J-READING
JOURNAL OF RESEARCH AND DIDACTICS IN GEOGRAPHY
1, 8, June, 2019, pp. 27-40 DOI: 10.4458/2252-02

J - READING
JOURNAL OF RESEARCH AND DIDACTICS IN
GEOGRAPHY
homepage: www.j-reading.org

Comparing learning geography with ArcGIS online and desktop

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Received: February 2019 – Accepted: May 2019

Abstract

To evaluate the use of different GIS platforms for learning geography this study presents the results of an experiment in which lessons with a desktop GIS and an online GIS are compared. Students from four secondary schools participated in geography lessons about global and Turkish earthquake risks using GIS. Of a group of 172 students 84 students used ArcGIS desktop software and 88 students used ArcGIS online. The results of the comparison in a pre-test post-test experiment show the online version to be more effective, but the results are not unambiguous. A questionnaire used to understand students' attitudes after the lessons and GIS platforms showed that most students were positive about the online version as well as the desktop version. In reaction to survey statements on the GIS platforms the WebGIS group scored more positively than the desktop GIS one. Although unfortunately this investigation could not be carried out in a classroom setting it may help the discussion on using GIS platforms in secondary education and inspire further research.

Keywords: Desktop GIS, Geography Education, Secondary Schools, WebGIS

1. Introduction

Although GIS has been gradually spreading around the world, its use in teaching and learning different subjects in schools remains unsatisfactory in many countries (Doering and Veletsianos, 2008; Kim et al., 2011; Roulston, 2013). Kerski et al. (2013) addressed this by indicating that GIS has not even become a commonly used teaching tool in the US and the UK where the use of GIS in education was pioneered more than two decades ago. This slow rate of utilizing GIS in schools has been attributed to a number of hardware, software, pedagogical, and administrative challenges (Baker, 2005; Bednarz and Audet, 1999; Kerski, 2003; Bednarz and Van der Schee, 2006; Milson and Kerski, 2012). The challenges vary from country to country but are often related to GIS software. A lack of financial resources to obtain and upgrade software and digital data, difficulties in installing software, a lack of school IT and administrative support, and lack of opportunities for teachers to learn software are among others cited in different studies (Baker, 2005; Harris et al., 2010). Most important of all is that from the start the available GIS software was *desktop GIS* developed for uses in science, business, and industry. Its interface and tools were not designed according to the needs of teachers and students. Therefore, they are difficult to use in teaching and learning (Bednarz, 2004; Bednarz and Ludwig, 1997; Favier and Van der Schee, 2012; Liu and Zhu, 2008; Harris et al., 2010). A desktop GIS is installed and operates on a personal computer. Users can only display, update, query and analyze geographic data locally. A desktop GIS is not accessible on a server or externally, therefore limiting access to how and where it can be managed. With its complex tools and functionalities, desktop GIS software takes quite a long time for teachers to learn. However, time is what teachers usually lack resulting mainly from strictly controlled and overloaded curricula and the emphasis on increasing student scores from standardized tests.

Without proper and carefully designed strategies the complex nature of GIS software may divert students' attention from lessons to technology, therefore having the potential to affect students' learning negatively (Baker and White, 2003; Manson et al., 2014). Over the years the advancements in science and technology have made GIS software more user friendly and more easily available to teachers. However, GIS software related barriers still hinder the incorporation of GIS into secondary education, although teachers around the world find them less problematic compared to the past (Baker et al., 2009).

The combination of the great educational potential of GIS technology with the difficulties of using it for teaching and learning resulted in a recognized need for better approaches to the adoption of GIS in schools (Henry and Semple, 2012). Initially, user friendly GIS desktop software packages were developed specifically for educational purposes and with much less complex interface and tools, mainly by relying on existing professional GIS software. Urban World, designed to foster students' progress towards a better understanding of the urban environment, is one of these examples, and was developed as an ArcView application in the US of the 1990s (Thompson et al., 1997). Although being useful for educational purposes, these software packages were few in number and could not attract widespread attention due to their limited contents and capabilities for spatial query and analysis (Liu and Zhu, 2008).

