 2. The statistical model (*p<0.05, **p<0.001)

The continuous arrowed lines display positive prediction whereas the broken arrowed lines are used to show negative prediction. According to the results of the SEM analysis, the preservice teachers' levels of knowledge about RE sources significantly predicted their risk perceptions, while there was no significant relationship with intention to use RE sources. As shown in Figure 2, the preservice teachers' levels of knowledge about RE sources were negative predictors of the "dread" and "unknown" factors that cause risk perceptions. Moreover, one of the most important results is that the risk perceptions of individuals negatively predicted almost all of the TPB components (excluding the PBC) that predict the intention to use RE sources.

When risk perceptions and subjective norms are examined together, risk perceptions are seen to predict subjective norms negatively. In other words, the less individuals know about the risks of renewable energy sources and the more their uncertainty increases, the less they pay attention to subjective norms that include other people's discourses and evaluations of the social environment. On the other hand, when positive relationships are examined, it is seen that all the TPB components have a positive effect on intention, in accordance with the theoretical framework. Individuals' attitudes towards renewable energy sources, subjective evaluations involving the influence of other people and the environment (subjective norms) and perceptions of control related to factors outside individuals' own worlds (perceived control) positively affect the intention to use renewable energy sources.

Discussion and Conclusions

In this research, it was aimed to test the relationships among the knowledge levels, risk perceptions and intentions of preservice teachers regarding use of RE sources by using SEM analysis. For this purpose, an intention scale and risk perception scale related to RE sources were developed. As a result of the analysis, the factor structures of the risk perception and intention scales regarding use of RE sources were seen to be compatible with the theoretical framework in terms of validity and reliability. Of the two scales developed, the risk perception scale was divided into dimensions with the headings "dread" and "unknown" in accordance with the psychometric paradigm, which is a theoretical framework used in risk perception studies (Kılınc et al., 2016; Sjöberg, et al., 2004). Examining the intention scale, it was seen that it consisted of reliable factors including the TPB components of AT, PBC and SN, as well as intention, in line with the TPB framework. When the factors divided into sub-dimensions in accordance with the theoretical framework and with other studies (e.g. Halder et al., 2016; Karppinen, 2005) were subjected to SEM analysis, the structure in Figure 2 appeared. When this structure and the required values (RMSEA, etc.) are examined, it can be said to be a fit model. When beginning to discuss these results, it is considered that especially the relationship of the risk perceptions dimension with the knowledge level and TPB components may be regarded as interesting and of a type that will contribute to the literature.

The existing studies related to the use of RE in the literature consist of studies that are true to the framework of the TPB and reveal positive results of the TPB components, a finding which is also seen in this study (Alam & Rashit, 2012; Halder et al., 2016). In this context, testing the relationship between the TPB and risk perceptions can be considered important, as there are some studies (Kılınc et al., 2009; Wolsink, 2007), even though they do not directly include the term risk perceptions, which suggest that risk perceptions regarding RE sources may be a negative predictor of intention. For example, in their study, Kılınç et al. (2009; p.1089) mentioned that "there were some concerns about safety; although half of the students thought that renewable power installations were safer than other types of power generators, over half thought that renewable power generators could in some way harm plants, animals or humans that lived nearby". At this point, it is important to note that this study is not only important in raising the voice of such studies, but also in establishing this relationship and analyzing it with the SEM. When the findings shown in Figure 2 are discussed from this perspective, it is observed that the preservice teachers' knowledge levels regarding RE negatively predicted the "dread" and "unknown" factors that cause risk perceptions. Firstly, when the descriptive results are examined, it can be said that the knowledge levels of the preservice teachers' related to RE sources were high. Courses included in the curriculum such as environmental education, earth sciences, socio-scientific issues, and advertisements in the media such as public service announcements may have been effective in achieving these high levels of knowledge about RE sources in the preservice teachers. The fact that as the knowledge levels of the preservice teachers increased, their risk perceptions decreased may be because their fears decreased and because their fear of the unknown, which causes uncertainty, also decreased. Clues may also be found in the literature to the fact that as knowledge levels related to renewable energy sources increase, individuals' perceptions of risk towards that subject or object decrease (Upreti & van der Horst, 2004; Painuly,2001).

Moreover, another point that should be discussed is that individuals' risk perceptions negatively predicted almost all the TPB components (except for PBC) with regard to the use of RE sources. This result is consistent with the hypothesis in the proposed model. Of these results, firstly, when the relationship between risk perceptions and attitude is examined, it is seen that although individuals believed that there would be positive results of RE sources and they had a positive attitude towards using RE sources, their high levels of risk perceptions related to RE sources affected their attitudes negatively. Indeed, both of the risk sources which create these risk perceptions and which are separated under the headings of dread and unknown in other risk studies, also negatively predicted attitude in this study (as seen in Figure 2). Similarly, in some research findings (e.g., Graham, Stephenson, & Smith, 2009; Wolsink, 2007), it is stated that concerns that can be considered as risk perceptions of RE sources (noise, impacts on wildlife, plants, ecosystems and water quality) are responsible for negative attitudes in individuals towards RE sources. In our study, it was observed that the preservice teachers had similar risk perceptions under the dread and unknown headings and that these had a negative effect on attitude. According to Frewer et al. (2004) risk itself is also regarded as a negative attitude towards a specific object, and risk is closely related to other factors such as attitude. Therefore, the risk perceptions of the preservice teachers towards RE sources may have had a negative effect on their attitude. Considering the descriptive results related to risk (Table 1), this situation may contribute to discussion on the subject. For example, the preservice teachers experienced uncertainty about how scientists could manipulate the risks of RE sources and about how a disaster occurring in one region could also affect other regions. In particular, the preservice teachers may have encountered some examples in lessons such as nature of science and history of science related to unscientific use of some of the activities carried out by scientists. Again, in recent years, it is increasingly stated that science is becoming commercialized (Irzik, 2013). This situation may have led to a high perception of risk among the preservice teachers. Regarding another risk factor, that of a harmful effect formed in one region also impacting other regions, the preservice teachers may have been directed towards this factor by remembering the events at Chernobyl, which was a nuclear disaster that closely affected Turkey and the effects of which are still seen today in the form of health problems (Kılınc et al., 2013). Again, under the dread dimension related to risk perceptions, using RE sources for the first time and the fact that their use is not yet considerably widespread may have constituted the risk borne out of fear. In risk studies, first time use is one of the most important factors (Demirbağ & Kılınc, 2018; Kılınc et al., 2016). Therefore, all risks perceived in this way may play a leading role in forming negative relationships with attitude and other factors.

Regarding risk perceptions and subjective norms, although individuals are encouraged to use renewable energy sources by their social environment, the more individuals perceive risks in renewable energy, the less important this incentive becomes. In other words, the less individuals know about the risks of renewable energy sources and the more their uncertainty increases, the less attention they give to subjective norms that include the discourses of others and evaluations of the social environment. However important the social environment is, since it is individuals themselves who perceive the risks, the impact of the environment may be of secondary importance. Especially in studies such as self-efficacy theory studies, in which individuals' own experiences are compared with the discourses of other people, and belief system studies, people's self-assessment is more effective than the verbal persuasion of others (Bandura, 1997; Rokeach, 1968).

On the other hand, when positive relationships are examined, it is seen that all of the TPB components affected intention, in accordance with the theoretical framework. The descriptive results can help to enlighten us on this point. As RE sources provide an inexhaustible energy supply, as dependence on foreign resources is reduced, as sustainable development is ensured, and as global warming decreases, individuals will evaluate RE sources more positively and their intention to use them with a positive attitude will increase. Indeed, many studies have shown that eco-friendly attitudes are positively associated with social acceptability and intentions (Alam & Rashid, 2012; Bang et al., 2000; Halder et al., 2016; Lin et al., 2012).

When PBC is examined, it is clear that the preservice teachers gave more importance to safety, infrastructure and knowledge levels regarding RE sources and that they intended to use them after they were controlled. Individuals may have believed that these external factors would be provided by policy makers and authorities, and that they themselves could carry out these factors following their control. A number of studies (e.g., Alam & Rashid, 2012; Halder et al., 2016) have reached similar conclusions to ours, with positive findings revealing that PBC directed towards RE sources was a positive predictor of intention. Examining the relationship between SN and intention, which is another positive relationship, the preservice teachers stated that they intended to use RE sources when these received support from policy makers and the media. Similarly, in studies conducted on the subject, the effect of SN on individuals' intentions towards environmentally friendly behavior was found to be positive (Kano, 2013; Karppinen, 2005).

Implications

Firstly, considering the findings obtained, the implications of the study can be interpreted as follows. As seen in our study, the risk perceptions of the preservice teachers negatively predicted the TPB components. Therefore, researchers should assist users and stakeholders on the subject of risk mitigation and risk reduction related to RE sources. As stated in the literature, social acceptance regarding the use of RE sources should be realized and popularized (Upreti & van der Horst, 2004; Wolsink, 2007). In this context, in the matter of risk perception, which is one of the most important obstacles to logical decision-making and the use of sources of evidence (Kılınc et al., 2013), it may be necessary to raise public awareness and to develop public understanding of science. For this purpose, the opinions of experts (stakeholders such as engineers, risk psychologists, etc.) related to RE sources can be consulted. In addition, especially in risk assessment of the subject of RE sources, preservice teachers who are effective agents in the diffusion of innovations, it may be necessary to create educational environments in which individuals are taught to evaluate risk impartially. The impact created by such educational environments can be tested with studies related to risk. Since an increase in knowledge level negatively predicts risk, as can be seen in the findings of the study, and since this finding is encountered in a number of studies, it may be necessary to increase the knowledge levels of preservice teachers related to RE sources. Secondly, in the study, individuals stated that they would use RE sources when they possessed positive attitudes towards them. In this context, individuals can be further supported with regard to the positive aspects of RE sources. In particular, preservice teachers can be made aware of the factors that constitute attitude and which are studied in a decomposed way (perceived usefulness, perceived ease of use, compatibility) in the TPB, and the factors related to this type of attitude can be discussed in studies. With regard to SN, great responsibilities and duties fall on decision and policy makers and on the media, since the preservice teachers stated that they would be able to use RE sources provided that they were supported by politicians, government officials and the media. For this reason, support for the use of RE sources by the authorities can be given in the written and visual media through campaigns, advertising and discussion programs that explain why RE sources are needed in Turkey and in the world. For, unfair evaluation of evidence related to the risks of RE sources in the media may lead to dissemination of risks and distrust among the public and may weaken their acceptance of RE sources (Upreti & van der Horst, 2004). Finally, when the findings related to another variable, PBC, are examined, authorities and decision-makers should be responsible for providing security, meeting energy needs, conforming to climate conditions, providing energy reliability, and providing incentives like technical support and infrastructure related to RE sources. In particular, these factors can give important clues for social acceptance both to those who provide technical design and production of RE sources (engineers, etc.) and to policy-makers.

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Enhancing the critical thinking skills of grade 8 chemistry students using an inquiry and reflection teaching method

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Abstract

In contrast to traditional science instruction, which encourages students to memorize facts from textbooks, today's science instruction emphasizes the adoption of scientific process skills by students, as well as the teaching of critical thinking skills. Lebanese Chemistry teachers detected lack in middle school and high school students' critical thinking skills, such as analyzing data, interpreting experiments' results and arguing. Consequently, we elaborated the Inquiry and Reflection teaching method (I&R) based on White and Fredericsen's method (1998) and implemented it for three months to grade 8 chemistry students, in one Lebanese private school. Then we compared the control and experimental group students' scores on the Critical Thinking Test and the final exam. Findings showed that the experimental group students improved their critical thinking skills significantly, while the control group students' critical thinking remained the same.

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Introduction

There has been growing interest across the world in ways of developing children's thinking and learning skills (Fisher, 2005), as well as developing educational programs that assume that all individuals, not just elite, can become competent thinkers (Zohar, 2001). This interest was not only exclusive for schools and high-schools' students (Changwong, 2018); in fact, promoting students' critical thinking has been also an essential goal of higher education in many universities' faculties (Barroga, 2019; Zulfaneti, 2018). In contrast to traditional science instruction, which emphasizes lectures to efficiently present scientific information and encourages students to memorize facts from textbooks, today's science instruction emphasizes on problem-solving and inquiry-based laboratory activities. In other words, it emphasizes implementing critical thinking approach to the process of education and instruction (Burke, 2008; Fennimore, 1990; Kaplan, 2017; Karakoç, 2016; Padilla, 1990; Uribe Enciso et al., 2017; Zohar, 2005).

The particular ways in which people apply their minds to solving problems are called thinking skills. This term refers to the human capacity to think in conscious ways to achieve certain purposes. According to Fisher (2006), such processes include remembering, questioning, forming concepts, planning, reasoning, imagining, solving problems, making decisions and judgments, and translating thoughts into words. Perry (2016) linked between inquiry and critical thinking: "through a combination of hands-on and minds-on learning, inquiry engages students in a process through which they learn science content best". Other researchers saw inquiry as being the essence of critical thinking such as Kitot (2010), Caswell (2017) and Duran (2016) who stressed the effectiveness of inquiry teaching in enhancing students' critical thinking. Research has confirmed the value of an inquiry approach in fostering student learning (Bransford et al., 2000; Smallhorn, 2015), and suggested that inquiry-based learning contributes to improving students' abilities in system thinking (Orit Ben Zevi, 2005), as well as developing students' abilities in engagement, motivation, and self-confidence (Center for Inspired Teaching, 2017).

