Research Article   **Copyright © RIGEO 2019**

The Students' Behaviours at the Instructional Geocaching Applied in Problem-Based Environmental Education[*]

Rukiye ADANALI[1]
University of Muğla Sıtkı Koçman, Muğla, TURKEY

Mete ALIM[2]
University of Atatürk, Erzurum, TURKEY

Abstract

Environmental and disaster consciousness of teachers are of great importance for disasters education. The teaching of some natural disasters of climate in the Environmental Problems course at an education faculty in Turkey was carried out with the Problem Based Learning (PBL) approach supported with Instructional Geocaching Game (IGG). Geocaching is an outdoor location based-digital game in which players hide a box and then share its coordinates online. Other players can find it with GPS. IGG is an educational game played with small student groups designed by teachers. This study aims to demonstrate how the IGG activities conducted outside of the classroom with the PBL approach are applied and IGG's outcomes. The instrumental case study design was utilized with a group of 19 geography prospective teachers whom were selected by convenience sampling method. The students' views on the IGG were determined by the open-ended questionnaire and their behaviours were determined by out-of-classroom observation forms. Student performances were evaluated through the IGG portfolio. Document analysis for survey and portfolio data; descriptive analysis for observations were done. The findings revealed that students' problem-solving skills increased and they learned to use GPS technology; IGG contributed to the development of environmental awareness and disaster awareness of them by increasing motivation. In addition, some strategies for the practice of the game emerged. IGG facilitated students' PBL process and it was evaluated as a geography game by students. According to the results, the PBL-IGG approach is applicable in Geography and Environmental Problems courses.

[*]This article is based on the Ph.D thesis of first aouthor (Adanalı, 2018a).

[1]Corresponding author: Dr., University of Muğla Sıtkı Koçman, Education Faculty, Department of Social Sciences Education, Muğla, Turkey, rukiyeadanali [at] mu.edu.tr. ORCID: 0000-0002-7948-4751

[2]Prof.Dr. University of Atatürk, Education Faculty, Department of Geography Education, Erzurum, Turkey, metealim [at] atauni.edu.tr. ORCID: 0000-0001-7805-3215

In this present century, increasing human activities have begun to become more effective on the frequency and effects of the natural disasters of climate origin. So the atmospheric disasters not only cost countless lives and give environmental damages but also pose a threat to the prosperity of future generations. Natural disasters especially climate-related natural disasters are both a cause and a consequence of environmental problems, therefore one of the issues addressed in environmental education. At the 1992 International Charter on Geographical Education, it was stated that current problems such as environmental and development education, environmental quality, natural disasters, toxic and nuclear waste, climate change, atmosphere pollution, ozone depletion, limited resources, limited development, land use etc. should be handled with a geographical perspective (Artvinli & Kaya, 2010).

The GPS (Global Positioning System) technology, one of the developing digital technologies, is also an element of Geographic Information Systems (GIS), which is used in disaster management systems (Turoğlu, 2008). GPS, which has a wide range of usage in daily life, is an obligatory technology as well in some fields related to in search and rescue, agriculture, transportation, cartography, geology and geography. Geocaching is one of today's recreational activities that presents this prevalent technology in a fun format at outdoors for formal and informal learning environments, can contribute to the development of environmental consciousness.

Geocaching is a real-world outdoor treasure hunting game, supported by an online global community (Geocaching.com.) which provides the geographic information to the *Geocachers* (Geocaching players/treasure hunters) to find more than three million *Geocaches* (Geocaching containers/treasure boxes) placed by enthusiasts worldwide. Geocachers use the Geocaching®app and GPS-enabled devices to find these cleverly hidden containers, and share their experiences with others through Geocaching.com (Groundspeak, 2018).

Kocalar (2012) suggested that any environment should be used as a tool for environmental education and awareness, and environmental education should be popularized to reach all sections of the society. Geocaching itself has already led to the observation of the environment and respect for the environment (Burns, 2013; Ihamäki & Tuomi, 2009; Taylor, Kremer, Pebworth, & Werner, 2010); CITO, (cache in trash out) one of the events of Geocaching community, is related to the environment directly, reinforce this appreciation against nature. CITO is an environmental cleaning activity in a designated area (Burns, 2013; Robison, 2011). Geocachers collect garbage individually too during the game, but sometimes they do CITO just for this purpose (Robison, 2011). Therefore, Geocaching has characteristics that supports environmental awareness and informal learning due to its realization within the nature and environmental sensitivity (Adanalı & Alım, 2017; Albach, 2014; Burns, 2013; CARLY, 2018; Clough, 2010; Hall & Bush, 2013; Robison, 2011).

Instructional Geocaching (IGG) is the implementation of the basic principles of recreational Geocaching (the original Geocaching game), to integrate technology into the curriculum and to connect students to the learning process. The main differences in the use of the game for educational purposes can be explained as follows (Christie, 2007; Mayben, 2010): At recreational Geocaching, boxes are positioned at least 528 feet (161 meters) away from each other (Schudiske, 2014), but at IGG generally applied in school gardens, boxes can be hidden closer to each other; boxes coordinates do not have to be posted on Geocaching website and IGG boxes are for student use only. At IGG, the finding of the box is one of the main motivating factors as at traditional/recreational Geocaching, but the focal point is the lesson content placed inside the box. IGG boxes should contain an educational element related to the subject currently being studied in class (Christie, 2007; Donadelli, 2014; Mayben, 2010). Teachers can organize the form and content of boxes according to their needs, curriculum and school conditions (Zemko, Vitézová, & Jakab, 2016).

Although the theoretical foundations of IGG are based on especially constructivism, other alternative theories and methods also suggested such as multiple literacies theory, nature-deficit disorder theory, place-based learning (Hall & Bush, 2013), multiple intelligence theory, learning by discovery, active learning, game-based learning and out-of-school education (Christie, 2007; Donadelli, 2014; Donadelli & Rocca, 2014; Hall & Bush, 2013; Hendrix, 2012; Mayben, 2010; Schlatter & Hurd, 2005). Nevertheless, academic studies on IGG are still insufficient (Christie, 2007; Hall & Bush, 2013; Hendrix, 2012; Mayben, 2010). In Italy, Donadelli and Rocca (2014) based the pedagogical infrastructure of Geocaching activities, organized in 2012 for students aged 8 to 18, on non-class game-based geography education that intends cooperatively problem-solving. Christie (2007)'s 6E learning model, which is designed for teachers to learn GPS technology and Geocaching, includes applicable, active and constructive learning environments for primary and secondary school students. Buck (2009), Mayben (2010) and Hendrix (2012) conducted experimental research on subjects such as the effect of IGG on students' achievement, attitudes and critical thinking skill.

The social studies prospective teachers at Vitale, McCabe, Tedesco and Wideman-Johnston (2012)'s study, expressed that Geocaching can be used especially at geography education, but also at other education programs as well; it is an exceptional tool for cross-curricular integration; besides integrating technology into course, it is also addressing six of Gardner's eight intelligences (especially the spatial, bodily-kinesthetic, interpersonal and naturalist); their communication and cooperative learning skills improved in a fun and competitive learning environment.

Geocaching is also a useful tool at teaching technology in GPS related professions. Munro-Stasiuk (2006) realized that, even after teaching Remote Sensing and introducing GPS for three years, many of her students didn't learn the GPS technology well enough, so she was inspired by Geocaching to organize a GPS treasure hunt and she reached her goal. Zecha (2014) used the principles of Geocaching in GPS training. There is also some research in which Geocaching principles are used in a flipped English class (Freiermuth, 2017); in environmental education as an outdoor education

(Pelton, Pelton, & Moore, 2008; Robison, 2011; Zecha, 2012); in solving open-ended mathematics questions through a Problem-based learning strategy (Zemko et al., 2016), and in geotrekking activities designed as physical and mental activities for students to realize meaningful problem-based learning (Pelton, Pelton, & Moore, 2007).

As can be seen in the literature review, there is a limited number of studies in which IGG activities are used to support another teaching-learning method. In this study, IGG activities were used in the Environmental Problems course to support the PBL process. Geocaching's connections with the science of the environment and geography; its availability of use both smartphones and handheld GPS devices; carrying the pleasure that is taken at the computer to the open air and contributes to physical and mental health, and the claims that it is effective at improving geographic skills such as observation and map are some facts that took the researcher attention to Geocaching. It was considered in this study that environmental problems will be learned well directly through problems. So the main rationale of the study is to test the hypothesis that IGG supports PBL and determine how should it can be applied, and the learning outcomes of the IGG process.

Some of the Geocaching's characteristics support the PBL approach such as requiring technology, collaborative problem solving, and increasing motivation and active participation through a constructivist approach. As a matter of fact, at the Geography Course Curriculum for high school in Turkey (The Ministry of National Education/MEB, 2018) and ISTE (International Society for Technology in Education, 2018a, 2018b) standards, problem-solving skills and digital competence, which are among the 21st-century skills, are pointed out. At this period in which there is a deficiency at examples of active learning implementations (Artvinli, 2010); IGG that is especially applied at outdoors and supporting different teaching styles for teachers, can be a proper strategy to integrate the GPS technology and social media resources that young people are fond of, into educational environments in a practical and motivating way.