A real new perspective came with advancements in the Internet technology. Internet provides users with an alternative solution to a desktop GIS, offering *WebGIS* with the flexibility to work remotely and more interactively. This also opened up opportunities to tackle the majority of software related problems in utilizing GIS technologies in schools for educational purposes. After emerging as a promising technology by combining the power of the Internet and desktop GIS software in the 1990s, WebGIS provides teachers and students with a wide range of applications to display, visualize, query and analyze geographical information over the Internet.

Desktop GIS offers more functionalities and possibilities than WebGIS to analyze problems using digital maps. Although various WebGIS platforms offer many versatile benefits for teaching and learning, most of them have limitations especially for spatial analysis. Named atlas-style WebGIS by Baker (2005) these platforms are effective in data visualization and simple queries, but are not very qualified in data analysis. For example, PaikkaOppi, the very successful WebGIS platform used in Finland, has tools for spatial analysis, such as proximity, modeling, or buffering, but they are extremely marginal and limited only to the visual (Riihela and Maki, 2015). This kind of constraints does not cause big problems, especially when the GIS applications in schools are conducted based on some basic visualization tools and queries. However, if WebGIS platforms are to be used with project based approaches, then advanced geospatial analysis such as interpolation and the calculation of density may be necessary (Demirci, Karaburun and Ünlü, 2013). Advanced geospatial analysis methods and tools are major parts of desktop GIS software which are therefore popular in business and government. However, researchers see WebGIS as a powerful alternative for successfully incorporating GIS in education by removing many traditional barriers associated with desktop GIS (Baker, 2005; Henry and

Semple, 2012; Milson, 2011; Riihelä and Mäki, 2015). Being available online 24/7 and its presumed ease of use, mainly resulting from its simple interface and tools, are the main advantages of using WebGIS for teaching and learning. Using WebGIS reduces software costs and negates software installation issues and extensive work with IT staff in schools (Kerski et al., 2013).

Many WebGIS applications have been developed and used in education especially over the last two decades. While various studies have explored how effective WebGIS would be in applying constructivist learning approaches in classrooms such as project based, inquiry based, collaborative, exploratory, and inductive learning (Bodzin and Anastasio, 2007; Henry and Semple, 2012; Huang, 2011; Milson and Earle, 2007), others have focused on how these platforms affected students' skills such as spatial thinking and reasoning, relational thinking, and spatial decision making (Bodzin et al., 2015; Carver et al., 2004; Favier and Van der Schee, 2014). WebGIS platforms have been tested in education as either standalone technology or with other web-based platforms such as Google Earth (Bodzin and Anastasio, 2007). The availability of a simpler WebGIS has facilitated the use of GIS in classrooms after many years of a more professional desktop GIS.

As explained by Manson et al. (2014), there is little research evaluating the usability of various GIS platforms and identifying the most important barriers to their effective use in classrooms. Studies conducted so far have focused on the use of GIS in education used web platforms designed either with professional GIS software tools like ArcIMS or open sources. However, studies evaluating the effectiveness of different GIS platforms offered by professional GIS software companies like the Environmental Systems Research Institute (ESRI) are scarce. Since the majority of the GIS applications in schools around the world are carried out by using the GIS software produced by professional GIS companies (Baker et al., 2009), and GIS platforms are in constant development, there is a need to understand the potential of these web platforms for teaching and learning. Evaluating the usability and effectiveness in education of online and desktop GIS will help to understand how these rapidly changing technologies can be used to support teachers and students to use them efficiently and easily in classrooms. This study sets out to contribute to that aim by evaluating the usability of GIS for teaching and learning by comparing the use of two ESRI platforms, ArcGIS online and ArcGIS desktop, in secondary geography lessons.

