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PERCEPTION OF SPATIAL VARIATION IN ACTIVITIES PREPARED BY GIS IN GEOGRAPHY EDUCATION

(Research article)

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Abstract

In this study, it is aimed to give students the ability to perceive spatial variation and to reveal the impact of the activities on students' course success by using Geographical Information Systems (GIS) in geography education. The study group consisted of a total of 60 students attending to the 10th grade of secondary school in 2018-2019 academic year. The particiants were selected via appropriate sampling method in Berat Hayriye Cömertoğlu Anatolian High School in Alanya district of Turkey. In this quantitative study, pretest-posttest quasi-experimental research model was used. The courses were taught with traditional methods and GIS based activity techniques for the control and experimental groups, respectively. The data were collected using subject achievement test prepared by the researchers in accordance with the expert opinions in the field. At the end of the posttest, data were analyzed by performing t-test in SPSS 22.0. As a result, it was determined that the courses taught with GIS based activities gave students a higher level of perception of spatial variation skills compared to the courses taught with traditional methods. Also, it was clarified that the students in the course which were taught with GIS based activities were more successful.

Keywords: geographic information systems, spatial variation, geography education, GIS based activity

1. Introduction

GIS is an inevitable tool for extending student learning, when a suitable educational framework is provided in data analysis and spatial reasoning concepts. Also, teacher information technology based training is a crucial component in the successful teacher's application of GIS in the secondary education (Kerski, 2000). There are two important and complementary justifications for integrating GIS in secondary education: i) the educative justification: GIS and its theoretical and practical superstructure, GIS encourages teaching and learning of geography, and ii) the workplace justification: GIS is an interdisciplinary essential tool for many fields. Nowadays, the integration of GIS in secondary education has increased after several studies stated that GIS is also an educational tool rather than an information technology and contributes to generating an inquiry based learning environment (White & Simms, 1993).

Sui (1995) points out two different aspects of GIS education: "teaching with GIS" and "teaching about GIS". The purpose in "teaching with GIS" is to allow students to learn about geography and gain geographic skills by using GIS as an effective educational tool. The purpose in "teaching about GIS" is basically to teach GIS technologies and applications. The final decision between the educators focuses on "teaching with GIS" in geographic education.

However, GIS has been a significant contribution to help students to develop spatial thinking skills (Goodchild & Palladino, 1995; Patterson, 2003). The most valuable and powerful assertion for integrating GIS into the curriculum is its ability to enhance spatial thinking skills for geographic educators. For example, the National Geography Standards (1994) in the United States motivated and supported the inclusion of GIS in geography education, emphasizing that GIS could be used to develop students' geographic skills and ability to think spatially (Bednarz & Schee, 2006). There are three dimensions of spatial thinking: spatial visualization, spatial orientation, and spatial relations. The spatial relations, listed in Table 1, are the aspects of spatial thinking most often developed in geography classes (Golledge & Stimson, 1997).

Table 1. *Spatial thinking skills (Golledge & Stimson, 1997)*

Spatial Relations	Processes Used in Cognitive Mapping and GIS
Abilities (skills) that recognize spatial distribution and spatial patterns	Constructing gradients and surfaces Layering
Identifying shapes	Regionalizing
Recalling and representing layouts	Decomposing
Connecting locations	Aggregating
Associating and correlating spatially distributed phenomena	Correlating Evaluating regularity or randomness
Comprehending and using spatial hierarchies	Associating
Regionalizing	Assessing similarity
Comprehending distance decay and nearest neighbor effects in distributions (buffering)	Forming hierarchies Assessing proximity (requires knowing location)
Wayfinding in real world frames of reference	Measuring distance Measuring directions
Imagining maps from verbal descriptions	Defining shapes
Sketch mapping	Defining patterns
Comparing maps	Determining cluster
Overlaying and dissolving maps (windowing)	Determining dispersion

Cognitive maps are the basis of both spatial and non-spatial decision-making. They are produced by the interaction of spatial relational data, spatial thinking processes, and environmental attributes as filtered through perceptions, beliefs, values, and attitudes. It has been suggested that cognitive maps are an internalized geographic information system. Therefore, it is regarded as GIS supports students to learn geography by practicing spatial thinking such as linking and correlating spatially distributed data and developing cognitive mapping skills such as examining similarity and proximity (Lee & Bednarz, 2009).

