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COMMISSION ON CARTOGRAPHY AND CHILDREN

CONFERENCE ON TEACHING MAPS FOR CHILDREN: THEORIES, EXPERIENCES AND PERSPECTIVES BEGINNING THE 3RD MILLENNIUM

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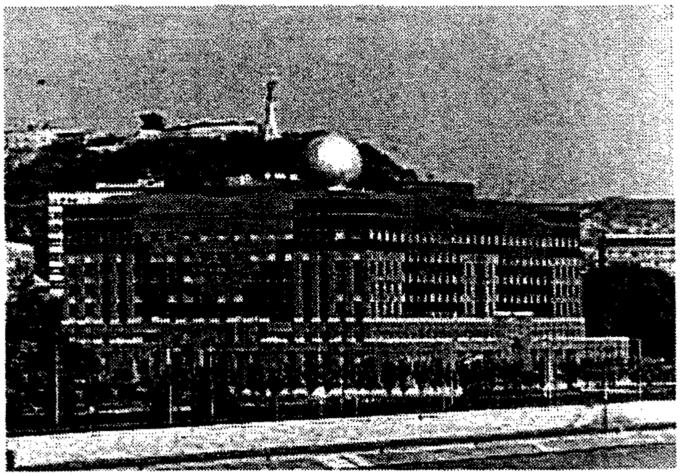

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Children's Understanding of Generalisation Transformations

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Abstract
Children are using maps presenting their local environment (large scale maps), their country or the surrounding countries (medium or small scale maps), as well as world maps (very small scale maps). Do children understand the decreasing map scales? Can children recognise the differences of spatial representations in various scale maps? Behind these two questions the process of cartographic generalisation is hidden. The aim of the present study is to clarify the children's conception of generalisation transformations. A questionnaire was given to 12-18 year-old secondary school children. The answers record children's response to the generalisation transformations. The results are helpful for teaching purposes and for designing more effective maps for children.

Introduction

According to the school curriculum children are using maps and atlases as tools of learning the content of geographic courses. Aim of teaching geography is the knowledge and understanding of spatial relationships. Children are using maps presenting their local environment (large scale maps), their country or the surrounding countries (medium or small scale maps), as well as world maps (very small scale maps). Do children understand the decreasing map scales? Can children recognise the differences of spatial representations in various scale maps? Behind these two questions the process of cartographic generalisation is hidden. Generalisation is the process that affects more than any other cartographic transformation the information that is contained within a map. Generalisation affects both location and meaning of information [Keates, 1989]. Furthermore, by reducing the map scale two crucial cartographic problems are arising. The first one refers to the reduction of the available space for the representation of a specific area and the second one to the need of enlarging the physical dimensions of spatial objects in order to make them clearly visible.

The aim of the present study is to clarify the children's conception of generalisation transformations. Spatial transformations such as simplification, aggregation, amalgamation, merging, collapse, displacement, etc., which control the graphic modification caused by generalisation, were tested. For the purpose of the study sample maps depicting feature changes due to scale reduction were composed, by applying the above mentioned generalisation transformations. A questionnaire was given to 12-18 year-old secondary school children. The answers record children's response to the generalisation transformations. The results are helpful for teaching purposes and for designing more effective maps for children. The same results are critical for building a robust environment on the topic of the didactic of both geography and cartography.

The state of the art

The understanding of how map-readers -especially the younger ones- conceive the decreasing map scales and recognise the modifications of the portrayed information on maps would contribute to the effective design of maps and atlases and the teaching of cartography. To date, there has been little investigation on the subject. Anderson [1995] stressed that little work has been done on what constitutes appropriate level of map generalisation and complexity for children. In a recent research, students 11 to 14 years of age, who were invited to construct a series of thematic maps using a specially designed software tool, revealed a weak notion of both spatial and numerical factors underpinning symbol generalisation [Wiegand and Tait, 1999]. Heamon [1973] examined how students 8 to 14 years old draw the outline of towns and villages presented on photographs and maps and concluded that children from the third and fourth year of the primary school onwards can be given the opportunity to make generalisations based on spatial data. Gimeno and Bertin [1983] described a graphic method of teaching cartography, which enabled students 10 to 11 year of age to discover by themselves fundamental principles of graphic symbolisation and apply the visual means to represent the concept of order. The same authors also described how students 9 to 10 and 10 to 11 years old discovered the procedures used to develop a map, which synthesises several phenomena. The students applied the processes of selection and generalisation transformations to the selected information like simplification, smoothing, collapse, and refinement to develop the map.

