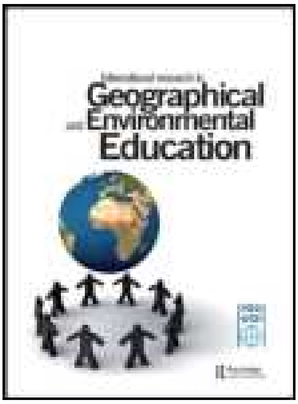

International Research in Geographical and Environmental Education
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/rgee20

Using Google Earth as an educational tool in secondary school geography lessons

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Published online: 18 Oct 2013.

International Research in Geographical and Environmental Education, 2013
Vol. 22, No. 4, 277–290, http://dx.doi.org/10.1080/10382046.2013.846700

Routledge
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Using Google Earth as an educational tool in secondary school geography lessons

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This article evaluates effectiveness of Google Earth (GE) as an educational tool in secondary school geography lessons and whether it contributes to students' achievement. A GE exercise was developed regarding the types of coastal formations. It was implemented in a ninth-grade geography lesson in three high schools in Turkey. The students followed the exercise from a printed set of instructions and entered the same steps on their computers. Pre- and post-tests were used to evaluate the effects of the GE exercise on students' achievement. A self-assessment form was also used to obtain students' opinions regarding GE and the exercise. This study revealed that the GE exercise was followed accurately and understood by the majority of the students in all the three schools. Students' overall achievement varied with average scores of 9.8 and 24.2 points in the pre- and post-tests, respectively. The majority of the students liked the GE exercise and found it useful and engaging. As is evident from this study, GE is an effective educational tool for secondary school geography lessons, especially when used with proper methods, materials, and objectives.

Keywords: Google Earth; geography lesson; secondary education; GIS; teaching

Introduction

Rapid developments in science and technology have provided new opportunities in geography education throughout the world. For centuries, textbooks, blackboards, globes, atlases, and maps were the main instruments used in geography lessons. However, computers, the Internet, and hand-held devices, such as smart phones and geographic information systems (GIS), have revolutionised opportunities for teaching and learning geography in secondary schools over the last few decades. The changes have required making the tools of geospatial technology available to teachers and students. Among the most important developments to be utilised in geography education has been geospatial technologies that are both available and affordable. By combining GIS, remote sensing (RS), and global positioning systems (GPS), geospatial technologies enhance geography lessons with a powerful tool for geographic analysis and are a very useful source for learning and teaching geography (Bednarz & van der Schee, 2006).

The benefits of using geospatial technologies, especially GIS, in geography education have been examined in a number of studies. GIS is a tool for storing, analysing, displaying, and processing spatially referenced information (McClurg & Buss, 2007), and has been reported to facilitate problem-based and inquiry-based learning (Johansson, 2003; Landenberger, Warner, Ensign, & Nellis, 2006), provides the opportunity for issue-based, student-centred, and standard-based education (Kerski, 2003), and empowers students to become active users of geospatial data and active learners of geography (William, 2001). The most important benefit of using GIS in geography lessons is the enhancement of

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spatial thinking skills among students (Bednarz, 2004; Demirci, 2008; Liu, Bui, Chang, & Lossman, 2010). Spatial thinking is an important skill used in everyday life to solve problems by analysing spatial relationships of objects and places with reference to locations, distances, directions, shapes, and patterns (Kidman & Palmer, 2006). GIS helps students to think spatially (Lee & Bednarz, 2009), ask spatial questions (Nellis, 1994), visualise spatial and non-spatial data (Marsh, Golledge, & Battersby, 2007), and perform spatial analysis (Bednarz & Schee, 2006).

The use of spatial technologies became more widespread internationally following the launch of the World Wide Web in 1991. Nearly one in six people across the globe was using the Internet by 2009 (Chalmers, 2009) and gave access to many web-based spatial technological systems, including Google Earth (GE). GE is a web-based program that allows users to view remote images and maps of the Earth's surface through the use of satellite and stored spatial data ranging from place names to street-level views of the landscape (Lisle, 2006). When it was launched in 2005, users enjoyed viewing the Earth at different scales, zooming in on visible physical and human characteristics, such as mountains, valleys, rivers, cities, and roads. More recent developments have provided users with higher resolution images of the Earth and have provided additional data layers that enabled the display of many types of information about Earth. Given that basic services of GE are free and accessible online, the number of users increased rapidly and reached more than 200 million people by 2007 (Google, 2007). Currently, GE is a powerful tool for both researchers and other professionals as well as for individuals who use its many different capabilities, such as locating an address, navigating to a new location on a smart phone, or sharing information with friends.

GE is not considered as a true GIS, even though it has stimulated thousands to engage in geospatial applications and thinking. According to Patterson (2007), GE has limited capacities and tools to support spatial analytical operations in comparison to a true GIS. However, GE's limited capabilities have allowed it to be easier to use. It does not require a long training period and expertise. In support of GE's user-friendliness, Goodchild (2008) stated, "Much of Google Earth's success is attributable to the extreme ease with which users can learn to manipulate its interface" (p. 34). GE's user-friendliness has revolutionised spatial thinking and changed the attitude of many people towards geospatial technologies. Currently, there are millions of people engaged in spatial thinking processes due to the usefulness and popularity of GE. Butler (2006) identified GE as "the democratization of GIS" (p. 777) and Goodchild (2008) expanded on the concept by indicating that GE made GIS technologies available to practically everyone, thereby allowing thousands of people to benefit from the different applications of GIS.

