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THE ROLE OF A MAP LEGEND – WHY TO STUDY THE ISSUE?

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Abstract: Cartographers' care about use and user issues has led to series of studies on how people read and interpret maps. The main aim of these studies is to adjust map design to the cognitive abilities of map user and make the whole process more effective. However, there are still many problems that need to be studied carefully.Despite the fact, that a legend constitutes the key for the map understanding, it has been undervalued so far. In many popular Geographic Information Systems (GIS) software packages there is available a limited scope of legend constructions, many of them with poor graphic design. Also in the process of map elaboration this element of map is often treated as a marginal issue, so that it is often prepared without the proper care.However, a map legend serves a wide range of functions. It can help map user understanding presented themes, their hierarchy and a way of classification. Map legend can also indicate the way of map reading and unrevealing "hidden" information. On the other hand, there is a wide scope of map legend constructions which can asses map reading. The questions that seem to be worth answering are: If differently designed legends result in various ways in task solution? Do some legend constructions determine more effective processes of map reading and decision making depending on the kind of a task? In the era of GIS in cartography and sciences related to spatial information, many decisions are made on the basis of maps, hence it is important to investigate thoroughly how legends could influence this process.

Keywords: map legend, functions of map legend, map use, map design, map design research

Introduction

For many centuries map design had been rather intuitive, based on common sense and experience of map maker. The consequent map perception and map use were unknown processes. With the development of thematic cartography and an increasing complexity of presented topics, cartographers have put an emphasis on functionality and usability of maps.

Since the 20th century the cognitive cartography and the user-centered approach toward map design have been developed intensively. The main aim of these studies has been to adjust a map design to the cognitive abilities of map user and make the whole process more effective. Ones of the first researchers who saw the need of involving achievements of psychology in the field of cartography were Karl Peucker and Max Eckert (Eckert 1908, Pietkiewicz 1930). But methodical and empirical research of cognitive map-design began in the middle of the twentieth century, when Arthur H. Robinson stated that purely artistic approach to map design resulted in a decrease of map usability (Robinson 1952). He suggested the solution by studies of perception processes in order to find out the results of map makers' decisions in map users' mind. Cartographers' attention focused on psychophysics – psychological discipline, which concerns the relation between strength of a stimulus and a following reaction. It has led to series of studies on how people read map by trying to test the magnitude-estimation of basics graphic variables: a size of graduated circles (Flannery 1971), a letter size, and a gray tone scale (Williams 1958). Moreover, the "just noticeable difference" as well as a speed and an accuracy of objects searching on the map were studied. Facing a series of critics for not providing significant rules useful for map makers as well as no general theory developed, map design research has suffered the decline since the late 1970s. Also "digital revolution" in cartography made the situation worse, disappointed researchers focused on new opportunities and problems

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connected with implementation computers in cartography. Having completed the most important difficulties in implementing computers and GIS software in cartography it turned out that computers has played significant role in revival of empirical map-design research. Computers smooth the way of an empirical process: it makes it easier to prepare test material, as well as to analyze results. Furthermore, the emergence of computers and GIS has led to implementing many new ways of map-design: animation, interactive maps, virtual reality, sonic maps etc. Nowadays, one of the most important challenges in cartography is to adjust the new forms of communication to the cognitive abilities of map user. As a result, there has been the increase of map reading research (Montello 2002). However, there are still many problems that need to be studied carefully, one of these is the role of map legend in the process of map reading.

Condition of a map legend

In many languages the term "map legend" is translated into the word "key": "Zeichenschlüssel" in German, "key symbol" in English etc. In fact, a legend constitutes the key for the map understanding and it is often essential to interpret the map content properly. In 1967 V. Geabler worried about neglecting the map legend by cartographers, after 30 years the situation did not change (Gaebler 1967). H. Schlichtmann (1997) also complained that the map legend deserved more attention that it had received. Is the situation of map legend so bad? If yes, does a map legend play so significant role that it is worth changing?

