

## ANALYSIS OF PERCEPTION OF CARTOGRAPHIC SIGN SYSTEMS IN LITHUANIAN GEOGRAPHY ATLASES FOR SCHOOL

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### INTRODUCTION

During the development of human kind, maps appeared earlier than writing. It is an informational means used for several thousand years. Evidently, maps have old communicational traditions. Maps are essentially important nowadays because a lot of important information is coded in them with signs that a person often needs in every day life. Every educated person should know the language of cartography – to read maps – as good as verbal, literal or numeral (mathematics) language. Therefore it is very important that cartographic language was taught as early as childhood.

Like any other language, cartographic language is comprised of certain signs. The initiator of American movement of semiotics C. S. Peirce has given such definition of sign: “A sign is something which stands to somebody for something in some respect or capacity” (Fiske, 2002). And a cartographic sign is a visually perceived graphic symbol used in map to represent a type of object, phenomenon (process), its place in space, shape, size, content, qualitative and quantitative attributes and change in time. It is a formalized graphic map language. As well as other artificial languages, it is one of forms of thought expression and an additional means of communication (Dumbliauskienė, 2004).

Map is not only a tool to collect and store information but also to transfer it. Nowadays the need for cartographic information is constantly growing, therefore it is very important to properly educate children's cartographic literacy in school. Information in geography atlases for school should be presented as clear and comprehensible as possible, i.e. knowledge presented in the map should be “written” in correct cartographic language so that students would quickly understand and memorize. So far there is no standardized cartographic sign system for economy maps in Lithuania. The creators of cartographic production still use different systems of cartographic signs. This makes the understanding, assimilation and quick memorizing of cartographic signs very difficult for users.

Although the analysed topic is very important, there has not been enough attention towards the improvement of cartographic signs in school cartography in Lithuania. Therefore currently performed research is significant for the improvement of quality of school cartographic production used in Lithuania. It is possible that the experience of this work will also be useful for the cartographers from other countries who are concerned about the language correctness of maps for school.

The objectives of scientific research: to improve the quality of cartographic sign systems, to improve cartographic language and to seek its correctness in Lithuanian geography atlases for school for students in senior grades.

### THE METHODOLOGY OF THE RESEARCH OF CARTOGRAPHIC SIGN SYSTEM PERCEPTION

One of the most important tasks of cartography – perhaps the most important – is to ensure a communication of cartographic publication, the transfer of information to the user, i.e. to ensure good readability of cartographic work (Dumbliauskienė, 2000a; Wolodtschenko, 2006). This means that maps intended for learning should be easily read and quickly understood, information should be easily memorized, therefore it is very important that the shape and colour of cartographic signs was as similar as possible (symbolic signs and colours used), in some cases even identical to the signified (imitating/stylized (also called iconic) signs and identical colours are used). Simple signs should be predominant. Cartographic signs in map legends should be correctly semantically differentiated. Taxonomical differentiation and transition expression should also be correct. An optimum cartographic base is recommended in maps in order to allow the user (student) to orientate in the map as good as possible. Pronounced graphic originality, especially in maps intended for junior grades, is very important. It is a method to attract children's attention and promote interest. Acceptable graphic and informational loads influence readability and quick perception of a map. But it should not be forgotten that the quantity of information in the map should also depend on the age of the user.

While performing the research of perception of cartographic sign systems in Lithuanian geography atlases for school, a methodology covering two aspects of work was used.



Table 2. An example of table for the research of signs in the aspect of syntactics

No.	Title of the map	Semantic differentiation			Taxonomical differentiation			Transition expression		
		Correct	Partially correct	Incorrect	Correct	Partially correct	Not expressed	Correct	Partially correct	Not depicted
(Title of geography atlas for school)										
1.										
2.										

Table 3. An example of table for the research of signs in the aspect of pragmatics

No.	Title of the map	Graphic load			Informational load			Cartographic base			Graphic originality		
		Overload	Acceptable	Low degree	Overload	Optimum	Low degree	Optimum	Average optimality	Not optimum	Pronounced	Moderate	None
(Title of geography atlas for school)													
1.													
2.													

