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# Impacts of GIS based materials in teaching relationship between faults and earthquakes in Turkey

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**Abstract**

The main objective of this experimental study was to reveal the importance and effectiveness of the Geographic Information Systems (GIS) based materials in the course of the earthquake topic to high school 10th grade students. The selected topic of the study was "The relationship between faults, plate movements and earthquakes in Turkey". The study was designed according to the pretest-posttest control group pattern. For this purpose, two homogeneous classes with 20 students each were selected via convenience sapling method in Çamardı 75th Year Martyr Lieutenant Mehmet Erdem Multi-Programme Anatolian High School in Niğde province of Turkey. One of the classes was considered as the experimental group and the other control group. The data were collected using a multiple-choice test comprising 27 questions developed in line with the Geography Education Curriculum of the Ministry of Education by the researchers. Within the content of the study; following the pretest, the control group was taught via conventional method and materials. And the experimental group was taught utilizing the materials prepared by GIS with ArcGIS 10.2 software indicating the relationship between the distribution of active faults and historical earthquakes (with magnitudes 5 and more) in Turkey. After posttest, the data obtained were analyzed through t-test in SPSS 22.0. The results revealed that the experimental group had higher score than the control group, which showed the significant effect of GIS based materials on student success. It was also determined that GIS based activities significantly increased the achievement level of the students compared to the conventional methods, and GIS platforms had significant potential in secondary school geography courses as an effective educational tool.

***Keywords:*** Geography education; GIS based materials; earthquake; fault



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## 1. Introduction

### *1.1. Background and Overview*

Turkey continues to witness many devastating earthquakes from the past to the present as a result of the active faults. In the tectonic structure of Turkey, located in the Alpine-Himalayan clench belt, it is possible to see the influence of Paleo and Neo-Tethys systems (Şengör, 1980; Şengör & Yılmaz, 1981). The most severe and destructive earthquakes occurred along the North Anatolian Fault, East Anatolian Fault and West Anatolian horst-graben systems, which determine the active tectonics of Turkey (Ketin, 2005).

Turkey has been subjected to many devastating earthquakes throughout history that have led to the loss of life and property due to active tectonics. While the moderate and severe earthquakes reveal the fact of seismicity of Turkey, they also indicate information about what to do before, at the moment of the earthquake, after the earthquake that should be taken into consideration crucially.

The subject of earthquakes is addressed within the curriculum especially in the way the constructivist approach according to the principles of critical and creative thinking, empathy, problem solving, decision making and information technology skills (CDÖP, 2005). The students should be taught the subject of earthquakes and faults in a cause and effect relationship by taking the student to the center of learning. The changes in the national curriculum in 2018 were mainly designed to encourage more constructivist approaches and methods to be used in classrooms, such as problem based, inquiry based, and student centered education strategies (CDÖP, 2018). The most important and powerful argument for incorporating GIS into the curriculum is its ability to enhance spatial thinking skills. Although GIS is an increasingly important part of geography programs in higher education, it is rarely used as a teaching technology, that is, there is a great deal of instruction about GIS, but little instruction with GIS (Bednarz, 2004). It is hoped that this study will encourage the readers to pursue avenues of research and development to take advantage of GIS and method to improve the quality of education (Kırıcı, 2019). In the context of the study, achievements related with earthquakes and disasters in the geography course curriculum prepared by the Ministry of Education were arranged in Table 1 (CDÖP, 2018).

Table 1. Achievements related with earthquakes and disasters in the geography course curriculum (CDÖP, 2018)

| |
|---|
| 10.1.2. Explains the features of geological times by associating them with tectonic events. |
| b. The geological history of Turkey is mentioned while the features of geologic time scale are given. |
| c. Tectonism of Turkey is explained. |
| 10.1.5. Explains the effect of internal forces on the formation process of landforms in Turkey. |
| The relationship between faults, plate movements and earthquakes in Turkey is given. |
| 10.4.1. Explains the causes and characteristics of disasters. |
| Examples of using GIS and other spatial technologies are given in solving geographical problems. |
| 10.4.2. Correlates the effects of disasters with their distribution. |
| 10.4.3. Relates the distribution and effects of disasters in Turkey. |
| 10.4.4. Explains disaster prevention methods. |
| a. Applications against natural disasters are given in different countries. |
| b. In our country, the importance of creating consciousness against disasters, especially earthquakes, is emphasized. |
| c. It addresses the responsibilities of individuals in the process of disaster occurrence. |

Source: Geography course curriculum (2018).