On the other hand, according to Magno (2010), metacognition has a significant path to critical thinking. Metacognition, which is the cognition about own cognition (Schneider, 2001), refers to higher order thinking that involves active control over the thinking processes involved in learning. Activities such as planning how to approach a given learning task, monitoring comprehension, and evaluating progress toward the completion of a task are metacognitive in nature" (Kizlik, 2011). Several studies have showed the positive effects of metacognitive guidance on learning outcomes (Zion, Michalsky & Mavarech, 2005).

This leads to a conclusion that the conjunction between inquiry and metacognition as a teaching method might develop critical thinkers. White and Fredericksen (1998) developed a computer enhanced, middle school science

curriculum that develops students' metacognitive knowledge and skills through a process of scaffolded inquiry. This method of teaching includes three phases: scaffolded inquiry, reflective assessment and generalized inquiry and reflection. Findings revealed that this approach was beneficial for both low-achieving and high-achieving students who understood the nature of inquiry, acquired the habits of thought, and considered the difficult subject of Physics understandable and interesting (White & Fredericsen, 1998). Moreover, White & Shimoda (1999), introduced a software, the SCI-WISE, to engage in "inquiry about inquiry," thereby making inquiry and metacognition topics of investigation. However, there is a need to create innovative instructional methods which do not depend on software or computer skills, especially in Lebanon where many schools are not well equipped with technology. Consequently, we elaborated and implemented the Inquiry and Reflection method (similar to White and Fredericsen's method without being a computer enhanced method), which includes four phases: the scaffolded inquiry, the reflective assessment, the argumentation and the generalization.

In the first phase of the Inquiry and Reflection method (I&R), students make conjectures, plan and conduct experiments, collect and analyze data, interpret results and draw conclusions. In the second and third phases, students compare and evaluate their own and each other's work, students also recognize what they have to argue about then they write out their case in support of the claims or positions they seek to defend. Finally, they resolve their dispute by agreeing that one conclusion is better supported than the others (O'Rourke, 2005).

This instructional method aims for students to perform analysis, interpretation, and argumentation skills. Analysis skill refers to the ability to visualize, articulate, conceptualize or solve problems by making decisions that are sensible given the available information. The ability to think analytically and creatively is crucial for success in the modern workforce, particularly for graduate students who aim to become physicians or researchers (Abdullah, 2015). Interpretation is a communication process designed to discover, to reveal meanings, to gain a deeper understanding of concepts by tying those concepts to experiments, since it requires a level of inference beyond what can be literally seen (Zagallo, 2016); it encompasses such sub-skills as: identification, categorization and expression (Wang, 2017). While argumentation, called the language of science (Duschl, 1999), has also been identified as a possible mechanism for conceptual growth and change (Nussbaum, 2003).

The Inquiry and Reflection Teaching Method

The Inquiry and Reflection Teaching Method includes four phases:

Scaffolded inquiry: Students are involved in "open-ended" questions and experience hypothesizing, investigating, planning experiment, conducting experiment, observing, analyzing the findings and concluding.

Reflective assessment: Students evaluate their own and each other's research. This process enables them to reason carefully, so the habits of thought will be involved in their skills.

Argumentation: students gather evidences to support the claims they seek to defend and then resolve their dispute by agreeing that one conclusion is better supported than another.

Generalized Inquiry and Reflection: the inquiry cycle, in conjunction with reflection, is repeated to help students refine their inquiry and reflection processes so they can apply to new learning situations and real-world situations.

Purpose of the study

The aim of this study is to investigate the effect of the Inquiry and Reflection (I&R) instructional method on students' critical thinking skills. Although critical thinking encompasses many skills, this study emphasizes on only three of them, namely the analysis, the interpretation and the argumentation skills. These skills are considered important for students in schools and their everyday life.

Research Questions

This research tries to answer the question: Does the I&R method of teaching enhance grade 8 students' critical thinking. Particularly, we sought answers to the following research questions:

Q_1: Does the I&R method of teaching affect grade 8 students' analysis skills?
Q_2: Does the I&R method of teaching affect grade 8 students' interpretation skills?
Q_3: Does the I&R method of teaching affect grade 8 students' argumentation skills?

Research Hypotheses

The research hypotheses corresponding to the above research questions are:

H_1: Students in the experimental group will significantly have better analysis skills than the control group students.
H_2: Students in the experimental group will significantly have better interpretation skills than the control group students.
H_3: Students in the experimental group will significantly have better argumentation skills than the control group students.

Method

A mixed research was conducted in order to answer the research question. The quantitative part consisted of a quasi-experimental design using a Critical Thinking test as a pre-test and a post-test. In addition, questions in the final exam, which included an "Analysis" question, an "Interpretation" question and an "Argumentation" problem were analyzed qualitatively and quantitatively.

Participants

The participants in this study were 38 grade 8 students from one Lebanese private school. They were distributed to two sections of 19 students each. An exam covering the content taught during the first semester which includes solutions, atoms, and compounds took place before the I&R implementation, where both groups were taught via the traditional method. By comparing both groups' grades on this exam, we didn't find significant differences between the two sections in terms of achievement, in other words, students in both sections had similar academic backgrounds. At the beginning of the second semester, section A was chosen, randomly, as the control group and section B as the experimental group. Both groups were similar in terms of students' age, gender and socio-economic background as they live in the same geographical area and belong to the same economic status.

Procedure

In the two semesters, the first researcher, who was the Chemistry teacher in both sections, taught both groups the same Chemistry content. In the first semester, both groups learned via the traditional method while in the second semester the experimental group students learned via the I&R teaching method and the control group students continued learning via the traditional method. The I&R method was implemented for eight weeks, 3 hours per week, covering the four chapters normally taught during the second semester: the "Chemical Reactions", the "Types of Chemical Reactions", the "Rates of Chemical Reactions" and the "Acidic and Basic Solutions". The steps of the I&R method were repeated in each of the four lab sessions; however, some of the scaffolding was removed each time. In the first session " Chemical Reactions", the experiments were designed by the teacher who prepared all the materials; in the second session "Types of Chemical Reactions" the students gathered and prepared all the necessary materials for performing the experiments designed by their teacher; however, in the third session "Rates of Chemical Reactions", students participated in the designing of the experiments, while in the fourth one "Acidic and Basic solutions" they designed all the experiments and gathered all the materials. From one lab session to another, the teacher asked students to make predictions about what they thought might happen in some simple real-world situations, in other words, they were asked to engage in a "thought experiment". The teacher had the class generate a set of alternative hypotheses, investigate, design experiments, analyze data, and present conclusions. Then the class got together to try to reach a consensus about which hypothesis best accounts for their results and which was the most accurate and useful, leading them to "discover laws". For this process, they had to criticize each other's hypotheses and conclusions and attempt to prove them wrong. An example of one of the lab sessions, acidic and basic solutions, appears in Table 1.

The control group students were taught the same science content by the same teacher mainly using lectures without any explicit attempt to stimulate students to engage in metaconceptual processes. In other words, the teacher provides the scientific explanations in the form of a lecture before the laboratory experiments. They discuss their observations after performing experiments. Throughout these discussions, the teacher didn't encourage students to predict the results of the experiments or to compare their initial ideas or predictions with the observed results.

Table 1: Example of one lab session

Duration: 40min

Title: Acidic and basic solutions

Objectives:
- Defining the terms: acid, base, pH
- Classifying solutions as acids or bases
- Learning the concept of neutralization

Keywords: acid, base, pH , neutralization

Researches: Students conducted a library research to define the terms: acid, base, pH and neutralization

Questions:
- What are the natures of: juice; milk; vinegar; water; soap; shampoo; oil; Pepsi; detergent
- Is it true that any acid added to any base gives a neutral solution?

Hypotheses:
Each group made his own hypotheses about the nature of the following solutions: juice; milk; vinegar; water; soap; shampoo; detergent; oil; Pepsi; 20ml HCl+20ml NaOH; 20ml HCl+40ml NaOH; 40ml HCl+ 20ml NaOH; 20ml vinegar+20ml NaOH.

Experiments:
Students planned to determine the pH of the following solutions, using a pH paper:
juice; milk; vinegar; water; soap; shampoo; oil; Pepsi; detergent (solutions from everyday life)
20ml HCl + 20ml NaOH (to verify the neutralization)
20ml HCl + 40ml NaOH
40ml HCl + 20ml NaOH
20ml vinegar + 20ml NaOH. (They chose another acid in order to compare the pH in both cases)

Materials:
Each group had a pH paper, an HCl solution, a NaOH solution, a bottle of vinegar, a bottle of milk, a bottle of juice, a bottle of water, a bottle of soap, a bottle of shampoo, a bottle of oil, a bottle of Pepsi, a bottle of detergent, a 50ml of graduate cylinder and a dropper.

Reports:
A week later, each student should present a lab report which includes: the hypotheses, the materials used, the procedure followed, the observations, the analysis and the conclusion he or she made.

Debate:
In the following session, groups should expose the investigations they did during the week about laws they discovered and their limitations, then the class got together to try to reach a consensus about which hypothesis best accounts for their results and was the most accurate and useful. As part of this process, they have to criticize each other's hypotheses and conclusions and attempt to prove them wrong.

Instruments

Critical thinking skills were measured by a 25-item test inspired by a sample of James Madison Critical Thinking Test, a worldwide known Critical Thinking test, that was adapted to the Lebanese curricula by six Lebanese teachers and educators, who first chose the items related to the Lebanese Chemistry grade 8 syllabus, and then translated and reformulated the questions for a better understanding. This test was used as pre- and

post-test to measure and compare both groups' critical thinking skills**,** before and after the I&R method implementation. It covered the analysis, the interpretation and the argumentation skills. The analysis skills appear in 7 questions where students have to distinguish necessary and sufficient conditions, to distinguish unstated conclusions, to distinguish reasons, and to discern whether pairs of claims are consistent, contrary, contradictory, or paradoxical. The interpretation skills appear in 7 questions which are mainly about identifying and avoiding errors in reasoning. The argumentation skills appear in 11 questions, where students have to evaluate whether an inductive argument is strong or weak, to evaluate whether a deductive argument is valid or invalid, to distinguish supporting, conflicting, compatible, and equivalent claims arguments, explanations, descriptions and representations, and to recognize ambiguity and unclearness in claims, arguments, and explanations. An item for each dimension is given as example in Table 2. A pilot test was performed where the test was administered to 50 grade 8 students from two schools who did not participate in this study. The validity of the test was provided by the teachers and educators from the two schools and the reliability was verified by the Kuder-Richardson coefficient value KR20 = 0.807. In addition, a final exam, including an "Analysis" question, an "Interpretation" question and an "Argumentation problem" was also used to measure critical thinking skills. This test was administered to both groups' students at the end of the second semester after the implementation of the I&R method was completed. The test questions were validated by Chemistry Education specialists.

Table 2: Examples of the Critical Thinking test' items

Analysis skills: Students have to distinguish necessary and sufficient conditions	Identify the correct relationship in the question below. Chilling pure water at sea level to a temperature below zero degrees Celsius is: A. Only a necessary condition for pure water to freeze. B. Only a sufficient condition for pure water to freeze. C. Both a necessary and a sufficient condition for pure water to freeze. D. Neither a necessary nor a sufficient condition for pure water to freeze.
Interpretation skills: Identifying and avoiding errors in reasoning	"Professor Fernandez is a famous medical doctor. So, I believe her when she says that global atomic energy is the cheapest way to produce electricity." A. Professor Fernandez's claim suggests that one thing caused another, when actually one thing merely happened after the other. B. Professor Fernandez makes a general claim about a group based on a sample that is not representative of the group. C. Professor Fernandez is not an expert on atomic energy. D. There is nothing wrong with the remark. E. Nuclear energy production creates poisonous radiation that will last for centuries.
The argumentation skills: Students have to evaluate whether a deductive argument is valid or invalid	(1) If today is Friday, then we have a test. (2) If today is Saturday, then we can sleep late. (3) Either we do not have a test or we cannot sleep late. A. Today is neither Friday nor Saturday. B. Today is Friday and we cannot sleep late. C. Either it is not Friday or it is not Saturday. D. Today is Saturday, but we have a test. E. None of the above.

Data Analysis

SPSS program was used to analyze the obtained data quantitatively. Independent-samples t-test was used to determine whether there was a significant difference between the critical thinking pre-test and post-test and the

final exam questions mean scores of the students in both experimental and control groups. Moreover, the Chi-square test was used to determine whether or not there was a significant difference between both groups' argumentation skills. The .05 level of significance was accepted for all the analyses performed in this study. In addition, the students' responses to the final exam questions were further analyzed qualitatively.

Results and Discussion

Results related to the Critical Thinking Test

Prior to treatment, an independent samples t-test was employed to the Critical Thinking pre-test to determine if there was a statistically significant difference between control and experimental groups. Results of the independent-samples t-test regarding the Critical Thinking pre-test are provided in Table 3 below. According to Table 3, the mean pre-test score of the experimental group was M = 10.052, the mean pre-test score of the control group was M = 9,882, and the difference between the two groups was not significant ($p>0.05$, $t=-.375$). This result indicated that students' critical thinking skills in both experimental and control groups were similar at the beginning of the experimental study.