## 2) Research of cartographic sign perception by way of survey (in schools)

Semiotic analysis revealed the advantages and disadvantages of cartographic sign systems. A questionnaire survey was added to the research, answers to which showed the peculiarities of students' perception of cartographic signs.

Organization of the survey. The survey was performed in nine schools in Lithuania. A total of 250 respondents participated: 50 eighth graders, 50 ninth graders, 50 tenth graders, 50 eleventh graders and 50 twelfth graders. The number of respondents was determined with respect to the requirements of reliability of scientific research results (Kardelis, 2007).

A non-probabilistic convenience sampling was used for the sample volume (the most known and easily accessible schools were chosen – with the least monetary expense) as well as probabilistic simple random selection (by choosing the members of population).

Preparing the questionnaire. A short description of performed research and the most important concepts were given at the beginning of the questionnaire. The respondent was also asked to give his/her city, gender and grade. 5 questions and 2 tasks were given in the questionnaire.

I–II question – the usage of atlases according to grades and publishing houses;

III question – the frequency of legend usage while reading information in economy maps;

IV question – the perception of information with respect to the types of cartographic signs;

V question – the need of sign standardization in geography atlases for school;

VI question (task) – a selection of easy comprehensible and unacceptable signs in given table that consists of main signs from economy maps in researched atlases (186 signs);

VII question (task) – choosing an industry depiction method from two examples.

Respondents had 45 minutes to fill in the questionnaire. In order to avoid rejective and unfair filling of questionnaire and to receive as good results as possible that would allow to provide recommendations for the improvement of cartographic sign systems, respondents filled in the questionnaires during geography lessons at school.

Answers to questions were processed with mathematical-statistical method, certain regularities were determined and conclusions were drawn.

## RESULTS

### THE MOST IMPORTANT RESULTS OF SEMIOTIC ANALYSIS

During the research 296 different cartographic signs from 4 geography atlases for school (from 3 publishing houses) were analysed.

After grouping the signs into spot, linear and area (fig. 1), it can be said that spot-type signs are predominant in the analysed sign systems – 68% of all signs. Such tendency can be explained by the fact that objects depicted in economy maps are usually located in certain spots. Linear signs are least used in sign systems – approx. 7% of all signs. Area signs form about ¼ of all signs (24,5%).

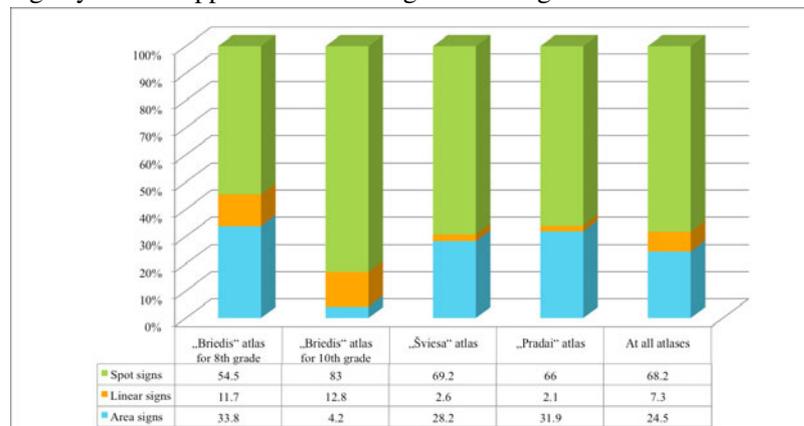


Fig. 1. The distribution of spot, linear and area signs in economy maps from analysed atlases

After semiotic analysis of geography atlases in the aspect of semantics it appeared that symbolic signs constitute about half of all signs used in analysed economy maps (47,8%), abstract signs cover 1/3 of all signs (31%) (fig. 2). The number of mostly motivated, easily memorized imitating/stylized signs in analysed economy maps was the least (21,2%).