2. Method

Secondary education in Turkey covers the education of children between 15-17 for at least three years after primary education. Geography is part of the secondary curriculum. In this study two GIS exercises were developed for the first year of secondary geography, so the average age of the students was 15. The exercises were used at four secondary schools in Istanbul, Turkey. The GIS exercises were carried out by two groups of students from each school; one group with desktop GIS and the other group with WebGIS in a computer laboratory. Tests were administered before and after the exercises to understand how desktop and online GIS platforms affected the students' achievements. The students were also presented with a survey at the end of the exercises to assess what their feelings and thoughts were about the two GIS platforms and the overall GIS exercises. The details of the methods used in the study are given below.

2.1 Development of the GIS exercises

Many themes in geography lessons in different grades focus on the understanding of space and spatial relationships and are suitable to being taught by GIS. This is also true for one of the main objectives of secondary school geography curriculum in Turkey: understanding why earthquakes happen and what risks they create in the world and in Turkey. In this study GIS exercises were used to teach students why earthquakes take place in association with the plate tectonics and what the earthquake risks are in the world and in Turkey.

As one of the commercial GIS software suppliers with desktop as well as online GIS software, ESRI products ArcGIS desktop 10.1 and ArcGIS online were used in the study. GIS data for the exercises were obtained from the book ‘GIS for Teachers’ written by the first author of this paper and published in Turkish with support from ESRI Turkey. The first GIS exercise named “which regions are tectonically the most active in the world?” intended to introduce basic plate tectonics, plate movements, earthquake locations, and risks around the world. The second GIS exercise named “why does Turkey often experience earthquakes?” aimed at providing students with an understanding of the earthquake risk in Turkey in association with the faults and historical earthquake data.

In order to implement the exercises with the desktop GIS, all the data were grouped, classified, and properly arranged as two separate ArcMap documents for the two GIS exercises so that students would be able to start the exercises with only a mouse click. The same data were transferred to and grouped in the ArcGIS online platform with their attribute information as two different applications for implementing the same two exercises with WebGIS. Student application documents for each exercise were prepared as Microsoft Word documents to allow students in desktop and online GIS groups to follow the exercises at different stages. The application documents were also used as lesson plans for each exercise and provided students with a detailed guidebook to understand why and how they would take steps in the exercises and which questions they would seek to answer at different stages. The learning activities identified at each stage of the exercises were designed for students to examine spatial patterns and relationships among the data presented as different layers.

The first GIS exercise concerning earthquakes in the world consisted of six stages. The first two stages focused on the analysis of the earthquakes with their location and magnitude. The third and fourth stages aimed to understand the location and types of volcanoes around the world. In the fifth stage students were given an unlabeled world map on the exercise document and asked to draw the plate boundaries by examining the location of the earthquakes and volcanoes. In the sixth stage the students were asked to add the plate boundary data to their GIS platform and compare the original data with the ones they drew. The last stage was designed to allow students to analyze the relationship between plate boundaries, earthquakes, and volcanoes and the earthquake risks in specific countries and across the world. The exercise document included 13 questions asked at different stages.

The second GIS exercise concerning the earthquake risks in Turkey also consisted of six stages. The first stage focused on the analysis of the earthquake locations in Turkey and its close vicinity. The analysis of the relationship between earthquake locations, landforms and faults in Turkey was targeted in the second stage, while the earthquakes in Turkey between 1995 and 2005 were explored with their magnitude and dates in the third stage. The major earthquakes in Turkey between 1903 and 2004 were analyzed in the fourth stage with their location, date, magnitude, and effects. In the fifth stage the students were given an unlabeled map of Turkey on the document and asked to draw the first degree earthquake risk zones of the country by investigating the location of earthquakes and fault lines. In the last stage the students were asked to add the earthquake risk zones of Turkey to their GIS platform and analyze the earthquake risks in particular cities, provinces, and regions across the country. The second GIS exercise document included 19 questions asked at different stages.

2.2 Implementation of the GIS exercises in geography lessons

The GIS exercises were implemented with 172 ninth grade students from four high schools in Istanbul, Turkey. One of the public schools involved in the study is a social science high school which is very successful in students’ achievement at university entrance exams. This school is called school A in this study. Only one private high school, school B, participated in the study, which is a science high school. The other two public schools were an Anatolian vocational high school (school C) and an Anatolian high school (school D).