GE has generated great interest among teachers and students in secondary education and has become a widely used teaching tool in classrooms globally. This interest is due mainly to GE's user-friendly interface. According to Patterson (2007), GE empowers students to explore Earth by engaging in spatially oriented learning in a dynamic, engaging, meaningful, and interactive manner. GE helps students develop spatial thinking and critical analytical skills and allows them to become active learners. GE is also a powerful tool for teachers since it enables them to use technology-based active teaching strategies to enhance students' learning.

The utilisation of GE in secondary education is cost effective. Many classrooms are already equipped with a computer, Internet access, and a projector, and these are the only technologies needed for the use of GE in lessons. Utilising technology available has permitted a cost-efficient inclusion of GE with traditional methods in many subjects, including geography, earth sciences, social sciences, and environmental sciences. Due to its association with space and spatial thinking, geography is among the most important subjects that can benefit from the use of GE technology in secondary schools. GE is especially practical for teaching about geomorphologic content, such as mountains, valleys, plains, deserts, and coastal characteristics. GE can also be used to teach lessons about the depositional and erosional features of running water, wind, glaciers, and waves as GE allows students to visualise the same processes in different global locations. Lessons about continents, oceans, rivers, lakes, islands, oceanic trenches, forests, and even transform faults can be enhanced for students' understanding through the use of GE technology (Lisle, 2006).

Physical features of the world are not the only properties that students can explore using GE. Cities, roads, land uses, urbanisation, distribution of population, and political boundaries are available for analysis, but are also updated as changes occur, giving the GE images an advantage of timeliness over printed maps. Organising visual field trips, implementing three-dimensional exercises, and measuring distances are applications that teachers can use with GE in their geography lessons (Cahill, 2007).

The availability of GE in schools and classrooms must be combined with appropriate instructional methodologies. Several research studies, especially regarding the use of GIS in education, have reported the importance of planned methods of GE use (Baker & White 2003; Bednarz, 2004; Walsh, 1992). Meyer, Butterick, Olkin, and Zack (2009) indicated that learning the technology at the expense of learning spatial analysis can occur, and the integration of the technology with the geospatial thinking is essential. Proper methods in the use GE during geography lessons are necessary. To identify suitable methods, it is first necessary to assess how GE affects students' comprehension and performance.

Research studies focusing on the use of GE in secondary education are limited, but the overall trend has been to report the importance and the role of GE in education (Goodchild, 2008; Lisle, 2006; Patterson, 2007). The use of GE within geography education may seem obvious given that it is a versatile means that allows students to observe, explore, analyse, and understand Earth. However, Patterson (2007) argued that more research was needed to identify the pros and cons of this technology through the development of different methods of using GE in geography lessons and the measurement of the effectiveness of GE-based classroom methodologies. The current research aims to evaluate whether or not GE can be used in secondary school geography lessons as an effective methodology and whether or not GE contributes to student learning.

Method

A GE exercise was developed for a ninth-grade geography lesson using Google Earth 5.0. The exercise was implemented in 2010 in two private high schools (school A and school B) and one public high school (school C) located in Istanbul, Turkey. One ninth-grade class from each school, with 25 students per class, participated in the study. The study consisted of two phases: The development of the GE exercise and the implementation of the exercise in schools.

Development of the GE exercise

While GE can be utilised as a tool to teach many different topics, the GE exercise developed was for a ninth-grade geography course that is compulsory for high school students in Turkey. The course focused mainly on topics in physical geography, such as plate tectonics, depositional and erosional forces, and landforms. The exercise, entitled, "How many types of coastal features can you identify?" aimed to provide students with an understanding of the types of coasts and of the processes that are involved in coastal modelling.

A new secondary school geography curriculum was developed in 2005, with 26 standards targeted in the ninth-grade geography course. One standard, "Students explain the forces shaping the earth's surface and their effects on landforms," was selected for the lesson (TTKB, 2011, p. 15). Coastal processes and the classification of coasts are taught under this standard in the Turkish ninth-grade geography course. High-quality satellite images presented on GE provide an opportunity to observe and analyse the types of coasts at different locations on Earth. Coasts were chosen as the topic of the GE exercise to allow students to use the technology as much as possible in their lesson. In this study, the general characteristics and natural processes of coastal formations were studied.

Across Earth there are many types of coasts that differ from each other in terms of shape, geomorphology, and the types of process that formed them. In this study, seven types of coasts, which are typically covered in ninth-grade geography textbooks in Turkey, were chosen to be explored in the GE exercise. The types of coasts that were included in the exercise were (1) longitudinal coasts, (2) transverse coasts, (3) Dalmatian coasts, (4) Ria coasts, (5) lagoons, (6) estuaries, and (7) fjords.

The GE exercise was organised into three different sections. The first section provided students with general skills to understand and use the web-based technology for the duration of the exercise. As few students had previously used GE during their lessons, the exercise began with an introduction to GE and its main tools and displays. Included in the first section of the exercise were instructions in using the main tools to explore Earth at different scales, searching for different places, creating placemarks and attaching text, pictures, and video, saving placemarks as Keyhole Markup Language Zipped (KMZ) files, selecting and using spatial data layers, and measuring distances. All of the steps were described in a short application that was called "How to use GE to locate Topkapı Palace?"