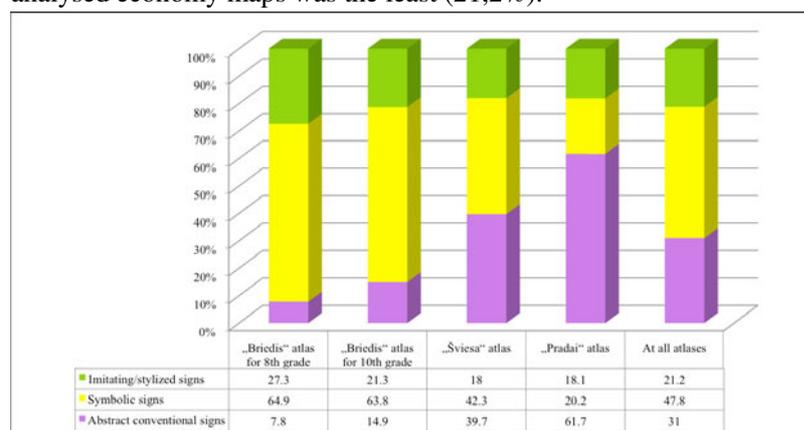


Fig. 2. Associativity of signs with respect to shape in economy maps from analysed atlases

Colour associativity (similarity) is an extremely important indicator that helps recognize objects in cartographic image more easily. There are many various cartographed objects and phenomena in topical cartography, therefore it is a difficult task to choose identical colour and to apply it when marking signs. Research revealed that almost ¼ (23%) of signs in the sign systems of analysed economy maps are of symbolic colours; indifferent colours are predominant (70%) and identical colour is applied rarely (fig. 3).

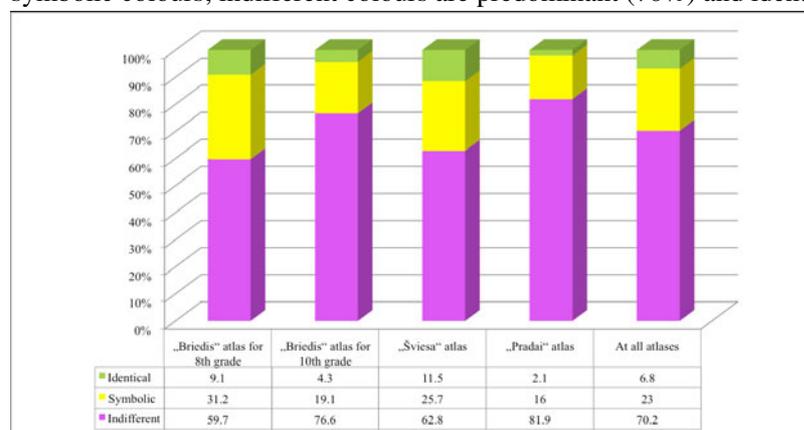


Fig. 3. Associativity of signs with respect to colour in economy maps from analysed atlases

After analysing in the aspect of syntactics it appeared that cartographic signs in legends of analysed maps are correctively semantically grouped. It was noted that often cartographic sign groups are not named, although the signs are grouped, i.e. they are presented in sufficient logical order. The grouping of cartographic signs improves the readability of cartographic signs.

Taxonomical (hierarchical) relations among signs that exist in reality are applied relatively rarely in analysed maps (fig. 4).

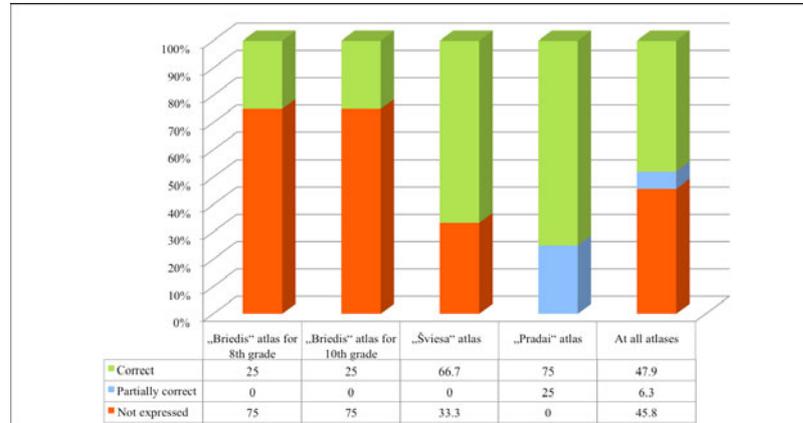


Fig. 4. Taxonomical differentiation (revealing hierarchical relations) in the legends of economy maps from analysed atlases

Not all economy maps have the presentation of transition expression through cartographic image (fig. 5). The correctness of quantitative, proportional and qualitative scales lies in the change of sign size, choosing colour tone and intensity or the correctness of shading intensity.