The schools that took part in the study were chosen so as to observe how the overall GIS exercises would be performed in different types of schools having a slightly different school curriculum, physical setting, financial resources, and achievement level. School A has more diverse and intense social science courses, while school B is just the opposite and favors science courses. School C is a general high school providing a holistic approach with a combination of sciences and social sciences, while high school D favors a great number of technical courses. Being one of the main social science courses in secondary schools, geography is a mandatory course in the 9th grades of all these schools with almost the same curriculum. As prior knowledge of GIS of students was not the focus, this study was conducted with 9th grade students.

Two groups of students were selected at each school, with the help of the geography teachers. One group of students was the desktop group implementing the exercises with ArcGIS desktop software, the other group was the online group carrying out the same exercises with the ArcGIS online platform in each school. The overall school performance of the selected students was as far as possible of equal achievement level. As the study did not aim to analyze gender effects, the selection of students did not take account of even numbers of boys and girls in both groups.

Computer laboratories equipped with a sufficient number of computers and high-speed Internet connection were the necessary infrastructures to implement the exercises at schools. However, computer and Internet conditions were not sufficient enough at all the chosen schools to implement the exercises successfully, therefore the GIS desktop and online exercises were carried out in a GIS laboratory at Fatih University in Istanbul. The desktop and online groups from the same school implemented the exercises at different times, before and after noon on the same day without any possible interaction between the two groups of students. The study aimed to analyze the effect of the use of desktop and online GIS in geography lessons. Therefore, the students' level of understanding, grades, materials, durations, and topics of the exercises were the same with only one exception being the platform that the exercises were implemented on.

The students who took the exercises did not have any prior experience withGIS software and therefore needed to gain a basic understanding of GIS and the platform that they would use during the exercises. The overall experiment with each group of students lasted four sessions, about 50 minutes each with ten-minute breaks in the laboratory. In the first session students were introduced to the history, functionality, uses and benefits of GIS accompanied by a Power Point presentation. The aim and detailed plan of the overall study that the students would be involved in were presented in detail. The pre-tests to measure the students' achievements with GIS were then administered. In the second session students were introduced to the GIS platform that they were to use in the exercises. The desktop group used the ArcGIS desktop GIS to get to know its basic tools and functions, while the online group was first taught how to obtain a free trial license and then introduced to the ArcGIS online with its basic tools and functions that they would use during the exercises. In the third and fourth sessions students implemented the two GIS geography exercises by using the given GIS platform (Figure 1). After the exercises the post-tests were administered with the same questions as those used in the pre-tests. Finally, the students were given a survey to collect their opinions about the GIS exercises and platforms used.

Students were given their exercise documents and asked to follow the steps which were taken by the lecturer on the master computer and shown by a beamer. Each student was given a separate computer. Students were told to work alone and asked to answer the questions given in the exercise documents. The geography teachers of the students attended the experiment and helped the students where necessary.

Figure 1. The students implementing the GIS exercises (a) control group with ArcGIS desktop, (b) experimental group with ArcGIS online.

2.3 Evaluation of the data

The usability of the WebGIS platform used in the study was mainly identified through the observations made and difficulties faced during the preparation and implementation of the GIS exercises. The effects of using desktop and online GIS platforms on students' achievements were measured by the analysis of the pre- and post-tests performed before and after the exercises. The pre- and post-tests included the same ten questions, five for each GIS exercise.

An unlabeled world map was given to the students in the first section of the test regarding the earthquakes in the world. In the first two questions the students were asked to mark the regions across the world experiencing major earthquake and volcanic activities. The students were asked in the third question to draw the main plate boundaries on the map with lines. The fourth question was asked to understand what the students knew about the relationship between earthquakes, volcanoes and plate boundaries, while in the fifth question the students were asked to name five countries where frequent major earthquakes are experienced.