K. Kałamucki (2005) conducted an interesting analysis which showed the undervaluation of the role of map legend during map use process. He compared the emphasis put on each map element in map reviews published in "Polish Cartographical Review" with the results of the questionnaire surveyed among map users. In the questionnaire the author asked subjects to divide the significance of the whole map into every element of a map design. It turned out that the element which had the greatest difference of attention in favor of map users was a map legend (Fig. 1). Actually both groups (map makers and map users) rated a map legend not high. The author complained that in the process of map elaboration this element of map was often treated as a marginal issue, so that it was prepared without proper care as one of the last stages.

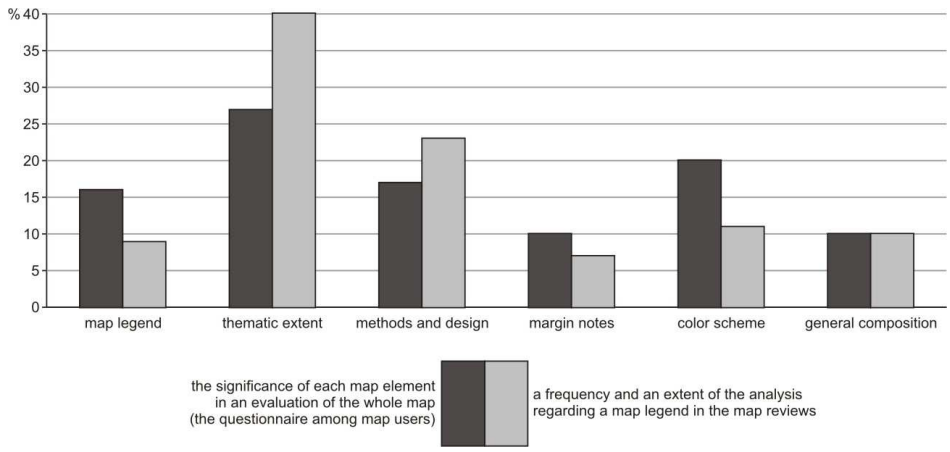


Fig. 1 Lack of a coincidence between the map users' and the authors of map reviews opinions regarding the significance of a map legend (according to Kałamucki 2005)

The methods applied in the study unable to develop wide and general conclusions, but the analysis seems to confirm the opinion that map legend is an undervalued element of the map.

Another example of a study that may lead to the similar conclusion bases on a different kind of material: Geographic Information Systems (GIS) software packages (Bajer a Korycka-Skorupa 2008). Currently, when many maps are produced by non-cartographer, it is important to provide the sufficient scope of correct solutions during each stage of a map elaboration. The analysis conducted aimed to evaluate quality and methodological correctness of diagram maps, proportional

symbols as well as chart maps, which can be produced using few most popular GIS software packages: MapInfo Professional, ArcMap and MapViewer (Fig. 2). The analysis regarded only diagram maps, but is can be considered as a sample of a quality of maps produced using GIS.

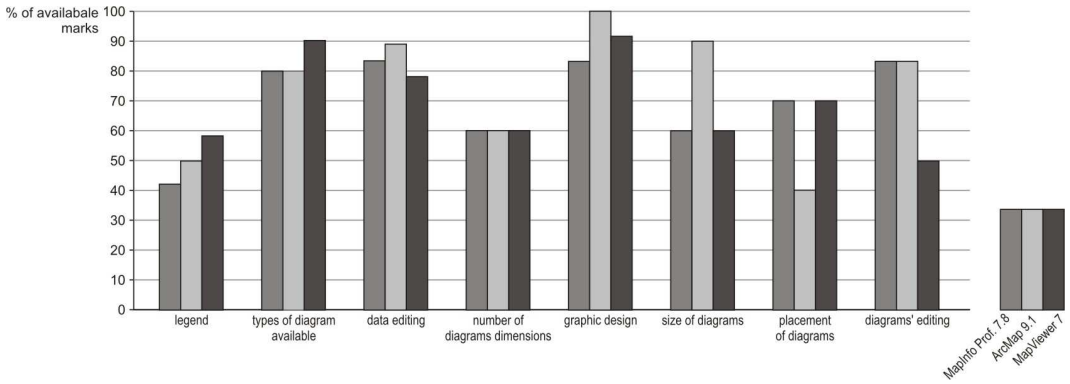


Fig. 2 Evaluation of various aspects of producing diagram maps in selected GIS software packages (according to Bajer a Korycka-Skorupa 2008)