The study is important in terms of to reveal the applicability of the PBL-IGG approach in geography and environmental education and how the IGG process works, IGG's impact on learning and its contribution to geographical education and IGG literature. For this reason, the Ph.D study called "The Effect of Problem Based Learning Supported by Geocaching Game on Teaching Natural Disasters" (Adanalı, 2018a) was conducted. In this study, students' opinions about IGG process designed to support PBL and PBL process were taken, and some data on problem-solving skills, academic achievement and persistence of knowledge, evaluating the student products, and student behaviours in and out-classroom implementations were gathered. The focus group interviews and the problem-solving inventory results of this doctoral thesis were discussed already by Adanalı and Alım (2017), and it is understood that IGG is a useful educational tool in environmental education and also supports the PBL. In this article, we focused on the data related to IGG collected in the doctoral study. The aim of this study is to demonstrate how IGG activities are applied and their results in the Environmental Problems course carried out with PBL approach.

The main problem discussed in this study is how the IGG activities that support the PBL process, affect learning environments. In order to fulfil this purpose the following research questions were addressed in the present study:

1. What are the views of students on Go-Geocaching and the IGG process?
2. What kind of behaviours did the students show in the IGG process?
3. How were the students evaluated in the IGG process?

Method

Research Design

This study has employed an instrumental case study design. Because the IGG approach's applicability and its effects in Environmental Problems course conducted with PBL were examined. In the instrumental case studies, although the effects of the event are examined rather than the event itself, the event itself is examined too for a clear understanding of the process (Stake, 2003, pp.136-137). How IGG supports the PBL process, how it can be applied to the Environmental Problems course, how does it affect the students' problem-solving skills and their attitudes towards GPS technology, Geocaching and the course are questioned in this study.

Participants

The participants of the study were 19 pre-service teachers who were at the 2nd year at a geography teaching program and taking the Environmental Problems course in the 2015-2016 academic year, in an education faculty. The group was taught by the first author and the convenience sampling method was used. The facts at determining the working group are as follow: Geocaching is closely related to geography; there is widespread use of smartphones among university students and Geocaching applications will be more easy and safe in the university campus. Shaunessy and Page (2006) proposed that the teacher should design the game in such a way that he/she can control the safety of students and boxes, and take into consideration the applicability of it in terms of time, play area and other conditions. In addition to this, it is expected that IGG will be experienced primarily by prospective teachers and to demonstrate its applicability and value in terms of geography education.

Data Collecting Instruments

In this study, open-ended questionnaire, out-of-class course observation form and IGG student portfolios were used to determine how the IGG applications supported the PBL process. At the end of PBL-IGG application, Go-Geocaching that is for recreational purpose was realized. The students' opinions about this activity and the IGG process were obtained through an open-ended questionnaire consisting of 13 questions. This data collection tool was preferred in order to get the participants' views about Go-Geocaching and IGG for a clear understanding. In the out-of-class course observation form, students' behaviours in Edu-Geocaching, Geocaching-CITO and Student-Geocacher activities, the ability to use the GPS, performing IGG tasks, collaborative working, intra-group communication, game pleasure, problem-solving situations etc., were observed by student videos. During the Geocaching game, a student from each

group made a video recording of his/her group with his smartphone and delivered it to the researcher at the end of the activity. In the IGG portfolio, there are some documents of IGG tasks done by students, the Geocaching Evaluation Scale (Table 3) and the Game Guidelines. The scale used in the evaluation of all the studies within the Geocaching activity was prepared by the researcher by searching the relevant literature. All the observation data of the process are presented under the headings as a result of descriptive analysis (Table 2). Likewise, open-ended questionnaire findings are given in Table 1 under the themes, categories and codes; directly citations from the students' views are also presented in the table. In the observations and survey findings, students were called S1, S2, S3 so that it can be understood which expressions belong to whom.

The IGG portfolio and the open-ended survey data were analysed by the document analysis technique. Document analysis technique is considered as non-interactive data collection tools used in systematic examination and evaluation of formal or private records in qualitative research (Bogdan & Biklen, 2007; McMillan & Schumacher, 2010), and also includes the examination of responses to open-ended surveys (Patton, 2002, p. 4). The out-of-class observation form was analysed through descriptive analysis; the new code, category and themes were reached after using the existing themes and conceptual frameworks that obtained from the literature review (Yıldırım & Şimşek, 2011, p. 107).

In order to ensure that the results of the study are valid and reliable, at the data collection and analysis, the interpretation and reporting phases of the study, Miles and Huberman (1994), McMillan and Schumacher (2010), Yıldırım and Şimşek (2011), Topu, Baydaş, Turan and Göktaş (2013)'s considerations were taken into account. Some of these are those: The process of gathering and analyzing data for validity measures was described in detail; characteristics and selection of the working group were explained; the application process of the research was explained in detail; different data collection tools were used in the study; direct quotations were included in the findings. Making triangulation; analyzing the data collection tools by correlating each other; confirming the observation findings with IGG portfolio and survey findings are some of the measures were taken into consideration for reliability. The whole research was carried out by the researcher herself and the feedbacks from consultants were also taken into account. The researcher was careful to be active and objective at every stage.

Implementation Process

The application was carried out during 12 weeks (There is also another week which was excluded from the course for a university event) in the Environmental Problems course. The process of the study consists of three stages (Figure 1). In the first phase that took 5 weeks, the PBL method was introduced to students and various activities were organized. In the second phase, which lasted for 5 weeks, two Educational Geocaching activities were organized besides 5 PBL sessions. In the third phase lasted for two weeks, Go-Geocaching was implemented for recreational purposes and the data collection period for the PBL-IGG process continued.

In this article, the IGG findings of PBL-IGG approach were examined, and the study is limited to IGG activities done with students, open-ended survey, out-of-class

observation and IGG portfolio document analysis findings. The IGG activities of the application outside the classroom are consist of the Pre-Geocaching (learning Geocaching), Edu-Geocaching (Educational Geocaching) and Go-Geocaching (recreational Geocaching by online connection to official Geocaching site) as Donadelli and Rocca (2014) recommended. Geocaching-CITO and Student-Geocacher were added to these activities.
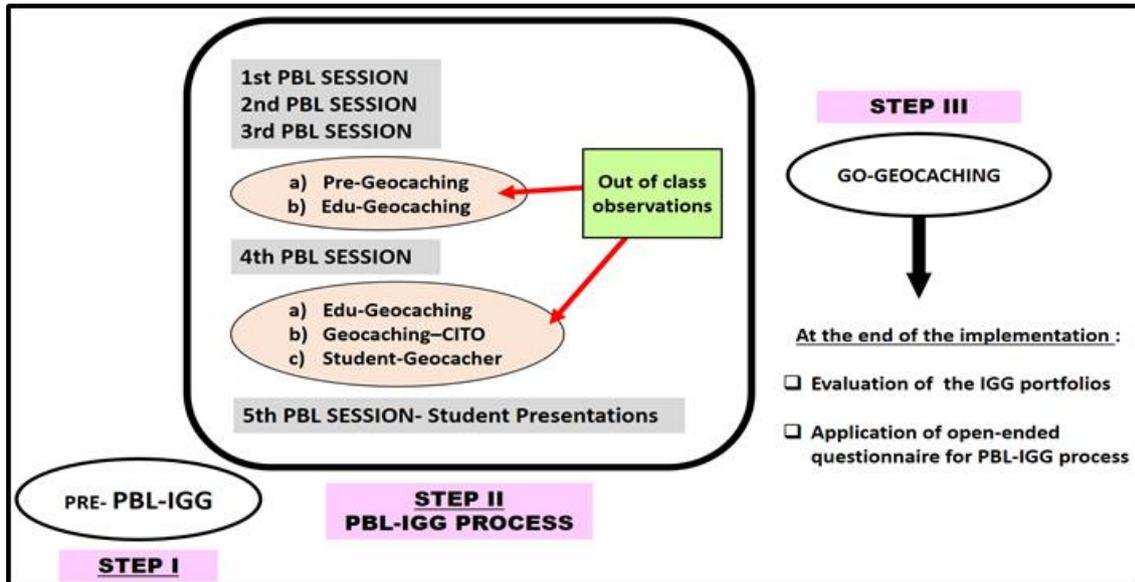

Figure 1. The stages of collection of the IGG data in the PBL-IGG teaching process

The first instructional Geocaching game (IGG) activity.