Table 3. Independent sample t-test results of the Critical Thinking pre-test

Group	N	Mean	SD	t	p
Control	19	9.882	2.689	-.375	.710
Experimental	19	10.052	1.649		

Results of the independent-samples t-test regarding the Critical Thinking post-test are provided in Table 4 below. According to Table 4, the mean post-test score of the experimental group was M = 18.368, the mean post-test score of the control group was M = 10.588, and the difference between the two groups was significant ($p < .05$, $t = -8.974$) in favor of the experimental group.

Table 4. Independent sample t-test results of the critical thinking post-test

Group	N	Mean	SD	t	p
Control	19	10.588	1.734	-8.974	.000
Experimental	19	18.368	3.419		

Results related to the "Analysis" questions of the Critical Thinking test

In the Critical Thinking test, the analysis skills appear in 7 questions. According to Table 5, results showed that there was no significant difference between the control and experimental groups regarding the "Analysis" questions of the Critical Thinking pre-test ($p>0.05$, $t=.283$). However, there was a significant difference between the two groups post-test ($p<0.05$, $t=-7.463$) in favor of the experimental group. This means that the experimental group students' improvement was significantly better than the control group in the "Analysis" questions of the Critical Thinking test.

Table 5. Independent sample t-test results of the "Analysis" questions in the Critical Thinking test

Test	Group	N	Mean	SD	t	p
Pre- test	Control	19	2.315	1.056	.283	.779
	Experimental	19	2.210	1.228		
Post-test	Control	19	2.421	1.070	-7.463	.000
	Experimental	19	5.421	1.387		

Results related to the "Interpretation" questions of the Critical Thinking test

In the Critical Thinking test, the interpretation skills appear in 7 questions. The t-test results, shown in Table 6, indicated that there was no significant difference between the control and the experimental groups regarding the "Interpretation" questions of the Critical Thinking pre-test ($p>0.05$, $t=.890$). However, there was a significant difference between both groups post-test ($p<0.05$, $t=-4.454$) in favor of the experimental group. This means that the experimental group improvement was significantly better than the control group in the "Interpretation" questions of the Critical Thinking test.

Table 6. Independent sample t-test results of the "Interpretation" questions in the Critical Thinking test

Test	Group	N	Mean	SD	t	p
Pre- test	Control	19	3.526	1.389	.890	.379
	Experimental	19	3.105	1.523		
Post-test	Control	19	3.473	1.123	-4.454	.000
	Experimental	19	5.421	1.538		

Results related to the "Argumentation" questions of the Critical Thinking test

In the Critical Thinking test, the argumentation skills appear in 11 questions. The t-test results provided in Table 7, showed that there was no significant difference between the experimental and the control groups regarding the "Argumentation" questions of the Critical Thinking pre-test ($p>0.05$, $t=-1.170$). However, there was a significant difference between the two groups post-test ($p<0.05$, $t=-5.566$). This means that the experimental group improvement was significantly better than the control group in the "Argumentation" questions of the Critical Thinking test.

Table 7.Independent sample t-test results of the "Argumentation" questions in the Critical Thinking test

Critical thinking test	Group	N	Mean	SD	t	p
Pre- test	Control	19	3.947	1.544	-1.170	.250
	Experimental	19	4.526	1.504		
Post-test	Control	19	4.631	1.605	-5.566	.000
	Experimental	19	7.473	1.540		

Results related to the final exam questions

Students' results of the "Analysis" question of the final exam

In the final exam given to both groups at the end of the experimental study, the "Analysis" question stated:

Given the following table, analyze and conclude:			
Content of the test tube	Catalyst	Beginning Mass	Final Mass
Egg white	Lipase	5g	5g
Cream	Lipase	5g	0g
Egg white	Protease	5g	0g
Cream	Protease	5g	5g

The results of the independent-samples t-test regarding the difference between both groups' mean scores on the "Analysis" question of the final exam are provided in the table 8 below. These results show a significant difference ($p<0.05$, $t=-5.102$) between the control and the experimental groups in favor of the experimental group.

Table 8. Independent sample t-test results of the final exam "Analysis" question

Group	N	Mean	SD	t	p
Control	19	0. 735	0.903	-5.102	.000
Experimental	19	1. 921	0. 533		

The "Analysis" question responses were also analyzed qualitatively by grouping the students' responses into categories taking into consideration the level of the analysis skill exhibited in each response. The level ranges from 0 to 5, where 0 represents a null level of analysis and 5 represents the highest level of analysis. Results are displayed in Table 9 showing that most of the experimental group students' responses belonged to the higher-level categories while most of the control group students' responses belonged to the lower-level categories. Hence the experimental group students improved their "analysis" skill more than the control group students.

Table 9. Rubric of the responses to the "Analysis" question of the final exam

Control Group (N)	Experimental Group (N)	Answer	Level
7	0	- No answer	0
2	0	- Lipase should be used in order to avoid loss of egg white's mass and the protease should be used in order to avoid loss of cream's mass.	
2	0	- The loss of mass indicates that there is a chemical reaction	1
1	0	- The lipase "has destroyed" cream and the protease "has destroyed" egg white	
1	0	- The lipase is the specific catalyst for cream	2
0	3	- There are chemical reactions in the second and third experiments, while there are not in the first and fourth ones	3
1	0	- The lipase is the specific catalyst for cream, and the protease is the specific catalyst for egg white	4
0	3	- The lipase is the specific catalyst for cream, and the protease is the specific catalyst for egg white. There are chemical reactions in the second and third experiments, while there are not in the first and fourth ones	5
3	7	- The lipase is the specific catalyst for cream, and the protease is the specific catalyst for egg white that's why there are chemical reactions in the second and third experiments while there are not in the first and fourth ones	
2	6	- The lipase is the specific catalyst for cream, and the protease is the specific catalyst for egg white that's why there are chemical reactions in the second and third experiments since the masses of egg white and cream disappeared, while there are not chemical reactions in the first and fourth experiments since the masses of egg white and cream didn't change from the beginning to the end	

Students' results of the ""Interpretation" question of the final exam

The "Interpretation" question of the final exam stated:

Patient has high stomach acidity. Doctor gives him Tums as medication. Interpret why.

The results of the independent-samples t-test regarding the difference between both groups' scores on the "Interpretation" question of the final exam are provided in the table 10 below. These results show a significant difference ($p<0.05$, $t=-3.693$) between the control and the experimental groups in favor of the experimental group.

Table 10. Independent sample t-test results of the final exam "Interpretation" question

Group	N	Mean	SD	t	p
Control	19	1. 205	0.560	-3.693	.001
Experimental	19	1. 842	0. 472		

The "Interpretation" question responses were also analyzed qualitatively by grouping the students' responses into categories taking into consideration the level of the interpretation skill exhibited in each response. The level ranges from 0 to 5, where 0 represents a null level of interpretation and 5 represents the highest level of interpretation. Results are displayed in Table 11 showing that most of the experimental group students' responses belonged to the higher-level categories while most of the control group students' responses belonged to the lower-level categories. Hence the experimental group students improved their "interpretation" skill more than the control group students.

Table 11. Rubric of the responses to the "Interpretation" question of the final exam

Control Group (N)	Experimental Group (N)	Answer	Level
1	0	No answer	
1	0	Tums "fights" the stomach acidity	0
0	4	Tums neutralizes the acidity	
1	1	Tums decreases the amount of acidity	1
2	0	Tums is a base	
3	0	Tums is a base which decreases the acidity's amount.	2
7	0	Tums is a base which should be administered depending on the amount of acidity	3
4	10	Tums is a base which decreases the amount of acidity and neutralizes its excess	4
0	4	Tums is a base which decreases the amount of acidity and neutralizes its excess, according to the following reaction: $H^+ + OH^- \rightarrow H_2O$	5

Students' results of the "Argumentation" problem of the final exam

In the final exam, both groups were given an argumentative problem to assess their ability to elaborate arguments, to generate counterarguments and to develop adequate rebuttals to others' counterarguments. The problem included the following questions:

- The hair's shampoo has a pH=6. What do you think; hair's shampoo is an acidic or a basic solution? Justify
- A Chemistry teacher from another school, according to another textbook, told his students: "we can't consider shampoo as an acid, since it doesn't burn skins; therefore, it isn't an acid, it is a base". What counterarguments can you give?
- The chemistry teacher is now talking to you: "the pH value of 6 could be insufficient for the determination of the shampoo's acidic character; in fact, after our observations in the lab we found that the pH of the tap water we tested was around 5.5, and we also know that water is neutral, therefore, shampoo could be basic because its pH is higher than those of the tested water.". Generate rebuttals to the teacher counterargument.
- After considering these two points of view, what do you think: is the shampoo, an acid or a base?

Table 12. Capacity of generating arguments, counterarguments and rebuttals

Group			Total
	Arguments		
	Unable	Able	
Control	6	12	18
Experimental	0	19	19
	Counterarguments		
	Unable	Able	
Control	18	0	18
Experimental	1	18	19
	Rebuttals		
	Unable	Able	
Control	15	3	18
Experimental	4	15	19

According to Table 12, all the experimental group students were able to give adequate arguments, while only 12 out of 18 control group students were able to give adequate ones. In addition, 18 out of 19 students in the experimental group generated adequate counterarguments, while all students in the control group were unable to give adequate ones. Furthermore, 15 students out of 19 in the experimental group were able to generate

adequate rebuttals, while only three students out of 18 control group students were able to generate adequate ones.

A Chi-Square test was done in order to compare both groups' students' argumentation skills in the final exam. The results of the Chi-Square test regarding the difference between both groups' argumentation skills are provided in the table 13 below. Results showed a significant difference ($p < 0.05$) between both groups in the capacity of arguing, generating adequate counterarguments and adequate rebuttals to others' counterarguments, according to Table 13.

Table 13: Chi-Square test results of the "Argumentation" questions in the final exam

	χ^2	df	p
Capability to generate arguments	7.559	1	.006
Capability to generate counterarguments	33.208	1	.000
Capability to generate rebuttals	14.352	1	.000

Further qualitative analysis revealed that many contradictions and inconsistencies exist in the responses of the control group students, who weren't able neither to maintain their opinion nor to defend it. In fact, in the first question, 17 students had considered the shampoo as an acid, while in the second and third questions, they said that shampoo is a base and an acid at the same time. Only two students didn't agree with the teacher, since they qualified the shampoo as a weak acid so it can't burn the skin. As one student changed his opinion at the end when he considered shampoo as a base (fourth question) since it is a weak acid.

On the other hand, all the experimental group students classified the shampoo as an acid since its pH is lower than 7, and none of them changed his or her opinion. On the teacher's argument: "if it was an acid, it would burn eyes and skin", eighteen of them gave adequate counterarguments such as: "it is a weak acid" or "it is not a concentrated acid", "its pH is higher than 1" or "stronger acids such as Pepsi and vinegar don't burn", etc…, the remaining student was unable to generate a counterargument. On the third question, all of the students explained that the pH of water is lower than 7 because of chemical reactions that took place; in other words, they defended the argument they gave on the first question. Therefore, the majority of the experimental group students elaborated arguments, examined and evaluated opposing side's reasons, and generated rebuttals to other counterarguments presenting a strong and valid argumentative discourse.

Discussion

Results of this study revealed that the control group students did not produce significant improvement in their critical thinking skills, while, the experimental group students progressed significantly. This was evident from the results of the Critical Thinking test as well as from the final exam. Firstly, the control group students' analysis skills did not improve significantly contrary to the experimental group students who benefited from the I&R method which accustomed them to analyze their own data and results at the end of each lab session as well as others students' results. Secondly, in the Critical Thinking post-test as well as in the final exam, the control group students' interpretation skills didn't improve significantly in contrary to the experimental group students. The I&R method positive impact was due to the fact that it trained students to interpret theirs and each other's data and results, and to generalize, conclude and discover the "laws" from the experiment. This result is in line with the Tebabal and Kahssay (2011) findings, whose study has surveyed the effectiveness of student-centered instruction in improving students' graphical interpretation skills. Thirdly, as they were performing argumentation skills during the debates after each lab session, the experimental group students became significantly better than the control group's ones in generating arguments, examining and evaluating opposing side's reasons, generating rebuttals to other counterarguments, and presenting strong and valid argumentative discourses. These results were evident in the final exam as well as in the argumentation questions of the Critical Thinking test. They are in line with the findings of Crowell (2011), and Kuhn et al. (2008), who stressed the importance of providing practice with dialogic argumentation to improve the quality of the dialog itself as well as individual thought, since by engaging in dialogic argumentation, they are exposed to alternative viewpoints and hence gains experience countering them. Moreover, Kuhn (1991) suggested that engaging students in sophisticated argumentative discourse can foster sophisticated thought, with whom Oaksford et al. (2008) agreed, claiming that argumentation is "the more general human process of which more specific forms of reasoning are a part".

In general, the present work supports earlier findings that inquiry teaching and learning showed positive impact in stimulating students' thinking skills by training students to think divergently at a higher thinking level as well as training the co-development of reasoning strategies and domain knowledge (Echevarria, 2003; Metz, 2004; Schauble, 1996; Tytler & Peterson, 2004; Zimmerman, 2007). Furthermore, the findings of this study support the findings from previous studies showing the positive effects of metacognitive guidance on learning outcomes (Tien, 1998; Zion, Michalsky, & Mevarech, 2005).