The second section of the pre- and post-tests included an unlabeled map of Turkey with the provincial boundaries and contained five more questions. In the first question of this section the students were asked to mark the regions experiencing frequent earthquake activities in Turkey. In the second question the students were asked to draw the main fault lines over Turkey. The names of the five provinces where the risk of earthquake is highest and lowest were asked respectively in the third and fourth questions and in the fifth question the students were asked to explain why Turkey has been experiencing many earthquakes with various magnitudes every year.

The students' scores from each test were calculated out of 100 by giving 10 points to each of the 10 questions. The scores of the pre- and post-tests were compared and statistically analyzed to determine which GIS platform led to better student performance over the other. A paired sample t-test was used to identify whether the students' scores differed significantly from the pre-test to the post-tests in both groups. An independent t-test was also used to compare the average pre-test and post-test scores of the students between the desktop and online groups.

Another goal of this study was to understand the students' attitudes towards the GIS exercises and the platforms used. A survey of 12 questions in three sections was used for this purpose after the GIS exercises. The first section contained three personal questions to identify the gender, school, and grades of the students. The second section included four questions and was designed to understand the students' knowledge and experiences with GIS prior to the exercises. The third section included Likert scale and open-ended questions. The two open ended questions in the survey asked the students to identify the difficulties they faced during the implementation of the GIS exercises and to provide recommendations in order to carry out similar GIS exercises more effectively in the future.

The first Likert scale question included 10 statements about the overall lessons that students took with the GIS exercises, the second Likert scale question contained nine statements regarding the GIS platform used. In the Likert scale questions students were asked to determine their level of acceptance by marking strongly agree, agree, neutral, disagree or strongly disagree. The statements of each Likert type question can be found in Tables 4 and 5 in the result section of this paper together with the students' responses. The internal consistency of the statements in these Likert scale questions was measured by Cronbach's alpha separately for the desktop and online groups. For the 10 statements of the first Likert scale question Cronbach's alpha showed a reliability at 0.917 for the desktop group and at 0.828 for the online group. In the second Likert scale question the internal consistency of the nine statements was calculated with Cronbach's alpha as 0.790 for the desktop group and as 0.752 for the online group. The students' opinions about GIS and its use in education were obtained by another Likert scale question containing six statements. The internal consistency of these statements was calculated with Cronbach's alpha as 0.719 for the desktop group and 0.695 for the online group.

3. Results

As shown in Table 1, 90 male and 82 female students participated in the application. There were small differences in number and big differences in gender between the schools. In school B, the private school, all participants were male but almost three-quarters of the participants from school D were female. Male and female student ratios were more balanced in schools A and C.

Schools	**ArcGIS desktop**			**ArcGIS online**			**Total**		
	M	*F*	*T*	*M*	*F*	*T*	*M*	*F*	*T*
A	10	9	19	7	13	20	17	22	39
B	19	0	19	22	0	22	41	0	41
C	12	11	23	8	15	23	20	26	46
D	7	16	23	5	18	23	12	34	46
Total	48	36	84	42	46	88	90	82	172

M: Male, F: Female, T: Total

Table 1. The number of students who implemented the GIS exercises.

Test / Group		N	Mean	Std. Deviation	t	df	p
Paired Sample t test							
Desktop GIS		84	-32,214	16,525	-17,867	83	,000
Online GIS		88	-25,091	13,018	-18,081	87	,000
Independent Sample t-test							
Pre-test	*Desktop GIS*	84	25,14	12,089	1,559	170	,121
	Online GIS	88	22,34	11,488			
Post-test	*Desktop GIS*	84	57,36	16,290	4,305	170	,000
	Online GIS	88	47,43	13,899			

Table 2. Analysis of the significance of the test scores.

Students were asked four questions about their prior knowledge of GIS and their experience with GIS. The students were first asked whether they had heard of GIS before taking part in this project. Only 28% of the students responded yes to this question, but the responses were different from school to school: 33% of the students from school A, 50% from school D, 17% from school B, and 11% from school C had heard of GIS. The students were also asked whether they had used a GIS software before and those who answered yes to this question were asked what software they used. Only three students from school D reported that they had used a GIS software before without giving any software name.