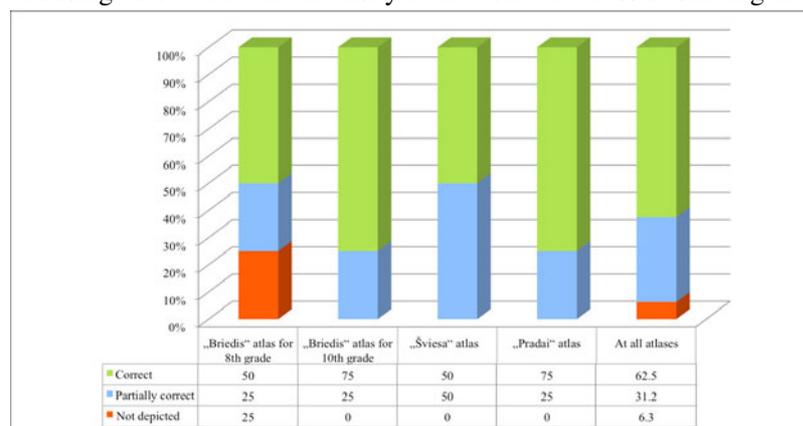


Fig. 5. Transition expression in economy maps from analysed atlases

Research in pragmatical aspect revealed that graphic load (fig. 6) in approximately 88% of analysed economy maps (while assessing visually) is acceptable (there are not many signs and writings, they do not cover each other and don't make reading difficult). Low degree graphic load (these are usually analytical maps, cartographed with cartogram methods, with low density of writings, a lot of “free” space in the map, considering its scale) was registered only in one of analysed atlases (in which such maps constitute 50% of all maps). There was no registered graphic overload (many signs that cover each other and are difficult to differ, map is difficult to read).

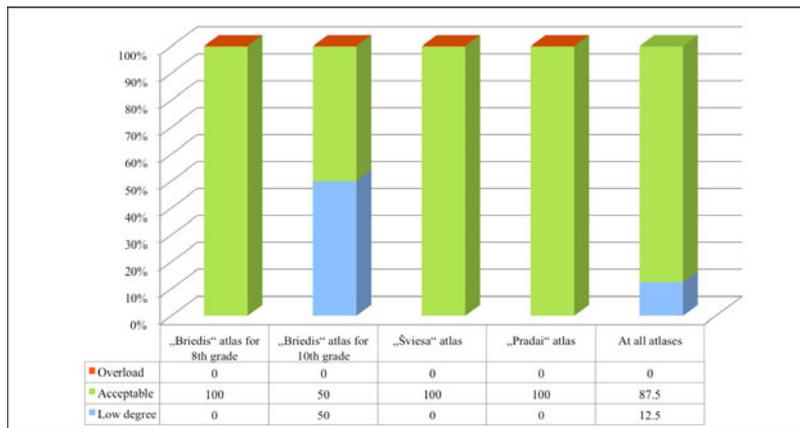


Fig. 6. Graphic load in economy maps from analysed atlases

Informational load of the map is related with graphic load, although these concepts are not identical because the quantity of information in map depends not only on the number of signs in it but also on their characteristics, various gradations, number of intervals, relations among signs, relation between topical content elements and cartographic base, etc. (Берлянт, 2003). Besides direct information, map also provides the user with potential information quantity which is difficult to measure since map reader's intellect, level of preparation to work with the map and knowledge possessed on the topic of the map have a lot of influence.