The main objective of the research is to reveal the importance and effectiveness of the Geographic Information Systems (GIS) based materials in the course of the earthquake topic to the students of high school of 10th grade with regard to the achievement of the curriculum. The study demonstrates that application of a GIS based practice in a classroom with one teacher and one computer can also be an effective teaching and learning method in geography (Kırıcı, 2019).

The sub-objectives of the problem are given below.

i. To determine the difference in student success between pretest and posttest in the experimental group where GIS based materials are implemented.

ii. To determine the difference in student success between pretest and posttest in the control group where conventional method and materials are utilised.

iii. To identify the effect of GIS based materials on student success.

### *1.2. Use of Geographic Information Systems in Geography Education*

GIS is a way of displaying and analyzing spatially referenced information which is used in education, industry and government to aid decision making and planning. Spatial thinking and analysis are essential in geography education. Kerski (2003) explained that GIS has simplified the processes of analyzing and presenting geographic information and has improved geographical inquiry in the classroom. Using GIS develops high level analytical and synthetic thinking. Besides, GIS supports students' geographical skills by improving spatial thinking ability.

The use of GIS enables large volumes of data to be readily and routinely incorporated into learning sequences. Using GIS provides a way of exploring not only a body of content knowledge, but also provides a way of thinking about the world (Bednarz, 2004; Kerski, 2008). The extensive range of real world data available for analysis through GIS enables students to study cultural and physical environments at a much broader range of scales than through standard classroom methods (West, 2003). GIS also helps students to learn geography by practicing spatial thinking such as associating and correlating spatially distributed phenomena and enhancing cognitive mapping skills such as assessing similarity and proximity (Kerski, 2000; 2001).

The use of GIS in school geography not only encourages intrinsic motivation by satisfying the conditions needed for optimal learning (West, 1998), it better positions geography within the school curriculum (Naish et al 1987). The use of collaborative GIS contains great potential to move students quickly beyond the practice of mapping where things occur and immediately launches them into determining why things occur (Baker & White, 2003).

Therefore, the recent revisions of the national curriculum and examination criteria for geography have made specific mention of the use of GIS. The changes in the national curriculum in 2005 were designed to assure constructivist approaches and methods to be used in classrooms, for instance problem based, inquiry based and student centered education strategies (Karabağ & Şahin, 2007). GIS can be used at different levels of improvement, from producing a simple map to complex spatial analysis, etc. GIS is undoubtedly a powerful tool for geographic analysis and a valuable resource to teach geography and spatial thinking (Bednarz & Van der Schee, 2006). Because GIS promotes students' geography skills and leads to more dynamic learning in geography, thus enhancing students' achievement. Various studies conducted focused on the mentioned significant impacts of GIS on students' achievement by using pretest and posttest revealed significant difference in the favor of the GIS-trained groups (Patterson et al., 2003; Liu et al., 2010; Kaya, 2011; Yurdam, 2013).

Unfortunately, despite the potential of GIS in secondary school geographic education, its use is not widespread throughout the world today. According to Lloyd (2001), the adoption of the use of GIS in secondary education are related to three major obstacles: i) technical factors such as the availability of hardware, software and data, ii) lack of teacher training and curriculum materials, iii) systemic issues that encourage or discourage innovation in education.

This study wants to draw attention to the implementation of GIS based materials in a classroom with only one teacher and one computer as an effective teaching and learning method. What this study demonstrates are: GIS based applications can indeed be applied in classrooms by teachers even when there is no computer laboratory available for geography lessons and this method can even contribute significantly to the student success.

## 2. Method

### *2.1. Research Design*

This research is designed according to the pretest-posttest control group pattern in order to determine the effectiveness of the experimental process applied. In the study, the experimental and control groups are similar to each other and randomly selected and the research pattern is organized as a semi-experimental pattern (Büyüköztürk et al., 2018).