The second section in the exercise provided students with fundamental information about the processes that shape the coastal formations. A short visual tour was used to introduce the general processes that shape the coastal formations. Explanations were provided in text boxes inserted on different coastal images so that students could read about the processes that shaped each coast.

The third section of the exercise informed students about the main characteristics and shapes of each of the seven types of coastal formations. A visual tour was used for each type of coast by selecting three or four examples from Turkey and from around the world. Each image in the visual tour was supported by additional text, videos, and photos, so that students compare and contrast the coastal formations, their locations, and their main characteristics (Figure 1).

The GE exercise was developed with the assumption that students would understand, follow, and complete the exercise individually using computers. A student handout was prepared that described each step of the exercise in detail. The handout was 22 pages in length and included 16 questions about coastal form and process. There were from one to three questions for each type of coast to ensure that students attended to the central physical geography in the exercise. The questions were repeated for each type of coast. For example, the following types of questions were posed: "What are the five main characteristics of Ria coasts?" and "Where in the world can Ria coasts be found?"

The purpose of the research was to determine the learning about the types of coasts and the natural processes that affect their formation through the use of the handout and

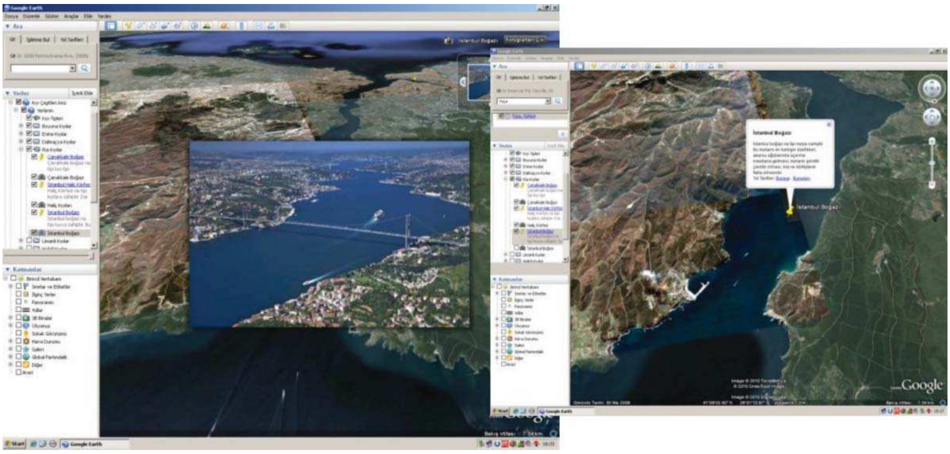

Figure 1. Istanbul Strait was one example of a Ria coast in the GE exercise that included videos, pictures, and text attached to different placemarks.

GE. Students used very basic GE capacities in the exercise. They viewed tours prepared for specific types of coasts, observed the coasts in different parts of the world, read the descriptions for the types of coasts from the textboxes, compared what they saw on GE and the pictures of geospatial information, and answered the questions for each type of coastal formation and process.

To evaluate the learning effects of the GE exercise, pre- and post-tests were administered. The pre- and post-tests included the same five questions. The first question asked students to name and to observe the shapes of the six different types of coastal formations out of the seven included in the exercise. The aim of this question was to assess whether or not students remembered and recognised what they viewed on GE during the exercise. In the second, third, and fourth questions, students were asked to explain how three different types, specifically the Dalmatian, estuary, and fjord coasts formed and in which two countries these types of coasts are found. The last question in the pre-test presented an unlabelled map of Turkey that had five different locations specified. The students were instructed to name the common types of coasts found in those locations.

The post-test included the same five questions as the pre-test, as well as a student self-assessment form. In the self-assessment form, there were eight questions that directed students to evaluate the exercise as well as to judge how useful GE was in enabling their understanding of the material. The questions were organised as follows.

(1) Students were asked whether or not they had previously used GE.
(2) If students answered “Yes” to the first question, then they were asked to identify the purpose of their previous use of GE.
(3) The third question examined which of the GE tools students learned to use during the exercise. Students were presented with a list of tools (Table 1) and asked to identify which one they used.
(4) The fourth, fifth, and sixth questions asked students to indicate what challenges they faced during the exercise, if they thought they were skilled enough to implement similar exercises, and what recommendations they would make when implementing similar exercises in their lessons.

Table 1. Which GE tools could students use by themselves after the exercise?

	I can use							
	School A		School B		School C		Total	
Activities on GE	*n*	%	*n*	%	*n*	%	*n*	%
Finding a place	17	68	15	60	18	72	50	67
Creating a placemark	18	72	14	56	15	60	47	63
Saving placemark as a KMZ file	16	64	15	60	16	64	47	63
Distance measurement	8	32	10	40	11	44	29	39
Exploring layers	11	44	14	56	14	56	39	52
Creating a visual tour	9	36	11	44	14	56	34	45
Hyperlink a text	13	52	14	56	15	60	42	56
Hyperlink a picture	18	72	15	60	15	60	48	65

(5) The seventh question asked whether GE and other spatial technologies should be used in geography lessons and why.
(6) In the final question, a self-assessment form, the students used an attitude scale with seven sentences and were asked whether or not they agreed with the sentences.