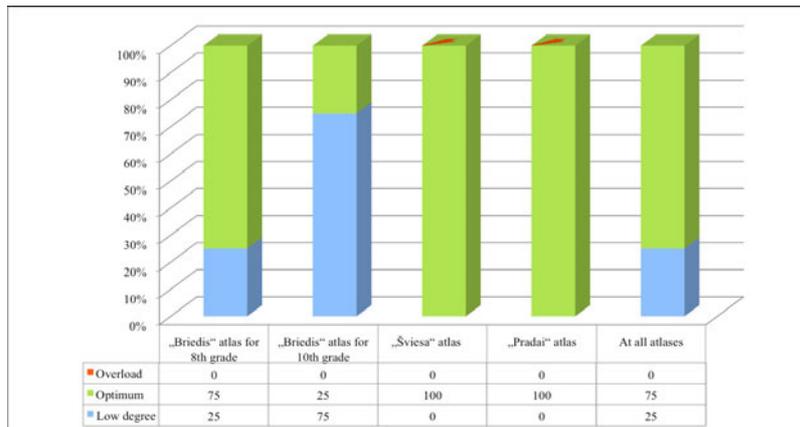


Fig. 7. Informational load in economy maps from analysed atlases

The research showed that analysed maps in geography atlases for school are not overloaded with respect to the quantity of information (when information is presented with a large quantity of differently shaped and multicoloured signs, detailed quantitative and qualitative scales, complex hierarchical sign structure, large variety of writings; the perception of information is aggravated), optimum load is predominant (when information is presented with 2-3 semantic sign groups, quantitative and qualitative scales have maximum 3 intervals or categories, 2 levels of hierarchical signs are predominant) (fig. 7).

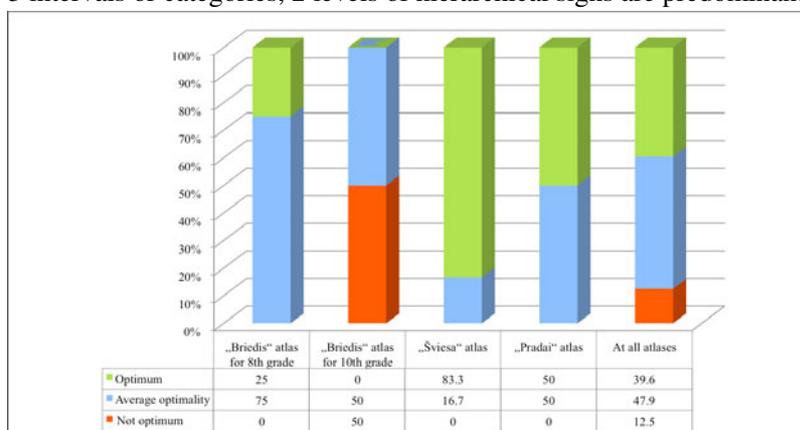


Fig. 8. Optimality of cartographic base in economy maps from analysed atlases

The perception of topical map is greatly influenced by presentation (cartographic net, scale, hydrography, administrative-territorial division, the most important settlements, roads, etc.) of its cartographic base (mathematical base  $\emptyset$  geographic elements). The quantity and details of cartographic base elements are influenced by the topic and scale of the map. It was established that cartographic bases of almost half of economy maps in analysed geography atlases for school were of average optimality (approx. 48% of all analysed economy maps) (fig. 8).

Graphic originality in educational cartographic production allows the students to notice and memorize various knowledge coded in the map more efficiently and less time consumingly. Unusual cartographic expression awakens students' curiosity and attracts attention, therefore publishers of cartography for schools should keep this in mind.

Graphic originality of more than half of all economy maps selected for semiotic analysis (54%) can be assessed as moderate (fig. 9). More pronounced graphic originality was noticed only in 21% of analysed maps and even ¼ of analysed economy maps did not have graphic originality.

