ACTA DIDACTICA NAPOCENSIA
Volume 6, Number 1, 2013

GEOGEBRA IN A GEOGRAPHY CLASS

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Abstract: Certain secondary school subjects, such as geography, contain topics which are based on mathematical concepts. However, some geography teachers either fail to recognize this connection or choose to ignore it when they teach. Instead, they present the subject matter as a collection of facts, which need to be memorized and reproduced by the pupils. In order to change the "classical" teaching paradigm and motivate both the teachers and the pupils to actively engage in teaching and learning through real world examples, we created a set of exercises related to the development of map skills, and taught the students of geography to implement them in GeoGebra.

Key words: GeoGebra, Education, Geography, Interactive drawings

1. Introduction

Geography can be taught in a variety of ways. Often the teachers see geography class as a collection of facts about a certain topic, and present it to the pupils as such. The pupils' role in such a class is reduced to memorizing and reproducing the facts. "*The school should teach the pupils geographic facts and skills, but also train them to observe, collect, categorize, interpret and combine geographic information from a variety of sources*" [1]. With today's technology, laptop computers, smartphones and tablets, the pupils can find most, if not all, of the required facts on the Internet. This makes the role of the teacher as a presenter of data obsolete. Obviously we must give up the perception that teacher must know everything and shift towards the concept of teacher as a mentor. The teacher must identify the skills and knowledge that the pupils need to acquire, and adjust his/her teaching methods accordingly. A multidisciplinary approach, where the teacher calls upon knowledge and skills from different subjects, such as geography, geometry and algebra, in order to succesfully solve real world problems, is obviously a preferred one. The teachers should posess solid and wide knowledge in all involved subjects, as well as organizational, pedagogical and practical skills, which is not always the case. Self confidence is also important, both in the teacher and the pupils. The integration of computer science and other subjects is a dynamic and widely researched topic. "*As the educational technology field moves away from the stand-alone technology course and moves toward integrating technology across all teacher preparation courses, some important issues need to be considered. First, do teacher educators typically have the necessary skills and knowledge to integrate technology into courses? In most cases the answer is no.*" [8]. The obvious conclusion is that educating the educators, in our case, students of geography, is essential if we are to change the way geography is taught in schools.

The first author teaches "Computers and Multimedia in Teaching" to students who are the future geography teachers. The second author teaches geography to secondary school pupils. This enabled us to conduct an experiment which involved one group of geography students and two first grade classes of secondary school pupils. We based our experiment on GeoGebra [9]. The first part of the experiment was conducted during the 2010-2011 school year, and is described in [4]. The second part of the experiment, described in this paper, was conducted during the 2011-2012 school year. We held six classes with one group of students in a computer lab with a data projector.

Although GeoGebra is oriented towards mathematics and geometry, it can be applied to many problems which are mathematical in nature. The authors, for example, have considered various topics on teaching numerical mathematics with GeoGebra, [2], [3]. The aim of this work was to develop interactive GeoGebra materials, to teach the students to implement them by themselves and to record the students' opinions. Our ultimate goal is to prepare future geography teachers to assume a more

Received 28 February 2013, published 31 May 2013.

active role in class and to act not as lecturers, but rather as mentors to their pupils. Thus it was essential that they realize the potentials of interactive geometry software, for example, GeoGebra and how it can help transform an ordinary class into an interesting exercise, which promotes group work and learning by discovery.

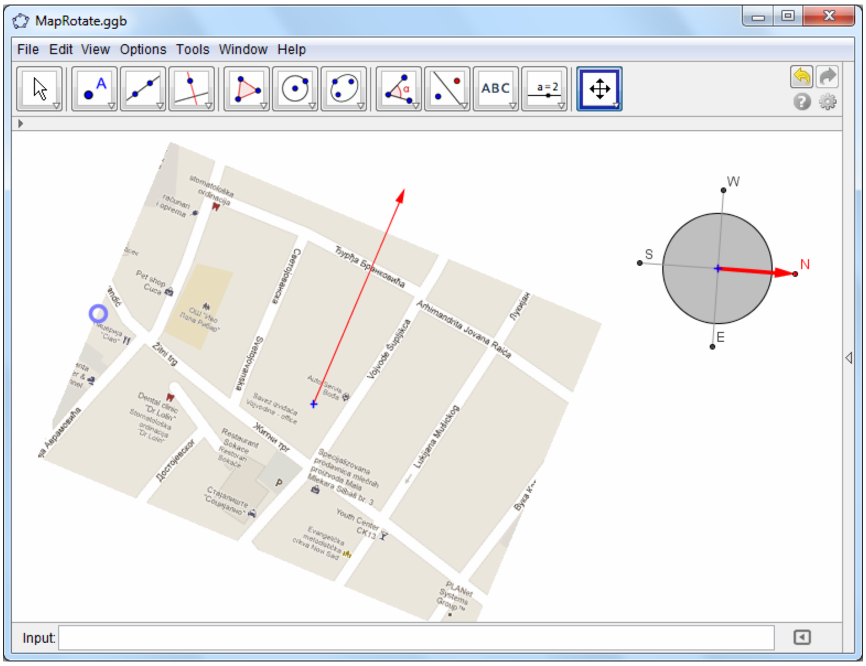
It should be noted that the use of any software in class should not be the goal in and of itself. Only in a carefully prepared and skillfully executed class will the software serve its purpose and be a successful tool for achieving instructional and motivational goals.

