DESIGN AND IMPLEMENTATION OF A PROTOTYPE SOFTWARE FOR INTRODUCING CARTOGRAPHY TO CHILDREN

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ABSTRACT

In the present paper the design and development of a software appropriate for introducing basic cartographic principles to school children aged from nine to fourteen years old is analyzed and discussed. The selection of the concepts incorporated in the software design takes in consideration recent cartographic and psychological research trends. The design of the software is based mainly on four components: the existing cartographic principles (i.e. geometry, generalization, symbolization, map characteristics, etc.), children's cognitive and educational level, the school curriculum, and contemporary trends for developing computer software. The prototype software is developed under an object-oriented environment, using Microsoft Visual Basic as programming language. It can be executed as an application under Microsoft Windows 95/98/NT v. 4/2000 operating environment on a typically configured PC with no special requirements. The graphical user interface (GUI) is simple, friendly and mouse driven in order to satisfy the needs and abilities of school children as users.

KEY-WORDS: *Children and cartography, visualization tools, human–computer interaction.*

INTRODUCTION

Cartographers have just recently realized the impact of automation in mapping and the approach to map use as an information processing problem. The approach to maps as spatial representations is an integrated way to face the problems of cartographic visualization. According to this idea cartographic symbolization is envisaged as a threefold concept that can be expressed by the questions: What is the meaning of symbols? Are symbols signs carrying meaning? How symbols mediate visual thinking? Actually these three questions express the lexical, the functional and the cognitive perspectives on the study of symbols [Howard 1980]. In early visual thinking, as in the case of young children using maps, it can be assumed that the cognitive perspective is not of main importance, since almost neither previous knowledge exists nor mental representations of the geographical space have been built at an efficient level. MacEachren [1995, p.368] also mentioned: “When visualization tools act as a catalyst to early visual thinking about a relatively unexplored problem, neither the semantics nor the pragmatics of map signs is a dominant factor. On the other hand, syntactics (or how the sign-vehicles, through variation in the visual variables used to construct them, relate logically to one another) are of critical importance”. Thus, in the present study, since spatial representations are addressed to school children, the interest is mainly focused on the syntactics components of visualization tools. Although the use of visual variables for the creations of cartographic symbols is still an open research topic in cartographic visualization many empirical studies have achieved effectively applied results.

This study presents a software designed mainly for elementary school children. Children using this software are introduced to cartographic concepts and are able to manipulate activities appropriate to create or upgrade their mapping skills. The introduced cartographic concepts cover a wide variety of topics, as: scale, projections, generalization, visual variables, and landform representation. The activities include mapping skills, as: length, area or angle measurements on maps, application of the elements of generalization, comparison of different ways of landform representation, use of visual variables in creating symbols for the representation of quantitative and qualitative data. Both cartographic topics and related activities are in accordance to the curricula of the geography courses (Nakos et al. 1999). The choice of visualization tools (symbols, dynamic change and sound) incorporated in the software is based on the trends of recent cartographic studies.

CHILDREN'S UNDERSTANDING OF CARTOGRAPHIC CONCEPTS

The development of the ability to understand map symbols occupies the period from kindergarten to grade two although this is not necessarily complete by the end of grade two [Downs et al. 1988, Liben and Downs 1992]. Participating at the composition of thematic maps using a specially designed software tool, first and second grade students of elementary school, without any cartographic experience, applied the appropriate visual variables to portray qualitative and quantitative data [Filippakopoulou et al. 1999]. In another investigation, second grade students could think abstractly and understood the symbolization of quantitative data on thematic maps of different scales and symbolization [Trifonoff 1995]. Investigating the development of competence in cartographic language of children aged eight to fourteen years, Gerber [1984] concluded that quantitative line signs and qualitative area signs were the most difficult for identification and quantitative line and point signs were the most difficult for comprehension. Gimeno and Bertin [1983] describe a teaching method of cartography, which enables students aged ten to eleven years to discover by themselves one of the fundamentals of graphic semiology, the concept of visual order. Wiegand and Tait [1999] investigating how students aged eleven to fourteen years constructed a series of thematic point symbols using a specially designed software tool, concluded that the students had a weak notion of both spatial and numerical factors underpinning symbol generalization.