3.1 The effects of the GIS exercises on students' achievement

The tests administered before and after the geography lessons with GIS provided an understanding of how the two GIS platforms affected the students' achievements from the lessons. The paired t-test applied over the test scores of the desktop and online groups of the students from four schools showed statistically significant differences ($p < 0,05$) from the pre- to the post-test scores (Table 2). The independent sample t-test shows no statistically significant difference between the pre-test scores of the desktop and online groups ($p < 0,05$). However, as seen in Table 2, the same test results indicate statistically significant difference ($p < 0,05$) over the post-test scores of the desktop and online groups. This result reveals that the students who implemented the exercises with the desktop GIS software were more successful than the students who carried out the same exercises with WebGIS, based on their post-test scores.

Schools	ArcGIS desktop			ArcGIS online		
	Pre-test (Average)	*Post-test (Average)*	*Increase (%)*	*Pre-test (Average)*	*Post-test (Average)*	*Increase (%)*
A	32.3	60.8	88.2	29.7	60.3	103
B	24.7	53.8	117.8	17.8	39.6	122.5
C	26.0	52.6	102.3	17.1	43.6	155
D	18.7	62.2	232.6	25.5	47.6	86.7
Total	25.1	57.4	128.7	22.3	47.4	112.6

Table 3. The pre- and post-test scores of the students.

Table 3 shows the students' scores in the pre-tests and post-tests. Desktop and online groups received on average 25.1 and 22.3 points out of 100 from the pre-tests and an average 57.4 and 47.4 points out of 100 from the post-tests. The pre-test and post-test scores differed considerably among the schools. Table 3 also shows the average progression between pre-test and post-test. This increased in the desktop and online groups by 128.7% and 112.6% respectively. The progression in points of all students in the desktop group is 127.7 points and 91.0 points in the online group. The difference is 36.7 points, but if we delete school D this difference is only 5 points. The impact of school D is obvious. Remarkable and not easy explainable is the big progression of school D in the desktop group and the below average progression of the online group in school D.

3.2 Students' opinions about the exercises, GIS platforms, and GIS

At the end of the experiment the students completed a survey to obtain their opinions about the exercises, GIS platforms used and GIS in general.

The Likert scale statements about the different exercises in the experiment and students' responses to each statement are displayed in Table 4. The strongly agree and agree sections were grouped as positive responses, the strongly disagree and disagree options were classified as negative responses.

Table 4 reveals that the vast majority of students in both groups were positive about all the statements. The students in the desktop group were somewhat more positive than the online group in 7 of the 10 statements in Table 4. Most students in both groups found the exercises interesting and entertaining. Over 85% of the students in both groups found the tools, materials, and methods used in the exercises successful, while the same number of students considered the exercises helpful for understanding the geography lesson. Over 80% of the students in both groups could follow the exercises without difficulty. Some statements give a clue about the students' overall satisfaction with the GIS exercises. One of these statements says, "I followed the exercises without getting bored". Two out of three students (strongly) agreed with this statement in both groups.

The Likert scale questions of the survey about the GIS platform used are presented in Table 5. This table consists of five items with a positive statement agreed with by the majority of the students and four items with a negative statement disagreed with by the majority of the students. The percentage of positive reactions on the first five items and the percentage of negative reactions on the last four items is higher in the online group than in the desktop group.

Table 5 shows that the majority of the students in both groups reported the visual interface to be pleasant (over 78%), and the tools and buttons usable and understandable (over 71%). Many students in both groups also agreed that they learned to use the software with its basic tools (over 82%) and think that they will be able to carry out similar exercises on the same platform easily (over 78%). Over two thirds of the students in both groups were positive about the smoothly running software. Table 5 also shows that although the language of the GIS platforms was English, only 18% of the students in the desktop group and 16% of the students in the online group reported the language to be an obstacle to learning the tools of the platform. For most students, software use did not overrule students' attention for the geography exercises.