Implications

Teachers and curriculum developers could benefit from the study to develop instructional strategies and curricula that help students enhance their critical thinking skills, especially their analysis, interpretation, and argumentation skills. Researchers and educators could plan workshops and seminars for future and in-service teachers. As there is evidence that the I&R method has improved students' thinking skills, thus, teachers are encouraged to integrate the I&R teaching method in their classrooms. This could be done easily even in the schools that are not well equipped since the materials and chemical products used in the lab experiments are available and not expensive. In addition, teachers do not need more time to implement the I&R method since both methods required the same amount of class time.

Limitations and recommendations

By implementing the I&R method, we initiate the experimental group students to become critical thinkers as they were trained to make conjectures, to conduct experiments, to study variables, to analyze data, to interpret results, to generate adequate arguments and counterarguments. However, one semester is not enough to generalize the positive impact of the I&R method likewise its implementation in only one school. This is true for more than one reason. Firstly, some students need more time to adapt themselves with the I&R method. Secondly, longer instructional periods may be needed for accomplishing the development of young thinkers and researchers. Longitudinal studies may be essential in this respect. Thirdly, this instructional method could be used in other subjects, such as Biology and Physics. Fourthly, it would be better to implement this teaching method in public as well as in private schools in order to compare its impact. Studies in schools in other geographical regions are also needed for a wider generalization, since several variables might influence the results, such as students' socioeconomic backgrounds, teachers' habits and beliefs, and school systems.

Conclusion

This study was conducted to investigate the impact of the I&R instructional method on grade 8 students critical thinking. The I&R method implementation has shown to enhance students' thinking skills, particularly their analysis, interpretation and argumentation skills. By fostering students' critical thinking skills, this instructional teaching method could initiate them to become thinkers and researchers. As critical thinking continues to be an important component in school curricula of the 21st century, we need to find ways to help students improve their abilities to think critically and their disposition to use these skills and strategies that incorporate inquiry and metacognition are shown to be beneficial.

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Measuring Scientific Process Skills with Different Test Formats: A Research from the Perspective of Cognitive Styles

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Abstract

Considering that each student has a different cognitive structure, in addition to providing students with the perspective of a scientist, evaluating this acquisition; it is an important dimension of science education in the context of measurement and evaluation. In this context, the scientific process skills (SPS) of the students with different cognitive styles were examined and it was aimed to interpret the SPS measured in different test format according to cognitive styles. The study was a causal comparison and the study group consisted of 40 students at the seventh-grade level. Cognitive styles of the students were determined by using Group Embedded Figures Test. Open-ended, performance-based and multiple-choice tests were used to evaluate the scientific process skills. Criteria scales were used in the evaluation of open-ended and performance based SPS tests. The data were analyzed by MANOVA method which is a multivariate analysis of variance. Findings indicated that students with field independent cognitive style are more successful in multiple choice SPS test. However, it was concluded that there was no significant difference between mean scores of students in the field-dependent and field-independent cognitive style in both open-ended and performance-based SPS tests. Within the scope of the research, possible factors causing this result such as the difference of students' cognitive style tendencies, the test format used to measure scientific process skills, or the structure of the measured scientific process skills were discussed.

Introduction

Lowery (1997, p.112) expresses the relationship of children with science in National Science Teacher Association (NSTA) Pathways to the Science Standards guidebook as follows;

> Every child is born a scientist. Children have the nonstop curiosity that prompts them continually to compare their internal world with the input of their senses and struggle to make sense of it all. It is the challenge of elementary science to keep that curiosity alive.

In elementary science, the development and evaluation of "scientific process skills" is an important factor in overcoming this difficulty and maintaining children's curiosity in learning science. However, researchers emphasize that scientific process skills reflect the behavior of scientists and the processes that scientists follow in accessing information (Meador, 2003; Padilla, 1990; Rezba, Sprague, McDonnough, and Matkins, 2007). When the national education curricula of the countries that are successful in the PISA study organized by Organization for Economic Co-Operation and Development (OECD) every three years are examined, it is noteworthy that the focus is on scientific process skills from pre-school to university period. As a matter of fact, the Programme for International Student Assessment (PISA) research emphasized what the student knows and can do with it (OECD, 2019). Parkinson (1988, p.8) stated that a scientific method is more important than remembering scientific facts in discussions about science processes. At this point, issues such as acquiring, developing and evaluating scientific process skills become an important dynamics of education systems.

Scientific Process Skills and Importance

When the perspectives of the researchers on the scientific process skills are examined in the literature, it is remarkable that they refer to the concepts of a tool/implementation (Harlen, 1999; Ostlund, 1992) in learning, producing and organizing information. Science-A Process Approach (SAPA) has been grouped scientific process skills as basic and integrated skills, which facilitate learning, acquire research ways and methods, enable

students to be active, develop the sense of taking responsibility in their own learning and increase the permanence of learning in science (Tan and Temiz, 2003). Padilla (1990) stated that Basic Science Process Skills are classification, communication, measurement, inference and prediction. Scientific process skills should not be considered only as the ability to carry out the stages in solving a scientific problem (Ergin, Şahin Pekmez and Öngel-Erdal, 2005).

It is necessary to evaluate scientific process skills as a lifelong skill and an understanding development in understanding daily life and solving the problems encountered. Because an individual who acquires scientific process skills can solve a problem, he/she encounters in daily life by using scientific methods. For example, a farmer, who is engaged in animal husbandry, can make various experiments on nutrition, collect data, find information about animal breeding methods in the country and in the world and compare them with their own methods in order to obtain milk in the highest yield. As a matter of fact, the success of science today is proportional to the ability of the student to transform the science knowledge learned at school into a skill in daily life. When the PISA questions that OECD performs every three years are examined, it is remarkable that the questions address a problem encountered in daily life. In PISA research (in terms of science literacy), high-level competencies point out the ability of the student to use the science knowledge in a wide range of contexts in a creative and autonomous way (OECD, 2019). Starting from the fact that scientific process skills have an important role in science education, countries especially include the development of process skills in science education programs.

Measuring Scientific Process Skills

Besides acquiring and developing scientific process skills, it is also important to measure these skills, evaluate their development and interpret them in a meaningful way. Based on this importance, various scales of scientific process skills have been developed abroad since the 1960s. When these scales are examined, it is noteworthy that most of them determine their scientific process skills with multiple choice tests (Aydogdu, Tatar, Yıldız and Buldur, 2012; Burns, Okey and Wise, 1985; Dillashaw and Okey, 1980; Demirçalı, 2016; Feyzioğlu, Akyıldız, Demirdag and Altun, 2012; Molitor and Kenneth, 1976). In order to measure the skills of middle school and high school students to create and interpret line graphs, a test was developed by Mckenzie and Padilla in 1985 in a multiple-choice format with the original name The Test of Graphing in Science (TOGS). This test was later modified by Adam and Shrum in 1990 with open-ended standards and was prepared for use in individual evaluations rather than class evaluations (Ateş, 2001).

When the literature is examined, there are also studies that determine the scientific process skills based on performance. For example, Solano-Flores (2000) asked students to design an experiment by giving them various solutions and experimental materials, and to find out the factors influencing the creation of soap bubbles by experimenting. Ateş (2005) developed the "Ability Test for Determining and Controlling Variables", which has an open-ended format to determine the ability to identify and control variables. Temiz (2007) created a SPS question pool consisting of a total of six modules, three of which are multiple choice and three are open ended. Aktamıs and Sahin Pekmez (2011), on the other hand, developed a measurement and evaluation tool with multiple types of questions to evaluate scientific process skills with different measurement and evaluation techniques. The test includes multiple choice, matching, gap filling, open-ended, and structured questions. Özkan (2015) designed the scientific process skills scale for 60-72 months old children in a structure that includes instructions such as "-there are buttons of different sizes here, -group these buttons and reassemble buttons and stones by other features". Based on this literature summary, we can say that the course of research aimed at measuring scientific process skills in the literature draws attention to the perception that has changed from past to present.

It is seen that there is a transition and change in the question types from multiple choice test format to open ended, performance based, structured etc. test formats. However, it is a remarkable issue that these studies are limited. From this point of view, when the literature is examined, the necessity of comparing scientific process skills with different types of questions arises. The scarcity of studies in this field in the literature suggests that the evaluation of scientific process skills with only one question type is a factor that should be discussed. In this study, this factor is one of the main objectives in measuring students' scientific process skills with different test formats. Another reason for the use of different types of question types is the individual differences that students have. In education, gender, physical characteristics, socio-cultural-economic-demographic characteristics of the student, etc. can be mentioned about many different individual characteristics that should be taken into account. Cognitive styles are just one of these individual differences.

Cognitive Styles as an Individual Difference

Witkin, Moore, Goodenough and Cox (1977) expressed cognitive style as the preferred way/method in the process of retrieving, organizing, applying, remembering and storing it for use when necessary. Sternberg and Grigorenko (1997) emphasized that cognitive styles represent a bridge between cognition and personality, two different areas of psychological research. However, cognitive styles should not be perceived as a mental ability. Studies that point to the difference between cognitive styles and mental (intellectual) abilities (Messick, 1982; Witkin, 1977) argue that mental abilities are specific to verbal or numerical content or area, while cognitive styles intersect with both talent and personality areas. According to Messick (1982), the dimensions of intellectual talent mainly refer to the level of content and cognition. However, while mental ability requires What? how? what kind of information is processed by which process, which format and how well? questions, cognitive styles express cognition style and form (p.7-10). From this point of view, we can say that cognitive styles reflect a cognitive wording in the organization of knowledge and experience, not a mental ability. It is important to reflect the cognitive styles, which is a characteristic feature, to the educational process (Messick, 1982; Sternberg and Grigorenko, 1997). Witkin and Goodenough (1981) addressed individuals in two ways: field-dependent and field-independent in terms of their cognitive styles. This polar structure, also known as a psychological differentiation, refers to the extent to which a person's perceptual space is dependent on this perceptual space regardless of the organization (Sternberg and Grigorenko 1997).

In the field-dependent cognitive style, the overall organization of the total perceptual space dominates the individual's recognition of a pattern. On the contrary, in the field-independent cognitive style, the individual is more likely to see parts of the field separate from the organized space (Witkin, Oltman, Raskin and Karp, 1971, p.4). It is possible to see that field dependent and field independent students have the same level of cognitive capacity. However, their ability to use information and the process of using materials may differ (Sari, Altiparmak and Ates, 2013; Saracho, 1997). In addition, Riding and Rayner (2012) stated that the correlation between intelligence and cognitive style tests is very low, even close to zero.

Students with field independent cognitive style are more successful in remembering details, words and concepts, and writing what they hear. They like to work individually. They prefer teaching methods that discover and question. Field dependent students are successful in summarizing, remembering visualized concepts, prefer a social teaching environment because they like interpersonal interaction (Jonassen and Grabowski, 1993; Rasinski, 1984). This characteristic difference of individuals indicates that learning activities, teaching and assessment methods should also be different.

Because the way each student configures information in his mind and reflect this structure is different. According to Messick (1982), who has many studies leadings the field in cognitive styles; education should deal with not only information but also the way the student thinks. The goals and objectives in education should be expanded with the development of strategic thinking and flexibility in the use of multiple thinking methods. Based on the potential contributions of the reflection of cognitive styles of Samuel Messick into educational environments (1982, p.7-10), it can be said that the use of measurement tools suitable for every cognitive style in the assessment and evaluation dimension will make a decisive difference in the outcomes of education and training.

In this study, it was aimed to provide diversity of implementations by using measurement tools in different formats in the evaluation of scientific process skills. Thus, it was aimed to draw attention to the need to eliminate the drawbacks in measuring scientific process skills by uniform tests. In addition, the interaction of tests in different formats used in measuring scientific process skills with cognitive styles was observed. It is thought that this dimension of the research will fill the gap in the field.

Method

Research Goal

The aim of this research is to determine the scientific process skills of seventh grade students with different cognitive styles by measuring tools in different formats and interpret them according to field dependent/field independent cognitive styles.

Research Design

This study was designed as a causal comparative study. Causal comparative method includes the comparison of samples which differ in critical variables but are comparable (Balci, 2005, p.264). Cohen, Manion and Morrison (2002) stated that in the causal comparison studies, there are at least two groups effected differently from the same situation. Briefly, in order to determine the possible causes and effects of the present situation, these groups are examined in terms of some variables. In this study, field dependent and field independent cognitive styles of the students were determined and the effect of these variables on the mean scores obtained from different measurement techniques used to determine scientific process skills was examined. However, causal comparison studies should not be confused with empirical research trying to establish a cause-effect relationship. As a matter of fact, in the case of causal comparison research, the situation investigated unlike the experimental researches arises independently from the manipulation of the researcher (Cohen, Manion and Morrison, 2002).

Sample

The population of the research is the seventh-grade students studying in Mamak locality of Ankara province. The sample of the study consists of seventh grade students studying in a public school in mamak locality. Since a comparison will be made according to the cognitive style differences of the students in the study group, firstly the cognitive style tendency of the students in the study group was determined. The Group Embedded Figure Test was applied to 80 students studying at seventh grade level in the school. As a result of the implementation, it was determined that 34 students were field dependent, 37 students were field independent, and nine students had field-intermediate cognitive style. Since it is desired to make a comparison between the scientific process skills of the field dependent and field independent students according to the SPS test formats, the students with the field- intermediate cognitive style were excluded from the scope of the research.