2. GeoGebra examples

We developed a set of interactive GeoGebra drawings, which we first demonstrated to the students, and later instructed them to implement them by themselves. We provide a brief overview of several examples and a more detailed explanation of the implementation for one example. All examples are available online [10].

2.1. Map rotation

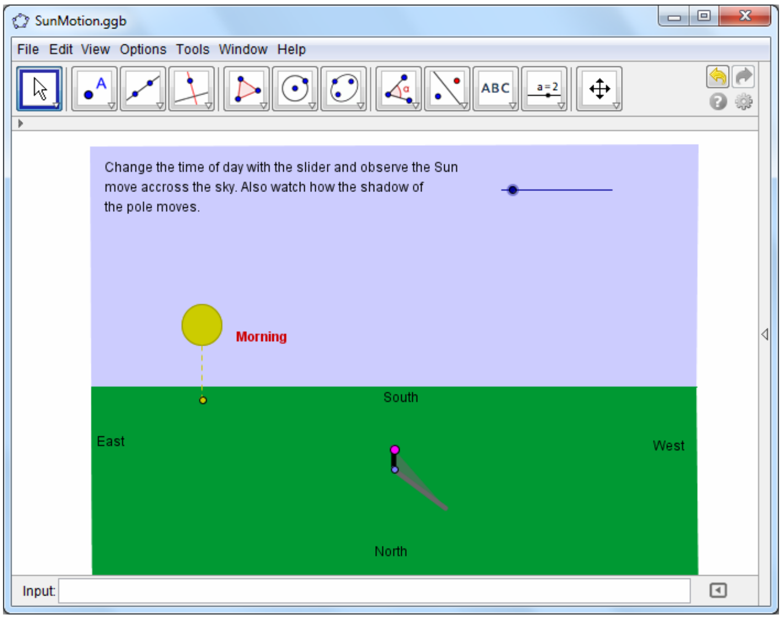
The first example extremely simple, yet it teaches an important skill. The map needs to be rotated until the arrow denoting north aligns with north on the compass (Picture 1). Then the pupils need to tell which cardinal direction is "up" on the map. This example teaches the pupils to adopt the correct frame of reference when reading the map and compass.



Picture 1. *Orienting the map towards the compass*

2.2. The motion of the Sun

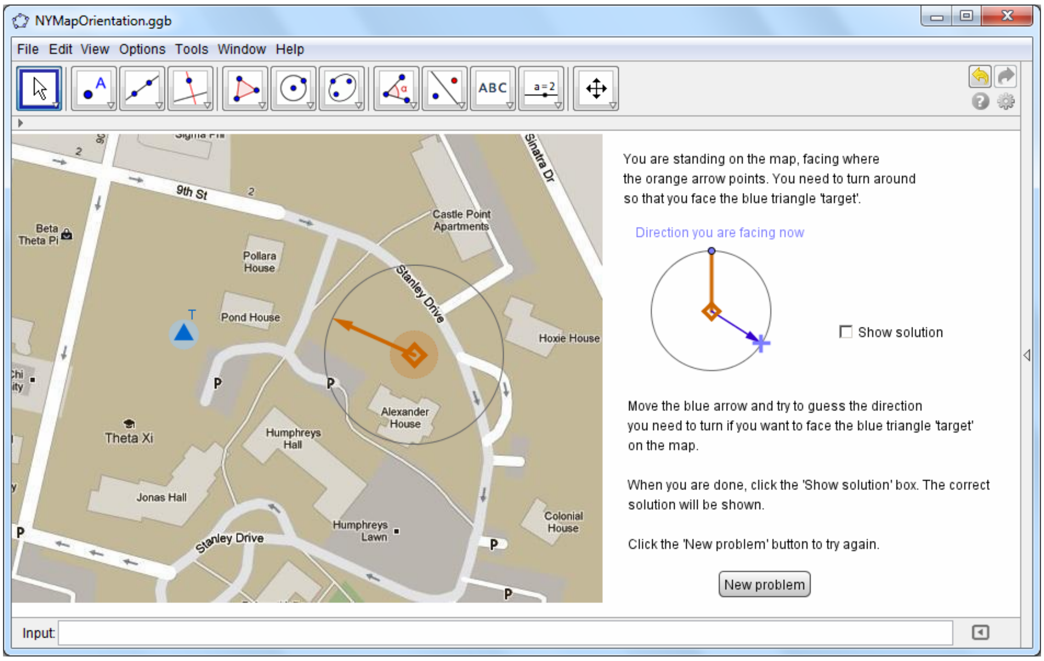
This example demonstrates the motion of the Sun across the sky and how shadows move. Time of day is controlled with the slider. In class, we asked the students to determine general directions by observing the shadows and using this example for reference.