Landform is an important geographical phenomenon and is frequently a significant element of map but the interpretation of the conventions of relief mapping is a difficult task for schoolchildren. Students of eleven or twelve years old appear to have difficulties to grasp the concept of contours and even older students have difficulties to visualize the landform from the contours [Boardman 1989]. On the other hand, a substantial proportion of children by the age of nine could draw accurate contour maps for discrete symmetrical model hills [Wiegand and Stiell 1997]. The age of nine seems crucial for introducing children to landform representation [Filippakopoulou et al. 1998]. Examining the ways different methods of landform representation were read and interpreted by elementary school students, Filippakopoulou et al. [1998] also reported that students' performance in extracting landform information was higher on hill shading maps than on maps with contours or contours and hill shading. The results justified the suggestion of Wiegand and Stiell [1997] for strategic use of maps employing hill signs other than contours in teaching relief mapping.

Children of elementary school have difficulties to construct a mental model of a spherical earth with people living around despite the information they receive for the earth shape [Vosniadou and Brewer 1992]. This deficiency is expected to affect the understanding of abstract concepts like meridians and parallels, and map projections. Our knowledge about the subject is limited. Map projections are usually introduced relying on reference to shadow projections but a significant number of college students fail to understand even the simplest cases of shadow projections [Downs and Liben 1991]. Instruction on coordinate systems is based on Euclidean understanding of spatial relations but even college students fail to represent the basic horizontal and vertical coordinates available in the everyday environment [Downs and Liben 1991]. Muir and Frazee [1986] suggested that geographical coordinate systems should be introduced to children at the formal stage of development. On the other hand, by the age of six years children understand Euclidean spatial relationships and are able to use grid references [Somerville and Bryant 1985, Blades and Spencer 1989]. Carswell [1971] investigating the topographic map reading and interpretation abilities of students in grade four, five, and six, concluded that symbols and directions appear to be the least difficult skills that they be mastered in intermediate grades. Scale, grid system, and elevation seem to be of equal difficulty and may be learned and used, even though not mastered in the intermediate grades [Carswell 1971]. However, a recent study revealed that schoolchildren of third to fifth grade of elementary school had difficulties to define relative directions even on the basic axes on a map [Michaelidou 2001]. Concerning measurements in scale, the ability to carry out accurate measurements and to proportionally reduce the scale is developed by the age of eleven or twelve years according to Piaget and Inhelder [1967] but students aged eleven to fourteen years had difficulties to enlarge a map [Bausmith and Leinhardt 1998].

Little work has been done on what children understand concerning map generalization. Gimeno and Bertin [1983] described a teaching method of cartography, that students aged nine to eleven years discovered the procedures used to develop a map, which synthesizes several phenomena, and applied procedures of selection and generalization transformations, like simplification, smoothing, and refinement, to the information presented on the map. The difficulty in applying each one of eight generalization transformations by students of secondary and tertiary education varies quite a lot [Filippakopoulou et al. 2000]. Students scored the highest results applying simplification and the lowest results applying aggregation transformation. In the same study, approximately, only 30% of high school students managed to enclose accurately in a frame on a small scale map the region depicted on a larger scale map.

The brief literature review cited above reveals a trend of the studies to investigate students' performance when they act as cartographers and take cartographic decisions [Gimeno and Bertin 1983, Bausmith and Leinhardt 1998, Wiegand and Tait 1999, Filippakopoulou et al. 1999, 2000]. Bausmith and Leinhardt [1998, p.106] cited that: "Map making is an effective instructional activity because it allows for the development of coherent, interconnected mental representations and understanding of maps elements. However, making a map per se may not be sufficient to build such understanding". Bausmith and Leinhardt concluded that map making is most effective when combined with principled instruction on the basic map elements (scale, symbol, and projection). Castner [1983] suggested allowing children working with problems of representation and argument in graphic media to discover, in meaningful ways, the nature of cartographic communication. Filippakopoulou et al. [1999], as well as Wiegand and Tait [1999], attempted to explore the cartographic schemata held by school students by examining their own solutions to map making problems using specially designed software tools.

Based on the ideas mentioned above, a software was design to introduce cartography to young map users. The software introduce basic cartographic concepts and principles, and incorporates activities which allow the users to take decisions about different map making problems and to look at more than one possible solution to a question. The advantages in creating such teaching situations are cited by Castner [1990].