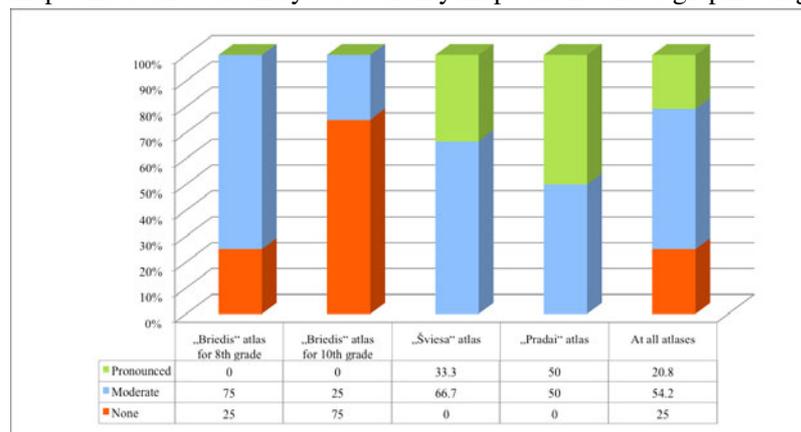


Fig. 9. Graphic originality in economy maps from analysed atlases

#### RESULTS OF QUESTIONNAIRE SURVEY

Usage of legends while reading maps. The frequency of using legend indirectly describes the quality of creation of cartographic sign systems: is it difficult or easy for students to memorize signs, recognize cartographed objects, perceive provided information.

It was established that students not always use legends in order to understand signs in economy maps (fig. 10). 75% of all respondents claim that they use legends in order to understand only certain signs, approximately 15% of 8-12th grade students understand information provided in economy maps only with the help of legends and 10% of students never use legends – they understand cartographic signs without explanations present in them.

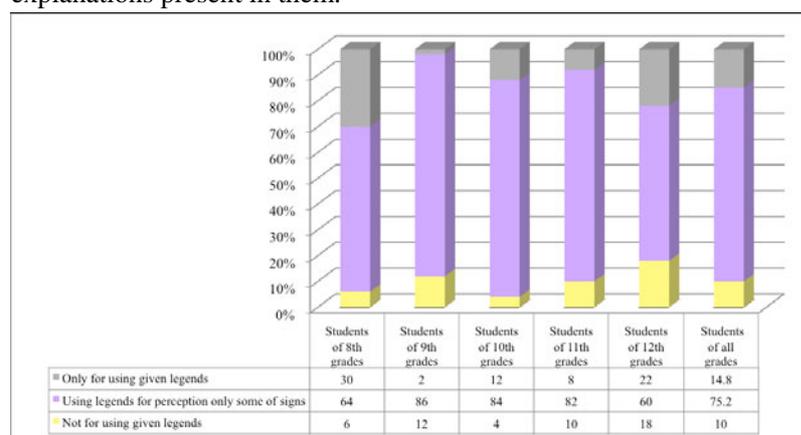


Fig. 10. Usage of legends in economy maps in order to perceive provided information.

Perception of signs based on the level of similarity to the signified. The research revealed (fig. 11) that students perceive information in economy maps the easiest where imitating/stylized signs are used – more than half of students (52,4%) responded this way. A slightly lower percent of students (42,4%) read cartographic text the easiest when it is presented with symbolic conventional signs, and only 5% of students prefer abstract conventional signs.

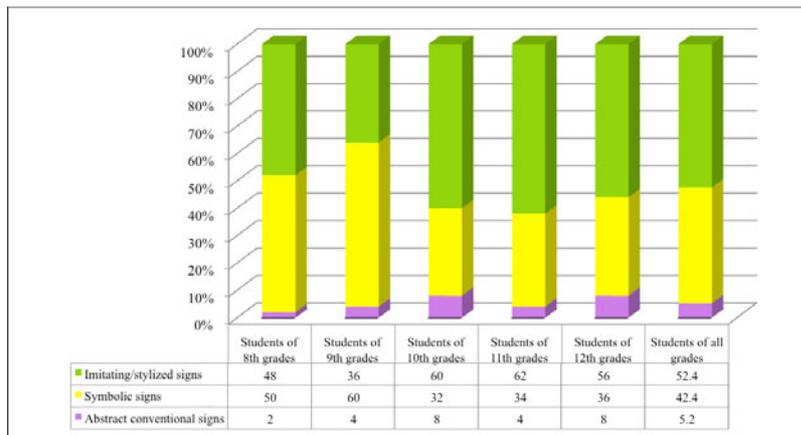


Fig. 11. Perception of information in maps where imitating/stylized, symbolic or abstract conventional signs are used (8–12th grades)

Students' opinion regarding the standardization of signs. It was established that 69,2% of all students think that sign systems should be standardized (fig. 12) and only less than 3% disagreed with it; approximately 1/3 of respondents simply don't have an opinion on this issue.