At the 8th week of the implementation (May 06, 2016, on Friday), the first IGG event, which lasted approximately one and a half hours, was held in the students' free time (at the exit of the course). The groups formed for PBL implementation (Meteorlar group-5; Hapşurup group-5; SVAM group-4; Okuyan-us group-5 participants) were not changed in IGG activities too. The first IGG activity consists of two stages: Pre-Geocaching and Edu-Geocaching. First of all, the students were taken a presentation of the Geocaching game (in the classroom) and then the Pre-Geocaching played at outdoor, lasted for 15 minutes. The purpose of Pre-Geocaching was to teach students the basic rules of the game and how to use the GPS device. The Edu-Geocaching phase of the activity was taken approximately 30 min (Figure 2).
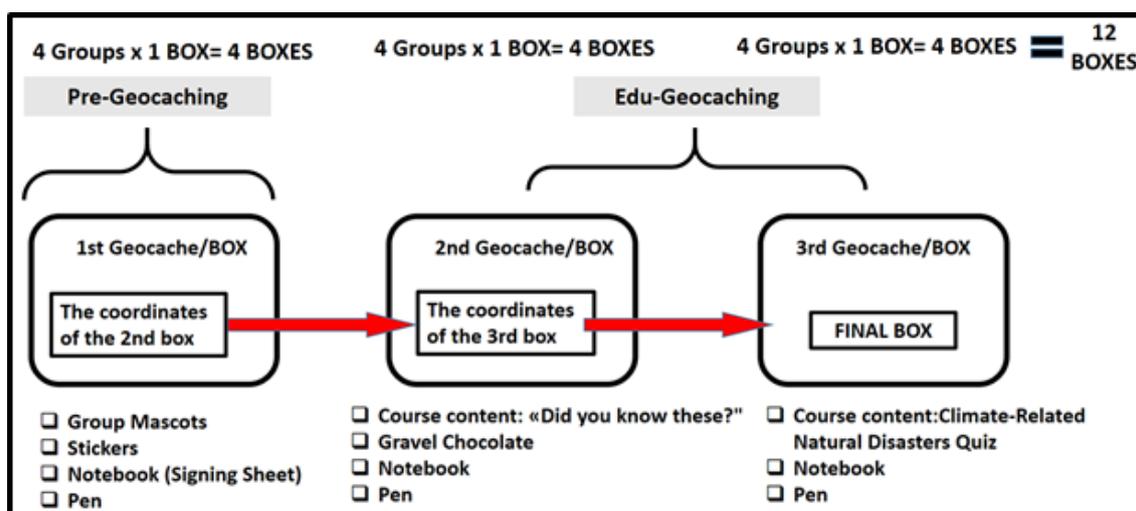
Figure 2. Pre-Geocaching and Edu-Geocaching process

In Edu-Geocaching activity, it was aimed to provide students with helpful tips for the tasks given to the groups in the PBL scenario. In this stage of the game, medium-sized plastic containers were hidden in a way that finding them was more difficult. A separate instruction form was prepared for each group in the game. The instruction forms included the coordinates of the first traditional Geocaching box. Groups reached the coordinates of the second Geocaching boxes in the first boxes and the third Geocaching boxes in the second Geocaching boxes (Figure 2).

The two-course materials related to the basic principles of the PBL problem were placed in the second and third boxes of the groups as IGG task (Figure 2). The second IGG box task was "Did you know these?"; a short text about climate originated disasters, that students should have to read to their group members loudly. In the text, some striking statistical values of the damage caused by disasters in Turkey and in the world, and what may the results of increasing the global climate change for Turkey were mentioned. In addition, the definition of Integrated Disaster Management which students had difficulty in understanding it in PBL sessions was given. These titles were designed for students to remember the learning outcomes of the problem subject. In the last boxes of the groups, students were asked to solve the Climate-Related Natural Disasters Quiz (CRNDQ) composed of 12 multiple choice questions. In the test prepared according to the problem gains, multiple choice questions related to the basic principles of the problem (causes, consequences and the distribution of the climate-related disasters) and some specific questions for the subjects that students ignored during the PBL process (disaster prevention, measures to be taken individually for global warming, long-term problems caused by disasters) and some questions about similar organizations of other countries like AFAD (Republic of Turkey Prime Ministry Disaster and Emergency Management Presidency) were included. The majority of these questions were the questions that students would not able to solve with their general knowledge. In order to solve the questions, the students should have been examined the problem subjects deeply. As a matter of fact, students left behind three PBL sessions until this event. The researcher confronted the students with these questions at the IGG,

in order to evaluate to what extent, they researched the basic principles and acquisition of the subject.

For the first IGG activity, 12 boxes were hidden in the bushland within the university campus. The preparation of the boxes took about half an hour and hiding of them took two hours of the researcher. Preparing of the tasks placed in the box had taken a day of the researcher. A geocacher's views about preparing and hiding of the boxes were taken. The day after the game, the researcher collected all the boxes, evaluated the student materials and announced the results on the students' own Facebook page.

The second instructional Geocaching game (IGG) activity.

In the ninth week, after the 4th PBL session (May 11, 2016, Wednesday), the second Educational Geocaching event that took about two hours, was held in the free time of the students. In the first part of the event, the Edu-Geocaching game took 20 min.; in the second part, the students played Geocaching-CITO and, in the third part, the Student-Geocacher game inspired by the work of Matherson, Wright, Inman and Wilson (2008), was played (Figure 3). Geocaching-CITO (1 hour) and Student-Geocacher (30 min) were combined and run together. A total of 12 boxes were hidden in the IGG section of the event. In the Student-Geocacher event, each group hid 2 boxes of their own.
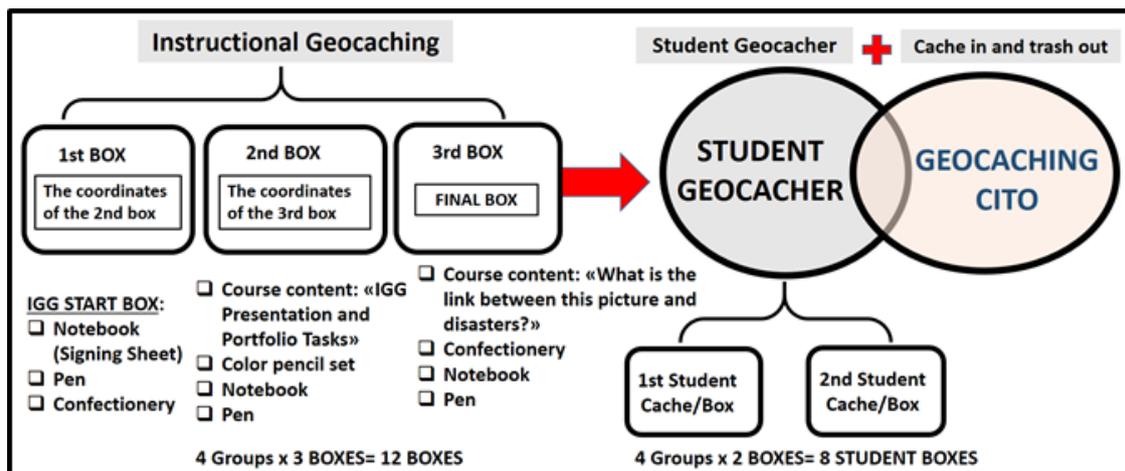

Figure 3. Edu-Geocaching, Geocaching-CITO and Student-Geocacher process

In the IGG, the researcher gave each group a task related to PBL problems (Figure 3: The 2nd IGG box). For the 5th PBL session, the Meteorlar group's IGG tasks were to make a short (5 min.) presentation that answers the questions about GPS technology (What is GPS? How does it work? In which areas is it used?) and to add the GPS research report into their IGG portfolio. Other tasks were: What does a family disaster plan contain? Prepare and present a family disaster plan (Hapsurup Group); what does a school disaster plan contain? Prepare and present a school disaster plan (Okuyan-us Grubu), and What should be done in the first 72 hours called *the golden hours* as well, for search and rescue in disasters (SVAM Group). The third IGG box contained the same content for all the four groups, that was the picture about the contents of a disaster bag. Through the context of this picture, students' attention had been taken to disaster drills, family disaster plans and so the disaster education.

After the IGG boxes were found, all students came together at the meeting point. The researcher first showed two students from each group in sequence through a sample box, how to define and record the coordinates of the boxes hidden onto the GPS. Then the students took the waypoints of various places in the region with GPS receivers. After this activity (took about 15 min.), the researcher distributed two medium size plastic boxes on which the groups' name was written, to each group. Students were told to hide these two boxes on the name of their groups and note their coordinates onto the group's instruction forms. In the Student-Geocacher event, students were expected to get the coordinates of the points they had determined and to learn how to hide their boxes properly. Then some plastic gloves and garbage bags were given to them. They were asked to doing environmental cleaning as well while looking for a suitable place to hide their boxes. After about one hour, the groups returned to the meeting point and exchanged the coordinates of the boxes. For example, the SVAM group found the student boxes hidden by the Meteorlar group. Student groups scattered around again to find these boxes.

Figure 4. Images from the IGG events

The Go-Geocaching event.

In Go-Geocaching (The Recreational Geocaching Activity), students were asked to play the original game by being a member of the official Geocaching site. Thus students could play this game for recreational purposes at any time as well. In order to do this, the researcher hid three boxes at the points where the people coming from outside can easily enter and exit inside the university campus and published the coordinates on geocaching.com page. The students who found the boxes shared their experiences

through the Geocaching.com web page. The Go-Geocaching event was held on 01.06.2016 and lasted approximately 2 hours.

