THE USE OF PRIMARY GRAPHIC ELEMENTS IN MAP DESIGN BY FIRST AND SECOND GRADE STUDENTS

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Introduction

Cartographic research has reported that early elementary school children have shown advanced mapping behaviors in reading positional, locational and wayfinding information using large scale maps. More recent studies revealed that Grade 2 students understand the map as a representation of space and can be exposed to more advanced cartographic means, such as thematic maps. The idea of designing thematic maps and using them as teaching aids, even in early school years, sounds interesting and challenging. But, are the cartographers ready to design such maps? Do they know young children's needs, attitudes, and more over, their feelings about mapping? We believe that cartographers have to follow careful steps before designing maps for children of such a young age, since these maps will introduce these children to mapping activities and probably affect their future attitudes towards maps. Among the very first concerns of the map designer must be the method used to symbolize geographical data, concepts, and relationships so the children can be helped to assign the intended meaning to the multiple kinds of symbols, variations, and combinations. At this initial stage of map design, however, a basic problem arises as stated by Anderson [1996], "little research has been conducted into what, for a child, characterizes a particular map symbol. Is it the symbol's color, shape, size, the feature's function, or some combination of these? For a young child, is the parameter of size secondary to shape or color when more than one variable is used to symbolize a feature?" A similar position is reached by Castner [1990], who argued that the discrimination of hue, value, chroma and texture is fundamental for developing one's visual perception. According to Castner, initial lessons in cartography and geography may begin with perception of texture and colour as a beginning.

The child of the pre-operational period (approximate ages: 2-7 years old) is capable of manipulating symbols that represent the environment, but the understanding of representations and fundamental spatial concepts is restricted by limitations of pre-operational thought [Piaget and Inhelder, 1956]. Downs et al. [1988], argued that essential to map understanding is the "stand for" relationship which must be grasped at the holistic level (i.e. the relation between referent and the symbolic representation taken as a whole) and the componential level (i.e. the relation between elements of the referent and elements of representation). Marzolf and DeLoache [1994] reported that three year old children appreciated the overall map-room correspondence, whereas experience with a model-room symbolic relation helped two-and-a-half year-old children to appreciate a map-room relation as well.

Downs et al. [1988], cited that the interaction of three factors shapes the ability of children to understand the components of a representation:

- context: map components are not interpreted as discrete, isolated elements and the systematic interrelationships between them are appreciated;
- iconicity: map components are interpreted symbolically and not literary;
- convention: the graphic form of map components is recognized as arbitrary.

Interpretive challenges

The development of the ability to appreciate the above factors occupies the period from kindergarten to Grade 2, although this is not necessarily complete by the end of Grade 2. Problems concerning interpretation during this period have been identified [Downs et al., 1988; Liben and Downs 1992]: children have difficulty in fully appreciating the dual and arbitrary character of symbols. With respect to iconicity, students interpret map components literally on the basis of what they "look like" rather than what they signify. Sometimes this interpretation is advantageous when, for example, a river is identified because of symbol's blue colour. Most of the time, however, this leads to incorrect conclusions. Children's responses have evidence of reification, an over extension of the symbol to the referent. The visual variable of the symbols is presumed to characterize the referent. For example, children thought that a road

shown in red on a map would actually be red in real world. Extension in the reverse direction also occurs, and children assume that some characteristics of the referent should necessarily be evident in the symbol. Children's responses were also sometimes out of context. They could not always appreciate dimensional systematicity and had difficulty in maintaining size and scale relations. For example, a lake was correctly identified on an aerial photograph, whereas a boat was interpreted as a fish. Children also had problems in maintaining perspective. For example a child, who correctly identified a building, claimed to see its doors and windows. Downs et al. [1988], argued that the above problems are a reflection of the limitations inherent in pre-operational thinking which could be predicted by Piagetian theory. They also indicated that confusion of scale could be linked to lack of understanding of proportionality and metrics, from confusion of perspective to children's failure to construct projective spatial concepts, and from reification to nominalism.