SOFTWARE DESCRIPTION

In the present study an attempt is made to incorporate the conclusions of the empirical studies concerning children's cartographic "attitudes" in the design of the software, which is characterized by advanced visualization tools like animation, dynamic change, and sound provided by the current trends of human-computer interaction of computer science. The software is addressed to children of age from nine to fourteen years old.

Although computer science advances provide graphical technology that let us interact with information in innovative ways, like multimedia environments or virtual worlds, there is little knowledge about the cognitive value of any graphical representation [Scaife and Rogers 1996]. This consideration becomes more emerging when designing software addressed to young children. In an attempt to identify some key conceptual design issues, Scaife and Rogers [1996] suggest that any human-computer interaction incorporating advanced graphical representations with "added" cognitive value for particular users, should meet the following properties: explicitness and visibility, cognitive tracing and interactivity, ease of production, combining external representations, and distributed graphical representations. The software program was designed to be as close as possible to the needs, attitudes and experiences of young children. Following the properties proposed by Scaife and Rogers [1996] the software was developed under an object-oriented environment by assigning the cartographic concepts and activities as classes and objects, which are characterized by various properties and behaviors.

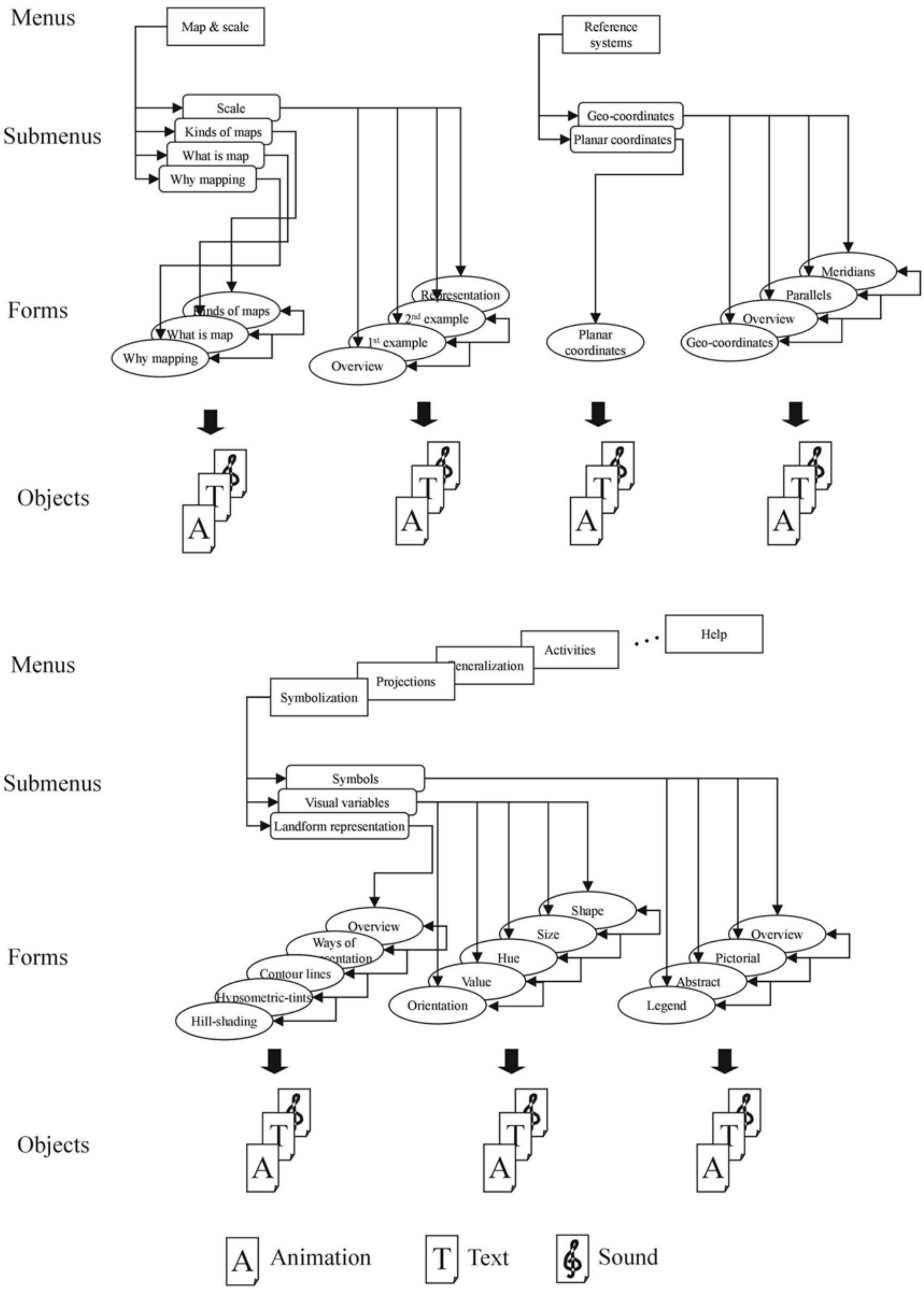

Figure 1. The components of the software

These logical prerequisites were transformed to physical graphic objects selected from the library tool supported by the developing environment. The utilized graphic objects are: forms for menus or views and images, command buttons for navigating through the software or for executing specific actions and sound or texts as auxiliary knowledge resources. More specifically, dynamic views were designed for the definition and discussion of geographic concepts of abstract meaning (e.g. meridians and parallels, or generalization), since according to the Gestalt principles objects moving together are perceived as a group [MacEachren 1995]. The control of the software graphical objects is executed by clicking or double clicking on the mouse. In order to diminish any possible control error and to enhance the user interaction every action is followed by a response of a visual effect on the selected command button along with an execution of a special sound. In Figure 1, a diagrammatic illustration of the software's components is given.

