

HABILITATION THESIS REVIEWER'S REPORT

Mgr. Bc. ZDENĚK STACHOŇ, Ph.D.

**EXPERIMENTAL RESEARCH IN CARTOGRAPHIC VISUALIZATION**

**The topic actuality, its importance for social practice and science development**

The reviewed research work on cartographic visualization matches well with the current global trend, supported also in the context of its research agenda by the International Cartographic Association, especially in term of cartographic theory, the usability of maps and geographic information visualizations. Empirical research of the cartographic communication principles is increasingly important in social practice and for the development of cartography, especially concerned with perception of technological development and multidisciplinary cooperation into cartographic visualization processes.

The development and widening range of visualization technologies and their tools increase the range of experts who deal with the verification of theoretical starting point processes and are involved in the development of new research tools, methodologies and applications. In this sense, young researchers with their interdisciplinary education may take advantage applying individual approaches in new topics and solutions integrated with procedures and knowledge of relevant disciplines focused on the visualization of reality. The author of this work can be assigned to this generation of scientists-researchers, who combine the development of scientific, application and pedagogical aspects in modern cartography.

The subject habilitation thesis is primarily targeted at the empirical research of the principles of cartographic communication which was initiated by the Czech cartographer A. Koláčny already in 1969, being developed then by M. Konečný and his students at the Faculty of Natural Sciences of Masaryk University in Brno. The long-term scientific focus of the supervisor and the entire university workplace on experimental cartography, high-quality research and technical conditions, broad international cooperation and direct contact with practice in verification of research results are important factors that positively influenced the content and results of the work. In the subject work, the author systematized the current domestic and global trends on the discussed theme, addressing a highly actual topic; his results are immediately applicable in practice through the tools created for further experimental research, or specific proposals for the creation of more effective map visualizations with an emphasis on the user aspect.

### **Fulfillment of the set goal**

The aim of the work was to present in selected experimental studies the author's long-term research in the field of cartographic visualization theory, highlighting their application potential in cartographic theory and research practice. The author met targeted goals describing the creation of new research tools and methods for cartographic visualization, respectively verifying their functionality using selected aspects of cartographic visualization (specifically: research on differences in visual search of map stimuli, research on bivariate mapping and complex spatial tasks with individual and group user access using 2D and 3D cartographic models).

In theoretical part, the outcome of the work reflected in the author's proposal for the modification of the concept of cartographic communication focused on the user, in the redefinition of established cartographic concepts on direct response to dynamically changing technologies and communication environments. The results of the applied experimental part of the work, focused on the complex of cognitive processes, confirmed the differences on the perceptual and cultural level of user perception of cartographic visualizations. To this must be added the 6 basic pillars of cartographic visualization research identified by the author on the p. 45 of the work:

„1. Clear terminological anchoring of cartographic concepts in the existing terminological apparatus of related fields and modern technologies (e.g., virtual geographic environments). 2. The need to expand interdisciplinary cooperation, especially with experts in cognitive psychology, applied informatics and other related fields. 3. Research into the processes of effective perception of generalized information. 4. Research into the effective use of multivariate mapping methods. 5. Expansion of research into the basic mechanisms of 3D geovisualizations and immersive virtual geographic environments. 6. Research into geography education“.

### **Processing methods used**

The author used the wide range of meaningful methods of scientific research based on empirical-theoretical procedures. Both methods and research tools/applications are described in detail in the attached articles and reference literature. It should be highlighted the author's effort to bring "order" to very heterogeneous terminology associated with the visualization, including the interpretation of terms and definitions in English, the translation of which into the Czech language will not be easy.