Implementation of the exercise in schools

The GE exercise was implemented in three high schools, of which two were private. From a ninth-grade class, 25 students participated in each school. One of the private high schools (school A) was in the Anatolian high school category, which differs from general high schools in Turkey. It provided study in foreign languages with a special emphasis on science education. Anatolian high schools accept students following an entrance exam, so their students' achievements on the university entrance exam are higher than those in general high schools. The second private high school (school B) was a general high school and the third school (school C) was a newly established public high school.

The physical settings, including schools and classrooms, in private high schools tend to be better than public high schools. Therefore, the students from schools A and B participated in the GE exercise using computer laboratories, whereas the students in school C conducted the same exercise in a nearby university classroom because they did not have a computer laboratory. In the computer laboratories, the GE program was installed on and KMZ files were transferred to each computer. KMZ is the compressed version of the KML (Keyhole Markup Language), which is GE's file format to store and share placemarks and all their attachments (Conroy, Anemone, Regenmorter, & Addison, 2008). The GE documentation and attachments for the exercises were saved as a KMZ file so that they could be transferred to each computer being used.

The exercise and the three sections were estimated to last for 2 hours. First, students were given the pre-test, which lasted approximately 10 minutes. Following the pre-test, students were seated in front of individual computers and the student handouts were distributed. Students were then asked to read the instructions from the handouts and follow each step by answering the questions. The teacher guided the implementation of the first section of the exercise, and students followed the rest of the exercise individually. The anticipated time to complete the exercise was 60 minutes. Following the exercise, students were given the post-test and the student self-assessment form, with an anticipated

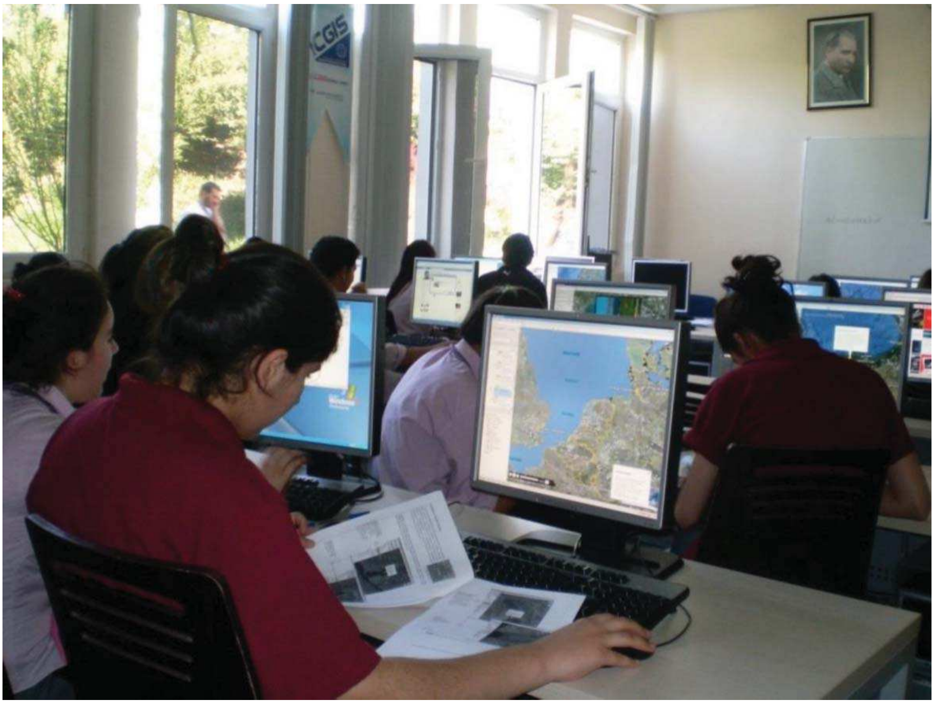

Figure 2. Students from school C are participating in the GE exercise in a laboratory.

time to complete the two sections being 20 minutes. The same GE exercises were implemented in each school at different times (see Figure 2). The time expended on each stage of the exercise was recorded for each school.

Data analysis

The analyses of the results of the GE exercise were conducted using both quantitative and qualitative methods. The students' performances in the pre- and post-tests were analysed using percentages, frequencies, and paired *t*-test to determine statistically significant changes in students' performances. The data were also analysed among the schools to determine if outcomes differed based on school setting.

The students' written answers were analysed to determine whether or not the students followed the exercises and their understanding about coastal forms and processes. First, the handouts were examined to determine how many questions were answered, irrespective of whether the answers were correct or incorrect. Then, the accuracy of the answers was determined. Qualitative methods were used to evaluate the students' responses to the self-assessment questions.

Results

The GE exercise was completed in each school on different days. The exercise and the pre- and post-tests were completed in 1.5 hours at schools A and B and in 2 hours at school C. There were several reasons for this difference in time requirements. The students in schools A and B appeared better prepared to use computers in their lessons. They did not encounter difficulty following the exercise and using computers. Although they finished the exercise in the anticipated time of 2 hours, the students at school C used more time learning GE's main tools and completing the exercise in its entirety. It was apparent that prior experience with computers in the classroom influenced the time spent completing the exercise in each school. Schools A and B were private and their information and communication technology (ICT) conditions were better than school C, which did not have a computer laboratory.