Again, map design related to a legend seems to be undervalued: the aspect that gained the smallest score (about half of the available marks) is a legend. There is available a limited scope of legend constructions, many of them with poor graphic design. To present few detected limitations that has appeared in legends: in MapInfo Professional a legend is produced automatically, a map maker can not determine the size of symbols appearing in the legend, in spite of the fact that they may not correspond with the size of the symbols in the map. Moreover, producing maps with two bar charts in each characterized place, when charts are independently scaled, there is no quantitative scale in the legend, so there is no information provided about what number represents each size (Fig. 3).

In ArcMap, labels presented in a map legend can be edited in significantly limited way: only the title can be taped, whereas editing of the names of layers as well as feature classes is limited to a change of visibility. A default legend for the proportional symbol map provides no information about the units of presented data. Trying to show the units, other information about the data disappears. Furthermore, the legend for a proportional symbol map that shows the structure of presented data, has only one sample of symbols with the value that represented by it (Fig. 4).

MapViewer is the software that has gained the highest score concerning a legend among the analyzed GIS packages, but it is still below 60% of available marks. For example, MapViewer provides a limited editing function of labels, what often results in e.g. uneven numbers in ranges presented in the legend.

Many serious mistakes and drawbacks can be found, despite the fact that the studied packages are the most popular and are not the first version published. In the successive versions are removed the revealed drawbacks, so the detection so many limitations in a map legend design during the analysis may be surprising.

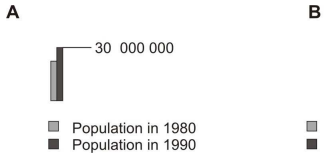


Fig. 3 Poor quantitative information in the legend when scaling together both bar diagrams (A), and no quantitative information when bar diagrams are scaled independently (B)

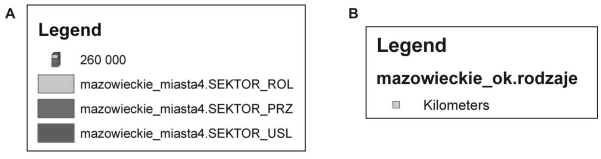
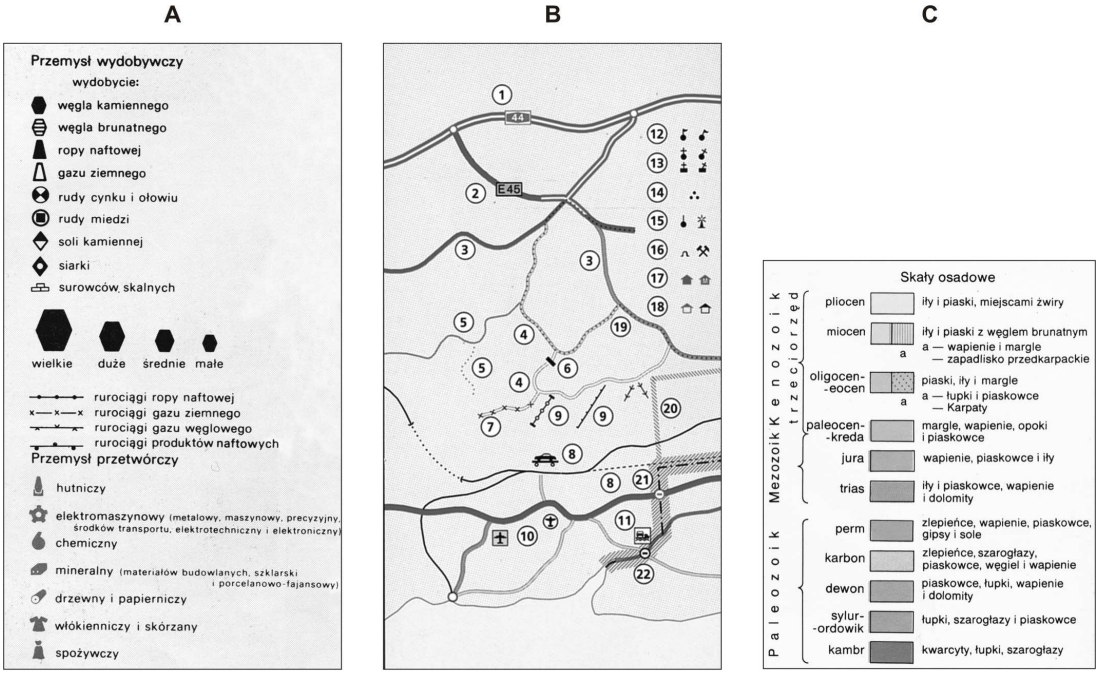