To the sources of problems in symbol identification mentioned above, Anderson [1996] added colour and particularly insufficient value contrast. Anderson [1996] examined the nature and the role of the visual variables of shape, colour and size in symbol identification by six year old children. The map reading task required the students to identify and locate point, line and area symbols on two maps: a large-scale pictorial and an abstract. She concluded that "although shape may be an important variable in symbol identification, its significance varies with the nature of the map symbol (point, line, area) and representation (pictorial, abstract)" (119). Anderson also suggested that for pictorial point, the symbol's shape is a more important characteristic than colour, but if the prototype of the referent is lacking, this can be confusing. Abstract point symbols present problems in identification, which may be attributed to their complexity. Shape is the important variable for the identification of line symbols for both pictorial and abstract maps. Colour is the more important variable for area symbols since there is no dimension of shape. Association of a colour with particular phenomenon sometimes lead to the correct identification of "green trees" or "gray roads" but other times caused confusion. Sometimes the children's responses illustrated attention to more than one variable for the identification of one symbol.

Trifonoff [1995] went a step further and used symbols which represented quantitative information. She investigated the thematic abilities of seven and eight year old children in Grade 2. Students viewed maps of different scales (of neighborhood, city and nation) which displayed different types of symbolization: gray tone shading, red tone shading, graduated circles and redundantly coded circles which varied in size and value (gray tones of shading). The purpose of the study was to determine if children could think abstractly and understand the symbolization of quantitative data on maps. Results indicated that the map tasks were appropriate for this age level. A statistical test of reaction times revealed that children interpreted all scales and perceived all methods of symbolization equally well. The redundant symbols never produced the fastest reaction time, but the four methods of symbolization showed no significant differences in mean reaction times. The interpretation of quantitative information presented on thematic maps was within the ability level of Grade 2 students. Children could also interpret the spatial patterns depicted on thematic maps and it appeared that spatial patterns were most easily identified with area symbols rather than point symbols. Most of the students expressed their preference on the colour map to show low, medium and high values.

Children's preference to specific visual variables is the subject of interest for the present study. The main purpose of this study was to explore if children have an innate sense in applying the variation of primary graphic elements, which in cartographic language is transformed to visual variables [Robinson et al., 1995] to symbolize the properly qualitative and quantitative thematic information on maps. Subjects of the study were seven and eight year old children (Grade 1 and 2) who had not been exposed to mapping activities. Their responses, therefore, were based on intuition, rather than their acquired knowledge.

Methodological approach

Based on the study's goals, and particularly on the idea of exploring human intuition for the interpretation of the visual variables, the first task of the investigation was the selection of participants. Students at an early elementary level, first and second grade (6-8 years old), with no experience in either using maps or any knowledge on spatial representations were selected. On the other hand, all of them had some experience with using personal computer, since they had attended an introductory course on computer technology. The students carried out the test at their school, in a familiar classroom.

The second task was the design of the base map. After thoughtful consideration, the map on a display rather than a paper map was chosen as the means of the investigation. Three were three reasons for this choice. The first one is our belief that working on a personal computer is an attractive activity for young children, and is preferable to writing or drawing on a paper surface, something closer to their studying procedures. The second considered that in the near future maps on display will be common and easy to access. Therefore, students should be introduced to them at an early age. The third, and main reason for this choice involved the idea of organizing the investigation like a video game as a "metaphor" to map compilation, since the aim of the study was the exploration of intuition in using visual variables to formulate cartographic symbols. Based on the above considerations a large scale map was designed,

portraying water surfaces and a built-up land area. The planimetric information included roads, green areas, buildings and block outlines. In order to avoid a confusing base map, lettering and landform information were not included in the presentation. Five sets of symbols were compiled to represent the visual variables of size, shape, hue and value. The fifth set employed pictorial symbols.

The third step provided instructions to children: "Place the symbols you prefer to symbolize the following themes." Two of the themes referred to qualitative point data, while remaining themes included in the test referred to quantitative point data differentiated in order scale. The themes were:

- museum, theatre and church;
- houses of low, moderate and high rent;
- blocks with few, many and too many inhabitants;
- police office, hospital and fire station.