During the execution of the software program an output text file containing several attributes referring to the users –name, surname, school's id, and grade– and their choices of the performed activities, are automatically recorded for future evaluation of students' performance.

A general remark to be mentioned here is that the evaluation of children's interaction with maps in the case of computer use has some advantages compared to the conventional map use. In relevant experiments based on analogue maps the answers of the subjects should be filtered from subjective factors, like drawing skills, utilized drawing materials, etc. These limitations can be resolved through mapping in a digital environment.

The cartographic concepts

According to the cited basic cartographic concepts the software incorporated the following issues:

- Map (definition, kinds)
- Scale (definition, verbal–graphical form)
- Geographic and planar reference systems (geographical–planar coordinates, meridians–parallels)
- Projections (normal–transverse–oblique, cylindrical–conic–azimuthal, equidistant–conformal–equal area)
- Landform representations (hypsometric tints, contour lines, hill-shading)
- Design of symbols using visual variables (point–line–area symbols, abstract–pictorial symbols, shape, size, hue, value and orientation), and
- Generalization (simplification, classification, symbolisation and induction)

Several typical views of the software forms are illustrated in Figure 2.

The cartographic activities

The software includes several data sets covering the world derived from maps of very small scale, the continent of Europe derived from maps of small scale and the area of Greece derived from maps of scale 1:1,000,000. The spatial data cover a wide range of themes, like coastlines, contour lines, borders, lakes, rivers, roads, railways, and cities. Additionally, the spatial data are associated with thematic data referring to toponyms and population attributes. Both spatial and thematic data constitute a database appropriate to support users activities over the cartographic concepts introduced in the software.

As it has already been mentioned, the activities, which are incorporated in the software, aim to familiarize the users with mapping tasks and to make them take cartographic decisions. For example:

- To classify qualitative and quantitative data; to apply the appropriate visual variables to symbolize qualitative and quantitative data; to identify symbols in the context and fill the legend.
- To select the layers of information to be depicted on a map in order to enable an hypothetical user to extract specific information.
- To select the map that includes locations with specific geographical coordination.