In this study, in the explanation of the achievement of the geography course of the 10th grade of secondary education as “the relationship between faults, plate movements and earthquakes in Turkey is given.”, experimental and control groups were determined to test the effectiveness of course teaching with GIS based materials on student success. While the course was taught with maps prepared in ArcGIS 10.2 software in the experimental group, traditional teaching method was performed in the control group. The dependent variable of the research is the academic success of the students, and the independent variable is the course taught using GIS based materials and the traditional teaching method.

### *2.2. Study Group*

As the universe of the research; Nigde province, Çamardı District, 75th Year Martyr Lieutenant Mehmet Erdem Multi-Programme Anatolian High School of 2018-2019 academic year, 10th grade students in secondary education was selected (Kırıcı, 2019). A total of 40 students studying in the 10th grade of the school formed the experimental and control groups. 20 students took part in the experimental and the control groups, respectively.

### *2.3. Data Collection*

In the first stage of data collection, a multiple choice test consisting of 35 questions were prepared to be used in the knowledge testing (Kırıcı, 2019). 8 questions were eliminated after the detailed evaluation of the specialists in their fields (2 academicians, 2 geography teachers and 1 assessment and evaluation expert working in the Ministry of Education). Then, remained 27 questions were decided for the knowledge testing. The most reliable way to ensure coverage validity is to use a specification table (Büyüköztürk et al., 2018). Therefore, a statement table was prepared showing the degree to which the subjects covered by the research in the ratio of their weight and importance are included in the measurement tool. A pilot application of multiple choice test consisting of 27 questions was conducted in the school of application before the research. After the pilot application, it was observed that there was no need to make any changes in the questions (Kırıcı, 2019).

The students were informed about GIS before the practice by geography teachers. Since the school did not have a GIS laboratory, the students did not have the opportunity to see any GIS software. ArcGIS 10.2 was introduced to the students and encouraged to use it by providing them with the opportunity for application during the practice.

After the application of the pretest consisting of the same test questions to both classes, “10.1.5. In Turkey, the relationship between faults, plate movements and earthquakes is given." achievement in the 10th grade geography curriculum was described through a textbook and wall map using traditional methods in the control group. The same subject was explained with GIS based material after the pretest in the experimental group. The course of the experimental group was given with the distribution map of active faults in Turkey prepared in ArcGIS 10.2 by demonstrating the related layers at first (Figure 1).

