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The Interaction of the Didactic of Cartography and Geography

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Abstract

In this paper, the interaction of the basic elements of the didactic of geography and those of cartography, are examined and discussed and an implementation approach of introducing cartography in the elementary schools is proposed. Although the didactic of geography is an independent scientific topic, is based on the theory and the results of other sciences, such as geography which determines the content, general didactic, psychology and pedagogics which help to form the teaching methods on the one hand and evaluate the teaching process on the other. But, what is the role of map inside the body of such a complex mixture of scientific topics? This question could be answered theoretically by examining the relation between geography and cartography. Considering the didactic of cartography in isolation from the didactic of geography, three keywords: why, what, and how of school cartography are determined. A theoretical approach is developed for the determination of these keywords, and methods of introducing the cartographic concepts to primary school students are proposed.

Introduction

Cartographic procedures determining the content and the form of school maps depend on both educational and psychological issues. Specifically, the targets of education and the curriculum of subjects related to space define the thematic content of the school maps. From the aspect of psychology, conclusions of studies affect the way spatial information is portrayed on maps and specify the quality and the quantity of information, which can be assimilated by children. In Greece as well as in other countries a systematic educational approach of teaching cartography is not included in the primary school curriculum. Mainly, the subjects related to space are included in geography, which uses the symbolic language of map to communicate spatial information. The targets, the curriculum and the means of teaching geography are issues of interest of the didactic of geography.

The didactic of geography is based: i) on the theory and the applications of the science of geography, ii) on the principles of general didactic and furthermore of children's psychology and pedagogics, which form the teaching methods, and iii) on the evaluation process of educational targets. These three components of the didactic of geography are referring to the organization, implementation and evaluation of the different ways of teaching geography and are expressed by three fundamental key-questions: *what* must be taught, *how* can be taught, and *why* should be taught. In elementary schools, maps are the dominant media for the communication of spatial information. Students must be taught the basic elements of cartography in order to be able to read and interpret maps. This leads to the necessity of introducing the didactic of cartography, having three issues of interest: *what* must be taught –concerning mapping, *how* can be taught –concerning the appropriate teaching methods, and *why* should be taught –concerning reasons for teaching mapping. In this paper, the interaction of the basic elements of the didactic of geography and those of cartography are examined and discussed, and an implementation approach of introducing cartographic courses in the elementary schools is proposed.

The relation between geography and cartography

Geography can be expressed today by the following definition: '… is the science that studies spatial patterns and structures, which are produced by historical events and defined by the dominant modes of production. On this conception, geography and specifically human geography in contrast to physical geography is a part of a science which focuses on the dialectic relationships between social procedures on the one side and physical environment and spatial interelations on the other side', [Myridis, 1989]. According to Hartshorne [1959]: 'Geography is concerned to provide an accurate, orderly, and rational description of the variable character of the earth's surface'. Browsing in other definitions, Ackerman [1963] argues that: '… its goal is nothing less than an understanding of the vast, interactive system comprising all humanity and its natural environment on the surface of the earth'. Taaffe [1970] in the process of defining geography is emphasizing that: 'Geography is concerned with giving man an orderly description of his world'. Furthermore, according to Yates [1968] geography is: '… a science concerned with the rational development, and testing, of theories that explain and predict the spatial distribution and location of various characteristics of the surface of the earth'.

On the other hand we can focus on the most representative definitions of cartography. In the Multilingual Dictionary of Technical Terms in Cartography -Commission II of the International Cartographic Association- the map is approached as follows: 'A map is a representation normally to scale and on a flat medium, of a selection of material or abstract features on, or in relation to, the surface of the Earth or of a celestial body', [Meynen, 1973]. In the same source, cartography is defined as: 'The art, science and technology of making maps, together with their study as scientific documents and works of art'. In this frame, the science of cartography and the corpus of the established techniques of the field of cartography define a robust set. This set 'is concerned with reducing the spatial characteristics of a large area-a portion or all of the earth, or another celestial body- and putting it in map form to make it observable' [Robinson et al., 1995]. The purpose of cartography is to collect and analyze data and measurements of the various patterns of the earth and to represent them graphically on such a reduced scale that the elements of these patterns can be made clearly visible, [Raisz, 1948]. Specifying the abilities of a cartographer, the same author argues that: 'The cartographer is both a scientist and an artist. He must have a thorough knowledge of his subject and model, the Earth. In representing it in different ways he must omit more or less, according to the scale and purpose of his map. This means that he must have the ability to generalize intelligently and to make correct selection of the essential features to be shown'.