Unfortunately, GIS has been slow to disseminate into secondary education (Bednarz & Ludwig, 1997; Audet & Ludwig, 2000). The reasons are related with technical factors such as software, hardware, related data requirement and inefficacy of teacher training and curriculum materials. Additional drawbacks emphasized in other studies are the lack of time available to teachers for conducting GIS based activities (Kerski, 2003) and unwillingness of teachers to discover and practice new technologies and insufficient consideration for GIS within the curriculum (Bednarz, 2004). Also, Bednarz & Ludwig (1997) pointed out that one of the most important obstacles of GIS dissemination was the lack of curricular connection between showing students how to use GIS and teaching geography with GIS. Hence, there is a great deal of instruction about GIS, but little instruction with GIS.

In view of Turkey, a new secondary school geography curriculum was constructed in 2005 with a strong emphasis on information communication technologies (CDÖP, 2005). GIS is included as an important teaching tool for activity planning in the new curriculum. The teachers are also motivated to introduce GIS in the classrooms with the available hardware, software and data (Karabağ & Şahin, 2007). In 2018, national curriculum is arranged in order to support more constructivist approaches and methods consisting of problem based, inquiry based, and student centered education strategies (CDÖP, 2018). The curriculum basically aims to gain the map skills (spatial distribution detection, accurate map interpretation content) and ability to perceive variation and continuity (finding similarities and differences, perceiving variation and continuity over time, sensing variation and continuity in space, questioning the causes of variation and continuity in geographical processes, the necessity of spatial decision making and analysis for geography). The most significant factor for integrating GIS into the curriculum is its ability to develop spatial thinking skills.

Several studies strongly emphasized on the importance and contribution of GIS to secondary education so far (Kemp et al., 1992; White & Simms, 1993; Lemberg & Stoltman, 2001; Kerski, 2003; Wigglesworth, 2003; Wilder et al., 2003; Bednarz, 2004). This study mainly focuses on to present a guide to give students the ability to perceive spatial variation and to reveal the impact of the activities on students' course success by using GIS in geography education. A statistically significant increase in students' success and spatial awareness was documented.

2. Method

2.1. Research Design

In this quantitative study pretest-posttest quasi-experimental research model was used to give students the ability to perceive spatial variation and to assess the impact of the activities on students' course success by using Geographical Information Systems (GIS) in geography education.

The courses were taught with traditional teaching methods and GIS based activity techniques for the control and experimental groups, respectively. While the course was taught with activities prepared in ArcGIS 10.2 in the experimental group, traditional teaching method was utilized 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 activities and the traditional teaching method. In the research model, both groups are assessed before and after the experiment under equal conditions (Karasar, 2020).

In this quantitative study pretest-posttest quasi-experimental research model was used. The data were collected with the help of the subject achievement test prepared by the researchers in accordance with the expert opinions in the field. At the end of the posttest, data were analyzed by performing t-test in SPSS 22.0. As a result, it was determined that the courses taught with GIS based activities gave students a higher level of perception of spatial variation skills compared to the courses taught with traditional method in geography teaching. Also, it was clarified that the students in the course which were taught with GIS based activities were more successful.

2.2. Study Group

As the universe of the research; Antalya province, Alanya District, Berat Hayriye Cömertoğlu Anatolian High School of 2018-2019 academic year, 10th grade students in secondary education was selected (Baysal, 2019). A total of 60 students studying in the 10th grade of the school formed the experimental and control groups. 30 students took part in the experimental and the control groups, respectively. Appropriate sampling method was used in the selection of the students participating in the study. This method is one of the methods commonly used in the social sciences (Büyüköztürk, 2016).

2.3. Data Collection

The subject success test (multiple choice type) consisting of 32 questions prepared by the researchers was used as a data collection tool of the research (Baysal, 2019). 7 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). After the expert opinions and pilot implementation, remained 25 questions were decided for the knowledge testing.