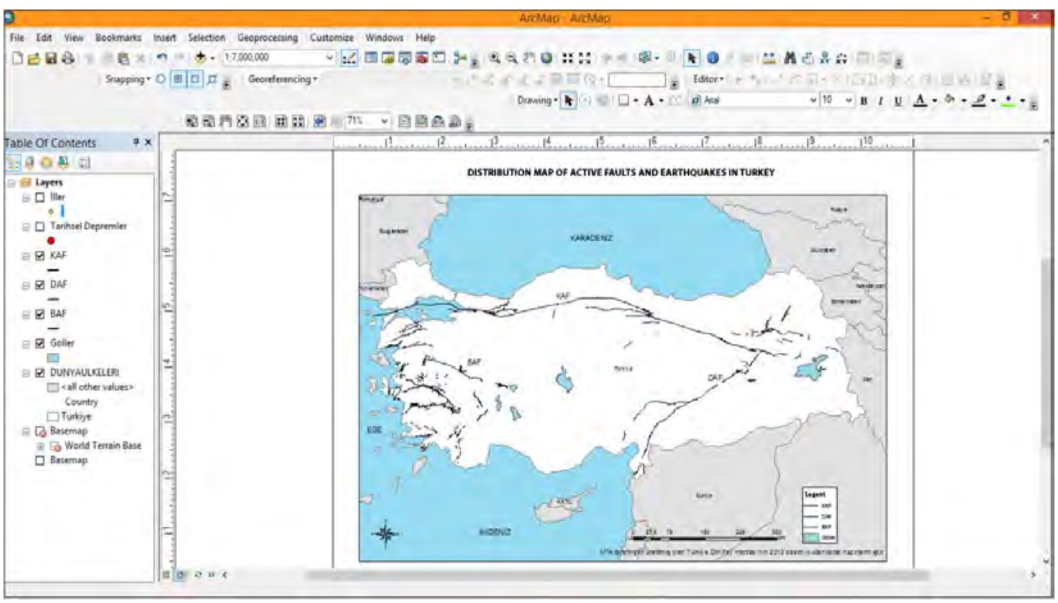


Figure 1. Distribution map of active faults in Turkey

Then, the layer of the city centers was activated with the active fault layers (KAF, DAF, BAF) in order to discuss with the students whether the active fault lines passed through the residential areas (Figure 2). After the end of the course, students were asked oral questions to create an interactive sharing environment.

The questions raised are given below:

1. What are the characteristics of the locations where the active fault lines pass through? Please answer.
2. Is there a relationship between active fault lines and earthquakes? Please explain.
3. What are the important industrial cities located on the active fault lines?
4. What are the disadvantages of settling on active fault lines? Please explain.
5. Do you live in a city settled on an active fault line?

The related map on the screen is removed while the students answering the questions. The students' motivation is increased by this way, and at the same time, permanent trace learning is aimed through the use of GIS (Kırıcı, 2019).

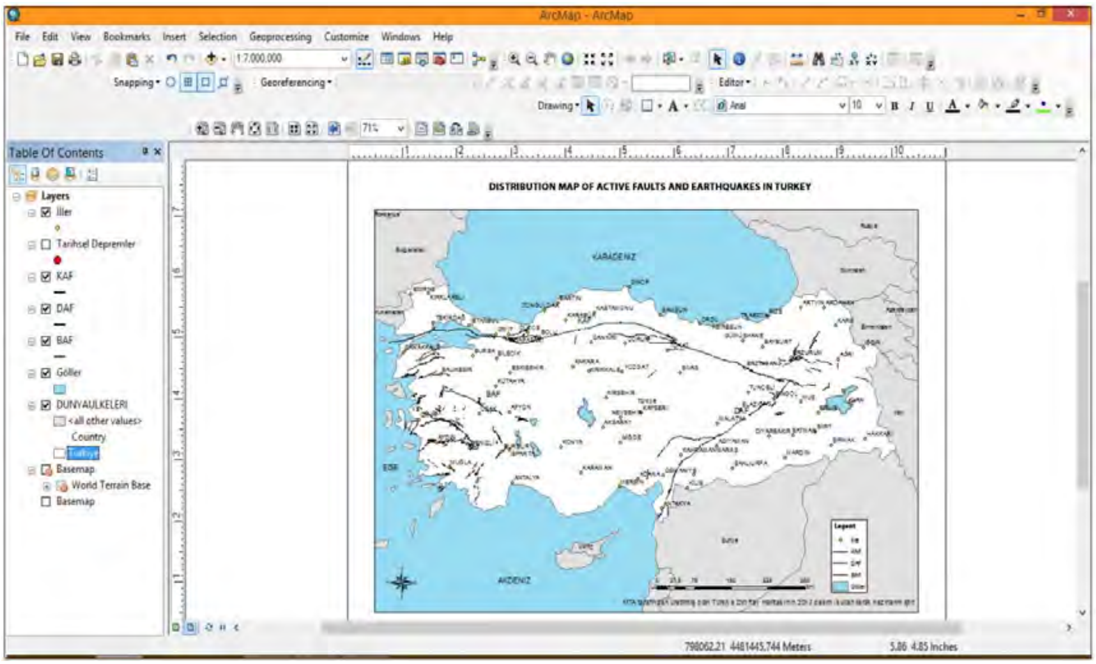


Figure 2. Distribution map of active faults and the location of city centers in Turkey

After the evaluation of the distribution of active fault lines and city centers by students, the layer of the historical earthquakes with magnitudes of 5.0 and higher that had occurred in Turkey since 1900 to the present day was activated (Figure 3). The students easily noticed the direct relation between the distribution of the active faults and the historical earthquakes occurred.