Table 6 presents students' opinions about GIS. The majority of students in both groups agreed or strongly agreed with the six statements. More than 80% of the students in both groups agreed that GIS makes students learn by doing and therefore supports effective learning. Over 70% of the students agreed that GIS should be used in geography lessons as an educational tool.

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Statements	**Positive Responses**		**Neutral responses**		**Negative Responses**	
	Desktop	*Online*	*Desktop*	*Online*	*Desktop*	*Online*
The exercises were useful to get to know GIS and its uses	96.5	94.3	2.3	4.6	1.2	1.1
The exercises were helpful for understanding the lesson	91.8	89.8	2.4	6.8	5.8	3.4
My overall performance during the exercises was sufficient	91.7	85.2	4.7	12.5	3.6	2.3
We were given enough time to implement the exercises	88.2	84.1	5.9	10.3	5.9	5.7
The tools, materials, and methods used in the exercises were successful	85.9	93.2	9.3	4.6	4.8	2.2
The exercises made the lesson entertaining	81.2	77.3	7.1	18.2	11.7	4.5
I could follow the exercises without difficulty	81.2	86.3	10.5	10.3	8.3	3.4
The exercises were interesting	77.7	84.1	12.9	8	9.4	7.9
I liked the exercises very much. If only all the lessons were conducted like this	72.9	65.9	15.3	23.9	11.8	10.3
I followed the exercises without getting bored	65.8	64.8	18.8	26.2	15.4	9

Table 4. The students' opinion about the exercises.

Statements	Strongly agree or agree		Neutral responses		Strongly disagree or disagree	
	Desktop	*Online*	*Desktop*	*Online*	*Desktop*	*Online*
I learned how to use the software with its basic tools	82.3	92	9.4	4.5	8.2	3.4
The visual design of the interface was pleasant	78.8	80.7	5.9	11.3	15.3	8
I believe that I will be able to carry out similar exercises on the same platform easily	78.8	85.2	11.7	11.4	9.5	3.4
The tools/buttons on the platform were usable and understandable	71.8	88.6	15.3	6.8	12.9	4.5
The software was running fast and smoothly, I didn't have to wait while it was processing	70.3	68.2	15.5	14.7	14.2	17.1
The language of the platform was an obstacle for me to learning its tools	17.6	15.9	18.8	10.2	63.6	73.9
There were many tools and buttons on the software. They distracted my attention.	16.5	10.2	15.3	15.9	68.2	73.9
The GIS platform was very technical, so I had difficulty in understanding and using the software	11.8	11.5	17.6	14.9	70.6	73.6
I could not pay enough attention to the exercises, because I was trying to understand how to use the software	9.4	8	14.1	10.2	76.5	81.8

Table 5. The students' opinions about the GIS platform used for the exercises.

Statements	Positive Responses		Neutral responses		Negative Responses	
	Desktop	*Online*	*Desktop*	*Online*	*Desktop*	*Online*
GIS makes students learn by doing; therefore supports effective learning	92.9	87.6	4.7	11.3	2.4	1.1
GIS has not been properly utilized in secondary school geography lessons in Turkey	87.1	84.1	9.3	10.3	3.6	5.6
GIS increases students' success in geography lessons	82.4	88.6	12.9	8	4.7	3.4
GIS should be used in geography lessons as an educational tool	80	73.8	16.5	20.5	3.5	5.7
The potential of GIS for geography lessons is not adequately known in Turkey	80	79.5	14.1	13.6	5.9	6.8
I want to know GIS better and benefit from it	77.7	79.6	16.5	15.9	5.8	4.5

Table 6. The students' opinions about GIS.

3.3 Students' reactions to the open questions

All these positive reactions to using GIS do not mean that the students did not have any problems during the exercises. In an open question at the end of the survey the students were asked if they had any difficulty in the entire application process. In the desktop group 38% of the students and in the online group 15% indicated that they had encountered problems during the exercises. The students who indicated that they had difficulties during the exercises were asked to provide details of the difficulties. The difficulties expressed most frequently were related to the exercises: 18 students in both groups said that the exercises were too long, difficult to follow or boring and 16 students in both groups had difficulties regarding the software and hardware. The language of the software was expressed as a difficulty by 10 students in both groups and another 10 students expressed difficulties regarding the interface of the platform (the tools and buttons were too complex to use).