In order to create the maps that will be used in the GIS based activities, the population data for the years 1980 and 2018 in Alanya district was obtained from the Turkish Statistical Institute (TSI). The land use data is provided by Alanya municipality development plans, Landsat satellite images for 1980 and 2018, and 1/25 000 topographic maps of General Directorate of Mapping (GDM). Also, Google Earth Pro, Google Earth Engine Time Lapse technologies and, where necessary, on-site land observations have been utilized. Alanya is selected as a study area due to the rapid increase in the population after 1980 (Table 2). It will be easy to observe the historical variation of population related with the socioeconomic activities. Alanya experienced significant changes in population and land use pattern with urbanization between 1980 and 2018 (Baysal, 2019).

Table 2. *Population of Alanya*

Years	1980	1985	1990	2000	2007	2018
Total Population	74.148	87.080	129.936	264.240	226.236	312.319
Urban Population	22.190	28.733	52.460	88.346	91.713	312.319

Source: TSI population statistics (http://www.tuik.gov.tr)

At first, the students were informed about GIS and its components and usage areas before the practice by the geography teachers. After the application of the pretest consisting of the same test questions to both classes, "10.2.6. In Turkey, the historical process of population is evaluated in terms of social and economic factors." achievement in the 10th grade geography curriculum was described through a textbook using traditional methods in the control group. The distribution and variation of population in Turkey and the structural characteristics of the Turkish population are the covered topics in the course. The same subject was explained with GIS based activities 1, 2, 3 and 4 after the pretest in the experimental group (Figures 1-7), (Baysal, 2019).

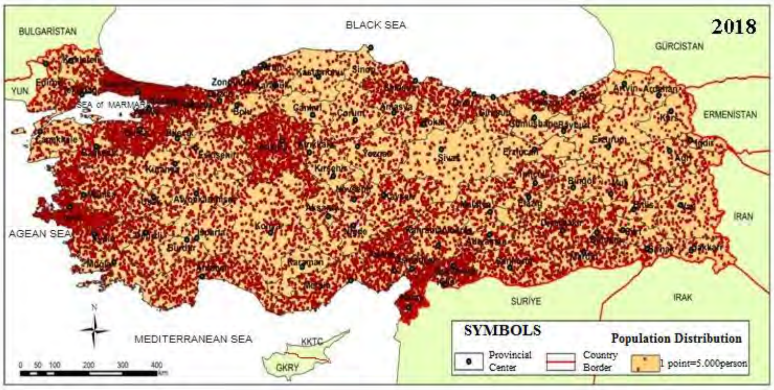
In Activity 1, the population density maps of Turkey for 1980 and 2018 were prepared to use in teaching population variation and population distribution in Turkey. In Activity 2, urban and rural population distribution maps of Turkey in 1980 and 2018 were produced in order to perceive the variation related to the rural and urban population structure of Turkey changing over time within the context of the topic of structural characteristics of the Turkish population. The maps of the years 1980 and 2018 were generated so that students can easily observe and compare the historical variations in order to be suitable for both achievement and to gain the ability to perceive spatial variation.

By using the population data from TSI, the distribution of the population on a provincial basis was formed by point density method. Each point was set to show 5 thousand people in the study. Activity 1 was prepared with the help of the questions aimed at distinguishing the similarities and differences between the population distribution maps of Turkey in 1980 and 2018 (Figure 1). This activity was used in teaching the topics of population variation and population distribution in Turkey.

Activity 2 within the framework of structural characteristics of the Turkish population was implemented with the rural and urban population density maps of 1980 and 2018 and related questions raised for making query during the course (Figures 2-4). In order to create the maps, rural and urban population values of the provincial populations of Turkey for 1980 and 2018 taken from TSI were transferred to the polygon data, so that the rural and urban population amount of each province is separate. In this way, the distribution of rural and urban population on a provincial basis is formed by point density method.

ACTIVITY 1

Map 1



Map 2

Map 1, 2 given above show the changes in population distribution in Turkey between 1980 and 2018.

1.What changes are observed in Turkey's population distribution between these years? Is the population evenly distributed ? Please explain.