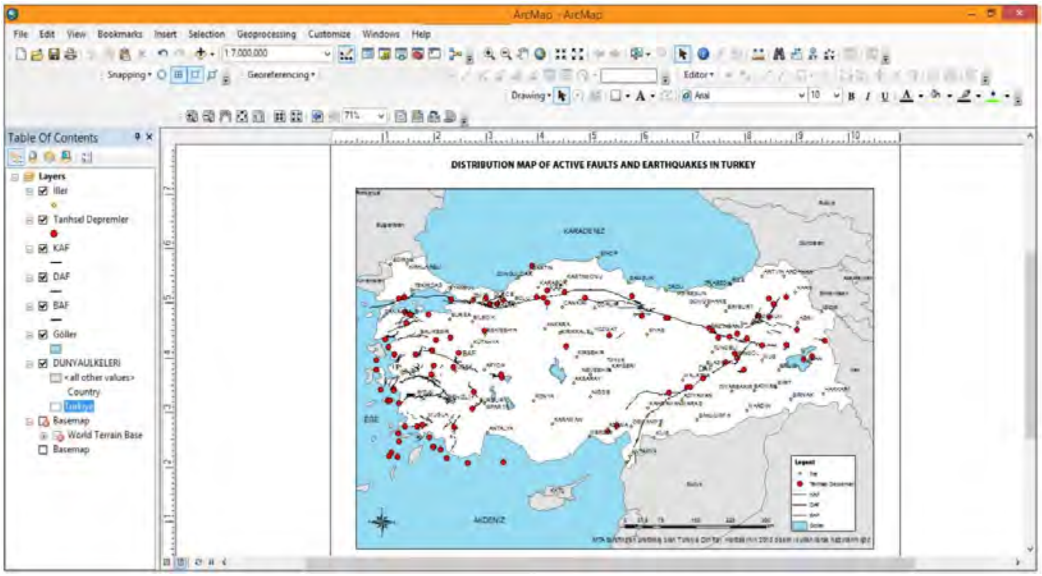


Figure 3. Distribution map of active fault lines and the historical earthquakes (magnitude 5 and above) in Turkey

The database information entered about historical earthquakes (magnitude 5 and above) is shown by using the "identify" feature in Figure 4 (example of Van earthquake). At this stage, each student was asked to query any historical earthquake point data and share the database information with the class and discuss the related earthquake occurred on which active fault line. The students' participation in the course and active use of the ArcGIS software were ensured in this manner.

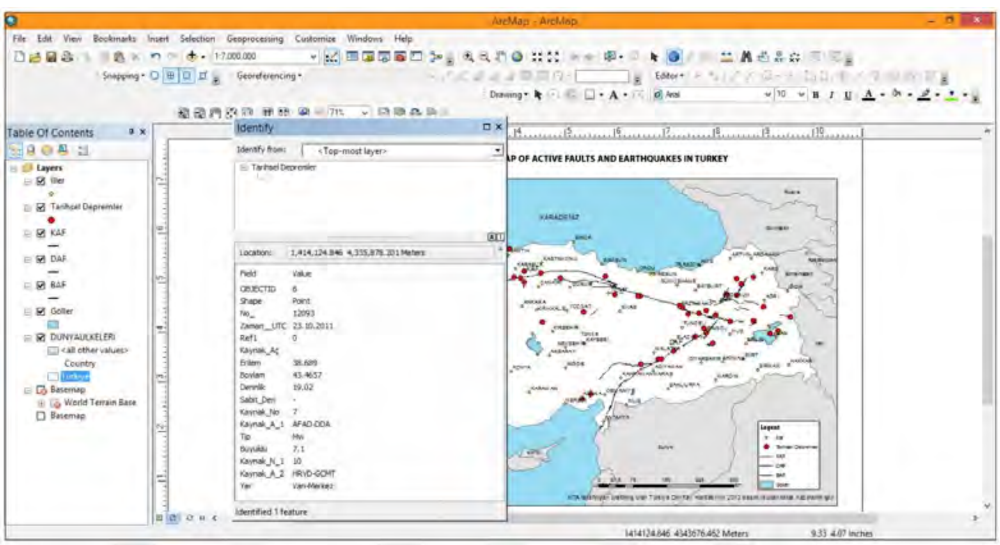


Figure 4. Query of the historical earthquake (magnitude 5 and above) data with "identify" feature, example of Van earthquake

Finally, the posttest was applied to the students after the explanation of the subjects in 6 hours. The effect of the courses on student success in experimental and control groups was tried to be revealed with the posttest.