Castner [1983] emphasised the need to distinguish between scale-dependent generalisation and function-dependent generalisation when children are introduced to maps and mapping.

The objectives of the present study are twofold. The first is about recognition of a region presented on a map as the scale of the map reduces. The second is about understanding the spatial transformations defined by McMaster and Shea [1992], that alter the representation of the information of the maps as the scale reduces.

Generalisation transformations

People see and use maps of a wide range of scales, as for example, large scale maps of their local environment, medium scale maps of their country or of extended geographical areas, and small scale maps of continents or of the world. As the scale of the map decreases the representation of geographical information is imposed to modifications in order to retain graphic legibility and respond to the purpose of the map. Information at the lower level of classification hierarchy may be omitted. Features of the representation may be simplified, exaggerated or enhanced. These changes may cause overlap between features, leading to their displacement. Competition of space may enforce the reduction of features dimensionality, as for example from area to line, or dictate the join of features. All these processes constitute the application of generalisation.

After a review of different definitions for generalisation Keates [1989] concluded that the principle elements of the process seem to fall into two main groups: scale and graphic requirements (legibility), and characteristics and importance. The scale of the map controls the available space, in which there are minimum requirements for graphic legibility. Legibility itself depends on symbol size, form and colour and the amount of information concentrated within an area. The retention of the essential characteristics of the phenomena represented (in terms of shape and configuration) and the graphic emphasis according to the degree of importance attached to the features facilitates correct interpretation.

Different transformations in the course of generalisation are introduced to the map to maintain legibility and to accommodate relative importance. These transformations affect both components of the information contained within a map – location and attribute at location. Various transformation sets have been described [Shea and McMaster, 1989; Mackaness, 1991; McMaster and Shea, 1992; Jones, 1997]. McMaster and Shea [1992] described in a comprehensive way ten transformations altering the representation of the data from a spatial perspective and two from attribute perspective. As the scale decreases the map-reader may recognise the effects of the following spatial transformations:

1. *Simplification transformations* have the effects of retaining the least number of data points necessary to represent the character of map features and of rejecting the redundant point considered to be unnecessary to display line's character.
2. *Smoothing transformations* act on lines by decreasing the constituent detail and adjusting the positions of existing points. They produce a simplified version by planing away small perturbations and capturing only the most significant trends of the line.
3. *Aggregation transformations* merge point symbols of the same class into a single area symbol when the points come into a close proximity and prohibit each other from being portrayed.
4. *Amalgamation transformations* apply to a set of adjacent area features that are of the same class. They merge these features into a larger element retaining the general characteristic of the region.
5. *Merging transformations* act on two or more adjacent lines, with a separate distance between them and merge them into one line positioned approximately halfway between them.
6. *Collapse transformations* reduce the dimensionality of an area feature to a point or a line.
7. *Refinement/typification transformations. Refinement transformations* act when features of the same class are either too numerous or too small to be portrayed to scale. They eliminate the smallest features or those, which add little to the general impression of the distribution. The general pattern of the features is maintained with those features that are chosen to remain shown on their correct location. *Typification transformations* act in a similar way to the refinement process maintaining the general pattern of the features but with the remaining features shown in approximate location.
8. *Exaggeration transformations* apply to features to enlarge or exaggerate their shape or size to meet the specific requirements of the reduction of the scale.
9. *Enhancement transformations* apply to features that need to be exaggerated or emphasised to meet the specific requirements of the map. They deal primarily with the symbolisation component and not with the spatial dimensions of the feature although they produce some spatial enhancement.
10. *Displacement transformations* are used to face the problem that arises when two or more features come in conflicting either by overlapping each other or becoming too close to be clearly discernible. The features are moved from their true planimetric locations to allow for the application of symbology.

Attribute transformations include classification, and symbolisation:

1. *Classification* is the process of ordering, scaling and grouping features by their attributes.
2. *Symbolisation* is the process of graphically coding information and placing it into a map context [Robinson et al., 1995].