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2. Round up the areas where the population is concentrated in different years and write down where it is.

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3. Write down the factors affecting the distribution of the population based on areas where the population is frequent and sparse.

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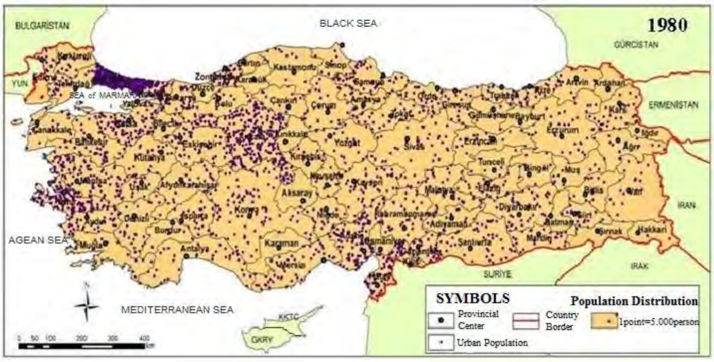
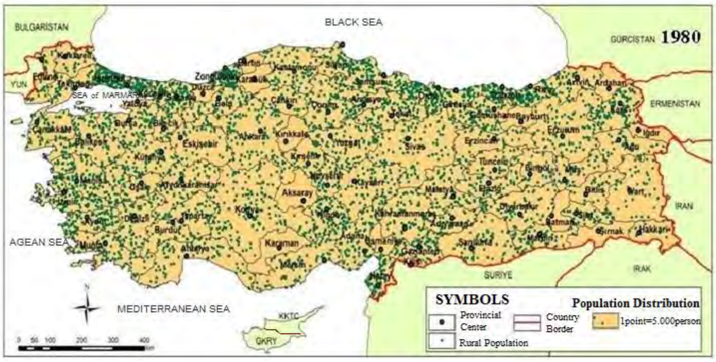
Figure 1. Activity 1: The population distribution maps of Turkey in 1980 and 2018

ACTIVITY 2



Map 1



Map 2

Map 1, 2 given above show the distribution of urban and rural populations in Turkey in 1980, respectively.

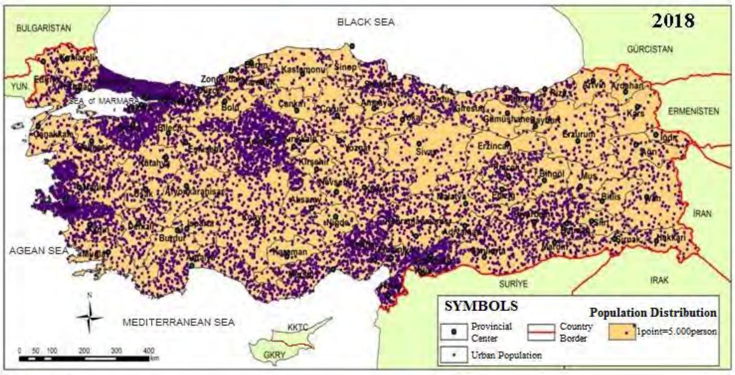
1. Urban and rural population distribution of Turkey in 1980;

- Population with a higher density ↓ Causes →
→
→

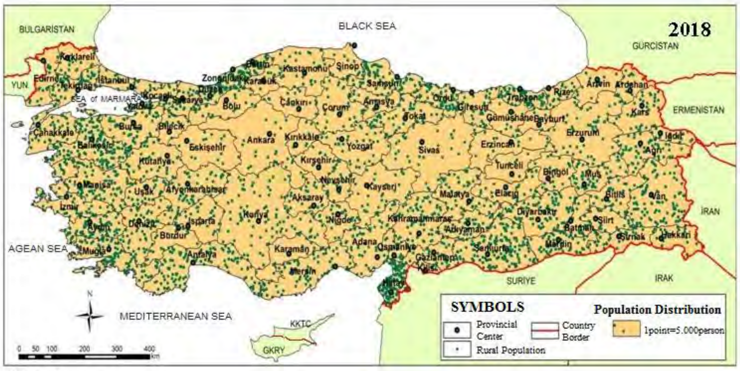
- Population with less density ↓ Causes →
→
→

Figure 2. Activity 2: Urban and rural population distribution of Turkey in 1980

ACTIVITY 2



Map 3



Map 4

Map 3, 4 given above show the distribution of urban and rural populations in Turkey in 2018, respectively.