Findings

What Are the Views of Students on Go-Geocaching and the IGG Process?

In Table 1, under the theme of the effects of Geocaching to learning, the contribution of the game when played as recreational and educational purposes were discussed according to these categories: *Natural and technological factors affecting the game; the contributions to problem-solving skills; the benefits of using Geocaching for educational purposes.*

In the open-ended questionnaire, students stated that bad weather conditions affected their game performance, but in these conditions, handheld GPS was more useful than the smartphone. Students stated that in the Go-Geocaching event, the boxes they were looking for were different in size and shape, and they found the places where the boxes were hidden quite interesting. According to students, smartphones are easy to reach and use, thanks to the internet connection, clues, maps and photos about the Geocaching boxes can be seen from the official Geocaching page, and due to the image quality, they have more advantageous than GPS. GPS comes to the fore with the fact that it does not need an internet connection and makes more clear orientation when searching for boxes. However, students stated that they found the use of GPS more useful in the game.

Table 1.
Students' Views on the Effect of Geocaching Game on Learning

Category	Code	Student Opinions	f
Natural and technological factors affecting the game	Bad weather conditions	*"...When the rain relented, we went out. After a short time, the exacerbation of rain stopped our game again…"* (S7)	14
	Advantages and disadvantages of GPS device	*"...GPS gave more accurate results but didn't provide images and information like a smartphone…"(S10)*	12
	Advantages and disadvantages of using smartphones	*"...We chose to use the phone because it was easier to access…"* (S1)	8
The contributions to problem-solving skills	To gain the ability of cooperative problem-solving	*"...As we went as a group, we solved the problems together with the mutual exchange of ideas…"(S15)*	14
	To find solutions to the GPS-related problems	*"...There were problems with the device. When we came to the exact point, the GPS compass arrow was changing direction continuously because we were moving too much. We noticed our fault and then we moved more slowly as we approached the box. Another problem was that the GPS device didn't give the exact position of the box, so we started looking around for it when we were getting closer to its exact location…"* (S8)	8

	The solutions they produced during at hiding their own boxes	*"...We decided to hide our boxes to the places where others could find them as well. We didn't have any trouble after saving the coordinates of the place accurately into the GPS device…"* (S9)	6
The benefits of using Geocaching for educational purposes	Instructional Geocaching activities connect the course with real life.	*"...Our motivation had increased. Since Geocaching was played at outdoors, it provided us to link the Environmental Problems course with daily life. For example, when we were playing this game, we realized that the environment was not clean and we should develop the conscious of this in society…"* (S12)	4
	Geocaching is a Geography game.	*"...Geography is the most appropriate course to use. The GPS device, coordinates, the places where we hide the boxes, are the topics related to geography. Application of it in geography course is efficient in every aspect. Studying at the field increases the motivation of students towards the course."* (S9)	6
	IGG increases motivation and permanent learning.	*"...Learning by doing is the most permanent learning. The application of Geocaching in courses is a chance for both getting away from the boring classroom environment and have fun for students. Learning becomes permanent as long as you have fun and want to learn. This game completes the fun-learning duo. I learned with fun and curiosity. My information became permanent…"* (S10)	18
	IGG supports the PBL method.	*"...First of all, as a student, we remembered the subjects we had forgotten in the research section of our course with Geocaching game and we closed this gap. We also measured our readiness through the occasional tests in the IGG boxes. As a result, I can say that the game has a positive effect on our learning…"* (S2)	9

The codes of *to gain the ability of cooperative problem solving, to find solutions to the GPS-related problems*, and *the solutions they produced during at hiding their own boxes* were analysed under *the contributions to problem-solving skills* category. In IGG and Go-Geocaching applications, students expressed that they experienced technical problems especially with GPS and they solved these through group work; they stated that they preferred to hide their own boxes in moderately difficult places.

The category of *the benefits of Geocaching game* was discussed under the headings of *IGG's connection to real life, Geocaching as a geography game, increasing the motivation and permanent learning*, and *the support of IGG to the PBL*. The students stated that Geocaching is basically a geography game, and finding it useful to apply in lessons such as Environmental Problems. They stated that the geography course is mainly based on field studies, so the course should be taught especially in out-of-class environments; and determined that map skills such as ground direction finding, coordinates and location finding, using the GPS are the main subjects both in Geocaching and geography. Accordingly, the most suitable lesson for Geocaching game is geography and therefore it can be identified as a geography game. Four of the students stated that the methods of protection from disasters and practical information about the disaster plans were given in the boxes as the course content, while at the same time it was allowed them to observe the environmental pollution around them.

Therefore, they thought that they linked the issues learned, with real life through Geocaching and it was very suitable for the course. The students said that supporting the learning with Geocaching completed the fun-learning duo; increased the interest and motivation towards the course, and the knowledge became permanent because of learning by experience in an enjoyable way. The students also stated that group work was at the forefront in both PBL and IGG processes and the communication within the group was strengthened.

What Kind of Behaviours Did the Students Show in the IGG Process?

Two instructional Geocaching activities were held on 05.06.2016 and 05.11.2016 during the implementation of PBL-IGG. Students' outdoors behaviours in these two IGG activities were obtained through student videos. In Table 2, the behaviours of students during the IGG activities and the frequencies (f) of them are given.

Table 2.
The Student Behaviors in IGG Group Studies

Behaviours	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	f
1. Listening to the views of group members	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	19
2. Explaining their own views on the problem	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	19
3. Discussion of the problem	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	19
4. Problem-solving	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	19
5. Taking a joint group decision	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	19
6. Working in collaboration	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	19
7. Interacting with other groups	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	19
8. Active participation	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	19
9. Carrying out IGG tasks	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	19
10. Observance of the Geocaching rules	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	19
11. Be able to find the boxes	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	19
12. Be able to hide the boxes	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	19
13. Collecting the garbages	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	19
14. Using the GPS receiver for several times	•	•	•	•	•		•						•				•	•		9
15. Paying sufficient attention to IGG tasks	•	•	•	•	•						•	•	•	•						9
16. Observing the environment	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	19
17. Being excited and curious	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	19
18. Motivating each other	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	19
19. Feeling themselves in a race	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	19
20. Having fun	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	19
21. Videotaping their group work	•	•	•	•	•	•			•	•	•								•	10
22. Hiking at a fast pace	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	19
23. Running	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	19
24. Quick action and decision making	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	19
25. Losing some materials	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	19

When the out-of-class observation data for the IGG activities in Table 2 are examined, the first striking feature is the collaborative problem-solving structure of IGG activities. During the games, all students actively participated in the process, solved the problems together and a positive interaction environment within the groups was formed. In addition, it was observed that students perceived the IGG as a race; had fun in the process; walked at a fast pace and ran from time to time. During the game, students also observed their environment while carrying out their tasks; they often complained of the environmental pollution in searching and hiding boxes, and also in Geocaching-CITO activity. Although all students did the traditional Geocaching and IGG tasks, it was also observed that they had lost some IGG materials in the field or forgotten them. In addition, it was observed that the GPS receiver was mostly used by certain students and that some groups did not wholly fulfil the tasks.

How Were the Students Evaluated in the IGG Process?

In Table 3, the evaluation of the IGG portfolio products of the first and second IGG activities, which were organized in order to support the PBL process, was conducted. This evaluation included observations of outdoor activities and observations of the researcher's Go-Geocaching activity as well. As a result of the document analysis, it was seen that the necessary information wasn't written onto the signing sheets in some of the boxes and some IGG duties were missing. For this reason, the average score of the groups at the IGG portfolio assessments for their ability to perform the IGG duties and to apply the rules of the Geocaching game is "2" (medium). However, the students have wholly fulfilled their assigned IGG tasks (What does a family disaster plan contain? etc.) in their presentations at the last session of PBL. In addition, it was observed that students worked collaboratively in IGG applications and fulfilled the requirements of the games. The criterion of using the handheld GPS device correctly in the evaluation scale was scored above the middle (2, 5).

Table 3.
Average scores of the IGG

The Geocaching Game Rating Scale 1: Low 2: Medium 3: Enough	avg.
A) Criteria for applying Geocaching	
1. Active participation in the game	**3**
2. Regular participation in Geocaching activities	**3**
3. To be able to use the hand GPS device correctly	**2,5**
4. Ability to use the Geocaching App downloaded to the smartphone (Go-Geocaching)	**3**
5. Finding the boxes/caches by working collaboratively	**3**
6. Hiding the boxes/caches by working collaboratively (Student-Geocacher activity)	**3**
B) Applying the Traditional Geocaching Rules	
7. Repositioning Cache in its original location	**3**
8. The signing of the logbook	**2**
9. Adding date and time	**2**
C) Performing Geocaching Tasks (The IGG Tasks)	
10. Carrying out the tasks given in the Geocaching boxes	**2**

Conclusions and Discussion

When out-of-class observation, IGG portfolio analysis and open-ended questionnaire findings are evaluated, it is concluded that IGG application supports the PBL process and connects students to the PBL process. In addition, various application strategies for

IGG activity have emerged based on non-class observation findings. As a matter of fact, observation data gave in-depth information about the strengths and weaknesses of the game. Therefore, the results of the out-of-class observation and portfolio were evaluated firstly and then the results of the open-ended survey were discussed.