Two criteria that are taken as the basis for determining the study group are the gender factor and the previous semester's science course grades of students. The main rationale for the science course achievement points (school report) criterion is to ensure the equivalence of students (field dependent and field independent cognitive style) in terms of success before applying the SPS tests. In this context, 20 students from each cognitive style, whose science course achievement points were close, were selected. Care was taken to ensure that the selected students are equal in gender (for both cognitive styles). The t-test was conducted to examine the equivalence of students in the field-dependent and field-independent cognitive style in terms of the science course achievement points (school report), and there was no significant difference between the groups [$t\ (38) = 2.59$, $p > .05$]. In summary, the study group of the study consists of 40 seventh grade students (20 female and 20 male) selected from different class of a public school in Ankara.

Data Collection Tools

Within the scope of the research, four different data collection tools were used.

Group Embedded Figures Test

Group Embedded Figures Test was used to identify field dependent/independent cognitive styles. This test was developed by Oltman, Raskin and Witkin (1971). İt is still popular today and preferred by researchers to examine differences from cognitive styles (Karaçam and Ates, 2010; Mefoh, Nwoke, Chukwuorji and Chijioke, 2017; Saracho, 1997; Özarslan and Bilgin, 2016).

The test consists of three parts. In the first part, seven questions are easy and students are expected to practice. In the other two parts, there are nine questions with increasing difficulty. For these two parts, students are given five-minute periods. Students' cognitive tendencies are determined according to their answers to 18 questions in the last two sections. The questions in the first part are not included in the scoring because the students are intended to practice. The score can be graded between 0-18 and the students who are of the most correct in determining the simple shape within the complex shape are classified as field independent and the students with the least correct are classified as field dependent. In this study, the method formulated by Alamolhodaei (1996) was used to classify the cognitive styles of the students.

Scientific Process Skills (SPS) Multiple Choice and Open-ended Test

In the research, "Scientific Process Skills Measurement Test" developed by Temiz (2007) was used to examine students' scientific process skills. The scope of the SPS Measurement Test; It consists of six modules consisting of determining variables, create hypotheses, changing and controlling variables, saving data (creating a data table), drawing graphics and interpreting graphics. Temiz (2007) designed the SPS Measurement Test as a pool of questions that can be used in scientific process skills researches and in-class activities and foresees users to take the appropriate number and quality of materials according to their needs and create their own tests. In this regard, within the scope of the research, the Scientific Process Skills Measurement Test question pool has the ability to determine variables and create hypotheses one open-ended and five multiple-choice, experiment-design-ability one open-ended and two multiple-choice, seven multiple-choice from the ability to interpret data, save data and draw graphics two open-ended questions were chosen. In summary, the multiple choice SPS test consists of fourteen questions and the open-ended SPS test consists of four questions. For the validity and reliability analysis of the Multiple Choice SPS test, the pilot test was applied to 210 students. In the Multiple Choice SPS test, the student gets one point for the correct answer and zero point in all other possibilities. Accordingly, the maximum score a student can get from the test is 14, and the minimum score is zero. In accordance with the data obtained from the pilot implementation, the Cronbach Alpha value, which is the internal consistency coefficient of the multiple choice SPS test, was found 0.78. The average item difficulty of the test was calculated as 0.506 and the average item discrimination index as 0.41. The implementation time of the test is 25 minutes. The questions in the open-ended part of the SPS Test were evaluated according to Temiz's (2007) analytical criteria scales. In this context, a student can get a maximum of 54 points from the test (with a maximum of 22 points from the first question, a maximum of seven points from the second question, a maximum of 15 points from the thirth question and a maximum of ten points from the fourth question). The response time of the test is 25 minutes. In order to test the reliability of the scoring made by the researcher in the evaluation of open-ended questions according to the analytical criteria scales, the answer sheets of ten students randomly selected from 40 students were scored by two separate raters other than the researcher. The first author took place as the third rater in the process. Whether there is a difference between the point averages given by the raters was tested by one-way analysis of variance and reliability between raters was determined. The findings show that there is no statistically significant difference between the scores assigned by the three raters [$F(2,327) =. 000$, $p>0.05$].

Performance Based SPS Test

The measurements that the student is asked to show her/his knowledge by creating an answer or by making a product are expressed as performance-based measurements (Century, 2002). In such measurements, a student needs to research, inquiry and use his/her prior knowledge to solve the given problem or to perform a task. In this case, measurement is also an element that increases learning (Bekiroglu-Ogan, 2008). Scientific process skills require a performance-based evaluation activity by nature. In this study, a semi-structured test was developed to measure students' scientific process skills based on performance. In the development of the performance test, Spector's (1992) cycle has been accepted, which includes the processes of defining the structure, designing the scale, pilot implementation, item analysis, validity and norming processes. In this context, the steps followed in the development of the performance based SPS test are presented respectively.

Stage 1-Performance-based scientific process skills and subject selection

Firstly, it is determined which scientific process skills the test will contain. In this context, the focus is on the skills in which the student can best demonstrate his cognitive, effective and psychomotor skills. In this framework, a daily life situation was chosen in which the student can demonstrate the skills of determining the problem, creating hypothesis, determining and controlling variables, designing experiments, collecting data, recording and interpreting data and drawing conclusions. In the subject selection, energy, which is a subject that the students have already learned, was preferred. As a matter of fact, Bozkurt and Olgun, (2005) stated that it is not correct to evaluate the scientific process skills in a subject that students do not know or have an idea about. In this framework, students were told a story about “a day of Beril and her mother, who is a civil engineer, on the construction site” and the visuals in the story (construction site, crane, construction, warning signs, hard hat, etc.) were reflected on the writing board. Students were given a problem situation from daily life within the scope of gravitational potential energy. The choice of a construction and crane close to the school was effective

in choosing this daily life situation. Because it is thought that choosing an event that the student is familiar with from daily life will increase the student's interest to the problem situation in the affective sense.

Stage 2-Content structure of the Performance Based SPS test in the context of skills

In the performance based SPS test, the problem status and the materials to be used in the experiment were given to the students by the teacher. A semi-structured format was preferred in the creation of the test draft considering the grade level of the students. In this context, students were asked to design an experiment using the materials provided to explain their daily life status. The performance based SPS includes the skills presented in Figure 1.

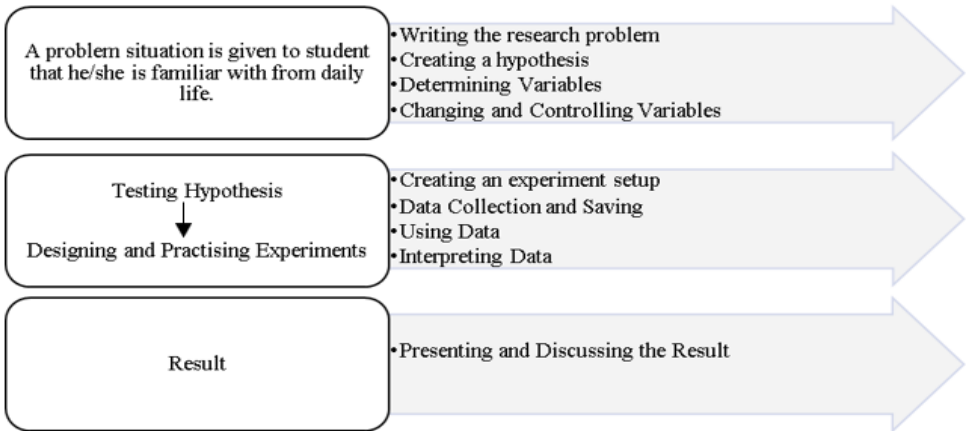

Figure 1. Content structure of the performance based SPS test in the context of skills

Stage 3- Expert opinion

The draft prepared was evaluated by three field experts in line with the criteria given in Table1.

Table 1.Criteria considered in the creation of a performance based SPS test

Criteria
The compliance of the given daily life context to the content/subject.
The Compliance of the given daily life context with the scientific process skills to be observed.
The Compliance of the performance task with the scientific process skills to be observed.
The Compliance of the given daily life context, questions and instruction to the age and grade level of the student.
The Compliance of the time given to the student to complete the performance based SPS test.
The Compliance of the instructions and questions asked in the performance task to reveal the knowledge and skills to be measured (Wiggins, 1996).
The given daily life context, questions and instruction are clear and understandable.
The suitability of the Analytical Criteria Scale to the scientific process skills to be measured
The criteria in the Analytical Criteria Scale are clear and understandable.

In line with the opinions and suggestions of the field experts, the Performance Based SPS Test was given final mode before the pilot implementation.

Stage 4-Pilot implementation

Performance based SPS pilot test was applied to ten students. With the pilot implementation, students' response time of test, concepts and terms they could not understand, and sections that were not understood in the directive were determined. Arrangements were made in accordance with these determinations and the completion time of the test was determined as 30 minutes. In pilot practice, it was determined that students did not know some concepts about SPS. In addition, it has been observed that performing the performance task in a daily life context increases the students' interests and motivations.

Stage 5- Creating an analytical criterion scale

In the research was based on a process-based assessment approach in terms of performance evaluation. For this reason, Analytical Criteria Scale was used for evaluation. According to Temiz (2007), the analytical criterion scale is the form of performance divided into different levels. Analytical criteria scale is created to give different grades to different dimensions of a study or product. When evaluating with the analytical criterion scale, it is necessary to focus on the process evaluation more than product evaluation. In this study, SPS scale development studies of Temiz (2007) and Aktamıs and Sahin Pekmez (2011) were utilized in establishing the criteria of the scale used in evaluating the performance based SPS test. In this context, a Performance Evaluation Analytical Criterion Scale was created in line with the Experimental Design Evaluation Analytical Criterion Scale, the Experimental Design Analytical Criterion Scale (Temiz, 2007) and the measured skills and expected behaviors (Aktamıs and Sahin Pekmez, 2011). In addition, the data obtained from the pilot implementation were also used in the development of the analytical criterion scale.

Analyzing of Data

In the research, One Way MANOVA method was used to determine whether there is a difference in the scores obtained from different SPS tests formats according to cognitive styles (field dependent/ independent). MANOVA is a powerful and multivariate statistics used in experimental and scan study (Büyüköztürk, 2007; p: 138). Analyzes were presented in the Findings section.

Findings

In this section, firstly, the findings related to the assumptions of MANOVA and then the findings related to the analysis of the data obtained from the research with the method of MANOVA are given.

Findings Related to Providing Assumptions of MANOVA

Whether the scientific process skills measured by tests in different formats differ according to the cognitive styles that students have (field dependent/independent) were tested with MANOVA. Accordingly, statistical assumptions required for the analysis of MANOVA for one independent (cognitive style) and three dependents (multiple choice, open-ended and performance-based SPS) variables were tested. First, Box's M test was performed to examine the distribution of covariance matrices. The test results showed that MANOVA analysis can be performed and variance covariance matrices of dependent variables are evenly distributed (Box's M = 9,309 p> .05). Thus, the assumption of equal distribution of covariance matrices, one of the basic assumptions of multiple variance analysis, was met. Levene's Test results for the homogeneity of variances are given in Table 2.

Table 2.Levene's test results for homogeneity of variances

Dependent Variable	*sd1/sd2*	*F*	*P*
Multiple Choice SPS Test	1/38	,701	,408
Open-Ended SPS Test	1/38	,360	,552
Performance-Based Test	1/38	,696	,410

When Table 2 is examined, Levene F test values are higher than the limit value of .05. This value shows that there is no significant difference between the groups in terms of the distribution of error variances of the dependent variables in determining the homogeneity of error variances. In addition, this value shows that variances are homogeneous. In line with the analyzes, it was decided that the necessary assumptions were met in order to use MANOVA and analyzes were carried out.

Findings Regarding SPS Levels of Students with Field Dependent and Field Independent Cognitive Styles

The results obtained from the one-way MANOVA analysis of the scores obtained from the multiple choice, open-ended and performance-based tests of the students with field dependent and field independent cognitive styles are given in Table 3.

Table 3. MANOVA results of the multiple choice, open-ended and performance-based tests scores according to cognitive styles

Effect	*Wilks' λ*	*F*	*Hypothesis sd*	*Error sd*	*p*
Cognitive Style	0.617	7.452	3	36	0.001

MANOVA results reveal that students with field dependent and field independent cognitive style showed a significant difference in terms of scientific process skills scores measured by different tests [Wilks Lambda (λ) = 0.617, F (3, 36) = 7.452, p <.05]. This finding showed that the scores obtained from the linear component consisting of multiple-choice test, open-ended test and performance-based test scores differ depending on the cognitive style differences.

Within the scope of the study, findings the analysis of variance regarding whether the scientific process skills measured by the multiple choice, open-ended and performance-based tests differ according to student's cognitive styles are presented in Table 4.