In another open question the students were asked to provide recommendations for carrying out similar exercises more efficiently in the future. Reactions came from 27 students in the desktop and 19 students in the online group. The biggest group of recommendations were made about the software: 30 reactions said that the software should be made simpler, more attractive, faster, easier and more entertaining. Ten recommendations in both groups focused on the exercises that were too long and needed more interaction between students and lecturer.

4. Conclusions

In line with previous studies (Kerski et al., 2013; Lee and Bednarz, 2009; Lemberg and Stoltman, 2001) this study revealed that desktop and online GIS lessons help to increase students' achievements and interest in geography lessons. As Table 3 shows, the average scores of the students in both groups increased more than 100%. The differences between the desktop GIS and WebGIS group in this experiment are in favor of the desktop group. A closer look at the four participating schools reveals that one of the schools has a strong impact on these results which cannot easily be understood. Looking at the pre- and post-test progression (Table 3) we noted that the desktop group was more successful than the online group. However, when the average test scores were analyzed by schools, a different picture appeared. Only at school D did the desktop group increase its average score more than the online group. The three other schools had low pre-test scores in the online groups which may be part of the explanation for the bigger progression in the online groups in these schools. Further research is necessary to explain the special position of school D and especially the considerable progression of its desktop group.

In addition, this study shows that the students' attitudes to the exercises, GIS platforms, and GIS were positive in both groups. The vast majority of the students found the overall lesson very interesting, useful and entertaining and considered the GIS platform they used for the exercises pleasant and easy to use. With these results the study shows that ArcGIS desktop and ArcGIS online both seem to have a great potential for teaching and learning geography in secondary schools. This study did not show a clear difference between the students' opinions in both groups on overall exercises and GIS as a technology. However, the students' opinions about the GIS platforms they used differed between the groups (Table 5). The students in the online group found the GIS platform less complex, somewhat more usable and more understandable than their counterparts in the desktop group. This is consistent with the findings of other studies that WebGIS platforms have simple interfaces and tools and are thus more user friendly and less intimidating to use than desktop GIS software (Baker, 2005; Henry and Semple, 2012).

The study learns that both GIS platforms have potential to be used in secondary school geography lessons as an educational tool. It was a pity that the experiment could not be made in a school class but only in a university GIS laboratory. Further research should try to realize a classroom setting in more comparable schools with students' own geography teachers as instructors. However, using GIS in classrooms is not without challenges. The preparation of GIS lessons is not always easy. In this study the researchers invested a lot of energy and time before the exercises could be started. The key question in understanding a successful incorporation of GIS platforms into geography classrooms seems to be: to what extent will teachers be willing to spend time and energy to use GIS platforms in lessons successfully? Unless we provide teachers with more time and resources, we are not likely to see desktop GIS or WebGIS as a common tool in classrooms in the near future, no matter how advanced and sophisticated the platforms are.

Although the effect of working with desktop GIS or WebGIS in this study was not pronounced, this study gives some support for the idea that WebGIS is easier to handle in education than desktop GIS. For both GIS platforms it is important to develop teacher proof and student proof versions. To solve many software related problems of GIS platforms in schools, professional GIS software companies need to be encouraged to develop platforms by taking teachers and students' needs into consideration. Recommendations for developing GIS platforms for schools should include the next focus points: easy access, user friendliness, attractive by offering huge amounts of updated data and analyzing tools as well as information about different user strategies. Last but least the success of learning with GIS stands or falls with teacher training (Lay et al., 2015). The pedagogical use of GIS platforms should be emphasized especially for teaching with GIS in K12 education, while the teaching about technology should be minimized (Henry and Semple, 2012).

Acknowledgements

This work was supported by the Scientific Research Fund of Fatih University under the project number P51061303-Y. The Authors are grateful to Prof. Joop van der Schee, VU University Amsterdam, for his support to get this article published.

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