A thorough examination of the above definitions of the sciences of geography and cartography transpires that there is not only coincidence concerning keywords but also a common conceptual framework, which focuses mainly on the manipulation of geographical space, spatial characteristics and as a consequence of spatial data. It comes out that the consideration of the relation between the two sciences must not be restricted to the notion

that cartography supplies geography with presentation facilities – the maps. Cartographers, for many years, have stressed the common conceptual framework of the two sciences. Robinson and Petchenik [1976] pointed out that: 'The cartographer must therefore be, among other things, part mathematician, part production expert, part student of graphic semiology, and part geographer'. More specifically, on the same issue Raisz [1948] argues: 'It is said that a cartographer is 50 per cent geographer, 30 per cent artist, 10 per cent mathematician, and 10 per cent everything else'.

The didactic of geography and the role of map

The didactic of geography is a new established scientific topic, which is developed under the frame of specialized didactic. The specialized didactic brings into contribution the aspects that refer to the school curriculum, the teaching methods, and the evaluation of teaching process. A representative approach of the didactic of geography can be based on three keywords: *what, how* and *why*. These three keywords are coding the organization, implemention, and evaluation of the teaching processes of geography [Katsikis, 1992], (see Figure 1). Although the didactic of geography is an independent scientific topic, it is based on the theory and the results of other sciences, such as geography which determines the content (*what*), general didactic, psychology and pedagogics which help to form the teaching methods (*how*) on the one hand and evaluate the teaching process (*why*) on the other. So, an interesting question is rising: what is the role of map inside the body of such a complex mixture of scientific topics, having as goals the determination of the keywords: *what, how* and *why*? This question could be answered theoretically by examining the relation between geography and cartography cited above, and practically by analyzing systematically these three goals.

What, is defined by geography, which studies the spatial characteristics of physical and human environment. Geography defines the content of the courses that introduce students to the concepts of geographical space, taking into account their abilities as are determined by psychologists and pedagogists. Someone could argue that map is not involved at this initial level of determining the *what* of geography. But, a more analytical examination of the content of geography courses reveals that the concepts of the earth geometry and graphical representation of spatial objects are fundamental elements for the perception of geographical space. The geometry of the earth and the graphical representation of spatial objects are subjects of study and research of cartography, and they constitute issues that must be included in the content of geography courses.

Examining the way of *how* the knowledge concerning geographical space is transferred to students, a more obvious and essential contribution of the map emerges. Teaching methods of geography should incorporate the use of map in order to help students to perceive and understand spatial information. An effective use of map by students depends upon two conditions. Firstly, each school map should be designed following strictly basic cartographic principles and secondly students should be taught the basic elements of cartography in order to read and interpret spatial information in a successful way. Such an approach requires the development of another detailed branch of didactic, the didactic of cartography, having its own keywords: *what, how* and *why*. *What*, refers to the knowledge of the cartographic