How well students performed in the exercise?

The analysis of the student handouts showed that the majority of the students followed the GE exercises. Seventy-five students from the three schools answered approximately 92% of the questions on average (14.7 questions out of 16). Fifty-five percent of the students answered all of the questions, whereas only four students answered 50% or fewer of the questions. The students in school A answered the highest number of questions with an average of 15.5 out of 16 questions attempted. Eighteen students in the school answered all of the questions, whereas only three students left three questions unanswered. In school B, the average number of questions answered was 14.4. Eleven students answered all of the questions, whereas two students left six or more questions unanswered. The students in school C answered approximately the same number of questions as the students in school B, with an average of 14.2 questions answered. Twelve students answered all of the questions and three answered 50% or fewer of the questions.

In statistical summation, the students' answers from the handout were further evaluated regarding accuracy, with a point value of 6.25 for each question. The average score of the 75 students from the three schools was 81.2 points out of 100. This result suggested that students' understanding and performance in the GE exercise were very high. Thirty-four students scored 90 points or more, whereas 10 students received 50 points or less. Eight students received a score of 100, with all questions answered correctly.

The analysis revealed that students in school A scored the highest with regard to the questions asked in the handout, with an average score of 93.3 points out of 100 (Figure 3). The average score of the students from school B was 81.9 points, which was 11.4 points

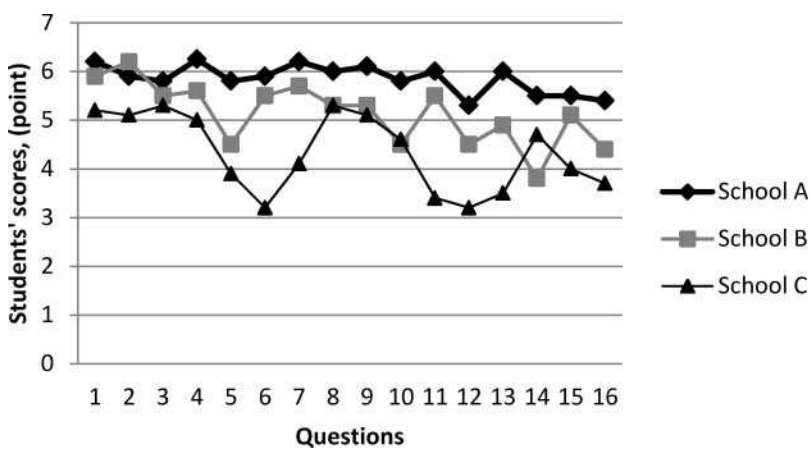

Figure 3. Students' scores for each question on the handout by school.

lower than school A. The students in school C scored the lowest, with an average of 68.6 points, which was 13.3 points lower than school B. The higher quality of education and the students' levels of success were observed to be associated with the highest performance level in the GE exercise in school A to which students were admitted with a high nationwide exam score.

The performances on the exercises were better on the first questions and gradually declined towards the final question. Questions asking where Dalmatian types of coasts were located in the world and how estuaries form along the coast proved to be especially difficult.

The pre-tests which included five questions and each correctly answered was assigned 20 points. Students from the three schools performed less well on the pre-test due to less knowledge related to the GE exercise. Their average score was 9.8 points out of 100. The students performed better in the first and the fifth questions, with an average of 3.2 and 5.5 points, respectively. However, most students did not answer the second, third, and fourth questions, leaving them blank. Their average scores for these three questions were 0.2, 0.5, and 0.5, respectively. The remaining three questions were open ended and asked the students how specific types of coasts formed. The results revealed that school A performed the best, with the highest average score of 12.6; school B and school C had averages of 7.7 and 9.3 points, respectively (Figure 4).

Average scores for students were higher on the post-test, which included the same five questions. Paired *t*-test result shows a significant difference ($p < 0.01$) between the pre- and post-test results for all three classes. The average score across all of the classes was 24.2 points, which was 14.4 points higher than the average pre-test score. The average scores for students on the first four questions were 4, 5.1, 4, and 3.2 points, respectively. Again, the students had the highest score on the fifth question, with an average score of 7.9 points. These results suggested that students improved on their scores for each question following the implementation of the GE exercise, although there were unequal improvements among the schools. As Figure 5 shows, students in school A were the most successful, with an average of 36.1 points, which was 23.5 points higher than their average pre-test scores. School B performed better than school C on the post-test, receiving 21.2 points on average. On the post-test, school B increased their pre-test score by 13.5 points. Although students in school C performed at the lowest level among the sample,

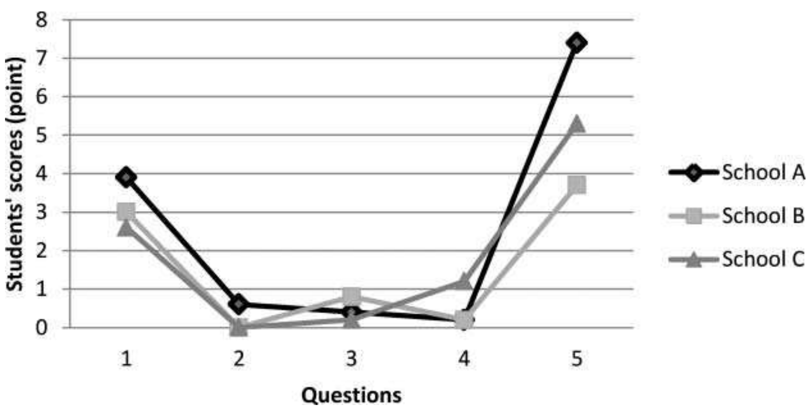

Figure 4. Students' scores for each question on the pre-test by school.