In the first IGG activity, although students quickly grasped the game and managed to use the GPS receivers, from time to time in the process, it was observed that they forgot some cache tasks; some of them had difficulty at entering the coordinates to the GPS device or difficulty at using the device. The main reason for this is that the students are too hasty and their desire to complete the game before the other groups. The other reasons are expecting the GPS device to show them the exact location of caches, and the use of the device required a little more professionalism since the weather was cloudy. As a matter of fact, in Christie (2007)'s study, the participants experienced technical problems with the GPS receiver. It was understood that it should not be expected to clearly show the exact location of the box at all times from the GPS.

GPS receivers receive signals from at least three satellites (normally four satellites) that are closest to them. Poor radio waves emitted by GPS satellites can pass through cloud, glass and plastic, but not through solid materials such as concrete, brick walls, or rock. In addition, factors such as the different physical characteristics of the atmosphere layers, the number of GPS satellites which the receiver be able to get signals and the angular position of the GPS satellites can cause such delays and errors (Turoğlu, 2008, pp. 83-84).

The students were more excited than expected, and although the process was not designed as a competition, they directly perceived the game as a race. For this reason, it was seen that performing the tasks of caches was lack and sloppy at some groups at the Edu-Geocaching phase too. This situation is also seen in the results of the IGG portfolio document analysis in Table 3. It was seen that students helped each other at performing their tasks, however, it was observed from time to time that some group members were not actively involved in the event or engaged in other things for short moments. This may be due to the high number of group members [Christie (2007) states that groups should consist of up to four people]; the absence of separate roles for each student within the group, and the failure of the IGG task to be fully designed to fulfil its function.

In the studies of Christie (2007), Donadelli and Rocca (2014), each student in the group had certain tasks that he/she had to perform alternately. Thus, during the game, each member of groups participated actively and kept documentation of the process. Students had group roles in Christie (2007), Donadelli and Rocca (2014)'s implementations such as the recorder, reporter, monitor, photographer, leader, observer. In this study, students were not given a specific role. The students formed their own roles in the process but they did not take reflective notes about their works like the group members mentioned above. The only task assigned to the groups in advance is to record their own work by cell phone.

Considering the IGG tasks given to support the PBL process in the first IGG event, It was observed that approximately one page of information text called "Did you know

these?" did not reach its purpose. As a matter of fact, the students were not able to give a meaning to this task which they were assigned just to read loudly to group members. Since they were in a hurry, the reading task was boring and took a long time for them, so the duty was completed slightingly. The reason why the first IGG task did not attract students' attention would be that it did not allow students to discuss. As a matter of fact, at the second IGG task, which was more detailed and longer than this task, the students solved the CRNDQ by discussing it among them. Christie (2007), Donadelli and Rocca (2014) suggested that IGG tasks should be designed to allow for discussion. According to them, after the activities completed, it is necessary to create suitable environments for students so that they can discuss the game experiences, the content of the cache and course.

The second problem at carrying out the IGG tasks is that the students do not have enough time to discuss them in depth during the game. Because of the short-term rainfalls; to not to drop behind from the other groups at this outdoor game, they moved as quickly as possible. The positive side of this situation is that the opportunities were provided for students to make quick decisions, multi-dimensional thinking and collaborative working in the game process (Christie, 2007; Donadelli & Rocca, 2014).

Donadelli and Rocca (2014) stated that there may not be enough time to discuss the ideas that emerged during the event, while Christie (2007) suggested that short instructions should be given to the students. As a result, IGG tasks carried out in the outdoor should be short, meaningful and challenging tasks; however, the challenging parts of these tasks that require research can be designed to be conducted in the classroom. For example, the first part of the IGG task can be designed suitable to complete at the field at the moment of the game, and the second part of it may be some tasks realized in the classroom such as a research problem, drawing a table-graphic, making presentations, writing essays, etc. In this study, there are tasks that students will perform at the time of the game (Figure 3: The 3rd IGG box) and within the class later (Figure 3: The 2nd IGG box).

Another reason for pushing the IGG duties into the background during the game could be that the assessment was not given more clearly. Although the students had a scale for the evaluation of IGG activities in the PBL-IGG guideline (Table 3), the fun dimension of the game had nevertheless exceeded the educational objective. Although having fun, keeping students' interest alive and keeping them motivated in the PBL process were some of the aims of the activities. Still, a more detailed assessment of the IGG activities could have enabled the students to fulfil their educational tasks more carefully.

One of the main reasons for this situation is that, although sufficient time was given to students, they cared about much the competition phenomenon which created by themselves. Christie (2007), and Vitale et al. (2012) stated that participants perceived the game as race and this competitive environment motivated them. In this case, it may be necessary to consider the game as competition in order to increase the value of the IGG tasks related to the course content. Therefore, higher scores can be given to the IGG tasks in the boxes. In addition, other criterias such as the working performance of

the group members, fulfilling their traditional Geocaching tasks, the facts and events they observed in the environment, the early completion of the process, and the sensitivity to the environment can be considered in these evaluations. These assessments may be obtained by asking students to take observation notes or fill in various forms through some group roles.

More functionalized IGG tasks, giving certain roles to each of the group members, such changes to be made in the assessment, can ensure that the students get maximum benefit from IGG activities and their participation actively. In addition, asking students to videotape their group work with a smartphone in IGG activities is a strategy that affects the practice positively. As a matter of fact, the researcher followed the students' behaviours, the functioning and non-functioning mechanisms of the game designed, and the student's environment, from the student videos. In addition, the students' IGG videos were helpful at preventing them from crossing into the other box without completing some IGG tasks and allowing the researcher to make a more objective assessment of them. There is also an opportunity for students to easily access the researcher in any emergency. Accordingly, student videos may also be employed in the design and implementation of IGG activities. This can be one of the ways to benefit from the smartphone technologies that students have, in addition to GPS technology in IGG applications. In her seminars, Christie (2007) evaluated the student works according to the results of her observations and the materials from the group members. In the studies of Adanalı (2018b) and Freiermuth (2017), it was determined that student videos had a positive contribution to the learning process and students really enjoy doing their own videos.

In the second IGG activity (11.05.2016), after the main IGG stage, the Student-Geocacher application was combined with the Geocaching-CITO event, in order to make students experience environmental pollution and to design and play the game later by themselves. While students were learning how to hide their own boxes and get coordinates, they also collected trash in the environment that was also their playground. This application also directly overlaps with the affective learning outcomes of environmental problems course. This activity took a long time (about 1.5 hours) of the students because of combining these two events. In the Geocaching-CITO section of the second IGG application, it was observed that the students didn't act as fast as they do in the previous games and no longer perceive the game as a race. In this process, the priority of the groups was collecting trash for a purpose.

The duration of the Educational Geocaching game depends on the age range of the students, the content of the course, the difficulty of the given tasks and the terrain, playing the game at indoors or outdoors [Geocaching can also be played in indoor spaces (The Geocaching Vlogger, 2015)], the number of students and GPS devices, and the number of boxes prepared. The game duration can be designed for 20 minutes or longer. In this process, the Geocaching experience of the educator who designed the game also holds an important place. For this reason, the students were expected to recognize the official Geocaching page through Go-Geocaching and use smartphones as well, besides GPS. In this way, they can communicate with professional players who

play Geocaching mainly for recreational purposes and increase their Geocaching experience.

In this sense, Go-Geocaching activities and Student-Geocacher activities supported each other; pre-service teachers gained preliminary experience to enrich their courses with IGG in their future professional lives. As a matter of fact, the prospective teachers who experienced IGG are in a positive attitude towards IGG. They think especially latitude and longitude concepts can be concreted and understandable through Geocaching, because it provides real-life experiences (Adanalı & Alım, 2017; Vitale et al., 2012).

Geography science basically examines the interaction between environment and human. The prospective teachers, who will transfer the geographical values to the students, are required to have the basic field competencies and related value judgments. They are also expected to have a positive attitude and approach towards geography. As a matter of fact, having value and attitude towards protecting nature is one of the special field competencies of geography teachers determined by MEB (2011).

According to the Tbilisi Declaration, increasing the knowledge and sensitivity for protecting nature and having a positive attitude towards in environment are aimed in environmental education (Ünal & Dımışkı, 1999). Environmental education should be transformed into positive and responsible human behaviour towards the environment rather than creating a sense of knowledge and responsibility. The methods which are used for the subjects about the environment, at reacting to adversities, keeping active participation and taking social interests to the forefront are the subjects of environmental education (Kaya, Çobanoğlu, & Artvinli, 2011).