Finally, the students were asked to select the map of their preference from those they had composed for each of these themes.

The software

The media of the investigation, as described above, was based on the use of specially developed software. The software program was designed to approximate the needs, attitudes and experience of young children as close as possible. For this reason, the format and execution copied that of a simple video game. Following the contemporary trends of information technology, the software was developed with consideration of an object-oriented environment. To record the study's analytic demands, the software incorporated a short demo, as well as different maps, themes, symbol sets, short instructions and comments. These logical prerequisites were transformed in to physical graphic objects selected from the tool library, supported by the developing environment. The utilized graphic objects included: forms for views (maps) and images (demo), command buttons for the themes and symbol sets, and texts for the instructions and comments. Considering the age of the study participants, control of the software graphical objects, was executed by either clicking or double clicking on the mouse. In order to diminish any possible control error and to enhance the user interface, every action was followed by a response of a visual effect on the selected command button, along with a special sound. A typical overview of the software format is shown in Figure 1. The software development also incorporated current trends of graphical user interface (GUI) generation.

Figure 1: Typical views of the GUI, the demo view (above) and a view consisted of four maps

The execution of the software program automatically created an output text file which contained: the names, surnames, school identification, grades, comments and the selections of the utilized symbols made by users in separate columns. This facilitated an effective means of producing study results which avoided time-consuming typing procedures and possible typing errors.

The investigation

The investigation was curried out in the following manner. Each student took the test sitting in front of personal computer next to an investigator, who introduced the program. For each student, the test lasted approximately twenty minutes. First, participants were introduced to the test as a game "having to do with map composition." An introductory image of the sky was shown on the display, along with three symbols of sun, rain and clouds. The student were asked to choose the appropriate symbol to represent sunny, rainy and cloudy weather respectively, in order to become acquainted with the computer functions necessary for the test. Representative sounds followed each choice, which made the test look more like a game. After the introductory task, students proceeded with the map composition. Participants were asked to create the thematic maps, by symbolizing the required features and were asked to use the available sets of symbols. At the end, participants were asked to choose the map that best portrayed the represented features.

Results

The investigation will be applied to different schools in the Athens district area. The initial results of the pilot study are presented here. Fifty-two students 6-8 years of age (17 in Grade 1 and 35 in Grade 2) participated in the pilot study. They came from six different sections of the same school in a suburban area of Athens. Participants of this sample were chosen on the basis of their teachers having evaluated them as "good" students.

In analyzing the results, no significant differences were found regarding either gender (male/female), or grade level (first/second) among the subjects who participated in the pilot study. Figure 2 represents an overview of the study's total results by bars arranged in rows and columns. Each graph (a, b, c and d) included in Figure 2 refers to each of the four groups of themes examined. The columns in every graph refer to the visual variables utilized to form the different sets of symbols. The rows represent the selections made by the students (called "Selected") and the appropriate selections according to the established cartographic rules (called "Correct").