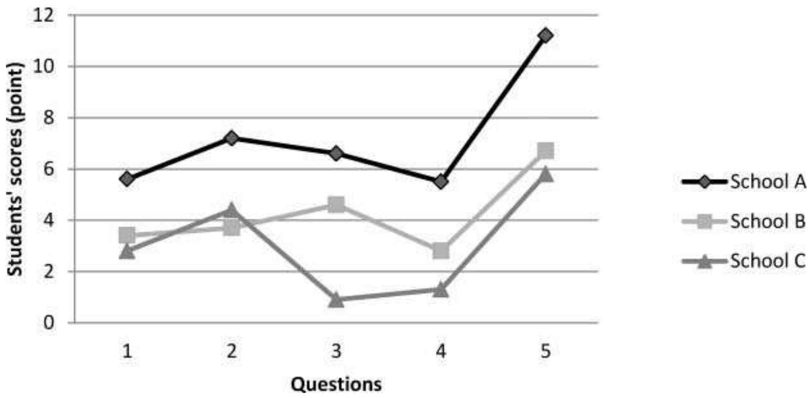

Figure 5. Students' scores for each question on the post-test by school.

they increased their average score to 15.2 points, which was a 5.9-point gain over the average pre-test score.

What did students think about the exercise?

The post-test included a student self-assessment form with six questions. The results of the self-assessment test revealed that more than half of the students (63%) from among the sample of schools had previously used GE. The percentage of students who had previously used GE was the highest for school A with 76%. The percentages for schools B and C were 52% and 60%, respectively. Of the 47 students who had previously used GE, 15 students (32%) had used it for their lessons either in the classroom or at home, whereas 32 students (68%) had used it out of curiosity to explore different places on Earth as a result of personal interests. Students in school A had never used GE for their lessons, whereas students in schools B and C had used it for different activities related to their lessons. This result was interesting since one would have expected the academic requirement of school A would be a catalyst for a concerted use of GE since a computer laboratory was available.

On the self-assessment form, students were asked whether or not they had learned how to use a number of tools after the GE exercise (Table 1). Nearly two-third of the students learned how to find a place, create a placemark, save the placemark as a KMZ file, and hyperlink a picture on GE with the exercise. Almost half of the students learned how to explore layers and hyperlink text to GE. However, more than half of the students were not proficient at measuring distances and or creating a visual tour on GE. Although these tools were available and used, they were not described in detail. There were no significant differences observed in the response patterns to the measuring of distances or visual tours among the students in the schools.

On the same self-assessment form, students were asked whether they had difficulty completing the GE exercise. Twenty-two students (30%) answered yes to this question and 17 of them indicated the problems they have encountered. It was quite surprising to discover that approximately half of the students who mentioned having difficulties were from school A, which was the most successful school with regard to this exercise in terms of average score. Only four students from school C, which had the lowest performance on this exercise, indicated they had difficulty with the exercise. The main difficulties that students reported were as follows: Computer screen was frozen; I had problems with placemarks; following all the steps of the exercise was difficult because it was too long; Internet connection was not very good; there was not enough time to finish the exercise; I could not follow the teacher; and I could not motivate myself very well.

From among the three schools, 19 students (25%) indicated on the self-assessment form that they did not have enough skill to participate in similar exercises in the future. Approximately half of these students were from school A, whereas four students were from school B and six students were from school C; they expressed similar negative perspectives. Sixteen students identified the skills they needed to improve to be able to use GE in different applications. Fourteen students indicated that they needed more practice with GE, whereas two students indicated that their computer skills were not sufficient for similar exercises.

Students were asked on the self-assessment form whether GE and other spatial technologies should be used in geography lessons. A majority of the students (81%) from the three schools answered yes to this question, with the highest acceptance from school A with 91%. Students who answered yes often stated that GE helps them understand the subject without memorisation, makes the geography lesson very visual, was very easy to use, was useful for many different purposes, facilitated what students and teachers do in the classroom, and was fun to use.

Seventeen students (23%) made recommendations regarding the implementation of similar GE exercises during geography lessons. Their recommendations were (1) the ICT infrastructure should be stronger in schools, (2) the teachers should conduct the exercises in class and students should follow teachers on computers, (3) the exercise should be accompanied by an audio soundtrack that explains the steps and subjects to the students, (4) the use of ICT should be emphasised more extensively in schools so that students use technology, (5) the GE exercises should be shorter, (6) the image resolution on GE should be better, and (7) the students should be given more time to complete GE exercises.