According to students, standardization of signs would help them assimilate knowledge more easily: once the “alphabet” of cartographic signs is learned, there would be no need to search for the meaning of signs in legends each time a new atlas is opened.

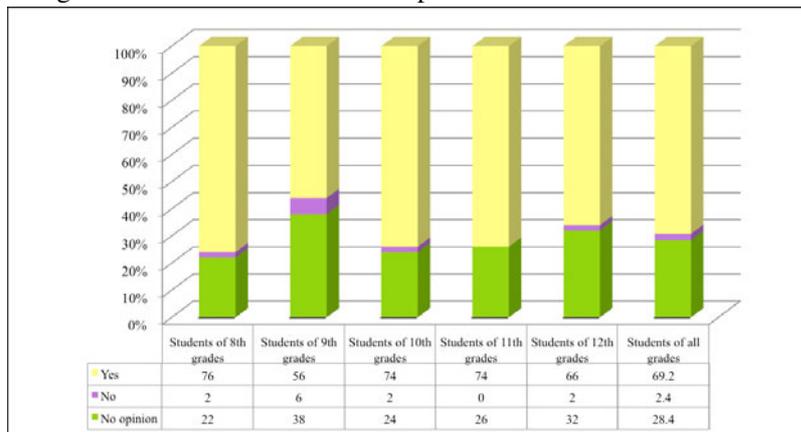
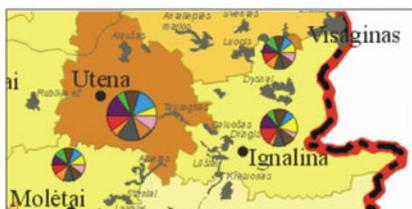


Fig. 12. Students' opinion regarding the unification of cartographic signs (standardization)

Choice of industry depiction method. During the research students were presented with two fragments of economy maps, where industry structure was depicted differently: a – circular structural cartodiagram depicting industry branches with corresponding colours, b – each industry branch is depicted with imitating/stylized, symbolic or abstract conventional sign.

a)



b)



Fig. 13. Industry depiction methods: a) map fragment created by the author, b) map fragment from “Universal world atlas” (1996) published by “Pradai”

More than 2/3 of all respondents (70%) approve the method of b fragment and 27,2 % of students think that version a is better, approximately 4% of respondents don't have an opinion (fig. 13).

Selection of specific easily perceived signs. The students were presented with a table containing cartographic signs used by different publishing houses divided into separate semantic groups: minerals, industry, agriculture, transportation. Respondents had to answer which signs are the easiest to understand and also to cross out unacceptable signs.

The research established that symbolic or imitating/stylized signs are the easiest to perceive in all semantic sign groups, and abstract signs were marked as unacceptable, perception aggravating signs in almost all the cases.

## **CONCLUSIONS AND RECOMMENDATIONS**

Semiotic analysis of sign systems used in economy maps of geography atlases for school showed that:

- When creating sign systems, the greatest attention is paid for they conveyance of associativity of sign shape and colour with the signified. Yet too little attention is paid to reveal relations existing in reality with the help of syntactics – semantic sign groups are not named, hierarchical relations not stressed, transition expression is used rather rarely. All this decreases the informativeness of maps and aggravates their perception.

- Informational scopes of maps do not increase with respect to the age of students, and in some cases they even decrease. Too high schematization and generalization of cartographic image condition that maps intended for senior grade students are in most cases analytical, only one process or phenomenon is cartographed, complex information is not depicted, there is a lack of graphic originality.