Research

Method

As it comes out from the review of the existing studies, focused on the keywords: children cartography and generalisation, there is a lack of information about the way children react to the generalisation procedure. The aim of the present study is to give a first insight on the conjunction of these two cartographic aspects. Children's reaction to generalisation procedure can be investigated through their ability in applying the spatial transformations of generalisation. Usually, the generalisation of a spatial object is obtained by applying more than one transformation simultaneously. For the purpose of this study, in order to investigate each spatial transformation separately, the investigation method was designed so that each one of eight spatial transformations was checked independently. The eight spatial transformations of generalisation are: simplification (see Fig. 1a), amalgamation (see Fig. 1b), merging (see Fig. 1c), collapse (see Fig. 1d&e), typification (see Fig. 1f), exaggeration (see Fig. 1g), displacement (see Fig. 1h), and aggregation (see Fig. 1i).

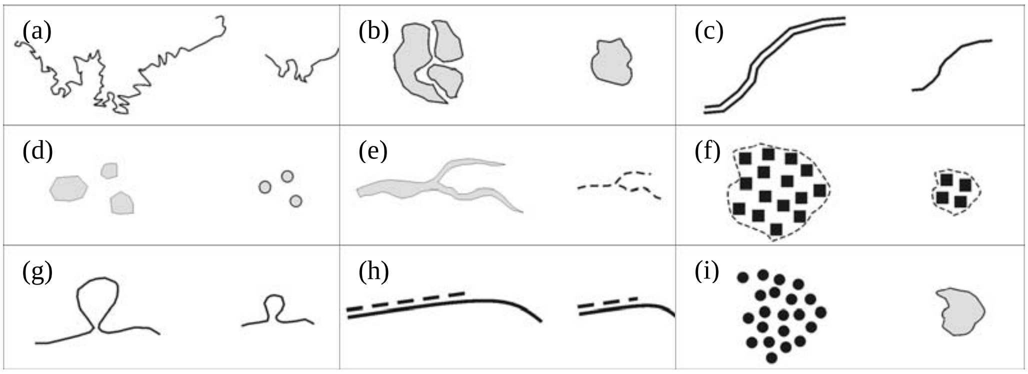

Figure 1. The eight spatial transformations of generalisation used in the study.

The spatial transformations of generalisation used in the study are illustrated in Fig. 1. Each part of Fig. 1 at the left side portrays an object in the original scale (large scale) and at the right side the object after the application of the transformation in the derived scale (small scale).

Subjects

A total of 64 subjects took part in the research at this preliminary stage. Thirty one of them were secondary school students (aged: 12-18), from various high schools, both public and private, of Athens district area. Furthermore, twenty two undergraduate students (aged: 22-25) of the Faculty of Rural and Surveying Engineering of National Technical University of Athens and eleven graduate students (aged: 25-35) of the same Faculty in Geoinformatics.

Materials

The subjects had to take a test, which had two parts. At the first part, two equally sized rectangular segments of topographic maps (one original and one derived), centred at the same location, in different scales (with a ratio scale 1:2) were given. The subjects were asked to enclose in a frame on the derived map the region depicted on the original map. At the second part, a brief description on the eight spatial transformations of generalisation was given along with graphical examples (see Fig. 1). Eight sample maps, composed for the purpose of the study, each one in two scales (one original and one derived), consisted the test material of the second part. In the derived scale map one or more objects were missing and the subjects were asked to draw the missing object(s) by applying the most appropriate according to their opinion spatial transformation of generalisation. The test (part 1 and part 2) took place in an office by personal interview lasted for half an hour. Fig. 2 illustrates all sample maps used for the second part of the study. It has to be noticed that the order of the spatial transformations between the sample maps and the description examples did not have the same sequence.