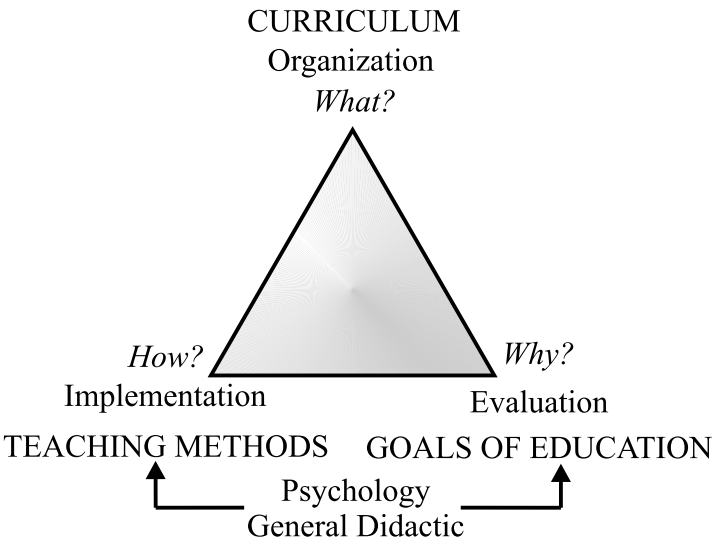

Figure 1. The three components of the didactic of geography

processes that students should acquire to read the school maps effectivelly. The determination of this knowledge should take into account the children's developmental stages. Referring to the *how* of the didactic of cartography the target is to compose teaching methods for using maps. Thus, a more systematic analysis of the didactic of cartography is required.

The Didactic of Cartography

A theoretical approach

So, considering the didactic of cartography in isolation from the didactic of geography, the *why*, *what* and *how* of school cartography must be analyzed (see Figure 2). Concerning *why*, the criteria of specifying the general goals of teaching cartography are mainly determined by the purpose and the importance of the cartographic knowledge to a specific recipient, the student, in a specific environment, the school, and by the general goals of pedagogy. Cartography can be considered as a branch of graphicacy. Graphicacy is another way to communicate besides literacy, articulacy and numeracy [Robinson et al., 1995], and therefore is considered as an integral part of the school curriculum. Liben and Downs [1992] focus on characteristics of one particular type of graphic representation –those that represent the world or "geo" and hence, "GEO-graphics". They stress the necessity "to provide experiences aimed at enhancing the general level of spatial skills as well as those that foster an understanding of graphic representation in particular". Phillips [1989] argues that: "all types of graphic information are different solutions to a common problem: the brain's limited capacity to store unprocessed information". According to him when the information is presented in the form of map or diagram, there is no longer any need to store the raw information. But as information passes on the higher levels of cognitive processing, the limitations are attributed in thinking itself and factors like age, experience, education and culture affect the way information is handled. "There is no doubt that we have to learn to read maps and other graphic displays and that there are many facets to this learning", [Phillips, 1989]. So, teaching cartography comes in accordance with the general goal of learning graphicacy and in addition it has a main contribution to the development of awareness of the spatial structure of the environment. Cartography's domain, the map, is defined as a graphic representation of the milieu, [Dent, 1996]. Map owns its importance to the fact that it represents spatial relationships and forms. Along with remote imagery and aerial photographs is a medium of perceiving spatial entities. It is mostly used as a tool that communicates spatial information to other disciplines and especially to geography. Finally, there is no doubt that students will use maps all their lives. So, teaching students "mapping" must be the general goal of school-cartography.

