

Towards a Framework for Measuring User Engagement in Geovisualizations Based on Open Data

Andrea Miletić ^{a,*}, Ana Kuveždić Divjak ^a

^a University of Zagreb Faculty of Geodesy, Kačićeva 26, Zagreb, Croatia (andrea.miletic@geof.unizg.hr, ana.kuvezdic.divjak@geof.unizg.hr,)

* Corresponding author

Keywords: user engagement, geovisualization, open data, engagement measurement

Abstract:

User engagement has become a key factor for successful and sustainable use of open data and for realizing the benefits that open data initiatives are promising. While governments, international organizations, and public institutions increasingly make their data available to use free of charge, ultimately, its value doesn't depend on the quantity of published datasets, rather on how users interact with it, interpret it, and apply it in real live context. To facilitate user interaction with open data, it is necessary to provide solutions that enable active engagement and meaningful understanding and use of the data.

Within this context, visualization, particularly geovisualizations, hold particular value for increasing citizen engagement with open data. By enabling interaction with spatial data, geovisualizations allow users to explore information dynamically, adjust their focus, and examine data at different levels of detail. These capabilities of geovisualizations are what distinguish them from more static forms of data visualization and are especially valuable for users with lower levels of data literacy, for whom raw datasets and complex analytical tools may be difficult to interpret and use. In this sense, geovisualizations can serve as an interface between open data and users, facilitating greater accessibility and understanding.

However, despite its recognized importance, the concept of user engagement in geovisualization remains under-researched. In the Human-Computer Interaction (HCI) literature, **user engagement** is often used as a broad concept, referring to a range of related but distinct phenomena, frequently overlapping with related terms such as interest, sustained attention, involvement, user experience etc (Peters et al., 2009). Recent studies, such as (Jansen et al., 2025) highlight significant inconsistencies in how user engagement is conceptualized, which leads to lack of reliable and standardized approaches for its measurement.

Although a wide range of methods has been used to evaluate geovisualizations, such as usability testing, eye-tracking, surveys, design-oriented analyses etc., these approaches are not specifically designed to measure user engagement. Instead, they typically focus on isolated aspects of user interaction, such as performance, perception, or interface design. Although valuable, these approaches do not capture the multidimensional and dynamic nature of engagement as a holistic user state.

This paper addresses this gap by proposing a conceptual framework for measuring user engagement in geovisualizations based on open data. The framework builds on insights from cartography, information visualization research, and human-computer interaction, where engagement is commonly conceptualized as a multidimensional construct encompassing **emotional, cognitive and behavioural** components (Doherty and Doherty, 2019). Within this framework, we define *user engagement as a state of active involvement in which users **behaviourally** interact with a geovisualization, **cognitively** process and interpret spatial information, and **emotionally** respond to the visualization in a way that sustains their interest and motivation.*

A key contribution of this work lies in the operationalization of these dimensions through clearly defined and measurable indicators tailored to geovisualization contexts. **Behavioural engagement** is reflected in observable user actions, such as interaction with map elements, navigation patterns, exploration of different data layers etc. It can be measured using interaction-based methods, including log data analysis and eye tracking, with indicators such as fixation duration, fixation count, time to first fixation, gaze path, session duration and return frequency, dwell time, number of clicks etc. **Cognitive engagement** relates to the processes through which users interpret spatial patterns, relationships, and trends, reflecting their level of understanding, attention, and mental effort. It can be assessed through task-based measures such as task accuracy, completion time, and the ability to correctly identify patterns and relationships in the data. **Emotional engagement** captures users' interest, curiosity, and motivation, reflecting their subjective experience and emotional

response to the geovisualization. It can be assessed using subjective, self-reported methods, such as questionnaires or rating scales, with indicators including perceived interest, satisfaction, engagement, and motivation to further explore the data.

By systematically linking engagement dimensions with appropriate evaluation methods and indicators, the proposed framework moves beyond fragmented assessment approaches and enables a more comprehensive and structured evaluation of user engagement in geovisualizations. It provides a practical foundation for combining objective behavioural data with subjective user perceptions, supporting a more nuanced understanding of how users interact with spatial data and how different design elements influence engagement.

The framework is intended as a methodological basis for future empirical research and practical applications in cartographic design. It supports the development of user-centred geovisualizations by enabling researchers and practitioners to systematically assess engagement and identify design strategies that enhance user interaction, understanding, and motivation. In the context of open data, such an approach contributes to more effective communication of spatial information and to fostering meaningful engagement among diverse user groups. This positions user engagement as a key evaluation dimension in cartography, extending beyond traditional usability and effectiveness measures towards a more holistic understanding of map use.

Acknowledgements

This work was supported by the results of the Twinning Open Data Operational project that has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 857592, and was funded by the GeoVizEyeTrack project, financed through the National Recovery and Resilience Plan (NRRP) with resources from the European Union—NextGenerationEU. Andrea Miletić acknowledges support from the “Young Researchers’ Career Development Project—Training of Doctoral Students” (DOK-01-2020), funded by the Croatian Science Foundation.

References

- Doherty, K. and Doherty, G., 2019. Engagement in HCI: Conception, theory and measurement. In: *ACM Computing Surveys*, 51(5), pp. 1-39.
- Jansen, B. J., Guan, K. W., Salminen, J., Aldous, K. K. and Jung, S.-G., 2025. What is user engagement? A systematic review of 241 research articles in human-computer interaction and beyond. In: *Proc. of the 2025 CHI Conference on Human Factors in Computing Systems (CHI'25)*, New York, USA, Article 457, pp. 1–19.
- Peters, C., Castellano, G. and De Freitas, S., 2009. An exploration of user engagement in HCI. In: *Proc., International Workshop on Affective-Aware Virtual Agents and Social Robots (AFFINE'09)*, Boston, Massachusetts, USA, pp. 1-3