The self-assessment form provided important clues regarding students' opinions of the GE exercise and its use in geography lessons (Table 2). The data analysis reported that 77% of the students from the three schools liked the GE exercise, whereas 15% said the opposite and 8% remained neutral. Approximately two-thirds of the students (72%) thought that they should use GE more frequently, with 11 students (15%) remaining neutral and 10 students (13%) disagreeing. Similar results were recorded regarding whether or not related exercises would increase their interest in geography lessons. Seventy-one percent of the students agreed or strongly agreed with the sentiment of increased sentiment, whereas 16% remained neutral and 13% disagreed. Sixty-two percent of the students thought that the GE exercise helped them understand the topic without memorisation, whereas 19% remained neutral and 19% disagreed. In total, 64% of the students found the GE exercise entertaining, whereas 18% remained neutral and 18% disagreed. Approximately two-third of the students (64%) thought that the GE exercise increased their interest in GE and similar spatial technologies, whereas 15% remained neutral and 18% disagreed (Table 2).

An overall evaluation of the students' opinions revealed that 69% of the students expressed opinions in favour of GE and the exercise, 15% of the students remained neutral, and 16% disagreed in their opinions of GE in geography. However, students' acceptance of opinions varied dramatically among schools, with an obvious difference in school C. Whereas 61% of the students in schools A and B agreed or strongly agreed with the six statements, there were 84% of the students from school C who agreed or strongly

Table 2. The students' opinions regarding the GE exercise.

Sentences	AS School A	AS School B	AS School C	AS Total	A School A	A School B	A School C	A Total	N School A	N School B	N School C	N Total	D School A	D School B	D School C	D Total	DS School A	DS School B	DS School C	DS Total
I liked the GE exercise	36	44	68	49	32	24	28	28	12	8	4	8	16	20	0	12	4	4	0	3
I will use GE more frequently from now on	44	44	52	47	20	16	40	25	20	20	4	15	16	20	4	13	0	0	0	0
Similar exercises will increase my interest in geography lessons	48	32	52	44	24	24	32	27	12	24	12	16	16	20	4	13	0	0	0	0
The GE exercise helped me understand the topic without memorisation	24	40	40	35	28	24	28	27	16	16	24	19	24	20	8	17	8	0	0	2
The exercise was entertaining	20	44	56	40	28	16	28	24	24	16	12	18	24	24	4	17	4	0	0	1
The GE exercise increased my interest in GE and similar spatial technologies	28	40	52	40	36	16	28	27	8	28	8	15	24	16	12	17	4	0	0	1

Response (%) $n = 25$ in each school, $n = 75$ in total.

Note: AS, agree strongly; A, agree; N, neutral; D, disagree; DS, disagree strongly.

agreed with them. A similar difference was observed in the percentage of students from each school who disagreed with the statements. In schools A and B, there were 23% and 20% of the students, respectively, who disagreed or strongly disagreed with the statements, whereas it was 5% in school C (Table 2).

Discussion

In this study, a GE exercise was prepared and implemented into ninth-grade geography lessons in three high schools. The objective was to evaluate the effectiveness of GE in geography lessons and to determine GE's potential role in students' learning. The GE exercise was successfully implemented by the majority of students among the schools.

The overall structure of the GE exercise and its implementation may be used to analyse the changes between pre- and post-tests. The students' scores on the post-test suggested that the students did not understand and internalise the content and technology presented in the exercise. While they answered the questions in the handout, they did not apply the same information when answering the post-test questions. Different factors may have influenced this outcome, such as the students, their participation in the exercise, the exercise, and its method of implementation.

The exercise was too long and the time given to complete it was too short in the opinions of many students. This may have been a factor influencing the lower achievement level of the students in the GE exercise. The exercise covered seven different types of coasts, with each type of coast having a visual trip with placemarks in different locations, texts, videos, and photos associated with it. It may have been difficult for students to retain all of the information over a 1-hour period. The data collected suggest that if the exercise was shorter and if the students were given a longer time period to complete the exercise, then achievement may have improved.

The same five questions were asked on both the tests. On both the tests, students performed better using graphic-based questions than objective knowledge-based questions. Students' achievement may have been better if all questions had included graphics similar to those presented on GE.

Conclusion

This study demonstrated that the geospatial tools, user-friendly interface, and easy access to the Internet have made it an effective platform for teachers and students to view, understand, and analyse the Earth with its different features in geography lessons.

A GE exercise was used to teach ninth-grade students the types of coasts and the processes that formed them. The exercise was then used to research the effects of GE on student learning in a geography lesson. Students' performances, motivations, and enthusiasms during the exercise and students' opinions about GE following the exercise demonstrated that GE is effective for geography lessons. GE serves as a tool to visualise what is taught in the classroom and as a platform on where students think about, engage with, and comment about dynamic Earth maps in digital format. One of the most important results of the study was that the majority of the students liked the GE exercise and found it useful and engaging.

The use of geospatial technologies in education has become more widespread across the world with the increasing number of countries where GIS and other geospatial technologies are being used in secondary school curricula (Demirci, 2011; Milson, Demirci, & Kerski, 2012). Geospatial web applications are replacing the usual desktop GIS applications (Papadimitriou, 2010), and the majority of the students (81%) taught in this study responded that GE should be used in geography lessons more frequently.