After analysing the selection of easily perceived cartographic signs by students and with respect to rules and principles of formation semiotics, a possible cartographic sign system (Table 4) is suggested. This sign system is created not only by suggesting new but also by using existent cartographic signs, and by modifying shape and/or colour of certain signs.

- It is recommended to depict the group of mineral signs with literal symbols (based on D. I. Mendeleev's table of chemical elements), by writing them inside corresponding geometric figures depicting the subgroup of minerals (ferrous and non-ferrous metal ores, materials for fertilizers, etc.). Outlines of literal symbols and geometric figures are suggested to be marked in black colour. In order to depict oil, gas, coal, amber and gemstones, imitating/stylized or symbolic signs are recommended to be used. Advantages of depiction method: quick recognition of the sign, more accurate place of localization, depiction of sign subgroup and quantity (increasing information).

- Imitating/stylized and symbolic signs are recommended to be used for the group of industry signs. Based on semantic relations among signs, identical symbolic colours are suggested to be used for signs of the same semantic group, e.g. black metallurgy, metal processing, car manufacturing, ship building are depicted in black (or blue) colour by showing the relation among these industry branches. It is recommended to depict the structure of industry in senior grade and universal geography atlases with a structural circular sign by colouring its sectors with different colours corresponding with industry branches. Advantages of depiction method: easy perception of sign, accurate place of localization, increasing map information (depicting quantity and structure).

- It is suggested to use imitating/stylized and symbolic cartographic signs in the group of agriculture signs. In some cases, when there is a lot of information in the map, ranges of object prevalence are offered to depict by use of shadowing of identical or symbolic colour. Writings are suggested to be used for the territorial distribution of agriculture objects.

- Linear and motional signs (signs-vectors), as well as spot-type signs, are used in the group of transportation signs. It is a sign system requiring least modifications. Colours are mostly needed to modify according to semantics of objects or phenomena and relating them with the colours of industry or minerals. The quantity of cartographed phenomena or objects is depicted with the thickness of line. If there is a need to specify the type of transported cargoes, they can be named with writings. When marking spot-type objects it is suggested to use imitating/stylized or symbolic signs by writing them inside a geometric figure. It is a means to indicate a more accurate place of sign localization and the sign is better distinguished from background.

- With respect to the fact that various publishing houses use different sign systems in economy maps in geography atlases, it is suggested to create a state-level standardized sign system (students themselves agree with standardization (unification) of signs). Of course, a standard sign system should be discussed by expert commission and improved during several tests (or experiments).

*Table 4. Signs selected by students as easily comprehensible*

Naudingųjų iškasenų gavyba		Pramonė		Žemės ūkis		Transportas	
Oil		Nuclear power stations		Citrus fruit		Seaports	
Oilfields		Electrotechnics		Grape		Airports	
Gas		Chemical industry		Date – palms		Gas pipelines	
Gas fields		Oil refining		Tea bushes		Oil pipelines	
Hard coal		Metallurgy/ferrous metal industry		Tabacco plants		Energy stocks	
Lignite		Nonferrous metallurgy		Coffee		Minerals	
Ironstone		Metal processing		Potatoes		Industrial production	
Manganese ore		Motor-cars industry		Sugar beet		Agricultural production	
Nickel ore		Shipbuilding		Sugar-canes		Wood	
Copper ore		Wood working		Flax			
Mercuric ore		Light industry		Sunflowers			
Gold		Meat		Cotton – plants			
Platinum				Wheat			
Phosphorite				Maize			
Potassium salt				Rice			
Amber				Cattle			
Diamond				sheeps			
Mineral water				Pigs			
				Goats			

### PLANS FOR FUTURE

While seeking to improve the cartographic sign systems in atlases for school, it is intended to continue research. It is planned in the future:

- to analyse not only economy but also other topical maps in geography atlases for school;
- to perform a semiotic analysis of cartographic sign systems used in history atlases for school;
- to present recommendations for the improvement of cartographic sign systems of geography and history atlases for school.
- to seek that cartographic sign system in Lithuanian geography and history atlases for school would be standardized

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