Fig. 4 A poor information about the scaling and unit of data presented (A) and the result when trying to show the unit (B)

Map legend significance

Facing so many drawbacks in opinions and practice concerning map legend design one should have in mind the consequences of such limitation. It is directly linked with the scope of functions a map legend serves.

H. Schlichtmann (1997) set together the functions of map legends. The main function is an explanation of symbols, so the legend establishes links between signs used on the map and their meanings. This function seems to be obvious for every map user, but H. Schlichtmann distinguished also a range of other functions. A legend presents the concept within the structure, so that specimen symbols are grouped according to their meaning, as well as the hierarchy of the information. Such organization may be according to substantive, temporal and spatial criteria (Fig. 5).



„Atlas geograficzny dla klas 6-7” 1998, Warszawa: PPWK

„Księga świata”, 1996, Warszawa: GeoCenter

„Geograficzny atlas Polski”, 1999, Warszawa-Wrocław: PPWK

Fig. 5 Grouping specimens in the legend by various criteria: substantive (A), spatial (B) and temporal (C)

Most frequently a substantive criterion is applied (Fig. 5A). Another way of the presentation context is a natural legend, where a legend is an auxiliary map into which specimens are placed (Fig. 5B). The next function specified by the author is provision of additional information about mapped territory. A legend may furnish information, in terms of units or of structure, which is not expressed through the symbolization in the map face. Latent structural information is made explicit, e.g. in the legend of a geological map: the color scheme does not furnish information about the age of rocks, but the sequence of specimens in the legend makes the age attribute clear (Fig. 5C).

The other way of serving this function is adding supporting and complementing data in the legend, e.g. in the shape of transformation the set of specimens into a diagram showing additional characteristic. The next function is provision of a record of data-processing which has taken place prior to mapping. The most common example is class intervals, but it can also be served by: a matrix showing correlation between two sets of data presented, statements informing about characteristic included during data manipulation (e.g. "Less than 3 farms are not shown" etc.). Legend can

also serve as an aid in the interpretation, especially as a set of symbols: a cloud of dots or bundle of isolines (Fig. 6).

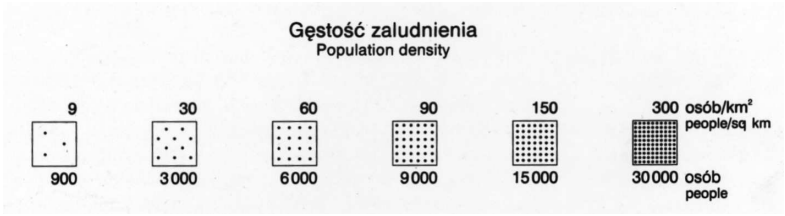


Fig. 6 A map legend as an interpretational aid

The last function mentioned is an inventory of the signs. This function is served e.g. in a legend for the map series, where specimens in the legend depend on what is presented in the map face: in different regions there are different sets of objected. Also in a matrix legend, where a category is characterized by two set of characteristics, if some category is not presented in the map - the place in the legend is left blank. Furthermore, a presentation of quantitative values in ranges may be more precise thanks to the map legend. Delimiting ranges map maker can indicate which values are not observed in the mapped territory by leaving a "gap" between the highest value of one range and the lowest from the successive one or by providing uneven the smallest and the highest values of extreme ranges (Fig. 7).