Table 4.Variance analysis of multiple choice, open ended and performance based sps scores according to cognitive styles

Test	Cognitive Style	*N*	$\bar{x}$	*S*	*SD*	*F*	*p*
Multiple Choice SPS	Field Dependent	20	8,4	1,78	1-38	15,69	,000
	Field Independent	20	10,85	2,1	1-38		
Open-Ended SPS	Field Dependent	20	31,1	9,5	1-38	,394	,534
	Field Independent	20	33,11	10,5	1-38		
Performance Based SPS	Field Dependent	20	33,35	9,2	1-38	,146	,705
	Field Independent	20	32,15	10,6	1-38		

* p<.05

Considering the values in Table 4, in terms of Multiple Choice SPS test mean scores [F (1, 38) = 15.69, p<.05], the scores of the students with field independent cognitive style were statistically higher than the students with field independent cognitive style. When the open-ended SPS test mean scores [F (1, 38) = .554 p> .05] and Performance Based SPS test mean scores [F (1, 38) = .705 p> .05] are examined, there is no significant difference between test scores of the students with field independent and field dependent cognitive styles.

Results and Discussion

Scientific process skills of students who have different cognitive styles within the scope of the research were measured in three different test formats: multiple choice, open-ended and performance based. Findings obtained; showed that students with field independent cognitive style were more successful in multiple choice SPS test. However, it was concluded that there was no significant difference between the achievements of students in the field-dependent and field-independent cognitive style in both open-ended and performance-based tests.

When the relevant literature is examined, no research has been found regarding the measurement and interpretation of scientific process skills according to cognitive styles, which is an individual difference. However, research examining the relationship between individual characteristics such as creativity (Aktamıs and Ergin, 2007), critical thinking (Akar, 2007; Koray, Köksal and Özdemir, 2007; Rudd, Baker and Hoover, 2000) and emotional intelligence (Ergin and Özgürol, 2011) and scientific process skills attracts attention. In addition, studies investigating the relationships between learning styles and SPS (Arı and Bayram, 2011; Duran, Işık and Mıhladız, 2011) suggest that some learning styles are more advantageous in terms of SPS.

The results of this research showed that students with different cognitive styles have different success in scientific process skills. This may be due to the difference of students' cognitive style tendencies, the test format used to measure scientific process skills or the structure of the measured scientific process skills. To start with students' cognitive style features; Field Independent students can be more successful in the tests with multiple choice questions test format due to the features of not being effected by the illusion of the fields, analyzing the fields (Liu and Reed, 1994), distinguishing the differences easily (Simsek, 2004). However, Witkin, Moore, Goodenough and Cox (1977) stated that students with field independent cognitive style are more easily able to recognize unstructured problems, wrong structures in activities, and unclear hints of problems. As a matter of fact, this finding has been revealed by various studies (Karacam, 2005; Karacam and Ates, 2010). The absence of a significant difference in terms of the scores of fields independent and field dependent students in the open-ended and performance-based scientific process skills test shows that the advantage/disadvantage arising from

the measurement tool in measuring scientific process skills may be eliminated. In the research, questions about determining variables and establishing hypotheses in open-ended questions require higher level qualifications (Temiz, 2007). In addition, in performance-based questions, the student is expected to design an experimental setup, test the hypothesis, and interpret the collected data. This type of test, on the other hand, provides the student with the opportunity to fully demonstrate his/her scientific process skill beyond the ability to solve multiple choice questions. It is possible to explain this result with Saracho's (1997) statement that field dependent and field independent students have the same level of cognitive capacity, however, their ability to use information and the process of using materials may differ. In addition, Güven (2007) stated that not only can each style have positive features, but also negative features, and in some cases, it is important to see the detail, in some cases it may be an important the whole. In this context, diversification of measurement tools (Monica, 2005) appears to be an important issue in the measurement of scientific process skills since the types of questions prepared in various types can effect students with different cognitive styles in different ways. Research states that cognitive style differences are a factor that teachers should take into account in shaping learning environments and developing flexibility, improving the quality of education of all children and improving educational opportunities (Saracho, 2017). In addition, it should be noted that an effective teaching process is shaped and completed by an effective evaluation process. The use of measuring instruments in different formats both during the teaching process and at the end will ensure that the disadvantages caused by cognitive styles are eliminated. In fact, research showed that cognitive styles can effect students' preferences for learning process (Saracho, 2017). For this reason, it is necessary to care about the individual differences of the students and not to impose only a uniform assessment activity on the student. Indeed, Hamblin (1981, p.21) described this situation as the pedagogically equivalent of imposing a false self on someone and expresses it as a destructive act in the long run. In line with the findings obtained from the research, it can be said that open-ended and performance-based test results provide important data to the teacher about the skills that the student needs to be developed-supported and their preferences regarding teaching and assessment activities.

Recommendations

The findings of this study show that when scientific process skills are measured with open-ended and performance-based tests, there is no significant difference between students with different cognitive styles, but when scientific process skills are measured with multiple choice test, a result is in favor of field independent students. This result shows that there is a need to discuss how scientific process skills should be measured. For this reason, it is thought that using open-ended or performance-based tests by moving away from traditional methods in measuring scientific process skills will produce more valid results. In this context, researchers are recommended to develop valid-reliable SPS measurement tools that include question types in different formats suitable for the Curriculum.

The scarcity of research in the field clearly reveals the necessity to investigate the relationship between scientific process skills and cognitive styles. In addition, the findings of this study reveal the possibility that the results obtained by measuring scientific process skills may result from differences in students' cognitive styles. If there are differences between SPS achievements measured using different measurement techniques, the findings of previous studies investigating SPS success should be reviewed. In this context, researchers are advised to conduct research that deals with the relationship between scientific process skills and cognitive styles, and that takes care of students' individual differences in determining and developing scientific process skills.

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Using Virtual Reality in the Classroom: Reflections of STEM Teachers on the Use of Teaching and Learning Tools

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Abstract

The purpose of the study was to determine teachers' opinions about virtual reality (VR). Virtual Reality Interview Form (VRIF) administered to seven teachers after the implementation of VR practices. Teachers received three weeks of intensive training. Afterward, teachers applied VR for two months in their classrooms. Later, interviews held with them. Findings indicated that different VR practices, including Google Cardboard, were used in the classroom. According to the teachers, using virtual reality in the classroom captured students' interest, increased their creativity, allowed students to take virtual trips, increased students' motivation, improved students' technology literacy, individualized learning; made students easier to understand difficult concepts. The potential problems of using VR were not asked the teachers; however, teachers mentioned that online safety and security, student access, and technology gaps were the problems they faced. The findings of this study suggest that the use of VR allows teachers to visualize abstract topics and enrich instruction. A VR orientation module would be provided teachers with opportunities to learn, practice, and apply their VR skills before being placed in the classroom.

Introduction

The rapid changes in science and technology fields directly affected the economy and industry. As a result of this change, the individuals are expected to have different skills such as critical thinking skills, creativity, problem-solving, and virtual collaboration skills than skills business world asked workers to possess before (Davis, Fidler, & Gorbis, 2011). The World Economic Forum (2017) also mentioned the importance of such skills (i.e., problem-solving, human management, and emotional intelligence) in today's business world. Changes from workers triggered educational reform movements around the world. Different countries have modified the science and mathematics curriculum to meet the business world expectations. Educational reforms have broadened and changed teachers' and students' roles. Schools put much pressure on teachers' shoulders, and as a result, teachers' workload has changed. Since educational reforms in science and mathematics curriculums were one domain-oriented reform, these educational change movements in education did not satisfy the business world and did not meet the needs of technology and engineering areas (Dugger, 2010). Considering science and mathematics separated from technology was one of the reasons for the failure of these educational movements (Morrison, 2006). Nuffield Foundation (1990) in England recognized this missing point and introduced the Design & Technology (Banks & Barlex, 2014). Afterward, countries integrated these four areas, science, technology, engineering, and mathematics into their curriculum.

A science, mathematics, technology, and engineering (STEM) education is an interdisciplinary approach that will offer students opportunities to understand the world around them (Yıldırım, 2016). Every individual must meet the needs of 21st-century skills and understand the basic concepts of STEM areas. Instead of separating four disciplines, STEM education integrated them into one cohesive teaching and learning paradigm (Ng & Adnan, 2018). STEM had different roles while integrating different disciplines during the practice of teaching. Some researchers (such as Roehrig, Moore, Wang, & Park, 2012) highlighted that engineering education should have a central role. On the other hand, another researcher, Corlu, Capraro, and Capraro (2014) defined STEM education was an interdisciplinary approach that mathematics and science were a vehicle to bring together concepts from more than one discipline. Additional to these perspectives, other educators put emphasized on technology. For instance, Şahin (2015) claimed that technology facilitated the discovery of new products and enhanced the implementation of STEM activities in different ways. When technology use analyzed for STEM education, two patterns emerged: (1) direct integration of technology into STEM activities design and embedding of technology into STEM activities; and (2) using technology as a facilitator of enriching STEM

activities (Şahin, 2015). Recently, the increased availability of 3D printing, 3D modeling, robotics had opened the ways too many new applications in STEM education (Yıldırım, Yıldırım, & Çelik, 2018; Barroso et al., 2017; Chien, 2017; Kwon, 2017). 3D printings were used as an engaging tool in students' learning. Furthermore, virtual reality (VR), augmented reality (AR), mixed reality (MR) also became widely popular in recent years and were now widely used in many different field (Aslan, 2017; Cipresso Giglioli, Raya, & Riva, 2018).

Extended reality (XR), which blends virtual and real environments, is an umbrella term covering VR, AR, and MR. VR is an interactive computer-based environment where users interact with computer-generated environments (Schwienhorst, 2002). VR was defined as a computer-generated simulation of a 3D environment where users were immersed in learning scenarios created with computer technologies (Martín-Gutiérrez, Mora, Añorbe-Díaz, & González-Marrero, 2017; Kayabaşı, 2005). Variety of terms are used to label the technology in the educational research literature: virtual world (VW); virtual environment (VE); multi-user virtual environment (MUVE); massively-multiplayer online (role-playing) game (MMO(RP)G); immersive virtual world (IVW); immersive world; immersive online environment; 3D virtual learning environment; open-ended virtual worlds; simulated worlds; serious virtual world; social virtual world; synthetic virtual world; and virtual learning environment (VLE) (Girvan, 2018). In this research, VR is used as a term to describe any online environment that allows users to play, learn, or interact (Girvan, 2018); VR simulates real-life experiences and constructs thoughts by using computers and various technological accessories (Duncan, Miller, & Jiang, 2012; Hay, 1997; Yildirim, 2017). VR uses both 2D and 3D displays and provides users with realistic environments (Schwienhorst, 2002).

AR is a setting that combines a real setting with virtual objects. It is interactive in real-time; allows users to interact with digital images while viewing the real scene (Azuma, 1997). Though Azuma (1997) defines AR as a form of a virtual environment, there is a difference between AR and VR. VR allows users to immerse themselves in a simulated environment completely. AR supplements reality rather than completely replacing the environment. AR use digital information that would be images, audios, videos, and a touch (Kipper, 2013). AR allow users to use five senses (Kılıç, 2016). Therefore, users experience real world environment in which virtual objects and real objects are placed as seamless as possible (Kılıç, 2016). VR, on the other hand, blocks users' visual access to the real world since users' ears and eyes covered with digital screen. Another term, MR, is a setting that encompasses anything between a real scene and an immersed virtual scene (Milgram et al., 1995). Although VR, AR, and MR have been around for years, it is just entered the education arena. Until recently, a traditional computer equipped with a camera was the only technological instrument that had been used in the classroom. The explosion of mobile phones, laptops, rapid increases in computer speeds, and the increase in the availability of the internet to the public allowed to use of ER in different areas, including the classrooms. Several barriers, including high software and hardware costs, low-quality instructional design, and problems associated with the early computer systems, prohibited the use of ER in the K-12 educational settings (Olmos et al., 2018; Zantua, 2017). Recent advancements in smartphones, tablets, and laptops have weakened the obstacles and provided low-cost alternative ER technologies (Zantua, 2017). For instance, Google Cardboard viewfinder is an example of low-cost ER technologies (Truman, 2017). In 2015, Google introduced the Expeditions VR system, which is a virtual reality system for K-12 classroom use. Even though the Google Cardboard app and various VR apps provide a single user VR experience, Google Expedition provides affordable virtual field trips for the K-12 students (Lee, Sergueeva, Catangui, & Kandaurova, 2017). To conduct a virtual field trip, the Expeditions app needs to be downloaded on a smartphone, placed in a viewfinder, and connected to the router. Students are provided with a viewfinder with an inserted smartphone opened to the Expeditions app. The teachers select the field trip location from over 500 field trips on the computer or tablet. Students then see the opening scene for the field trip. Teachers guide students through the virtual environment by asking questions. The studies' low-cost VR in educational environments is just begun to examine. The low-cost VR offers opportunities for enhancing learning across a range of areas, and this area should be investigated further (Castelvecchi, 2016).