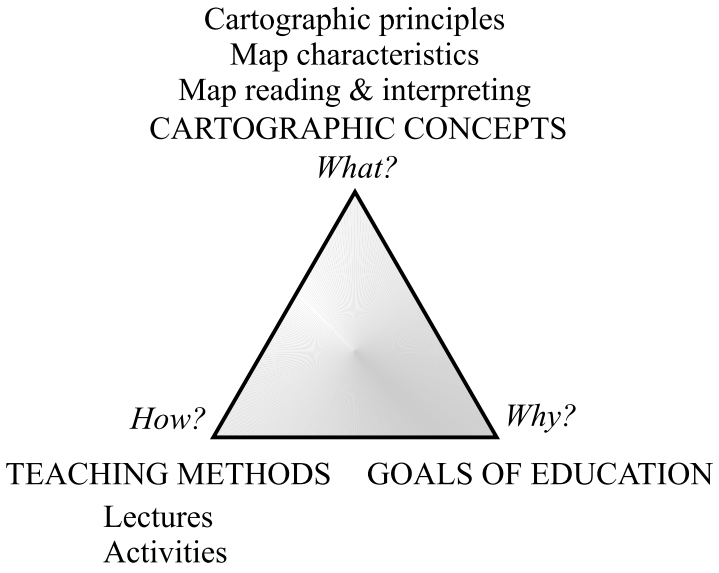

Figure 2. The three components of cartographic didactic

What, of cartographic didactic refers to the elements of cartography which must be transferred to the students in order to read and understand maps. Actually, *what* can be considered as the sum of three components. The first one refers to the conceptual and geometrical structure of the map as well as to generalization and symbolization procedures. Geometry concerns scale and projection. Scale, which is the defined dimensional relationship between reality and the map, is among the first things the students must be taught. The concept of map projection and its consequence of distortions in direction, distance or area is of main importance in map interpretation. The abstract structure of the map can be appreciated only if the map user is aware of the elements of

generalization (classification, simplification, induction and symbolization) as defined by Robinson et al. [1995]. Concerning symbolization, Gerber [1981] defines competence in cartographic language as the individual's ability to understand cartographic signs. He argues that: "competence may be understood as: the individual's understanding of the nature of cartographic signs as representations of spatial phenomena; the continuum of cartographic signs (ranging from signals through pictorial symbols to abstract symbols); the range of qualitative and quantitative signs and their representation as lines, points, areas or alphanumerals; the scaling of the information presented by such signs (nominal, ordinal, interval and ratio); and the conventions which have been adopted to begin to develop a standard cartographic code". The above issues cited by Gerber determine what should be taught concerning symbolization.

The main characteristics of maps, locations and attributes at locations, can be considered as the second component of the cartographic didactic content. The spatial relationships that can be extracted from maps concern, [Robinson et al. 1995]:

(a) relationships among locations,

(b) relationships among various attributes at one location,

(c) relationships among the locations of the attributes of a given distribution, and

(d) relationships among the locations of attributes of given distributions.

Map reading processes consist the content of the third component of *what* in the didactic of cartography. Keates [1996] breaks down the map reading task into the following processes: detection, discrimination, identification, recognition, interpretation and transformation. These processes have an increasing level of difficulty but each of them can be introduced in ways that range from very simple to very sophisticated. Description of each process based on Keates [1996], and skills that are related to it are cited:

- Detection refers to the ability of map user to detect symbols on the map. Locating symbols and patterns is a related skill.
- Discrimination refers to the ability of the map user to perceive differences between two or more symbols. The skills of appreciating the way visual variables are used to differentiate map symbols, and of comparing distances, lengths and directions are related to the process.
- Identification denotes the ability of map user to understand what the symbols represent. The skill of using legend is fundamental for identification.
- Recognition denotes the ability to acknowledge something familiar and is related to the skill of recognizing geographical features.
- Interpretation is connected with the ability to convert the information presented on map into meaning. The skill of understanding the meaning of map symbols and of distributions is attributed to interpretation.
- Transformation is related to the ability of map user to retain particular relationships between the map and the represented space. Skills like measuring in scale, appreciating the distortion of distance or direction, orienting the map in the field, appreciating the abstract form of representation, are related to transformations.

Keates [1996] argues: "Detection, discrimination, and identification can be regarded as the preconditions for map use. Beyond this point there must be a further stage of interpretation, by which the information is processed in order to be actively employed to deal with a particular map-using task". Discrimination can be affected by practice, identification is a learned behavior, recognition depends on familiarity with geographical features and interpretation is based on individual skill and knowledge. He clarifies that: "in actual map use it is difficult to draw any exact line between 'processes' such as identification, recognition, and interpretation, or to regard them as a fixed sequence of events which must occur in particular order". The author's comments are of valuable importance for the teaching methods of these mapping processes and they have to be highly considered in the next step of the current study, the *how* of the didactic of cartography.

How, of cartographic didactic refers to the teaching methods, which must be implemented so that the content of the subject matter of cartography can be transferred to the students. Teaching methods comprise both lectures and activities. Concepts can be taught through lectures and activities, whereas skills through activities that include map-use and map making. Although the goal is not to enable students to become efficient mapmakers, activities of map-making contribute to the development of cartographic concepts and map-use skills [Gimeno and Bertin, 1983].