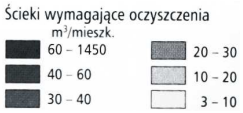


Fig. 7 Advanced precision concerning quantitative data: uneven numbers in extreme ranges present the highest and the lowest values in the data set

The scope of a legend constructions

Being aware such a wide range of functions that a map legend serves one has to own up that map legend indicates the way of map reading and helps unrevealing the “hidden” information. Therefore, during map elaboration map maker should design carefully this element of a map. In fact there is a great amount of solutions of the legend design that can be chosen by map maker. Layout, what is understood as the overall organization and settings of the legend (Sieber et al. 2005), incorporates the design of the space dedicated for the legend, as well as graphical features and technical specifications (e.g. placement of the legend).

To some extent the legend design is dependent on the method applied in the map face (Żyszkowska 2005). For qualitative information there is applied the legend in a shape of a "dictionary", where there are signs put in the row and next to the each specimen there is the corresponding meaning. But even in this case there are few option of specimens arrangement available, depending on space and shape of the area dedicated for the legend (Wolodchenko 1994). Also the order of specimens is the matter of map maker's choice. One of the suggestions bases on the Gestalt theory (Medyńska-Gulij 2007). Assuming that map user visually organizes the graphic information presented in the map face, the map legend should distinguish thematic content as the most important, later there should be explained the base contents. What is worth mentioning, the suggested solution is contrary to the most common order that is applied e.g. in the tourist map legends, where specimens are mainly arranged according to the graphic dimension: first points, then lines and areas at the end.

The next form of the legend is bar, it is applied for choropleth maps and isoline maps. The configuration of such a strip of specimens is also not obvious. There are different opinion is this matter. Some cartographers claim that better solution is horizontal orientation (Czerny 2003), just like the direction of writing and reading in Latin alphabet, whereas others consider the vertical orientation as the better option (Pasławski 1982), where the legend visualize the statistical surface. There is a research that confirms better tasks solution with legend boxes arranged in a vertical way

(Pickle et al. 1995), but it was studied in a limited extent and the authors admitted that more research was needed to fully assess the effects of the legend characteristic.

For the proportional symbols maps the legend is the series of figures or solids. The analysis of the legends in regional atlases (Frączek 1983), as well as the study of GIS software mentioned above, revealed many methodological mistakes that are made in this kind of legend. That means that no uniform criteria govern the design of this kind of legends. Legends can also be designed as a diagram: a bar diagram, a correlation diagram and in a matrix form.

Moreover, the very important and problematic issue is the design of legend that consists of few forms mentioned above. The order, the configuration etc. of them seems to be undergone no particular criterion in spite of the fact that maps with diverse content are difficult to understand and its legend is crucial to understand the map content.

Conclusions

Due to a direct connection between the structure of information and the design of the legend, map user by reading only the legend can develop some significant conclusions concerning the spatial pattern of presented objects, as well as the conception of the whole map: type of data presented (qualitative versus quantitative), content definition (analytical, complex or synthetic), objects selection dependent on the degree of generalization, the hierarchy of objects (Żyszkowska 2005). Such a wide range of information that can be derived makes a legend very valuable element of the map. In the era of GIS in cartography and sciences related to spatial information, many decisions are made on the basis of maps, hence it is important to be aware of the role of a legend in the processes of map reading, problem solving and decision making.

Having analyzed the wide range of legend constructions available, it is essential to investigate thoroughly how legend and its design could influence map user perception of the map. So far no standard criteria have been developed defining the final shape of the legend. Among those that should be included are: the hierarchy of the content, the logical arrangement and the graphic form of the symbols. The problem of an adequate legend construction remains unsolved especially in the case of thematic maps, i.e. those that characterize the widest scope of possible legend construction and whose legend is essential. Therefore the questions: "if differently designed legends result in various ways in task solution?" or "do some legend constructions determine more effective processes of map reading and decision making depending on the kind of a task?" seem to be worth studying.