Studies have shown that VR technology can be beneficial for students when appropriately adapted to the classroom and used (Black, 2017; Kickmeier-Rust, Hann, & Leitner, 2019; Zhou, Ji, Xu, & Wang, 2018). The use of VR in the classroom increases learners' engagement in an active learning environment (Allcoat & Von Mühlenen, 2018). While students involved in the VR system, users could not interact with the real world that surrounds them. Users interact with virtual objects. VR was one of the ways to manipulate, visualize, and interact with sophisticated computer systems and data (Çavaş, 2004). Another benefit is that using VR instead of physical ones allowed students to do more experiments than physical experiments (Yıldırım, Yıldırım, & Çelik, 2018). Thus, students collected more information in the same amount of time it would take to do physical experiments. VR was enabled students to learn more about the phenomena in the closest setting to real life by providing the learner with a three-dimensional environment (Kim, 2006). This kind of learning settings

improves students' success. VR also allowed learners to collaborate in the learning environment (Dickey, 2005). Furthermore, VR increases students' motivation to learn (Çavaş & Can, 2004). VR improves students' spatial abilities, whereas students' motivation for learning was improved. VR facilitate student-centered learning (Martin-Gutierrez & Meneses, 2014; Di Serio, Ibáñez, & Kloos, 2013). VR also improved the ability of hearing-impaired students' ability to find a solution for different problems (Passing & Eden, 2000). Since the idea of VR introduced, there has been significant interest in using VR technology in education. VR technology has been used in K-12 and higher education in different forms such as the expeditions programs to go on virtual field trips around the world, simulations, 360-degree video and photography, head-mounted display gear, data gloves, and bodysuits to give users a fully engaged with learning experiences (Black, 2017). As the schools have greater access to technology, a growing group of teachers has started to use VR in their classroom (Castaneda et al., 2017; Aktepe, 2011; Çağıltay, Çakıroğlu, Çağıltay, & Çakıroğlu, 2001). Even though, the benefits of VR and the difficulties of VR have been described by the research and teachers were well-supported to use VR during the instruction, the effectiveness of using VR in the classroom have not been monitored and evaluated (Çiftçi, Taşkaya, & Alemdar, 2013; Deniz, 2005). Therefore, this study aimed to evaluate teachers' experiences of using VR in the classroom and to determine teachers' instructional technology practices in the classroom. For this research, teachers from a variety of backgrounds (one English teacher, one biology teacher, two middle school science teachers, and three geography teachers) were selected and were involved in different tasks where they can experience different applications of VR.

Method

We used a qualitative method, a case study design, to reveal teachers' opinions about VR after applying VR in the classrooms and collected qualitative data. Case studies referred to a group of methods that allows examining the in-depth study of subject or situation within a specific period (Creswell, 2003). Different data sources used in the case of studies at the same time, and this provides a holistic interpretation of the study (Merriam,1998). This approach was selected as it would allow getting an in-depth understanding of the insight teachers developed the effectiveness, usefulness, critiques, and limitations of the VR.

Participants

The stratified purposive sampling method was used to select participating teachers. The stratified purposeful sampling allows researchers to capture significant variations rather than to determine common characteristics (Patton, 1990). Seven teachers (one English teacher, one biology teacher, two middle school science teachers, and three geography teachers) from different public schools volunteered to participate in this study. Teachers were selected from different seven school sites from central Anatolia. These schools represented a range of current technology initiatives, they had well-established maintenance arrangements to quick repairs, they were well-equipped, and they were willing to share their insights after the implementation of VR. Teachers' computer skills were in general at basic to intermediate level. They did not know about VR. While selecting teachers, recommendations from technology departments in each school were taken. Technology departments evaluated teachers based on their willingness to adopt technology into the curriculum, their openness to use technology, and their experience for using technology in the classroom. Technology departments suggested potential participants from volunteer teachers.

Table 1. Demographics

Characteristic			
Organization	Gender	Subject	Experience
Public School 1	Male	Geography	19
Public School 2	Female	Biology	23
Public School 3	Female	Geography	24
Public School 4	Female	English	8
Public School 5	Female	Sciences	10
Public School 6	Male	Geography	19
Public School 7	Female	Sciences	13

Vital information (the nature and the purpose of the study) was provided to the school administrators and technology departments before the selection of teachers. After teachers were identified consent forms and informative letters sent each teacher via e-mail, and the researcher maintained all consent forms. Since the maximizing, the impact of professional development was a high priority for the researchers, teachers who would

have a significant influence on their co-workers was another criterion. For this reason, teachers with at least three years of teaching experience were preferred over less experienced teachers. The demographics of the teachers collected through a demographic information form (Table 1).

Procedures

Three stages were involved in this study (Figure 1): (1) Pilot study: Instruction on VR took two weeks with one teacher. The first draft of the Virtual Reality Interview Form (VRIF) was given to three teachers (2) Three weeks (6 hours per week) training with teachers (3) Teachers' implementation of VR in the classroom for two months. The interviews were conducted with teachers at the end of the second month (Figure 1).

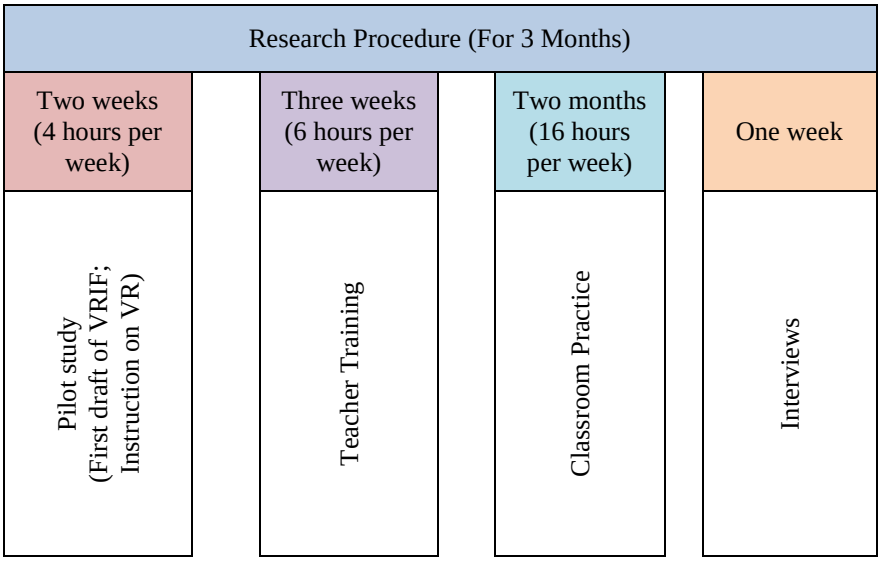

Figure 1. Research procedure

The pilot study was conducted with one elementary teacher to gather feedback from the participant experiences about using Google Cardboard and Google Expeditions, her implementation of VR, and Web 2.0 in the classroom. The elementary teacher was purposely selected for the pilot study. Since elementary teachers teach different subjects, they have content knowledge in different areas. Therefore, researchers assumed that an elementary teacher was the best option for the pilot study.

Table 2. Overview of Teaching

Teachers	Scope of the course	Thematic Units in Google Expeditions
Geography Teachers	Interactions in the physical environment; Changing populations; Climate Change (11th grade)	Loss of Arctic Sea The Sinking city if Venice Deforestation in Brazil
Biology Teacher	Human Anatomy, Body Systems (11th grade)	Human Heart, Human Respiratory System, Lungs, Auditory, Digestive System, Stomach, Oesophagus
English Teacher (Second Language Teacher)	Making comparisons, making simple inquiries (7th grade)	A luxury house, Human heart, Human respiratory System
Science Teachers	Human Anatomy, Body Systems (6th and 7th grade)	Human Heart, Human Respiratory System, Lungs, Auditory, Digestive System, Stomach, Oesophagus

After the pilot study, the professional development curriculum revised. The latest version of the curriculum included following areas: STEM education, the role of technology in STEM areas, Technological Pedagogical Content Knowledge, Implementation of Technology in the Classroom, Web 2.0, Virtual Reality, Google Expeditions, Curriculum Development. Seven teachers received intensive training during the professional development about the subjects that were given before. Teachers developed lesson plans on different topics where they incorporated different Web 2.0 tools, Google Expeditions, and Google Cardboard. Topics were

selected based on National Science, Biology, Geography, and Second Language Curriculum. Teachers shared student learning activity descriptions in an online classroom, Google Classroom, every week. Once the professional development completed, they implemented the lesson plans and student learning activities in the classroom during the two months. During the different implementation classes covering different topics was taught by seven instructors with extensive teaching experience in Science, Geography, English, and Biology. Topics covered in the classrooms based on subjects, grade, and thematic units in Google Expeditions were given in Table 2.

The study incorporated Virtual Reality Cardboard, similar to that shown in Figure 2, Google cardboard version 3.0 viewer in conjunction with a smartphone that is capable of running VR applications and VR 360° videos in an extensive professional development for in-service teachers. VR Cardboard is an affordable technology compared to other VR devices such as head-mounted display gears and data gloves. Google Cardboard and expedition has launched in 2016 and includes a collection of linked VR content and supporting materials that can be used along with existing curriculums for different subject areas. This technology can be used for visualizing of astronomy, biology, literature, math, foreign language, geography, and physics. Nowadays, teachers and most of the students own a smartphone, tablet, and VR cardboard; and Google Cardboards can be cheaply purchased. Since the smartphones and tablets are available for students and teachers in the classroom, these devices can be easily used in conjunction with Google Cardboard and Google Expeditions if the teacher wants to use Google Cardboard while teaching, the teacher installs the Google Expedition app on a mobile device or a tablet. Expedition app is free and available on Google Play for Android devices (https://play.google.com/store/apps/details?id=com.google.vr.expeditions). Following, the teacher purchased Google Cardboard for each student from AmazonTR. The price of the cardboard was around $4 for one student. With a single teacher tablet or a mobile phone and students' smartphones, Google Expeditions can be efficiently run during the class. Depending on students' preferences, some used tables which were available at the school and some students used their own Android phones. After installation of the app, the necessary purchasing gadgets, Google Cardboard, the teacher selects a specific VR Expedition and act a guide during that journey. Meanwhile, students open the app and act as Explorer of the teacher selected Expedition. Students view the same scene what their teachers view. Google Expeditions allow the teacher to select the content that is related to the aim of the lesson. Moreover, since each of the expeditions comes with information and questions about the 3D environment, this will allow students to engage with what they are seeing.

Figure 2. Virtual reality cardboard display

Instruments

Semi-structured interviews were conducted with the teachers to determine their opinions about VR. Semi-structured interviews were allowed the interviewee to follow the interviewer's train of thought, allows two-way communication (Merriam, 2009)."Virtual Reality Interview Form (VRIF)" was used as a data source in this study. The first draft of the interview form consisted of 17 questions and was designed by the researchers. This form was modified according to two field experts' opinions, and this modified version was used to be interviewed with three teachers. Thirty minutes of interviews with three teachers were audio-recorded and later transcribed. After necessary small changes were made, the second version of the form was created. This second version of the form consisted of 14 questions and used for the interviews with teachers (Table 3). The interviews completed with teachers conducted after their implementation of VR in the classroom. Teachers' interviews (105 minutes) were audio-recorded. These interviews were semi-structured, and participants were asked to detail their responses given in the questionnaire. The purpose of these interviews was to get an in-depth understanding of

teachers' use of VR. Through the interviews, the insight teachers developed regarding effectiveness, usefulness, critiques, and limitations of the use of VR to teach different subjects were examined. The study was summarized below in Table 3.

Table 3. Summary of the study

Method	Time	Participants
Feedback from experts for the first draft of the research questions	Three days	Two field experts
Semi-structured interviews	30 minutes	Three teachers
Instruction on VR	Two weeks	One teacher
Finalization of the interview form and curriculum	One week	-
Teacher training	Three weeks	Seven teachers
VR implementation in the classroom	Two months	Seven teachers
Semi-structured interviews	105 minutes	Seven teachers

Data Analysis

In order to obtain the results of this study, the data collected from one instrument, the VRIF, and analyzed with content analysis methods. Content analysis methods require to transform a large amount of data into a highly organized and summary of the results (Mostyn, 1980). The data analysis was conducted by the authors and involved several steps. First, audio recordings were transcribed. Then each author independently read responses. Second, researchers discussed their interpretations of responses and came to a consensus about the codes and perceived the meaning of responses. The coder reliability for the study was calculated by using formula [(Consensus / Consensus + Disagreement) * 100] and was calculated as (60/60 + 15) * 100) = 80% for the study (Miles & Huberman, 1994). Since the coding results are above %80, the coding was reliable (Miles & Huberman, 1994).

Results

The results of the analyses are reported in the following order: teachers' opinions about instructional technology practices and teachers' opinions about the use of VR in the classroom. To gain a deeper understanding of teachers' practice, researchers first explored teachers' opinions about the use of ITP for instruction, then teachers' way of using VR was examined.

Teachers' Opinions about Using the ITP for Instruction

The result of the analyses indicated that teachers provided answers related to their ITP in the classroom. All participants confirmed their use of technology to some extent in the classroom. More than half of teachers stated that they always used technology in their classes (Figure 3). Teacher five mentioned that she used technology practices to give children a comfortable learning environment.

Figure 3. The sample photos from different classes

Teacher six highlighted that her daily curricular goal determined her choice of technology use. Teacher four said she integrated technology to reinforce students' learning. The following exemplary statement provided an answer regarding technology use:

> T4: I use technology practices… not always, of course. I often include during the instruction or after the instruction.
>
> T5: I try to use technology practices at one of my lessons every week. I believe, teaching with technology practices will create a warm environment, and this will allow my students to learn.
>
> T6: I use technological practices whenever I need them. I do not always use technology. Depending on my daily curricular goal, I decide.

Following these questions, the kinds of technology practices used by teachers in the classroom were asked. Technology practices performed by teachers included animations, slides/prezi, smartboard, increased reality and 4d programs. Teachers pointed out that they mostly use animations and slides. Besides these two, smartboard applications, videos, increased reality, and the teachers also used 4D programs.