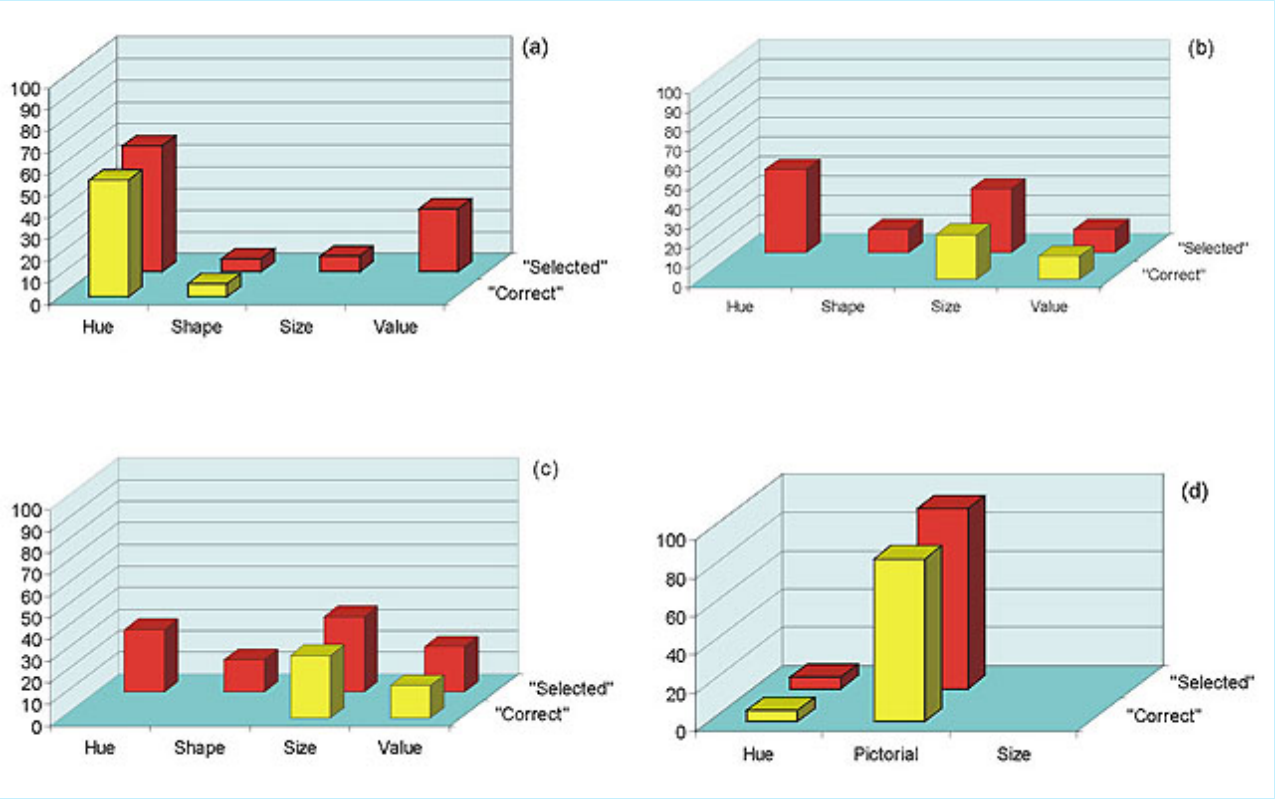

Figure 2: Total results of the investigation for the four groups of themes, referring to the maps representing: (a) the museum, the theatre and the church; (b) the houses of low, moderate and high rent; (c) the blocks with few, many and too many inhabitants; (d) the police office, the hospital and the fire station.

In summary, 2% of the students included in the sample failed in the test by making no correct selections. Twenty percent made one correct selection, 34% two correct selections, 25% three correct selections, and finally 14% of the students completed the test with perfect results by making four correct selections.

Discussion

The preliminary results of the pilot study reveal some interesting points to be discussed, even at this initial stage of the research:

- In portraying qualitative data, 60% of the children chose the correct visual variables (57% hue and 3% shape) and 40% the incorrect ones. When pictorial symbols were included in the sets of symbols the choices were 90% correct and 10% incorrect. This is because the large majority of children prefer the pictorial to any other kind of symbol;
- in portraying quantitative data for the theme referring to the rental house, 34% of the children chose the correct visual variables (11% value and 23% size) and 66% the inappropriate ones (hue and shape). In the second case of quantitative data portrayal, 44% of the children chose the correct visual variables (15% value and 29% size) and 56% chose the incorrect ones. Some of the children did not know the meaning of the term "rent", and this may have contributed to the difference in the correct response to this particular section. It is noticeable that among the children who chose the correct visual variables to portray the quantitative data, 70% preferred size rather than value;
- the fact that hue was chosen even for the portrayal of quantitative data has to be mentioned. An other point

worth mentioning is that shape concentrates the lowest preferences among hue, value and size;
- of main importance is the fact that when children employ size or value for portraying quantitative data, they apply them correctly (proportionally scaled according to the data ordinal scale) in a percentage from 52%-70%, regardless of their selections.

Conclusion

The results indicated that students of early primary school grades can be easily introduced to the concepts and use of visual variables to form cartographic symbols. Thematic maps can be used as teaching aids in early elementary grades.

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