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R e s u m é
Úloha mapových vysvetliviek – prečo študovať problém?

Po mnohé storočia bol mapový dizajn skôr intuitívny, založený na zdravom rozume a skúsenostiach tvorcu mapy. Následná percepcia a využitie máp bolo neznámym procesom. Záujem kartografov o použitie máp a problémy používateľov viedli k sérii štúdií o čítaní a interpretácii máp. Hlavným cieľom týchto štúdií je upraviť mapový dizajn na základe kognitívnych schopností používateľov mapy a zefektívniť celý proces. Neexistencia pravidiel pre tvorcov máp a všeobecnej teórie mapového dizajnu viedlo k úpadku výskumu. Tento problém bol opäť nastolený s nástupom geografických informačných systémov (GIS). Ostáva množstvo problémov, ktoré je treba starostlivo študovať. Jedným z nich je úloha vysvetliviek v procese čítania mapy. Aj keď vysvetlivky predstavujú kľúč k porozumeniu mapy, sú zatiaľ nedocenené. Mnohé populárne softvéry GIS majú limitovanú možnosť konštrukcie vysvetliviek, mnohé z nich so slabým grafickým dizajnom. V štúdii (Bajer a Korycka-Skorupa 2008) boli analyzované tri z nich, a to: MapInfo Professional, ArcMap and MapViewer, pričom sa zamerali na možnosť tvorby kartodiagramov a ich vysvetliviek. Najlepšie výsledky v porovnávaní dosiahol MapViewer.

V procese spracovania mapy je tento mapový element často braný ako okrajový problém, takže je často pripravený bez náležitej starostlivosti ako jeden z posledných krokov jej tvorby. Hoci vysvetlivky majú širokú škálu funkcií, pomáhajú používateľovi porozumieť zobrazované témy, ich hierarchiu a spôsob klasifikácie, môžu tiež naznačovať spôsob čítania mapy a neodhalené "skryté" informácie. Na druhej strane existujú široké možnosti tvorby mapových vysvetliviek, ktoré môžu odhadnúť čítanie mapy. Otázky, ktoré by bolo cenné zodpovedať, sú: či vysvetlivky s rôznym dizajnom majú za následok variantné riešenie úlohy? Môžu určovať niektoré stavby vysvetliviek efektívnejší proces čítania mapy a tvorbu rozhodnutí závislú na druhu dopytu?

V ére GIS v kartografii a vedách spojených s priestorovými informáciami, veľa rozhodnutí je uskutočnených na základe máp, a preto je dôležité dôkladne preskúmať ako môžu vysvetlivky ovplyvňovať tento proces.

Obr. 1 Nedostatok zhody názorov medzi používateľmi mapy a autormi hodnotení máp ohľadne významu mapových vysvetliviek (podľa Kałamucki 2005)

Obr. 2 Hodnotenie rôznych aspektov výroby kartodiagramov vo vybraných softvéroch GIS (podľa Bajer a Korycka-Skorupa 2008)

Obr. 3 Slabá kvantitatívna informácia vo vysvetlivkách pri spoločnom škálovaní dvoch stĺpcových kartodiagramov (A) a žiadna kvantitatívna informácia vo vysvetlivkách pri nezávislom škálovaní stĺpcových kartodiagramov (B)

Obr. 4 Slabá informácia o škálovaní a jednotkách prezentovaných dát (A) a výsledok pokusu zobraziť jednotky (B)

Obr. 5 Zoskupovanie znakov vo vysvetlivkách podľa rôznych kritérií: formálne (A), priestorové (B) a časové (C)

Obr. 6 Mapové vysvetlivky ako interpretačná pomôcka

Obr. 7 Zdokonalená správnosť týkajúca sa kvantitatívnych dát: nerovnomerné počty v extrémnych rozpätiach najvyšších a najnižších hodnôt v súbore dát

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