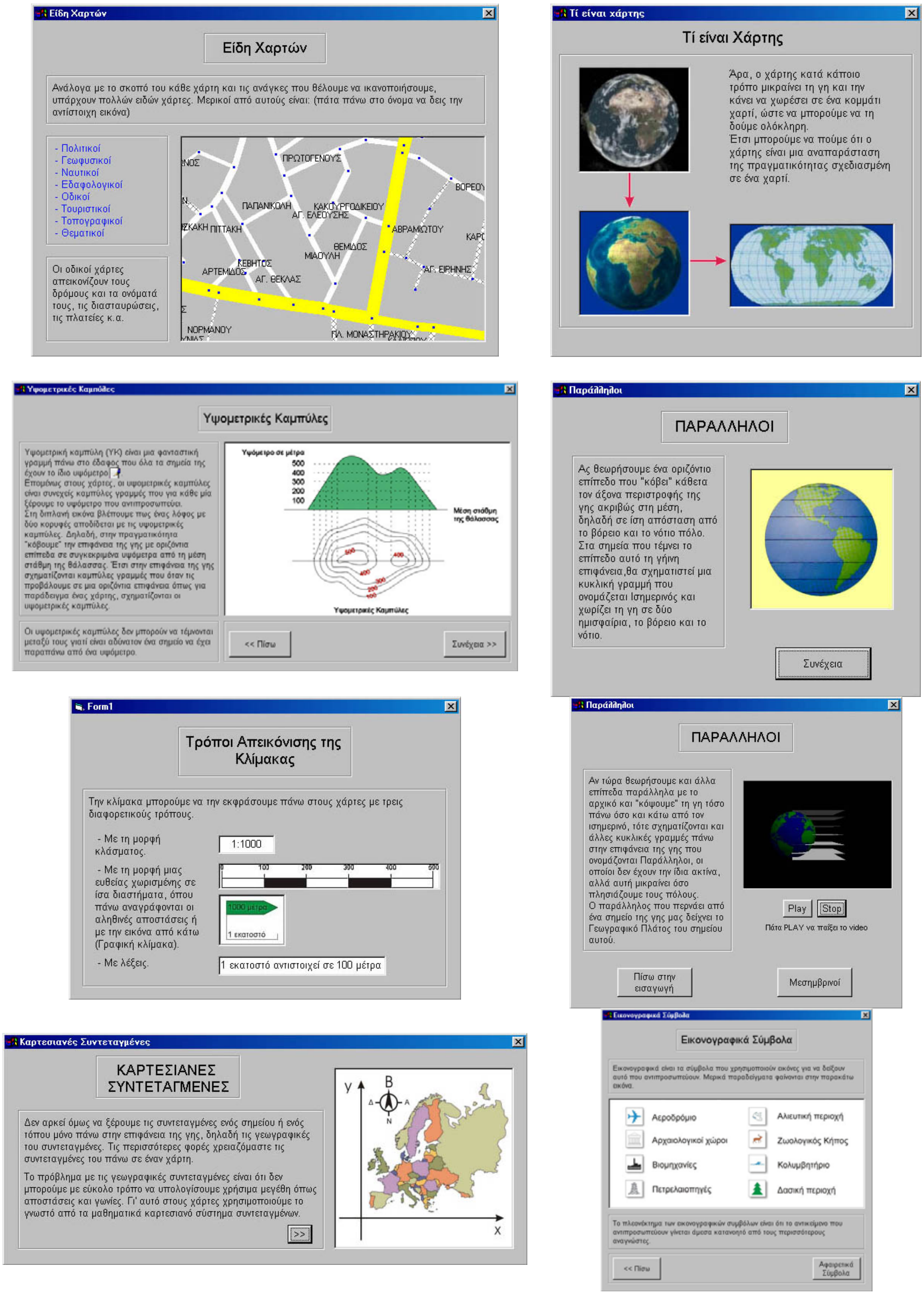

Figure 2. Characteristic views of the software

- To appreciate the differences in the area or the shape of a country depicted on maps of different projections.
- To choose the depiction of the outline of a country with the appropriate level of simplification in order to add it in a given map of a greater geographical region.
- To describe routes using different elements: distances and angles, directions, and coordinates.
- To choose from alternative methods of representation of the landform the one that is more appropriate for extracting specific information concerning the landform.

CONCLUDING REMARKS

Nowadays children are experienced in computer use, and besides using digital maps by getting acquainted with the existing software they become practical cartographers themselves. Unfortunately, most of the available mapping software programs use visualization tools emphasizing on fancy products instead of efficient and effective spatial representations.

The present study attempts to produce a software by which children can be introduced to basic cartographic principles and consequently perform mapping skill activities. The visualization tools used are those that there is evidence for their effectiveness. However, there is a need for further research to be done on this specific topic.

The next step of this study is to examine whether the pre-defined goals have been achieved. This will be done, by evaluating the children’s acquired knowledge on the basic cartographic concepts after using the developed software.

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