## **Results of work**

The results of the work are mentioned above in the achieved goals, therefore only the results and findings that interested us in the work are listed hereinafter:

- a systematic and up-to-date overview of cartographic visualization research methods and directions based on relevant cartographic theories (communication, cognitive, perceptual, map language, etc.),
- the number of verified tools for experimental research of cartographic visualization resulted in submission of the new Hypothesis research platform,
- analyzes of individual map symbol sets and cartographic legends based on eye-tracking in a unique combination along with the new universal tool for processing and analyzing experiments (Hypothesis),
- the range and complexity of the map tasks in the presented experimental studies with an emphasis on the reproducibility of the methods and tools used,
- specific results of quality assessment, or suitability of cartographic visualizations based on the perception and cognition of their content by different groups of users (layman/expert, male/female, socio-cultural aspect, etc.) that reflected in practical recommendations for more appropriate map signs/symbols, methods of their visualization and target groups of users.

## **Work structure**

The addressed work contains 51 pages of the original author's text plus 165 pages of 12 supplements that are selected scientific articles which reflect the author's long-term research in discussed issue. In the introduction *Commentary* the author refers to his authorship in the articles. In 11 of 12 mentioned studies, he has a significant author's contribution. In following chapters he presents the concept, motivation and theoretical background of the work, research methods along with terminology and socio-cultural context. The longest chapter *The results* is divided into 4 subsections according to the work objects, followed by chapter *Discussion, conclusions and future research*. The chosen sequence, targeting and chapters range is appropriate and clear; in terms of focusing and coverage of thematic areas they show the author's good erudition in addressed issues. From a formal, illustrative and educational aspect, the work is at a very good level with correct citing of sources. One can appreciate the author's illustrative graphic diagrams (Figs. 10, 12, 15, 26 and 27) and symbols used in the text, that

all help the reader to understand better the new concepts and the author's philosophy in the issue approach.

### **Discussion**

1. On the other hand, the work lacks an explicit indication of the number of the students Final theses that had been supervised by the author and had become the part of presented results. Please, could the author quantify them?
2. What is the author's opinion on the real use of immersive Virtual Reality (iRV) in cartographic education using the Collaborative Immersive Virtual Environment (CIVE)?
3. What advantages and disadvantages does the use of iRV have in cartographic education in comparison with open-source tools and GIS models (e.g. PETRASOVA, A., HARMON, B., PETRAS, V., TABRIZIAN, P., MITASOVA, H. Tangible Modelling with Open Source GIS. 2<sup>nd</sup> edition. New York, Springer, 2018)?
4. What are responses on and what are directions of the Hypothesis platform use by other authors in cartographic visualization research?
5. How does the author see the future development of the Hypotheses platform in cartographic research?

### **Conclusion**

From the cartographer and geographer point of view, I can say that several parts of the work are very interesting and inspiring. I agree with the author's final words that „ cartographic visualization remains a key output of cartography as a science. The results of the research demonstrate that different methods of cartographic visualization are suitable in a variety of ways for certain tasks and users with differences in experience, cultural background and other aspects. Cartographers should not therefore abandon experimental research or studies to verify the efficiency and effectiveness of maps and satisfaction with their use. “

The author comes out of and follows up internationally recognized procedures and experiences, his results shows progressive prospects of solutions that can be applied not only in terms of the Czech Republic and are beneficial not only for practice, but also for the scientific and professional community, which itself has already found them.

Concerning the content, the work is of the experimental character. The author manifests broad professional knowledge in relevant aspects of subject matter. It should be appreciated the author's purposeful and long-term research in the field of cartographic visualization in order

to create meaningful tools and procedures for multidisciplinary research teams. The professional erudition of the author is evidenced by listed bibliography and citation response. Published author's works or his bibliography exhaustively covers all relevant research topics published in quality impact periodicals.

The presented habilitation thesis is a scientific and original work of Z. Stachoň, its content contributes to further development of cartography with an emphasis on experimental research and its applicability in practice. The work solves current problems and evidences the results of the author's work in the field of scientific-research and pedagogical practice.

The habilitation thesis entitled “Experimental Research in Cartographic Visualization” by Zdeněk Stachoň **fulfils** requirements expected of a habilitation thesis in the field of Cartography, Geoinformatics and Remote Sensing.

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Dagmar Kusendová