In this study, which is mainly carried out with the PBL approach, the unit of climate-related natural disasters, which cannot be observed at any time and directly in the environment, is discussed. It is thought that supporting the course with IGG activities which provide real-life experiences, increased the sensitivity of pre-service teachers to the environment. In addition, the students stated that they learned better the individual and community measures against disasters that they did not study on enough in PBL process, and the IGG contributed to the development of disaster consciousness of them (Adanalı & Alım, 2017). In the second IGG event, when the task papers about the disaster bag in the third IGG box are examined it is understood that students do not have information about disaster bag and family disaster plan; the disaster training programs in which they participated before are mostly limited to fire and earthquake drills; they received superficial training to protect themselves from natural disasters such as flood and avalanche.

In the second IGG event, compared to the first IGG event, it was observed that students could use the GPS device more smoothly and learned GPS technology. Although it was aimed in the activities that all students would be able to practice effectively with this device, this result has not been achieved. In both IGG applications, the GPS receiver was used by the specific members of groups. One of the reasons was that students preferred to hand over the device to their friends who used it best to save time and move fast.

The other reason was that not every student had a GPS. In Christie (2007)'s research, one of the situations that the participants stated as a deficiency, was that each student couldn't have a GPS device and did not have enough chance to practice with it during the game. Donadelli and Rocca (2014) stated that the GPS receiver can be obtained from the surrounding institutions or universities, but this causes problems in terms of time and cost. In this case, the researcher could have identified one of the group roles as an observer (observes who uses the GPS receiver in turn, takes notes and delivers this to the researcher), as Christie (2007) did in her study; by this way, she could have made everybody use the GPS receivers in equal number.

Although GPS receivers have become cheaper today, their affordability is still an economic problem. For this reason, this shortcoming can be eliminated by using compass and map, as recommended by Donadelli and Rocca (2014), along with GPS receiver in IGG activities. In addition, the offline compass application on smartphones can also be used.

In the Student-Geocacher activity, students chose the places at medium difficulty while hiding their boxes. They hid their boxes in a tree low branches, into an old furrow-drain or into the bushes and especially tried to camouflage them. In this context, it was seen that students tried to produce more original ideas while hiding their boxes (Donadelli & Rocca, 2014; Hendrix, 2012; Matherson et al., 2008).

Since all the student-boxes had been found, it is understood that students have correctly defined and recorded the coordinates into GPS. While the students searched the boxes, they first scanned an area around 10 meters in diameter, based on the location where GPS brought them. The students looked everywhere in the first IGG event and searched the boxes directly through the trial and error method. In the second IGG event, they used the trial and error method but made predictions as well. Students thought about where the box could be hidden in the area where GPS brought them for the box, and this time they looked at specific places according to their predictions more consciously. In this process, it is seen that the students thought differently, made predictions and offered different solutions to the problem of where the box could be hidden.

On the basis of observation findings, it is seen that the students were in a continuous learning situation and made decisions by thinking strategically during the play. It can be also assumed that the important geographical skills such as location-direction determination, location finding, the perception of space and observation have developed (Burns 2013; Christie, 2007; Donadelli & Rocca, 2014; Mayben, 2010; Robison, 2011; Vitale et al., 2012).

The out-of-class observation and IGG portfolio analysis findings support the students' responses given to the open-ended questionnaire to a large extent. Students stated that the IGG application was organically compatible with the PBL process. As a matter of fact, they stated that through IGG activities, they had reinforced the course content of the PBL process; recognized and learned important issues which they had failed to notice during PBL. In addition, students expressed that they experienced learning and fun together at the same time and internalized the knowledge through

learning by doing in IGG activities; they had permanent information since IGG motivated them against the course and it was helpful to relieve the boredom of the PBL process. Similar results were obtained also in the focus group discussions of these students (Adanalı & Alım, 2017). In addition, the lack of intragroup and intergroup communication that emerged in the class during PBL applications (Adanalı & Alım, 2017), had been largely eliminated in the IGG process.

In other studies, about Geocaching in the literature it is seen that students are actively learning by discovery and doing; working collaboratively. Geocaching changes the routine in learning environments and increases the positive attitude and motivation towards the course; supports multiple types of intelligence and different learning styles (Broda & Baxter, 2003; Buck, 2009; Christie, 2007; Donadelli & Rocca, 2014; Freiermuth, 2017; Hendrix, 2012; Ihamäki, 2012; Mayben, 2010; Schlatter & Hurd, 2005; Vitale et al., 2012).

The observation findings and students' views of the research revealed that the IGG applications developed the students' problem-solving skills. The main problems students have faced during the games are: Where is the box? How should we seek the box? How should we solve the problem within the box? How can we move faster in the game? How can we solve the problems caused by the GPS receiver? Where and how should we hide our student box?

The students stated that they solved the problems which they encountered in the IGG process mainly through collaborative group work. While all group members were looking for the IGG box, they first searched the environment that GPS receiver showed them and made predictions about where the box might be. Students stated that while they were accomplishing the IGG tasks, they solved them through discussing among themselves and in case of any dispute they made decisions with unanimity; moved quickly by working collaboratively; and while they were hiding their own student-box, they were attentive to put them in the places where it is not too difficult to find.

The most challenging problem at the beginning of the process for students was the technical problems with handheld GPS devices. They said that to deal with this problem firstly they preferred to understand what the problem is and then develop strategies for solving it. Researchs on Geocaching show that IGG practices are an effective educational strategy that can be used to gain 21st century skills such as critical and creative thinking, communication and empathy, problem solving and decision-making skills, skills of using information technologies, and effective use of language (Anderson, 2008; Christie, 2007; Donadelli & Rocca, 2014; Freiermuth, 2017; Hendrix, 2012; Ihamaki, 2007; Matherson et al., 2008; Mayben, 2010; Schlatter & Hurd, 2005; Shaunessy & Page, 2006).

Adanalı and Alım (2017) applied the Problem-Solving Inventory (PSI-A) as a pre-test and post-test to these participants. According to findings, the preservice teachers claimed that their problem-solving skills increased. But the results of the PSI-A did not support their claims.

About the Go-Geocaching activity for recreational purposes, the students compared the smartphones and GPS receivers with each other, discussed their features and indicated their strengths and weaknesses. They observed that they were physically forced and their game performances had fallen at bad weather conditions, also had experienced that both devices could be ineffective in these conditions. As a matter of fact, also the findings of the observations revealed that the weather conditions may negatively affect the game.

In the study of Adanalı and Alım (2017), students stated that they also gained the ability to use technology and social media efficiently with these activities. Considering the general skills gained by students through GPS technology in this application, it is understood that IGG is not only an effective tool for integrating technology and enabling student participation in constructivist teaching environments, but also requires physical effort (Broda & Baxter, 2003; Buck, 2009; Burns, 2013; Christie, 2007; Donadelli 2014, Donadelli & Rocca, 2014; Hendrix, 2012; Ihamaki, 2007; Ihamäki, 2012; Matherson et al., 2008; Mayben, 2010; Robison, 2011; Schlatter & Hurd, 2005; Shaunessy & Page, 2006; Silva & Hjorth, 2009; Taylor et al., 2010). Hall and Bush (2013), Hendrix (2012), Ihamäki (2007), Pelton et al. (2008), Robison (2011), Schlatter and Hurd (2005) and Taylor et al. (2010) stated that Geocaching physically forces the players and contributes to their physical and mental health.

Another result of the students' opinions is that Geocaching is a *geography game*. According to students, geography and Geocaching are place-based, since they are very interested with the environment and have field trips, so they linked them with each other. They also stated that the game was integrated with the nature of geography courses since it included map skills such as finding locations through coordinates, and location-direction determination. In Geocaching studies, it is pointed out that the coordinate and location information which are the abstract concepts are embodied with GPS technology while playing Geocaching (Adanalı & Alım, 2017; Burns, 2013; Christie, 2007; Donadelli 2014; Donadelli & Rocca, 2014; Hendrix, 2012; Ihamaki, 2007; Lary, 2004; Mayben, 2010; Schlatter & Hurd, 2005; Shaunessy & Page, 2006; Vitale et al., 2012).

As a result of both IGG activities and Geocaching-CITO activity during the PBL-IGG process, students have developed a positive perspective towards environmental problems and protecting the environment. The students connected the course with real life in IGG activities, since during the game they were directly disturbed by environmental pollution. Zaman, Siyamoğlu, Özgürbüz and Veisalov (2016) proposed to increase the frequency and quality of applications that provide real-life experience in order to eliminate the real-life and professional experience deficiencies in the education of prospective teachers.

As the findings of the observations out of the classroom revealed, students have acquired environmental awareness by learning about natural disasters of climate origin. Therefore, it can be said that IGG, which is also an out-of-class education method, provides real and meaningful learning for students at environmental problems course (Adanalı & Alım, 2017; Broda & Baxter, 2003; Burns, 2013; Donadelli 2014, Donadelli

& Rocca, 2014; Hendrix, 2012; Ihamäki, 2007; Pelton et al., 2008; Robison, 2011; Sherman, 2004; Taylor et al., 2010; Zecha, 2012).