The effort of determining in detail the teaching methods of the cartographic concepts mentioned above would be too ambitious, since these teaching methods have to be defined by considering: the principles of general didactic, the curriculum of related subjects like geography and mathematics, and basically the cognitive theories that describe children's thinking and ability for spatial knowledge acquisition. As far as we know such an approach to the didactic of cartography has not yet been accomplished, although there is a lot of research already done in this direction. The present study is another contribution to the didactic of cartography, aiming to describe a procedure of how to introduce the cartographic principles through mapping activities. The three components of *what*, as previously defined, are faced as teaching topics, and ways of introducing them in primary schools are proposed.

An implementation approach

Starting with scale, the methods of introducing its concept should not require students to possess specific mathematical skills like multiplication or division. Two maps of different scale depicting the same area could be used. First students should detect the same feature on the two maps and then discriminate differences and use descriptive terms to express comparisons. Identification of what a unit in a scale bar represents at each map could be the next step. On a map they could compare the length of features or distances with the scale bar.

Concerning projections, students should detect and locate the same country on world-maps of different projections. They should discriminate and respond to differences in directions, distances or areas. Comparing the globe and the map, and showing how difficult is to project a sphere on a flat surface the first interpretation for the distortions could be accomplished.

To introduce the elements of generalization (classification, simplification, induction, and symbolization), maps of different scale depicting the same area could be used. It should be taken into account that these elements might impose different rate of difficulty to students. Particularly the element of induction seems to be the most difficult one. Students could become familiarized with the two aspects of simplification:

(a) by detecting which information is eliminated on the map of smaller scale, and

(b) by detecting the same feature on the two maps and discriminate differences at the level of smoothness or detail.

Regarding classification, students could detect and discriminate how the attributes or values of a feature are grouped on the two maps or the way a location on the reduced-scale map represents a group of locations. Landform representations could be used to introduce students to induction. The constructivist approach described by Gimeno and Bertin [1983] could be a very good example of how to introduce students to the fundamentals of generalization.

Regarding symbolization, at the beginning students should be encouraged to detect point, line, or area symbols, which represent point, line, and area data. Then they should become aware of the visual variables and get able to classify symbols by their similarities or order symbols by their differences. They could practice:

(a) To respond to differences between point or line symbols, which vary in hue or shape, and area symbols, which vary in hue.

(b) To respond to differences between point or line symbols of the same sub-class, which vary in size or value and of area symbols, which vary in value.

Afterwards they should learn to identify symbols using the legend. Initially they should learn to assign qualitative meaning to symbols and to name them. During this stage they should acknowledge the arbitrary way of using the visual variables to differentiate symbols for nominally scaled data. For example a star or a circle can be used to represent a town, a red or gray color can be used for roads on different maps. Then, comparing the size or value of a symbol on the map with the size or value of the corresponding symbol on the legend they should be able to assign quantitative meaning on the referential symbol. Thereupon they could learn to appreciate that the visual variables of hue and shape are used for nominally scaled data whereas size and value for ordering. At a later stage they could also learn to compare the size of a symbol on the map with the size of the corresponding symbol on the legend in order to estimate the represented quantity. Downs et al. [1988], Liben and Downs [1992], and Anderson [1994] report errors that children make in symbol identification. These studies could contribute to specify where emphasis should be given when map symbols are introduced to students.

The introduction of different types of landform representation to students is of primary concern. Contouring is the most precise way to represent the shape of landforms but it is difficult to be interpreted by children. Wiegand and Stiell [1997] argued that using maps employing hill signs other than contours could support children's understanding of relief mapping. Filippakopoulou et al. [1998] examined the ways different methods of landform representation are read and interpreted by primary school students and suggested that students can be introduced to landform interpretation through hill-shading representation. Students could benefit from the realistic representation of hill-shading to discriminate and identify landform characteristics. Then they should proceed with hypsometric tints or a combination of hill-shading and contours. The latter method might help students to discriminate and identify different patterns of contours. As it is a realistic representation method would enable students to visualize the landform and allow them to perform cartographic induction like appreciating surface slope.