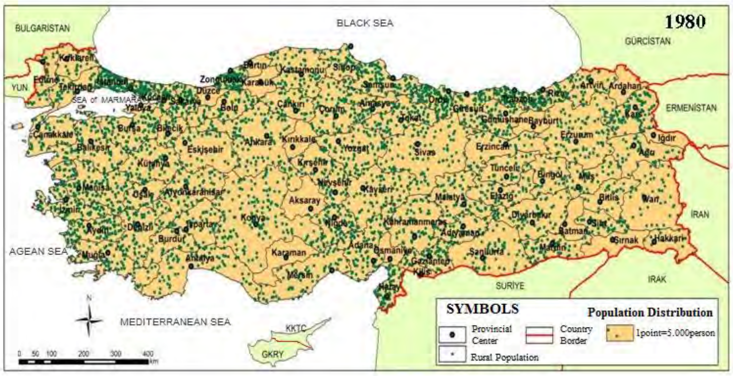
2. Turkey's urban and rural population breakdown in 2018;

- Population with a higher density ↓ Causes →
→
→

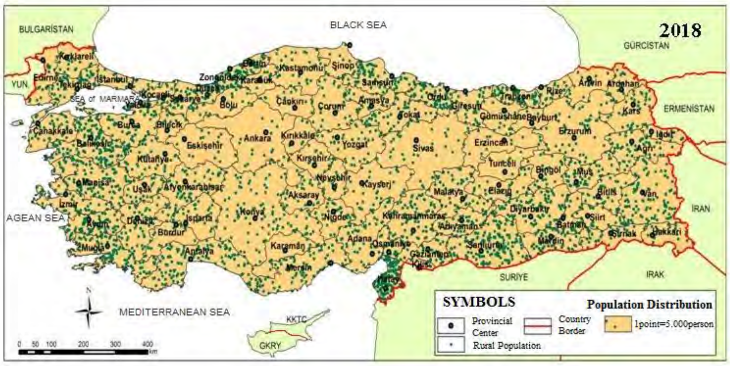
- Population with less density ↓ Causes →
→
→

Figure 3. Activity 2: Urban and rural population distribution of Turkey in 2018

ACTIVITY 2



Map 5



Map 6

Map 5, 6 given above show the distribution of rural population in Turkey between 1980 and 2018.

3. What changes are observed in Turkey's rural population distribution between these years? Please explain.

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-What could be the reasons for changes in rural population distribution between 1980 and 2018? Please explain.

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Figure 4. Activity 2: Rural population distribution of Turkey in 1980 and 2018

In the preparation for Activity 3, the population distribution of Alanya was performed by density analysis method. Density analysis, the density of details in point and line type, is one of the most preferred analysis for representations. The Kernel density method was selected in the Spatial Analyst tool in Arc Toolbox for the study. The areas where the population concentrates in 1980 and 2018 and the notable differences between the maps can easily be observed in this manner.

In order to create urban land use maps of Alanya in 1980 and 2018, GIS and Remote Sensing (RS) methods were used together to obtain satellite images of Alanya by using Google Earth Pro, Google Earth Engine Time Lapse technologies. The district center was taken as an urban area and the remaining areas were designated as rural areas. With the help of the topographic maps; public building area, residential area, industrial area, green area, agricultural area, under cover agricultural area (greenhouse) and pastures were determined and urban land use map of 1980 was produced. The satellite images were also examined and in addition to the district center, continuous residential areas were included in the urban area in the construction of the urban land use map of 2018 (Figure 5). In accordance with the Metropolitan Municipality Law, which came into force in 2012, villages were connected to the metropolitan as a neighborhood, and whole area of Alanya was included in the urban population. However, areas with forestry and scrubs, areas without settlement were shown on the map as rural areas (Figure 6).