A careful planning is necessary when preparing and implementing similar GE exercises in geography lessons, particularly if the goal is to improve the achievements of students. When implementing a similar GE exercise, teachers should devote several days or weeks of time so that students will have greater time to engage the topics covered and to learn the content and technological skills in the lesson.

Technology is beneficial for education when used with proper methods, materials, and aims. New methods should be developed and tested to understand the true value of GE with regard to geography education.

References

Baker, T., & White, S. (2003). The effects of GIS on students' attitudes, self-efficacy, and achievement in middle school science classrooms. *Journal of Geography, 102*(6), 243–254.

Bednarz, S.W. (2004). Geographic information systems: A tool to support geography and environmental education? *GeoJournal, 60*, 191–199.

Bednarz, S.W., & van der Schee, J. (2006). Europe and the United States: The implementation of geographic information systems in secondary education in two contexts. *Technology, Pedagogy and Education, 15*(2), 191–205.

Butler, D. (2006). Virtual globes: The web-wide world. *Nature, 439*, 776–778.

Cahill, K. (2007). Google tools on the public reference desk. *The Reference Librarian, 48*(1), 67–79.

Chalmers, L. (2009). Virtual spaces and networks in geographical education and research. *International Research in Geographical and Environmental Education, 18*(4), 239–244.

Conroy, G.C., Anemone, R.L., Regenmorter, J.V., & Addison, A. (2008). Google Earth, GIS, and the Great Divide: A new and simple method for sharing paleontological data. *Journal of Human Evolution, 55*, 751–755.

Demirci, A. (2008). Evaluating the implementation and effectiveness of GIS-based application in secondary school geography lessons. *American Journal of Applied Sciences, 5*(3), 169–178.

Demirci, A. (2011). Using Geographic Information Systems (GIS) at schools without a computer laboratory. *Journal of Geography, 110*(2), 49–59.

Goodchild, M.F. (2008). The use cases of digital earth. *International Journal of Digital Earth, 1*(1), 31–42.

Google (2007, June 26). Introducing Google Earth outreach. Google, Inc. Press Release. Retrieved from http://www.google.com/press/pressrel/outreach_20070625.html

Johansson, T. (2003). GIS in teacher education – facilitating GIS applications in secondary school geography. In K. Virrantaus and H. Tveite (Eds.), *Proceedings of the 9th Scandinavian Research Conference on Geographical Information Science* (pp. 285–293). Helsinki: Helsinki University of Technology.

Kerski, J.J. (2003). The implementation and effectiveness of geographic information systems technology and methods in secondary education. *Journal of Geography, 102*(3), 128–137.

Kidman, G.C., & Palmer, G. (2006). GIS: The technology is there but the teaching is yet to catch up. *International Research in Geographical and Environmental Education, 15*(3), 289–296.

Landenberger, R.E., Warner, T.A., Ensign, T.I., & Nellis, M.D. (2006). Using remote sensing and GIS to teach inquiry-based spatial thinking skills: An example using the GLOBE program's integrated Earth systems science. *Geocarto International, 21*(3), 61–71.

Lee, J., & Bednarz, R. (2009). Effect of GIS learning on spatial thinking. *Journal of Geography in Higher Education, 33*(2), 183–198.

Lisle, R.J. (2006). Google Earth: A new geological resource. *Geology Today, 22*(1), 29–32.

Liu, Y., Bui, E.N., Chang, C.-H., & Lossman, H.G. (2010). PBL-GIS in secondary geography education: Does it result in higher-order learning outcomes? *Journal of Geography, 109*(4), 150–158.

Marsh, M., Golledge, R., & Battersby, S.E. (2007). Geospatial concept understanding and recognition in G6-college students: A preliminary argument for minimal GIS. *Annals of the Association of American Geographers, 97*(4), 696–712.

McClurg, P.A., & Buss, A. (2007). Professional development: Teachers use of GIS to enhance student learning. *Journal of Geography, 106*(2), 79–87.

Meyer, J.W., Butterick, J., Olkin, M., & Zack, G. (1999). GIS in the K-12 curriculum: A cautionary note. *The Professional Geographer, 51*(4), 571–578.

Milson, A., Demirci, A., & Kerski, J. (Eds.). (2012). *International perspectives on teaching and learning with GIS in secondary schools*. New York: Springer.

Nellis, M.D. (1994). Technology in geographic education: Reflections and future directions. *Journal of Geography, 93*(1), 36–39. Retrieved from http://www.informaworld.com/smpp/title~content = t770943818~db = all~tab = issueslist~branches = 93 - v93.

Papadimitriou, F. (2010). Introduction to the complex geospatial web in geographical education. *International Research in Geographical and Environmental Education, 19*(1), 53–56.

Patterson, T.C. (2007). Google Earth as a (not just) geography education tool. *Journal of Geography, 106*(4), 145–152.

TTKB (2011). MEB, Talim ve Terbiye Kurulu Başkanlığı, Coğrafya Dersi Öğretim Programı [Geography Curriculum], Ankara. Retrieved from http://ttkb.meb.gov.tr/program2.aspx?islem = 1&kno = 59

Walsh, S.J. (1992). Spatial education and integrated hands-on training: Essential foundations of GIS instruction. *Journal of Geography, 91*(2), 54–61.

William, J.L. (2001). Integrating GIS into the undergraduate learning environment. *Journal of Geography, 100*, 158–163.