

Usability Evaluation of Interactive Cartographic Visualisations by means of Eye-tracking

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Abstract:

Interactive cartographic visualisations have become a common means of communicating spatial information on the web. Their usability, however, is influenced not only by the cartographic design of the visual representation but also by users' interactive behaviour as they explore the interface. Understanding how users visually attend to map elements and how they interact with interactive controls is therefore essential for evaluating and improving such systems. In recent years, eye-tracking has become an important empirical method in cartographic research for investigating visual attention and cognitive processes during map use. Nevertheless, the application of eye-tracking in studies of interactive cartographic visualisations still raises methodological questions related to experimental design, data interpretation, and the integration of complementary evaluation methods (Vanicek et al., 2026).

This contribution presents the methodological framework and main findings of a doctoral dissertation that investigated the usability of interactive cartographic visualisations using eye-tracking. The research combined theoretical and empirical approaches within the field of cognitive cartography and human–map interaction. The overall aim of the dissertation was to evaluate the usability of selected interactive cartographic products and to formulate methodological and practical recommendations for their assessment.

The research was structured around three interconnected objectives. First, a systematic mapping of existing eye-tracking studies focused on interactive cartographic visualisations was conducted using the PRISMA-ScR framework. This review synthesised the methodological characteristics of previous experiments, including experimental stimuli, task types, participant samples, and applied eye-tracking metrics, and identified methodological gaps relevant for future research. Second, based on the findings of the review and the broader literature on usability evaluation, an analytical framework was developed to select and combine evaluation methods for studies of interactive maps. Particular attention was given to approaches that can complement eye-tracking, such as think-aloud protocols, user experience questionnaires, and user interaction logging. The resulting framework guides the design of experiments based on the characteristics of the evaluated cartographic application.

The core empirical component of the research consists of five case studies evaluating selected interactive cartographic visualisations, primarily interactive web-based 2D maps and, in one case, an interactive 3D visualisation. These studies examine both the cartographic content and the user interface of the evaluated applications. Experimental designs included task-based user testing combined with eye-tracking measurements and, where appropriate, additional methods such as the talk-aloud method and interaction logging. The experiments generated quantitative eye-tracking metrics, as well as behavioural and subjective data, enabling a deeper understanding of user behaviour when interacting with cartographic interfaces.

The results provide insights into how users visually explore interactive maps, how interface components influence task performance, and how different evaluation methods can be combined to obtain a more comprehensive understanding of usability issues. The dissertation contributes (1) an overview of current eye-tracking research on interactive cartographic visualisations, (2) a methodological framework supporting the design of usability experiments with interactive maps, and (3) empirically grounded recommendations for improving the usability of selected cartographic interfaces.

By integrating systematic literature analysis with experimental case studies, the research aims to strengthen the methodological foundations of usability evaluation in interactive cartography and to support the design of more effective and user-centred cartographic visualisations.

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References

Vanicek, T., Vojtechovska, M., & Popelka, S. (2026). A Scoping Review of Eye-Tracking Studies on the Usability Evaluation of Interactive Geovisualisations. *International Journal of Human–Computer Interaction*, 1–26. <https://doi.org/10.1080/10447318.2026.2618556>