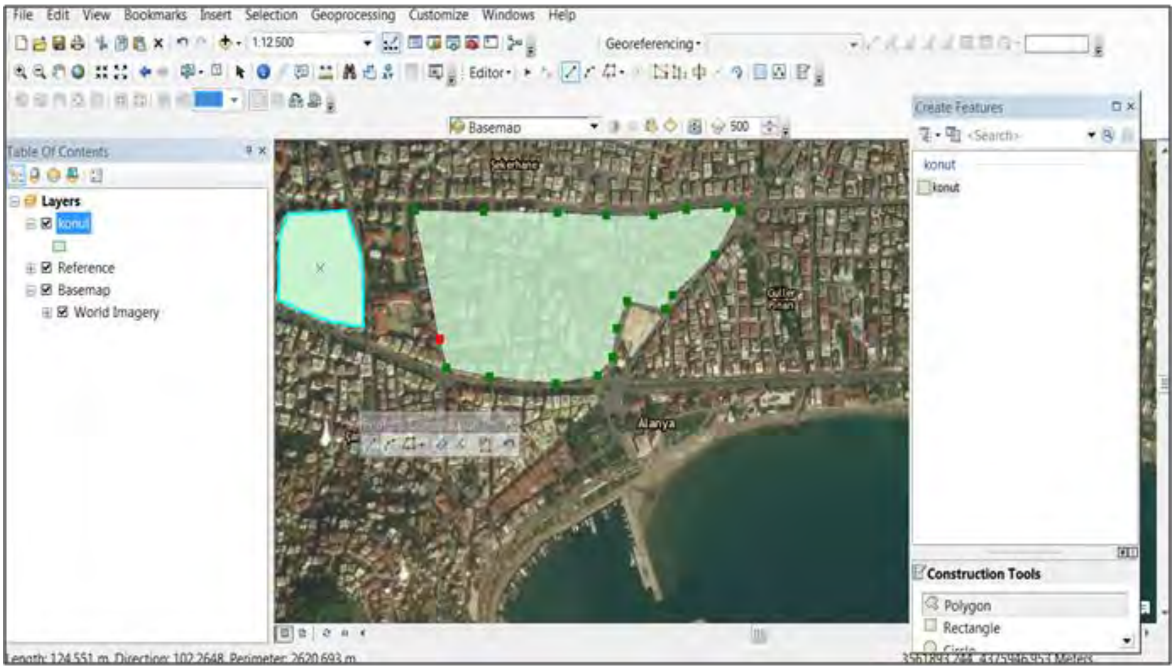
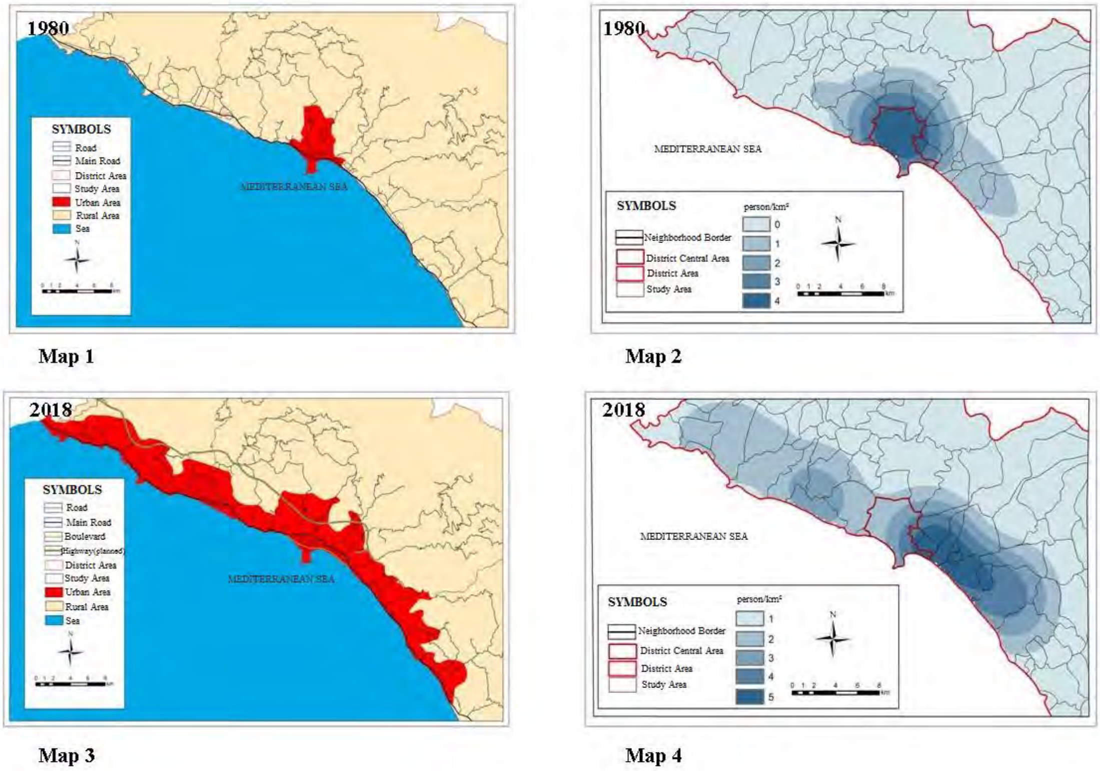