Picture 2. *The motion of the Sun*

2.3. Orientation in a city

The third example is a bit more complex. It shows a map and two markers (Picture 3). The diamond in the circle on the map represents a tourist, facing the direction of the arrow. The triangle represents a place the tourist wishes to see. The tourist must turn either to the left or to the right in order to face the triangle directly. The actual angle of rotation is set by moving the blue arrow in the circle on the right.



Picture 3. *Which way should the tourist turn to face the blue triangle?*

After an angle is chosen, the "Show solution" check box can be clicked to show the correct angle. This example is based on angle addition, and teaches orientation relative to current bearing.

2.4 Measuring the length of a road between two cities

The aim of this exercise is to demonstrate the use of polygonal lines for measuring distances between places along roads and rivers. We deliberately formulated this assignment in a general and vague manner: "Calculate the distance along a road between Cincinnati and Columbus". After they were presented this exercise, the students asked for clarification. In a discussion, we broke down the problem into several parts:

- Obtaining the map,
- Importing the map into GeoGebra,
- Tracing the road,
- Calculating the actual length of the road.

Obtaining the map

The first task was to obtain a usable map, on which the roads between the two cities are clearly seen. The students mostly used Google Maps and Bing Maps. Once they found a good map, they copied it into the Paint.NET image editor [11] and cropped it so that only the region of interest was left. They saved the resulting image (Picture 4) to a file on their computers.

Picture 4. *The road between Cincinnati and Columbus*

Importing the map into GeoGebra

The picture of the map was imported into GeoGebra with the *Insert Image* command. It was made resizable by attaching its two lower corners to two points on the x-axis. This step is essential, as the images do not normally resize with the rest of the drawing in GeoGebra, which would make determining the scale of the map impossible.

Tracing the road

The students traced the road between Cincinnati and Columbus in GeoGebra by placing a number of points along the road and connecting them with the *Polygonal line* tool. The line was then colored to make it stand out. Each student placed the points differently, and some were more elaborate than others. In our example, the length of the line (marked "road" in Picture 4) was 7.96 units. At that moment, we pointed out the difference between GeoGebra, which expresses quantities without unit identifiers (i.e. as dimensionless numbers), and real world, where distances are expressed in kilometers. We encouraged a discussion and steered the students towards realizing that, in order to convert the obtained value into kilometers, the scale of the map should be determined.

Calculating the actual length of the road

In order to determine the scale of the map, we instructed the students to find the linear distance between two cities in GeoGebra, and also in Google Earth, and to divide these two numbers. In our case, we measured the distance between Dayton and Springfield, using the *Ruler* tool in Google Earth (Picture 5).

Picture 5. *Linear distance between Dayton and Springfield in kilometers*

In GeoGebra, the length of a line segment (marked "linear" in Figure 6) between Dayton and Springfield was 1.79. By dividing this value with 37.38km, we calculated the scale of the map.