### *2.4. Data Analysis*

The related samples t-test was used for repeated measurements if assumptions were made to reveal the effectiveness of the experimental process, and the unrelated samples t-test for unrelated samples was used for the comparison of the experimental and control groups (Kırıcı, 2019). SPSS 22.0 (Statistical Package for the Social Sciences) was used for the data analysis. One of the methods used to determine the effect of the experimental process applied in the research is the difference analysis method based on increase/variation scores. In this method, the difference (increase/variation) between the pretest and posttest scores of the participants is calculated and the difference scores obtained are compared according to the experimental and control groups (Büyüköztürk, 2016). In order to determine the method (parametric/nonparametric) to be used in hypotheses testing, the distributions of the assessment results obtained in the study were examined. The findings are given in Table 2.

Table 2. Findings on the distribution of participants' success scores

| Group | Tested | N | Skew Coefficient | Kurtosis Coefficient |
|---|---|---|---|---|
| Experimental | Pretest | 20 | 1,24 | 1,11 |
| | Posttest | 20 | 0,59 | 0,51 |
| Control | Pretest | 20 | 1,16 | 0,70 |
| | Posttest | 20 | 1,03 | 0,39 |

The results are given for the distribution of the success scores obtained from participants in the research group in Table 2. According to the results, the skew coefficient values range from 0.59 to 1.24 and the kurtosis coefficient values range from 0.39 to 1.11. The variation in the skewness and kurtosis coefficient between -2 and +2 is generally interpreted as normal distributions (Hair et al., 2010).

Since the distribution is normal, parametric methods were used in the analysis. Therefore, an unrelated samples t-test was conducted in the independent measurements. While interpreting the results obtained from statistical tests utilised in the study, 0.05 significance level was taken into account.

In order to provide evidence for the reliability of the measurement results obtained from the success test used in the study, the reliability coefficient KR-20 (since it is rated as 0 and 1) was calculated. The findings are given in Table 3.

Table 3. Results on the reliability of scores obtained from the success test

| Success Test | N | Item Number | KR-20 |
|---|---|---|---|
| Pretest | 20 | 27 | 0,77 |
| Posttest | 20 | 27 | 0,82 |

The reliability coefficient of KR-20 for the measurement results obtained from the success test was 0.77 for the pretest and 0.82 for the posttest (Table 3). These values show that the scores obtained from the success test have a good level of reliability.

## 3. Results, Discussion and Conclusion

In this section, detailed information will be given about the results obtained in the research. Below are the unrelated samples t-test findings of the difference between the success pretest scores of the experimental and control groups in Table 4.

Table 4. Unrelated samples t-test results of the comparison of the success pretest scores of the experimental and control groups

| Group | N | $\bar{X}$ | Sx | Sd | t | p |
|---|---|---|---|---|---|---|
| Experimental | 20 | 35,34 | 18,92 | 38 | 1,38 | 0,308 |
| Control | 20 | 29,79 | 14,82 | | | |

The experimental group's pretest score average (35.34) was higher than the control group's pretest score average (29.79) in Table 4. This difference is not statistically significant ($t_{38}$=1,38; p=0,308>0,05). The results show that the pretest scores of the experimental and control groups are similar in terms of measured feature.

The descriptive results of the success pretest and posttest scores of the experimental and control groups within the scope of the research are given in Table 5.

Table 5. Descriptive analysis of success pretest and posttest scores of experimental and control groups

| Group | N | Pretest | | | | Posttest | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Min. | Mak. | $\bar{X}$ | Sx | Min. | Mak. | $\bar{X}$ | Sx |
| Experimental | 20 | 11,10 | 85,10 | 35,34 | 18,92 | 40,70 | 100 | 65,49 | 16,11 |
| Control | 20 | 11,10 | 66,60 | 29,79 | 14,82 | 25,90 | 70,30 | 38,30 | 12,78 |

The average of the pretest score of the experimental group was $\bar{X}$ = 35.34 and the standard deviation was Sx=18.92; whereas the average of the pretest score of the control group was $\bar{X}$ =29.79 and the standard deviation was $S_X$=14.82 (Table 5). Considering the posttest scores; while the average of the posttest score of the experimental group was

$\overline{X}$ =65.49 and the standard deviation was Sx=16.11, the average of the posttest score of the control group was $\overline{X}$ =38.30 and the standard deviation was Sx=12.78.