Figure 5. Base map (satellite image) of Alanya used in ArcGIS 10.2

Activity 4 was designed to perceive the variation of urban land use of Alanya between 1980 and 2018 (Figure 7). The activities were prepared paying attention to the course achievements, course goals and behavior in accordance with the principles of material preparation. During the preparation of the activities, a simple and understandable language was used and complex expressions were tried not to be included. The maps were used in the necessary size, dimension and colors for providing effective teaching.

ACTIVITY 3



Map 1, 3 show the change in urban land use in Alanya district between 1980 and 2018, and Map 2, 4 show the change in population density in the same years.

1. Interpret the change in urban land use in the region between 1980 and 2018. What may be the reasons for these changes? Type please.

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2. Interpret the change in the distribution of population density in the region between 1980-2018. What may be the reasons for these changes? Type please.

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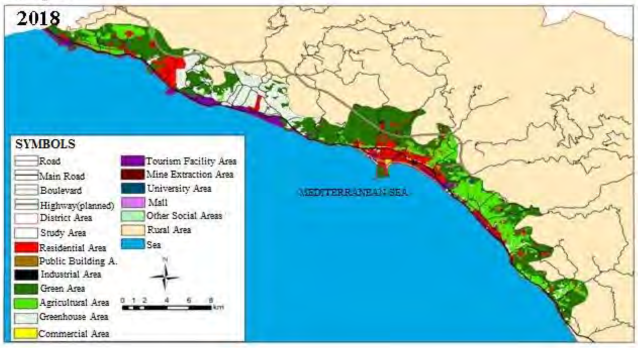
Figure 6. Activity 3: Urban land use and population density variation of Alanya between 1980 and 2018

ACTIVITY 4

Map 1



Map 2

Map 1, 2 show the change in urban land use that occurred between 1980 and 2018 in Alanya district.

1. What changes have occurred in urban land use in the region between these years? Write down these changes.

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- What are the causes of changes in urban land use?

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2. When urban land use maps of different years are examined in the region, it is seen that the land is used in various ways.Taking into account the way of use and changes, what conclusions can be made about economic activities in the region?

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……………………………………………………………………………………………………….
……………………………………………………………………………………………………….

Figure 7. Activity 4: Urban land use variation of Alanya between 1980 and 2018

Finally, the posttest was implemented to the students after the explanation of the subjects in 8 hours. The impact of the courses on student success and achievement in experimental and control groups was tried to be assessed with the posttest.

2.4. Data Analysis

SPSS (Statistical Package for the Social Sciences) 22.0 was used in the analysis of the data. The results of the score distributions based on the correct number of answers given in the success test results showed a normal distribution. Hence, the data were analyzed by performing t-test analysis.