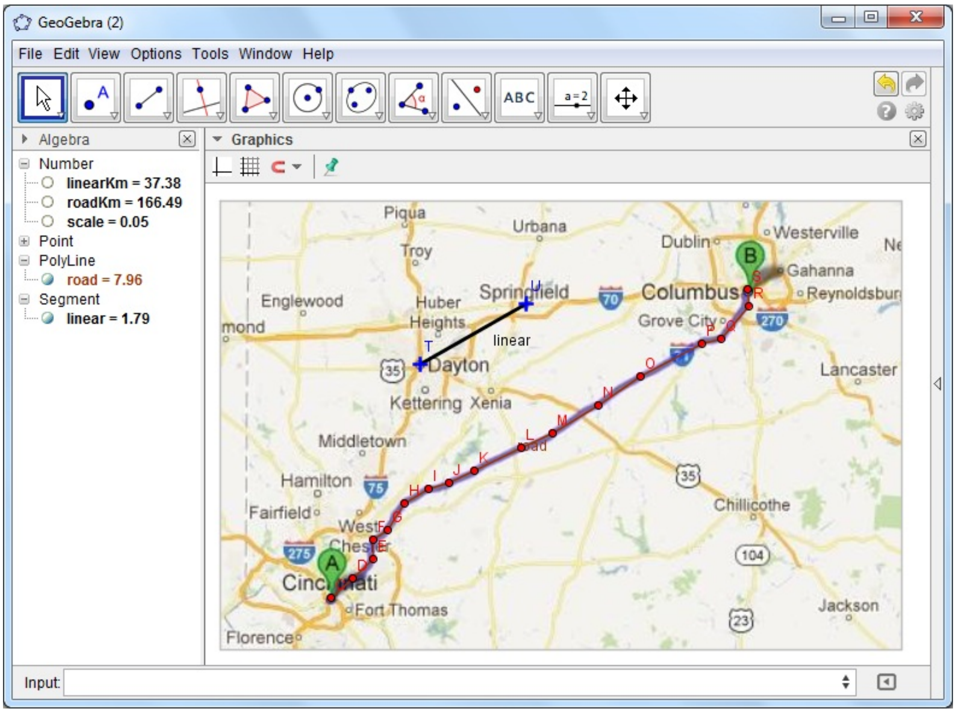


Figure 6. *Calculating the distance along a road*

By default, GeoGebra rounds the displayed number to two decimals and therefore displays the value of the scale as 0.05. The more accurate value for the scale is 0.047887. At this point, several pupils observed that we divided a dimensionless value with kilometers, so the result should be expressed as "0.047887 units per kilometer". From there it is easy to conclude that any length in GeoGebra can be converted to kilometers by dividing it with the scale. We calculated the distance between Cincinnati and Columbus to be 166.49 km. Driving directions in Google Earth produced the result of 172 km, which proved that our solution was correct.

Improving measurement accuracy

We asked the students to think about how they could improve the accuracy of the measurement. They suggested several ways, which we refined to the following points:

- Obtain a more detailed map,
- Increase the number of points which make up the polygonal line,
- Place the points more precisely on the road.

3. Poll results and conclusion

After the classes were held, we conducted a poll among our students. They were asked to write down their comments in free form. We present several characteristic responses here:

- **"I could've never thought of this myself"** – This comment reflects the students' low level of self-confidence. However, when reflecting on the actual exercise after it was completed, the same student said that "**It was easier than (he) thought**". The whole group of students agreed that the procedures demonstrated were easy to understand, once they had overcome the initial fear of the unknown.
- "**If there is no button for that, then it cannot be done.**" – One student found having to type in algebraic expressions into GeoGebra particularly difficult. Her explanation was that there were no visual clues to what needed to be done and she had to "imagine it all in her mind", which was a problem since she disliked mathematics. This is a particularly alarming belief, and we believe that it poses a significant obstacle in the students' development as interdisciplinary teachers.
- "**This is so different from what I was taught before. You must be doing it improperly.**" **-** During the many years in school, the students were consistently presented with lessons in a pure academic manner. The focus of our classes was shifted more towards the practical use of the technology and the integration with mathematics, with the ultimate goal of reaching a satisfactory solution in a reasonable amount of time. We noted that some students had difficulties accepting a different way of teaching and working in class. In the end, however, they did begin to understand the importance of completing the assignment, using whatever means were available.
- **"You tricked us into doing mathematics"** – The beauty of GeoGebra is that is makes mathematics easy. But, more importantly, it helped us demonstrate to the students that although there is mathematics in geography, it needs not be difficult.

The students' overall reaction to the course was positive. They agreed that classes are more interesting when presented in a dynamic way on a computer, and noticed that playing with GeoGebra helped them overcome their anxiety around the underlying mathematical concepts. It is our opinion that future teachers of geography should be educated in a more integrated way, with various subjects supplementing each other.

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