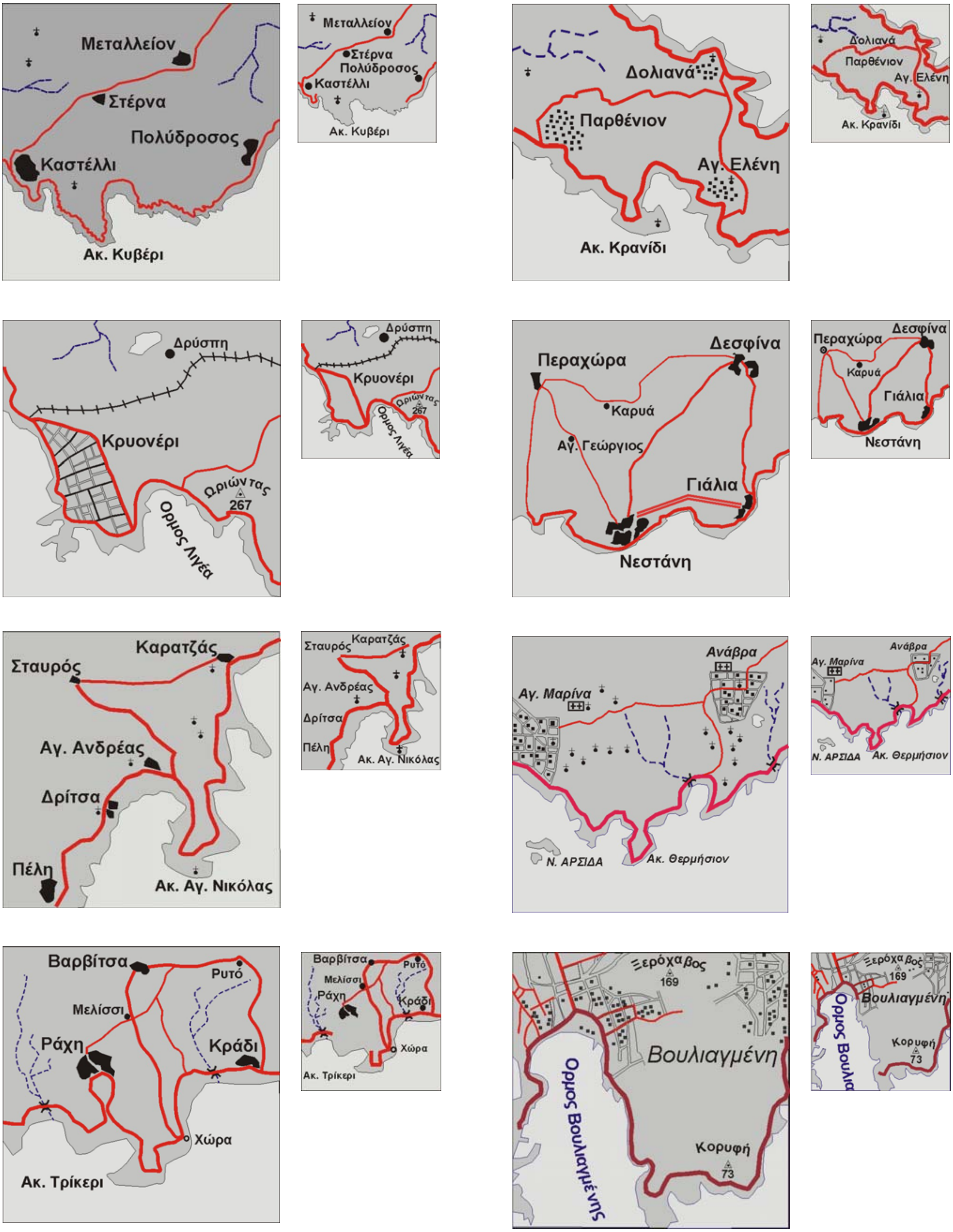

Figure 2. The eight sample maps at the original (left) and the derived (right) scale used in the study.

Evaluation

The answers were evaluated quantitatively. Concerning the first part of the study where the subjects were asked to enclose in a frame on the derived map the region depicted on the original map the answers were scored as 0%, 25%, 50%, 75%, and 100%. In the second part, the questions concerning the transformations, the evaluation was based on two criteria. With the first criterion the conception of each spatial transformation of generalisation by the subject was evaluated. With the second criterion the graphical representation drawn by the subject was evaluated. We tried not to be biased by the drawing ability of the subjects. Each answer was scored with 0 or 1 for the "conceptual" criterion, 0 or 1 for the "graphic" criterion and 0 or 1 for the judgement of the total result. Each questionnaire was evaluated by two persons separately, and there was no significant difference between the scores of the two evaluations. Tables 1, 2, 3 and 4 present the preliminary results of the study.

Table 1. Results of area reduction test in first part of the study (% distribution).

Area Frame	*High school students*	*Univ. undergraduate students*	*Univ. graduate students*
0%	11	4	9
25%	0	23	18
50%	25	23	27
75%	36	36	28
100%	28	14	18

Table 2. Results of spatial transformations of generalisation against "conceptual" criterion (% correct answers).