The analysis of the data regarding the reliability of the measurement tool was carried out with the KR-20 formula. The KR-20 reliability coefficients calculated for the measurement tool in the pretest and posttest were found to be 0.72 and 0,78, respectively. The calculated KR-20 reliability coefficients of pretest and posttest of the research data determined the high reliability and internal consistency of the tests. Finally, the results indicated that there were significant differences between the pretest and posttest results for the overall dataset. The course given with GIS based activities significantly increased students' success and geographic knowledge.

3. Results, Discussion and Conclusion

In this section, detailed information is given about the results obtained in the research. Below are the t-test findings of the difference between the success pretest scores of the experimental and control groups in Table 3.

Table 3. *t-test results of the comparison of the success pretest scores of the experimental and control groups*

Group	N	$\bar{X}$	S	p
Experimental	30	11,07	2,116	0,957
Control	30	11,03	2,580	

The experimental group's pretest score average (11,07) was higher than the control group's pretest score average (11,03) in Table 3. This difference is not statistically significant (t38=1,38; $p=0,957>0,05$). The results showed that the pretest scores of the experimental and control groups were similar in terms of the measured parameter.

When compared the pretest and posttest results of the experimental group, there was a significant difference in favor of the posttest from a statistical point of view ($p<0.05$) in Table 4. According to this result, it can be concluded that the use of GIS based activities positively affected the geography course achievements of students in the experimental group.

Table 4. *Pretest and posttest scores of the experimental group*

Success Test	N	$\bar{X}$	S	p
Pretest	30	11,07	2,116	0,000
Posttest	30	19,27	1,507	

In Table 5, there was a significant difference in favor of the posttest from a statistical point of view ($p<0.05$) according to the pretest and posttest results of the control group. It was noticed that there was also an increase in the success of control group students taught by traditional methods when compared to the beginning of the study.

Table 5. *Pretest and posttest scores of the control group*

Success Test	N	$\bar{X}$	S	p
Pretest	30	11,03	2,580	0,000
Posttest	30	14,67	2,604	

There was a statistically significant difference between experimental and control groups in favor of the experimental group in the posttest scores (Table 6). The results indicated that the experimental method was successful in increasing students' success levels in the experimental group. Thus, teaching the students about the distribution and variation of population in Turkey and the structural characteristics of the Turkish population with GIS based activities can be assessed as an effective tool in increasing the students' success in geography education.

Table 6. *Posttest scores of experimental and control groups*

Group	N	$\bar{X}$	S	p
Experimental	30	19,27	1,507	0,000
Control	30	14,67	2,604	

As a result, it was determined that the courses taught with GIS based activities in geography teaching gave students a higher level of perception of spatial variation skills compared to the courses taught with traditional methods. The study stated that GIS based activities can easily be applied in classes by teachers even when there is no GIS laboratory available. Also, it was clarified that the students in the course which were taught with GIS based activities were more successful. Overall, in parallel with the previous studies (Lemberg &Stoltman, 2001; Kerski, 2003; Lee & Bednarz, 2009; Tuna, 2009; Özgen & Çakıcıoğlu, 2009), the results of this study demonstrated that GIS based teaching is an innovative method that can be used by geography teachers to promote and motivate students to come up with the major goal in learning geography.

According to Kerski (2003), using GIS enhances high level analytical and synthetic thinking. GIS endorses students' geographical skills by improving spatial thinking ability. Therefore, a GIS based curriculum can significantly increase students' spatial awareness. The results of this study also showed that using GIS as an effective teaching tool can enhance students' spatial awareness while they learn more traditional topics in geography. Because of the GIS based activities, the students became more interested in information technologies and methods used in geography education to address the current issues in social life. They found the course beneficial, interesting and entertaining and assessed the GIS environment user friendly and an expanding career option. Their recommendation for progress was to provide more GIS based activities in geography courses in the near future.

Necessary technology and supporting pedagogic infrastructure should be provided for the successful implementation of GIS in secondary geography education. The spatial technologies must also be effectively incorporated into the curriculums. The students and teachers should be motivated to work together on GIS based projects to gain vital skills and experiences. As a bold step, decision makers must be encouraged to improve more effective education strategies for integrating GIS into schools and to establish a GIS Education Research Institute for providing a deep learning area for the researchers.

4. Acknowledgement

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