In order to determine the effect of the experimental process in the study, the score variations of the experimental and control groups to the pretest and posttest were calculated separately. An unrelated samples t-test was performed to test whether the difference scores obtained significantly changed according to the experimental and control group (the effect of the experimental process). The findings are given in Table 6.

Table 6. Unrelated samples t-test results for the comparison of the success score variations of experimental and control groups from pretest to posttest

| Group | N | $\overline{X}_{difference*}$ | Sx | Sd | t | p |
|---|---|---|---|---|---|---|
| Experimental | 20 | 30,16 | 8,84 | 38 | 8,53 | 0,000* |
| Control | 20 | 8,51 | 7,11 | | | |

Note: * p<0,05

The average difference of the experimental group's score increment from the pretest to the posttest was $\overline{X}_{difference}$ =30.16, whereas the average difference in the control group's score increment from the pretest to the posttest was $\overline{X}_{difference}$=8.51 (Table 6). This resulting difference is statistically significant (t38=8,53; p=0,000<0,05). The results show that the experimental process applied is effective in increasing students' success levels. In other words, in teaching the students about the relationship between the active fault lines and historical earthquakes (magnitude 5 and above) in Turkey, explanation of the course with GIS based materials is an effective tool in increasing the students' success status in geography.

The experimental effect variation by gender was tested within the scope of the research. For this purpose, the success score increments of the students in the experimental group from the pretest to the posttest were compared by gender. The findings are given in Table 7.

Table 7. Unrelated samples t-test results of the comparison of the score variations of students in the experimental group from the pretest to the posttest by gender

| Group | N | $\overline{X}_{difference*}$ | Sx | Sd | t | p |
|---|---|---|---|---|---|---|
| Girl | 10 | 29,23 | 9,46 | 18 | -0,46 | 0,652 |
| Man | 10 | 31,08 | 8,58 | | | |

Note: p<0,05

While the average difference in the score increment of the experimental group from the pretest to the posttest was $\overline{X}_{difference=}$ 29.23 in female students, the average difference in the score increment from pretest to posttest is $\overline{X}_{\text{difference}=}$ 31.08 in male students (Table 7). This difference is not statistically significant (t= -0,46; p=0,652>0,05). The results show that the effect of the experimental process applied is similar in male and female students.

In line with the previous studies (Patterson et al. 2003; Liu et al. 2010; Kaya 2011; Yurdam 2013), this study demonstrates that GIS helps to increase students' achievements and interest in the geography courses. The results of the study show that the experimental process applied is effective in increasing students' success levels. In other words, in teaching the students about the relationship between the active fault lines and historical earthquakes (magnitude 5 and above) in Turkey, explanation of the course with GIS based materials is an effective tool in increasing the students' success status in geography.

The study also states that GIS based practice is helpful for students to learn about GIS even if it is applied in a classroom with only one teacher and a computer. The study carried out is also important in terms of acquiring skills for problem solving through active learning and multidimensional thinking. Therefore, it is hoped that the findings of this study will be promoted and will inspire teachers to integrate GIS into their courses.

Nowadays, teachers can find easily GIS software, hardware, digital data and can integrate GIS in their course plans. In spite of the positive improvements, the usage of GIS in secondary education is still unsatisfactory. Then, it is essential to encourage teachers with the implementation of GIS projects into their course plans. Unfortunately, the successful integration of GIS into secondary education requires sufficient hardware, software, data, pre-service and in-service training and additional necessary courses in higher education. Therefore, informing and encouraging decision-makers especially working in the Ministry of National Education and General Directorates of National Education to take important steps to develop more efficient strategies for integrating GIS into schools is essential.

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The second author declares that the article has been generated from her M.A. thesis on teaching the relationship between faults and earthquakes in Turkey but the main researcher of the article is her supervisor who is the first author of the article.

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