Spatial transformations	*High school students*	*Univ. undergraduate students*	*Univ. graduate students*
Simplification	100	100	100
Aggregation	29	46	46
Amalgamation	61	82	91
Merging	68	91	82
Collapse	50	58	55
Typification	50	59	46
Exaggeration	89	73	73
Displacement	82	100	100

Table 3. Results of spatial transformations of generalisation against "graphic" criterion (% correct answers).

Spatial transformations	*High school students*	*Univ. undergraduate students*	*Univ. graduate students*
Simplification	87	86	100
Aggregation	29	36	27
Amalgamation	61	82	73
Merging	68	91	73
Collapse	43	45	18
Typification	50	55	46
Exaggeration	54	41	36
Displacement	79	77	100

Table 4. Total results of second part of the study (% correct answers).

Spatial transformations	*High school students*	*Univ. undergraduate students*	*Univ. graduate students*
Simplification	96	91	100
Aggregation	29	46	46
Amalgamation	61	82	91
Merging	68	91	82
Collapse	50	59	55
Typification	50	55	46
Exaggeration	86	64	64
Displacement	82	86	100

Discussion

Although the research has not been integrated a few comments can be stated based on the first preliminary results. The subjects that have already participated in the study are faced as belonging to three groups: the high school students, the undergraduate students, and the graduate students of the University. Comparing the results of these three groups we can notice:

- The high score of the high school children (in comparison to the one of the University students) in the first part of the study.
- The small differences in the scores among the three subject's groups, in most of the questions concerning the spatial transformations of generalisation.
- The understanding of each spatial transformation varies quite a lot. Simplification, amalgamation, merging, exaggeration, and displacement were successfully applied. Collapse and typification were not applied by almost half of the subjects, and aggregation was the spatial transformation that subjects got the lowest score.

Finally, it has to be mentioned that high school students had no significant difficulty in applying the spatial transformations of generalisation, although they did not have any previous cartographic education or practice on generalisation.

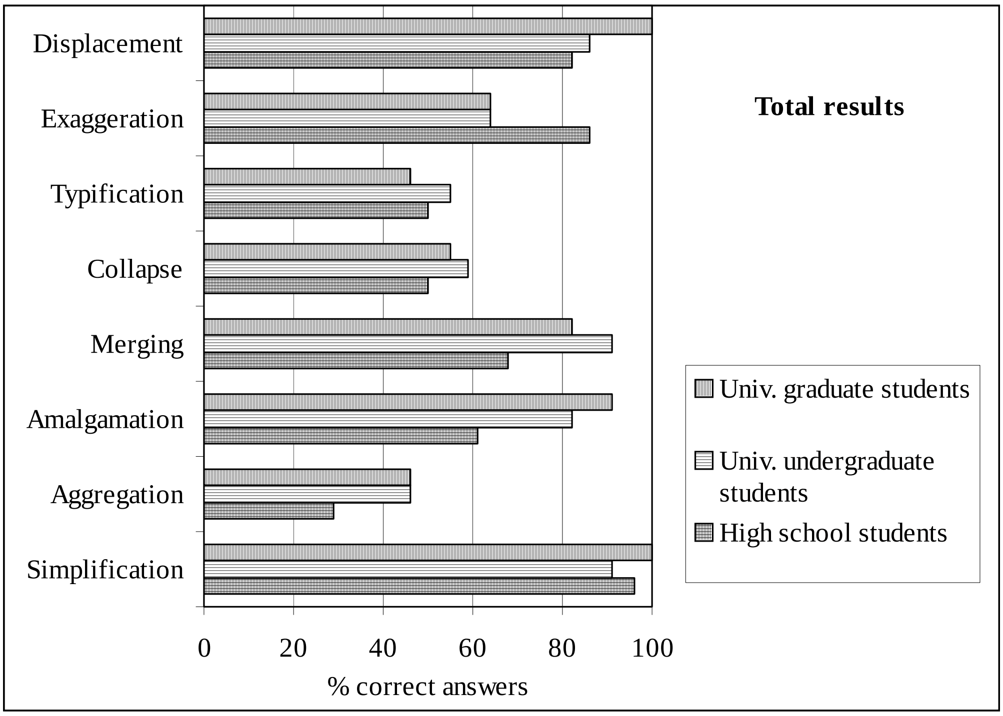

Figure 3. Comparison of the results of the three groups of subjects.

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