Students' familiarity with representations of statistical surfaces (or volume data) should expand beyond landforms. After getting acquainted with representations of point, line or area data students should be introduced to thematic representations of volume data and especially to choropleth maps, which represent volume data through area symbols. Students should be helped to visualize the magnitudes of the attribute values referring to unit areas as forming a three-dimensional surface. A perspective view of a statistical surface by erecting prisms over each unit area, proportional in height to the attribute values, could be displayed. Comparisons could be made with the corresponding choropleth representation of the same statistical surface, which uses range-graded categories varying in value to portray the same data. Students could detect the same area units at the two representations, compare the hight of the prisms with the values of the area and identify at which category the unit belongs.

Respecting spatial relationships, students should be trained to discriminate from the map the relevant information. The extraction of spatial relationships from both small and large scale maps poses different rate of difficulty to elementary school students [Michaelidou et al., 1997]. Concerning relationships among locations, students initially should practice to detect and locate different attributes and to extract topological relationships, judge distances, lengths, and directions. Ottosson [1988] cited the basic difficulties that children find in map understanding. He concluded that map understanding is based on an understanding of spatial relationships between real-world features and suggested that "recognizing the spatial relationships between real features and then comparing them with the map should initially be the dominating activity". Thus, large scale maps of a familiar to the students geographical space should be used for teaching the extraction of spatial relationships. The next step concerns attributes at locations, and students should learn to detect and recognize patterns of symbols representing the distribution of one or two attributes. They should also become able to detect and discriminate among locations where two or more symbols coexist. Finally, they should acquire the skills and the knowledge to interpret distributions and their spatial relationships.

Conclusions

In the present study the impact of cartography on the didactic of geography is examined and the need for the development of the cartographic didactic is recognized. Through a theoretical approach the didactic of cartography is analyzed and the keywords: *why*, *what* and *how* are determined. Concerning *why* the general goal of teaching students mapping is justified by the purpose and the importance of the cartographic knowledge. The keyword *what*, is comprised by three components: the cartographic principles (geometry, generalization, symbolization), the map characteristics (locations, attributes at location) and the map reading processes (detection, discrimination, identification, recognition, interpretation, transformation). The teaching methods (lectures and activities) define the third keyword *how* of the cartographic didactic that has to take into account the students' educational level and cognitive characteristics. At the implementation stage methods of teaching the cartographic concepts are proposed and activities introducing mapping skills to students are described, considering the results of previous cartographic and psychological researches. More specifically, an outline of a cartographic course curriculum appropriate for elementary school students as well as specific teaching methods and activities are given.

The outline includes:

- Introduction of the concept of scale, projection and distortions. The concept of scale can be taught through activities using maps of different scales. Students can discriminate differences and further they can express comparisons. Concerning projections students, for example, should detect and compare continents on world map of different projections. The concept of map distortions can be introduced by comparing a globe and its representation on the plane.
- Elements of generalization by means of simplification, classification, symbolization and induction. Maps of different scale of the same area can be used for the introduction of the elements of generalization. As far as symbolization is concerned, students can be initiated, at an early stage, to the visual variables and the different ways visual variables are applied to create symbols. Later on, students can appreciate the measurements of geographical variables, the scales of measurements and the ways of their portrayal. As induction is the most difficult element of generalization to be conceived, it can be introduced through realistic representations.
- Different methods of landform representation. Landform representations have to be gradually introduced through the realistic hill-shading representation, hypsometric tints, combination of hill-shading and contours, and finally through the abstract representation of the contour lines.
- Representative methods of thematic data mapping. Students having the knowledge of the function of visual variables can understand the simple thematic representations of point, line, area and volumetric data. More sophisticated ways of portraying volumetric data, like perspective views, can be introduced by mimicking the ways landform is represented.

Obviously didactic of cartography is of valuable importance and a lot of research has to be done on this topic, especially, if we consider that children of elemetary schools cannot express their needs directly.

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