When the findings of the research were evaluated as a whole with the findings of Adanalı and Alım (2017), the following results were reached: The PBL process was well supported by IGG activities and there are great similarities in terms of structure between PBL and IGG; IGG motivated some students who were overwhelmed at PBL; helped the PBL educator to ensure that students learn about specific topics related to the basic principles of the problem subjects; supported the enhancement and retention of the knowledge learned; the pre-service teachers learned how to integrate GPS and digital technology into the lesson through IGG; the problem solving skills not only developed at PBL but also through outdoor education; contributed to the increase of environmental and disaster awareness; IGG is an educational geography game that requires collaborative learning.

Although this game in the study did not designed directly to develop map skills and spatial thinking of the students, it is also understood that observation of the environment and some map skills had developed as well. On the other hand, the subject of natural disasters of climate origin, discussed in this study, is a common curriculum subject related directly or indirectly to mathematics, science and social sciences. When the related literature is evaluated, it is seen that Geocaching and GPS based teaching practices can be applied in different disciplines, primarily geography courses, and increase the motivation of students. The content of IGG boxes can be designed in a multidisciplinary manner; activities, tasks and clues related to the course content of the fields such as Science, Mathematics, Social Studies, Agriculture, Environmental Problems etc., can be placed into boxes in different ways (Adanalı & Alım, 2017; Broda & Baxter, 2003; Buck, 2009; Christie, 2007; Donadelli & Rocca, 2014; Hall & Bush, 2013; Hendrix, 2012; Ihamäki, 2007; Mayben, 2010; Vitale et al., 2012). In this study, the theme of the boxes is the natural disasters of atmospheric origin.

In this study, the applicability of the PBL-IGG approach has been studied by a rich triangulation in order to provide as generalisable as possible of the results. Therefore, the structure of the IGG, which is not yet known in the learning environments, has been examined in detail and the strengths and weaknesses of its use, as a supporting activity have been determined. In particular, the findings of the out-of-class observation revealed various strategies for the design and implementation of the game. The results of the research have determined the value of IGG in the learning environments; provided the basis for the new studies that IGG can be applied and presented new research questions.

Suggestions based on the IGG findings of the study can be listed as follows:
- IGG can be applied especially in geography courses at teaching map skills and spatial perception.
- The IGG box contents can be a multidisciplinary training tool at common curriculum subjects or on a common theme (such as natural disasters).
- IGG can be used in environmental education and as an enriching tool for learning environments of various nature, ecology and extracurricular learning projects.

- IGG games can also be organized as educational competitions that promote geographic knowledge, skills and psychomotor skills.
- IGG can be used in problem-based learning, project-based learning, collaborative learning, inquiry-based learning, place-based learning, and even for enriching traditional learning methods.

The suggestions offered to researchers who are interested in this issue are as follows:

- IGG learning outcomes can be pointed out more clearly by developing various scale and quantitative data collection tools which explain the effects of IGG, on learning, on the ability of using digital technology and at academic achievement.
- The contribution of IGG can be investigated at teaching different geography subjects at various levels of student groups.

References

Adanalı, R. & Alım, M. (2017). The Views of Preservice Teachers for Problem-Based Learning Model Supported by Geocaching in Environmental Education. *Review of International Geographical Education Online (RIGEO), 7*(3), 264-292. Retrieved from http://www.rigeo.org/vol7no3/Number3Winter/RIGEO-V7-N3-2.pdf

Adanalı, R. (2018a). Geocaching oyunu ile desteklenmiş probleme dayalı öğrenmenin doğal afetler konusunun öğretimine etkisi, Atatürk Üniversitesi, Eğitim Bilimleri Enstitüsü, Yayınlanmamış Doktora Tezi, Erzurum. (Tez no. 524524), Retrieved from https://tez.yok.gov.tr/UlusalTezMerkezi/

Adanalı, R. (2018b). The effect of digital documentary production through field work on geography students' problem-solving skills. *Journal of Education and Training Studies*, *6*(1), 113-123. doi:10.11114/jets.v6i1.2847

Albach, D. (2014). Geocaching as a means to teach botany to the public. *Plant Science bulletin 60*(2), 1–3. doi:10.3732/psb.1400001. Retrieved from https://www.researchgate.net /profile/Dirk_Albach/publication/264312677_Geocaching_as_a_means_to_teach_botany _to_the_public/links/53d8986d0cf2a19eee83523b/Geocaching-as-a-means-to-teach-botany-to-the-public.pdf

Anderson, M. A. (2008). Geocaching for fun and learning. *MultiMedia & Internet@Schools, 15*(2), 32-35. Retrieved from https://search.proquest.com/docview /229745123?accountid=8403

Artvinli, E. & Kaya, N. (2010). 1992 Uluslararası coğrafya eğitimi bildirgesi ve Türkiye'deki yansımaları. *Marmara Coğrafya Dergisi, 22*, 93-127. Retrieved from http://hdl.handle.net/11424/2589.

Artvinli, E. (2010). Coğrafi Bilgi Sistemlerinin (CBS) coğrafya öğretimine katkısı ve ortaöğretim öğrencilerinin CBS'ye ilişkin tutumları. *Kuram ve Uygulamada Eğitim Bilimleri*, *10*(3), 1255-1292.

Bogdan, R. C. & Biklen, S. K. (2007). *Qualitative research for education* (5th ed.). London: Pearson.

Broda, H. & Baxter, R. (2003). Using GIS and GPS technology as an instructional tool. *Social Studies, 94*(4), 158-160. doi:10.1080/00377990309600199

Buck, L. (2009). *The motivational effects of a GPS mapping project on student attitudes toward mathematics and mathematical achievement* (Ph.D. thesis). Retrieved from ProQuest Dissertations & Theses Global. (UMI NO. 3356452)

Burns, P. J. (2013). *Geocaching, learning, and nature in a location-aware sport* (MSc. thesis). Retrieved from ProQuest Dissertations & Theses Global. (UMI NO. MR95587)

CARLY. (2018, March 5). What is Geocaching? *Geocaching Official Blog.* Retrieved from https://www.Geocaching.com/blog/2018/03/what-is-Geocaching/

Christie, A. (2007). Using GPS and Geocaching engages, empowers, and enlightens middle school teachers and students. *Meridian: A Middle School Computer Technologies Journal, 10*(1). Retrieved from http://alicechristie.org/pubs/E6/

Clough, G. (2010). Geolearners: Location-based informal learning with mobile and social technologies. *IEEE Transactions on Learning Technologies, 3*(1), 33–44. doi:10.1109/TLT.2009.39

Donadelli, G. & Rocca, L. (2014). Teaching and learning with Geocaching. In T. Jekel, et al. (Eds.), *Teaching geography using geomedia* (1st ed. *pp.* 44-58). Newcastle upon Tyne: Cambridge Scholars Publishing. Retrieved from https://www.academia.edu/33203931/Teaching_and_learning_with_Geocaching

Donadelli, G. (2014). Outdoor learning and Geocaching. *Primary geography, 85*, 22. Retrieved from https://www.academia.edu/9737154/Outdoor_Learning_and_Geocaching

Freiermuth, M. R. (2017). 'I Found It!' A smartphone GPS treasure-hunting game in a flipped English class. *Innovation in Language Learning and Teaching*, *11*(2), 101-108, doi: 10.1080/17501229.2015.1066793

Groundspeak (2018) *Geocaching 101 Presentation.* Retrieved from https://newsroom.Geocaching.com/Geocaching-101

Hall, J. & Bush, L. (2013). Incorporating the game of Geocaching in K-12 classrooms and teacher education programs. In Keengwe, J. (Ed.). *Pedagogical applications and social effects of mobile technology integration* (*pp.* 79-97). IGI Global. doi:10.4018/978-1-4666-2985-1.ch005

Hendrix, R. (2012). *Student achievement impact of Geocaching integration in an agriscience lesson plan* (MSc. thesis). Retrieved from ProQuest Dissertations & Theses Global. (UMI NO. 1519769)

Ihamäki, P. J. & Tuomi, P. (2009). *Understanding 21st Century's Mobile Device-Based Games within Boundaries.* Paper presented at the DiGRA 2009: Breaking New Ground: Innovation in Games, Play, Practice and Theory. London, England. Retrieved from http://www.digra.org/dl/db/09287.32562.pdf

Ihamäki, P. J. (2007). *Geocaching at the Institute of Paasikivi-New ways of teaching gps technology & basics of orientation in local geography.* Paper presented at the International Conference on ICT & Accessibility, Hammamet, Tunisia. Retrieved from http://www.esstt.rnu.tn/utic/tica2007/sys_files/medias/docs/p28.pdf

Ihamäki, P. J. (2012). Geocaching: Interactive communication channels around the game. *Journal for Computer Game Culture, 6*(1), 133–152. Retrieved from http://www.eludamos.org/index.php/eludamos/article/view/vol6no1-10/6-1-10-pdf

International Society for Technology in Education (ISTE) (2018a). *ISTE Standards for Students*. Retrieved from http://www.iste.org/standards/for-students