Table 4. The Benefits of Technology Use

Themes	Codes	f
The benefits of technology use	Lectures supported by technology	4
	Support student centered-practice	3
	Improvement of Technology Literacy	2
	Makes difficult concepts clear for each student	2
	Establishing multiple learning setting	1
	Individualize learning	1
	Enable to see different perspectives together	1

Next, the benefits of technology use were asked to the teachers. It was concluded that using technology support students' learning, improve students' technology literacy, individualize learning, support student-centered practice, makes difficult concepts easier to understand for students, individualize learning, makes possible to establish multiple learning settings at the same time, and makes possible to see different perspectives (Table 4).

Figure 4. Sample photo of students using technology in the classroom

Several teachers with teacher-centered beliefs perceived that students' interaction with computers fosters student-centered learning. These teachers used technology to master what they already taught in the classroom. Other teachers with student-centered beliefs believed technology use in the classroom support student-centered learning and independent learning (Figure 4). With technology integration, students could learn at their own time. These teachers acknowledged that technology encourages students to explore the concepts. The exemplary answers were provided below:

T4: Technology helps students to understand tough subjects. Thanks to simulations, virtual labs, my students get a chance to experiment in an online environment. Since doing this kind of experiment dangerous, technology also creates a safe learning environment too. Furthermore, I do not need to request some laboratory materials from my school. It is also cheap.

T5: I believed technology creates independent learners. People do not need to follow the teacher's instructions anymore. Technology allows learners to individualize instruction.

T7: Technology impacts the way my students learn. Possibly my students are more independent now because they work independently. My students take ownership of their learning. Besides technology affected the way, I evaluated my students and my preparation for the class too.

T2: When I used different technologies in the class, students' motivation increased. They do not want to finish the activity that I open on the computer.

T3: Through computers, students can reach many sources. When I use a problem-based approach, they can easily access many sources available on the internet. In the beginning, they have difficulties in differentiating reliable sources, but not they are good at it. They use these sources to solve the problem that I pose at the beginning of the class.

Teachers' Opinions about the Use of VR in the Classroom

The analyses indicated that teachers used VR for different purposes (Table 5). Teachers believed that with the help of VR, learning would be exciting and fun. Teachers recognized that the use of VR increased students' attention and motivation in the classroom (Figure 5). They also used VR to travel distant locations such as the interior of the volcano. Furthermore, teachers highlighted that VR allowed teachers to act as a facilitator in the classroom. They devoted more time to learning students' learning styles, and based on their observations, they planned adjustments in the classroom.

Figure 5. The Use of Virtual Reality Cardboard in the Classroom

Furthermore, VR made it possible to explore the situations that were impossible to explore in the real world with the naked eye, for example visiting the inside of matter (molecules). The exemplary answers were provided below:

T2: Some modeling and animations programs were beneficial for students to visualize some concepts. For instance, with the use of VR, students traveled inside the human body and explored the organs.

T4: I do not think VR could make teachers irrelevant in the classroom. VR allowed me to track my students' understanding of the topics that I taught and made necessary changes based on my observations and these assessments. Also, the way I assess students changed too. I believe with the appropriate use of VR; teachers act as a facilitator in the classroom.

T5: Complex and challenging concepts such as climate change were easily explained with the use of VR. Students tried to come up with a solution for some environmental issues. This method would benefit students from a deeper level of connection with a concept.

T7: I recognized that VR learning experiences were valuable for rural students. They explored the inside of the cave. In daily life, students were not able to visit this place. Exploring caves, exploring submarines made the learning more exciting and fun. Students paid more attention to the topics and participated actively in the classroom.

Table 5. The Reasons for the Use of VR

Codes	f
Teacher act as the facilitator	4
Makes abstract knowledge visible, concrete	4
Learning by doing	2
Learning in depth	2
Students' motivation increase	1
Compensation for teaching decrease	1
Individual differences were important	1

Next, the areas of VR in general use were asked to the teachers. They pointed out that VR would be used in education, health, art, construction, home, and entertainment. The exemplary answers were provided below:

T5: VR could be used in different areas: such as cinema, the entertainment industry. VR was standard in science fiction movies. It is used to turn fantastical thins into things that seem real.

T6: VR could be used in many different fields, such as education, health, and traffic. For instance, VR could be used to educate people about driving safety. Besides, doctors also use 3D models to plan their operations.

T7: VR would be used to help students with special needs. You could do exercises with autistic students using VR.

Table 6. The Benefits of VR Use

Codes	f
Increase motivation	3
Learning in-depth	3
Student-centered learning	3
Teachers role change: the facilitator	2
Establish technology integration	1
Enhance teachers' ability	1

Next, the benefits of using VR were asked to the teachers. Teachers pointed out that the use of VR had some benefits. Students discovered new technologies. The VR made the teaching/learning process more exciting and fun for students. The VR could assist the teachers in improving their awareness of students' learning differences. VR was effective for experiments that difficult to carry out in the classroom. VR experiences motivated students to learn the topic. The VR increased student interest in learning activities and students fully participated in the activities. Table 6 provided a summary of teachers' opinions about the benefits of VR use. Teachers said the followings regarding the benefits of VR use they experiences:

T4: Unlike 2D visuals that I used earlier in the science class, students examined the inside of the molecules and other tiny particles in the mater. So, I had a chance to show and explain besides proton and neutron other small particles existed in the nucleus.

T5: I used to ignore tablet use in the class. Bringing a tablet with different applications into the classroom had drawn students' attention to the topic.

T6: Students found some topics boring before. With the VR applications, students paid more attention to the topic and wanted to learn the next topic.

Figure 6. Use of Virtual Reality Cardboard in Education

Lastly, the question about "How does the use of VR affect your opinion about technology integration in the classroom? Why?" was asked to the teachers (Table 7). Teachers mentioned that the use of VR in the classroom enhanced their intention to use technology for education (Figure 6). During teacher training, teachers developed specific skills such as the ways of determining students' needs, identifying the most recent technology, and combined these skills into practice. The exemplary answers were provided below:

> T2: The VR increased student participation and motivation for learning. VR created an experience for students to enhance their critical thinking skills cause students actively involved in problem-solving scenarios.

> T3: Students were excited about the topic. I do not have any evidence that showed students' improvement in learning, but I could assure you that they were excited about learning.

Table 7. The Effect of VR Use on Technology Use in The Classroom

Theme	Codes	f
The effect of VR uses on technology use	Positively changed	7
	Negatively changed	-
The positive change towards technology integration the class	Learning in-depth	7
	Improve students' understanding	5
	Increase motivation	3
	Makes abstract knowledge visible, concrete	2

Discussion

The present study was conducted to examine teachers' opinions about VR after the implementation of VR and ITP. The data obtained from interviews with teachers demonstrated that teachers used different instructional technology practices such as 4D programs, smartboard, simulations, animations, and videos. This finding supported by the data from captured classroom scenes too (Figure 5). This finding also supported the research which was determined teachers' instructional technology practices in the classroom (Keleş, Öksüz, & Bahçekapılı, 2013). Another finding from this study was that teachers used technology to prepare classroom instructional materials, to support student-centered instructions, to individualize learning, to make difficult concepts easier to understand for students. These results were consistent with the relevant literature (McKnight et al.,2016; Yüksel & Adıgüzel, 2012; Glassett & Schrum, 2009).

Furthermore, another aim of this study was to determine teachers' opinions about VR use for instruction. Teachers pointed out that using VR for instruction offers opportunities for students. These opportunities are: (1) VR captured students' interest, increased their creativity. (2) VR could allow students to take virtual trips and to explore situations that were impossible to explore in the real world. (3) Using VR for instruction increased students' motivation and attention to the subject. (4) Using VR allowed teachers to act as a facilitator in the classroom. (5) Using VR allowed students to discovered new technologies. (6) Using VR allowed teachers to devote more time to know their students', their learning styles. (7) VR allowed teachers to carry out experiments that difficult to do in the classroom. The captured scenes from the classroom while teaching respiratory system

support this findings as well (Figure 6).These results were consistent with relevant studies (Yıldırım et al., 2018; Keskin, 2017; Tepe, Kaleci, & Tüzün, 2017; Tüzün & Özdinç, 2016; Fineschi & Pozzebon, 2015; Jeong, Park, Kim, Oh, & Yoo, 2011; Çoruh, 2011; Kartigo, Kavakli, & Cheng, 2010; Sun, Lin, & Wang, 2010; Dalgarno, Bishop, Adlong, & Bedgood, 2009; Mishra, 2009; Aoki, Ohno, & Yamaguchi, 2005; Manseur, 2005; Bakas & Mikropuolus, 2003). For instance, Manseur (2005) used VR for teaching abstract topics such as molecular systems, galaxies, astronomy topics. The VR allowed students to visualize these topics and enriched instruction. Furthermore, during the interview teachers stated that VR was used in different fields in daily life such as education, health, and art.

The potential problems of using VR were not asked the teachers directly during the interviews; however, teachers mentioned that they had different barriers while implementing VR for instruction. These barriers were: safety and security, student access, and technology gap. Teachers pointed some teachers were confident in their technical abilities, but others had a lower comfort level in using and implementing the technology. They stated that teachers' age might be a barrier in their comfort level to use technology for instruction. Fernandez (2017) also highlighted that teachers were the leading facilitator for the adoption of VR for instruction. Additionally, teachers mentioned that the internet environment should be safe for students, and access to computer hardware would be ready for students. Regarding these barriers, student safety, access, and security should be a top priority before any student involvement in technology usage (Sharples, Graber, Harrison, & Logan, 2009).

Innovation in VR provides a better learning environment for students. However, there are some risks and negative aspects of the use of this technology in schools. First, the use of this type of application may cause students to isolate themselves from their peers (Gudoniene & Rutkauskiene, 2019; Liou et al., 2017). During the learning process, learners interact with teaching materials, imitate scientists or engineers' ways of producing knowledge/material, and collaborate with their peers, exchange ideas with one another. These types of interactions are not that common in VR environments. Even though there has been progressed made in the development of these devices, current devices only allow transferring one kind of information in one sense. There is a need to find a way to track user interaction with the environment in different senses. Current visualization tools and audio devices are expensive. For instance, one gadget from Oculus Rift and HTC Vive costs more than $300, and both require a computer with high processing capacity. To buy a complete set of these devices to enjoy a virtual reality experience, teachers need to pay more than $3500.

On the other hand, low-cost devices that use smartphones processing capacity exist in the market. These provided supplementary materials cost below $100. The supplementary materials in the market allow users to interact with the material in one sense—for instance, Samsung's track-pad increases users' interaction with the environment. If the teacher wants to add headphones with high quality, this price goes up. Manufacturers do not provide supplementary materials without charging mo. Therefore, teachers need to provide all the materials which seem impossible for the whole class.

The second barrier is the schools and the teachers (Liou et al., 2017). Teachers have not been trained to use this technology in the classroom. Teachers do not know what VR is and what its possibilities and its potentials are. Teachers' knowledge of VR technology in specific educational contexts is limited, or they do not know. Teachers' limited or no knowledge is, without a doubt, one of the main barriers.

The next barrier is content of VR technologies. The current VR content is not adopted based on topics in the curriculums. The current VR contents only offer students exciting experiences. Using them as teaching material or adapting them as classroom material is not easy or possible always. These materials must feed the curriculum and vice versa.

Conclusions

The use of VR in education has grown dramatically in recent years as a result of drastic improvements in technology and low manufacturing cost. Drop-in prices have made VR more accessible to the schools. The use of VR in the classroom allowed students to interact with unobservable phenomena, to take virtual trips, increased students' motivation, engagement, and creativity. Further, the use of these tools allowed teachers to act as a facilitator in the classroom. On the other hand, the use of VR brought some barriers as well such as safety and security, student access, and technology gap. Teachers' confidence and comfort level might be a factor that affects teachers' implementation of VR for instruction. An essential conclusion regarding teachers' comfort level was that teachers unconsciously might be rejecting the use of new technologies in the instruction. The possibilities for educators to explore, learn, and experience a VR should be offered for teachers. An orientation

module would be provided teachers with opportunities to learn, practice, and apply their VR skills before being placed in the classroom. Fernandez (2017) also supported the idea of developing modules for teachers and added two fundamental points of any VR training of teachers must have (1) The detailed information about VR (2) Possibilities and potentials of VR. Teachers also highlighted that whoever participates in VR, they must have the necessary computer skills. Furthermore, teachers should keep students safe in online environments. Further, support and collaboration between the instructional technology department, other departments, and law enforcement should determine students' safety and security in VR environments.

Limitations

The limitation of this study was based on the generalizability characteristics of the study. As previously mentioned, the research participants were selected from volunteers. Teachers' VR experience did not consider as a criterion for selecting a research participant. Therefore, future research should select teachers who met the criteria of having VR experience. VR had not been used for instructional purposes or enrichment activities in different subjects before. Since students had never been experienced VR, future research focuses on longitudinal studies across a school year to mitigate the effect of using the new approach. Due to time constraints, the shortage of the funds, and diverse cities teachers were in, only interviews conducted with teachers after the study. Therefore, additional qualitative data sources such as classroom observations, interviews with students, and the quantitative data sources such as surveys should be used as data sources in future studies. A case study for each teacher may also provide additional insight into teachers' and students' experiences with VR, as well as better insight into how VR influences students' and teachers' motivation, and students' learning.

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