International Society for Technology in Education (ISTE) (2018b). *ISTE Standards for Educators*. Retrieved from http://www.iste.org/standards/for-educators

Kaya, N., Çobanoğlu, M., & Artvinli, E. (2011). Sürdürülebilir kalkınma için Türkiye'de ve dünyada çevre eğitimi çalışmaları. 6. *Ulusal Coğrafya Sempozyumu*, 407-417. Retrieved from http://tucaum.ankara.edu.tr/wp-content/uploads/sites/280/2015/08/semp6_44.pdf

Kocalar, O. A. (2012). Coğrafya'da çevre eğitimi ve sorunları, Marmara Üniversitesi, Eğitim Bilimleri Enstitüsü, Yayınlanmamış Doktora Tezi, İstanbul. (Tez no. 349945). Retrieved from https://tez.yok.gov.tr/UlusalTezMerkezi/

Lary, L. M. (2004). Hide and seek: GPS and Geocaching in the classroom. *Learning & Leading with Technology, 31*(6), 14–18. Retrieved from https://files.eric.ed.gov/fulltext /EJ695752.pdf

Matherson, L., Wright, V., Inman, C. & Wilson, E. (2008). Get up, get out with Geocaching: Engaging technology for the social studies classroom. *Social Studies Research and Practice, 3*(3), 80-85. Retrieved from http://www.academia.edu/581638/Get_Up_Get_ Out_with_Geocaching_Engaging_Technology_for_the_Social_Studies_Classroom

Mayben, R. E. (2010). *Instructional Geocaching: An analysis of GPS receivers as tools for technology integration into a middle school classroom* (Ph.D. thesis). Retrieved from ProQuest Dissertations & Theses Global. (UMI NO. 3422966)

McMillan, J. H. & Schumacher, S. (2010). *Research in education: Evidence-based inquiry* (7th ed.). London: Pearson.

Miles, M. B. & Huberman, A. M. (1994). *Qualitative data analysis* (2nd ed.*).* London: Sage.

Milli Eğitim Bakanlığı. (MEB). (2011). Coğrafya *öğretmeni özel alan yeterlikleri*. Retrieved from http://otmg.meb.gov.tr/YetOzel.html.

Milli Eğitim Bakanlığı. (MEB). (2018). *Orta öğretim coğrafya dersi öğretim programı*. Retrieved from http://mufredat.meb.gov.tr/ProgramDetay.aspx?PID=336 .

Munro-Stasiuk, M. J. (2006). Introducing teachers and university students to GPS technology and its importance in remote sensing through GPS treasure hunts. *Journal of Geoscience Education*, *54*(4), 471-475. doi:10.5408/1089-9995-54.4.471

Patton, M.Q. (2002). *Qualitative research & evaluation methods* (3rd ed.). London: Sage.

Pelton, T., Pelton, L. F., & Moore, K. (2007). Geotrekking: Connecting education to the real world. In R. Carlsen, K. McFerrin, J. Price, R. Weber & D. Willis (Eds.), *Proceedings of SITE 2007--Society for Information Technology & Teacher Education International Conference* (pp. 2082-2088). San Antonio, Texas, USA: Association for the Advancement of Computing in Education (AACE). Retrieved from https://www.learntechlib.org/primary/p/24890/

Pelton, T., Pelton, L. F., & Moore, K. (2008). *Going on a geotrek: Gonna catch a big one.* The Power point presented at the 86th Annual Meeting of the National Council of Teachers of Mathematics, Salt Lake City, UT. Retrieved from http://web.uvic.ca/~tpelton/geotrekking/geotrekking-nctm08.pdf

Robison, D. (2011). Geocache adventures: Ubiquitous handheld computing as an aid to promote

environmental awareness amongst students. *International Journal of Innovation and Leadership on the Teaching of Humanities,1*(2), 47–56. Retrieved from http://www.academia.edu/1312228/IJILTH01.02_David_ROBISON_Geocache_adventur es_Ubiquitous_handheld_computing_as_an_aid_to_promote_environmental_awareness_ amongst_students_pp._47-56_

Schlatter, B. E. & Hurd, A. R. (2005). Geocaching: 21st-century hide-and-seek. *Journal of Physical Education, Recreation & Dance*, 76(7), 28-32. doi:10.1080/07303084.2005.10609309

Schudiske, E. (2014, May 6). The 4 Most Common Geocache Hiding Mistakes. *Geocaching Official Blog*. Retrieved from https://www.Geocaching.com/blog/2014/05/the-4-most-common-geocache-hiding-mistakes/

Shaunessy, E. & Page, C. (2006). Promoting inquiry in the gifted classroom through GPS and GIS technologies. *Gifted Child Today*, 29(4), 42-53. doi:10.4219/gct-2006-11

Sherman, E. (2004). *Geocaching: Hike and seek with your GPS* (1st ed.). Berkeley, CA: Apress.

Silva, A. de S. e. & Hjorth, L. (2009). Playful urban spaces: A historical approach to mobile games. *Simulation & Gaming, 40*(5), 602–625. doi:10.1177/1046878109333723

Stake, R. (2003). Case studies. In N. Denzin & Y. S. Lincoln (Ed.). *Strategies of qualitative inguiry* (*pp.* 134-164). Thousand Oaks, CA: Sage.

Taylor, J. K., Kremer, D., Pebworth, K. & Werner, P. (2010). *Geocaching for schools and communities*. (1st.ed). Windsor, ON: Human Kinetics.

The Geocaching Vlogger (2015, February, 11). Library Geocache, Shhhh!. Youtube.com. Retrieved from https://www.youtube.com/watch?v=9MtUiotNdgc

Topu, F. B., Baydaş, O., Turan, Z. & Göktaş, Y. (2013). Öğretim teknolojisi araştırmalarında geçerlik ve güvenirlik önlemleri. *Çukurova Üniversitesi Eğitim Fakültesi Dergisi*, *42*(1), 110-126. Retrieved from https://topslide.org/Journals/oegretim-teknolojisi-aratirmalarinda-gecerlik-ve-guevenirlik-oenlemleri-common-reliability-and-validity-strategies-in-instructional-technology-research

Turoğlu, H. (2008). *Coğrafi bilgi sistemlerinin temel esasları* (2. baskı). İstanbul: Çantay.

Ünal, S. & Dımışkı, E. (1999). UNESCO-UNEP himayesinde çevre eğitiminin gelişimi ve Türkiye'de ortaöğretim çevre eğitimi. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, *16*(17).142-154. Retrieved from http://dergipark.gov.tr/hunefd/issue/7822/102805

Vitale, J. L., McCabe, M., Tedesco, S., & Wideman-Johnston, T. (2012). Cache me if you can: Reflections on Geocaching from junior/intermediate teacher candidates. *International Journal of Technology and Inclusive Education (IJTIE)*, *1*(1). Retrieved from http://infonomics-society.ie/wp-content/uploads/ijtie/volume-1-2012/Cache-Me-If-You-Can-Reflections-on-Geocaching-from-Junior-Intermediate-Teacher-Candidates.pdf

Yıldırım, A. & Şimşek, H. (2011). *Sosyal bilimlerde nitel araştırma yöntemleri* (8. baskı). Ankara: Seçkin.

Zaman, S., Siyamoğlu, S., Özgürbüz, İ. E. & Veisalov, E. (2016). Coğrafya öğretmenlerinin özel alan yeterliklerine yönelik görüşleri (Trabzon Örneği). *Atatürk Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *20*(3). 813-837. Retrieved from

http://dergipark.gov.tr/ataunisosbil/issue/26967/283427.

Zecha, S. (2012). Geocaching, a tool to support environmental education!?– An explorative study. *Educational Research eJournal, 1*(2), 177–188. doi: 10.5838/erej.2012.12.06

Zecha, S. (2014) "Outline of an Effective GPS Education Trail Methodology", In GI Forum 2014. Geospatial Innovation for Society - Conference Proceedings. June. pp. 352 – 361. Retrieved from https://hw.oeaw.ac.at/ec_fundedresources/GI_Forum_2014___8211__ Geospatial_Innovation_for_Society/3_17_LWG_Zecha.pdf?hyperwave=action%3Dplain. action&cachekeY=85c44d7d07679703f50c4a3a7124e7fc

Zemko, M., Vitézová, Z., & Jakab, I. (2016, October). Geocaching as a Means for Modernization of Educational Process. In *European Conference on e-Learning* (p. 709). Academic Conferences International Limited. Retrieved from https://www.researchgate.net/publication/309563676

Biographical Statements

Rukiye ADANALI completed her Ph.D. in the Department of Geography Education at the University of Ataturk. Now she is working at the Department of Social Sciences Education at Muğla Sıtkı Koçman University. She studies on geography education, location-based games, project based learning, problem based learning, digital teaching materials, problem solving skills in K–12 and higher education, and teacher preparation.

Mete ALIM is a Professor in the Department of Geography Education at the University of Ataturk. He studies on geography education, curriculum development, and teacher preparation.