Exploring perception of design choices for visualizing qualitative data

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Summary

Visualization can be a powerful tool for analysis, communication, and decision-making in urban planning processes. However, visual representation is generally not prioritised, and formal standards for visualization are often lacking. In 3D-models a key challenge lays in presenting complex, layered and abstract information in an accessible way. This paper explores how design choices and graphic elements are perceived and interpreted by end-users in 2D and 3D urban data visualizations. Eight interviews were conducted with professionals working with data visualization within urban planning. Results highlight the need for adapted information to end-users and context, and guidelines and standards on how to visualize data.

KEYWORDS: design, data visualization, interview study, urban 3D-model

1. Introduction

Urban densification has environmental and societal consequences and to understand and communicate those, sustainability indicators are formulated (Khan and Zaman, 2018). Several indicators measure nonvisible consequences of infrastructure and building construction, both quantitatively, such as in air quality or noise levels, and qualitatively, such as social parameters, e.g. accessibility, safety, and social impact analyses. Social indicators are challenging to represent, making it difficult to communicate their impact to users. Visualization is an effective method for analysis, communication, and collaborative decision-making in urban planning (e.g. Hamilton et al, 2001) however, representing information effectively remains a key challenge (Parsons et al., 2020). Different users, target groups and situations have diverse needs, thus design decisions for visualizations are crucial (Metral et al, 2014). Planning is increasingly supported by integrated 3D-approaches (e.g. BIM, digital twins). Information visualization in 3D-models can be more accessible compared to 2D-methods by the inclusion of e.g. higher levels of details and realism, different scales and perspectives, and movement (Van Lammeren, 2010). This study aims to understand how different visualization concepts of qualitative data representing social impact are perceived by professionals working with visualization in urban planning. The study is part of the research project MiljöVis, which focuses on how to represent environmental and social data in 3D-coordination models in large-scale infrastructure projects.

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2. Methodology

An interview study combined with a think aloud method through task-based exercises was conducted to understand professionals' perception and interpretation of data visualization.

The interview part covered information about participants' background, expertise, professional experience and interests in visualization. The tasks included 4 exercises. In exercise 1-3, images were prepared to familiarize participants with visualization concepts such as interpretation of colours in 3D, interpretation of design choices in 2D, and readability of the design element "icon". In some images, colour scales were intentionally inverted; this abstracted familiar colour associations, such as blue and red and required participants to make sense of the colours placed in an unfamiliar way. Also, participants were asked to evaluate six different 2D-maps featuring symbols, colour fields and lines of diverse type where the legend was intentionally removed. In exercise 4, a short film-clip was prepared which synthesized the acquired knowledge from the previous tasks. Here, the focus was on the interpretation of design language in 3D (Fig. 1).

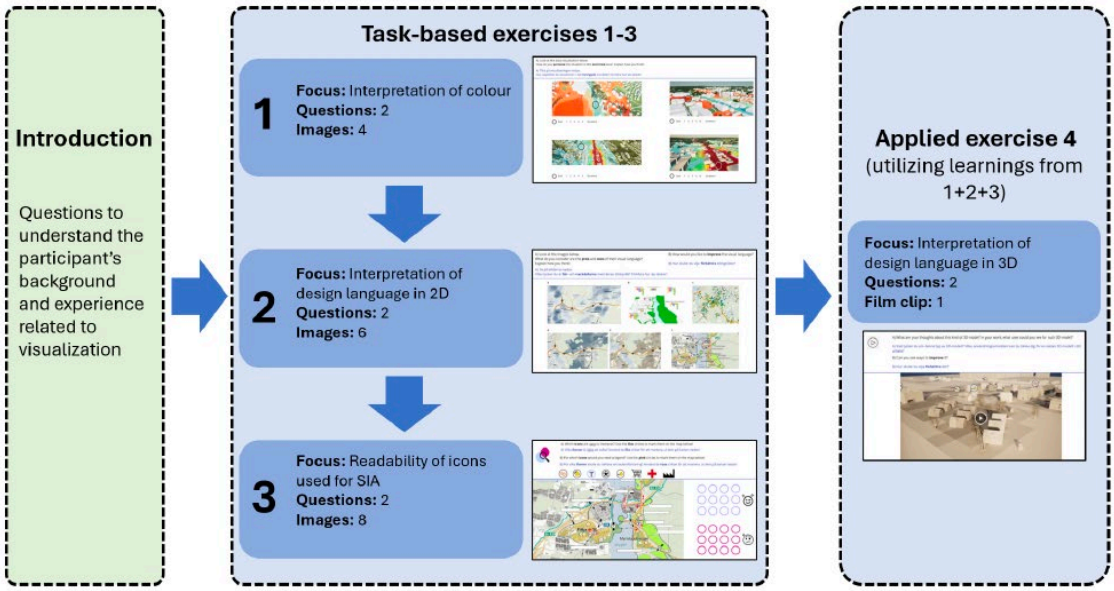

Figure 1. Schematic summary of the interview set-up.

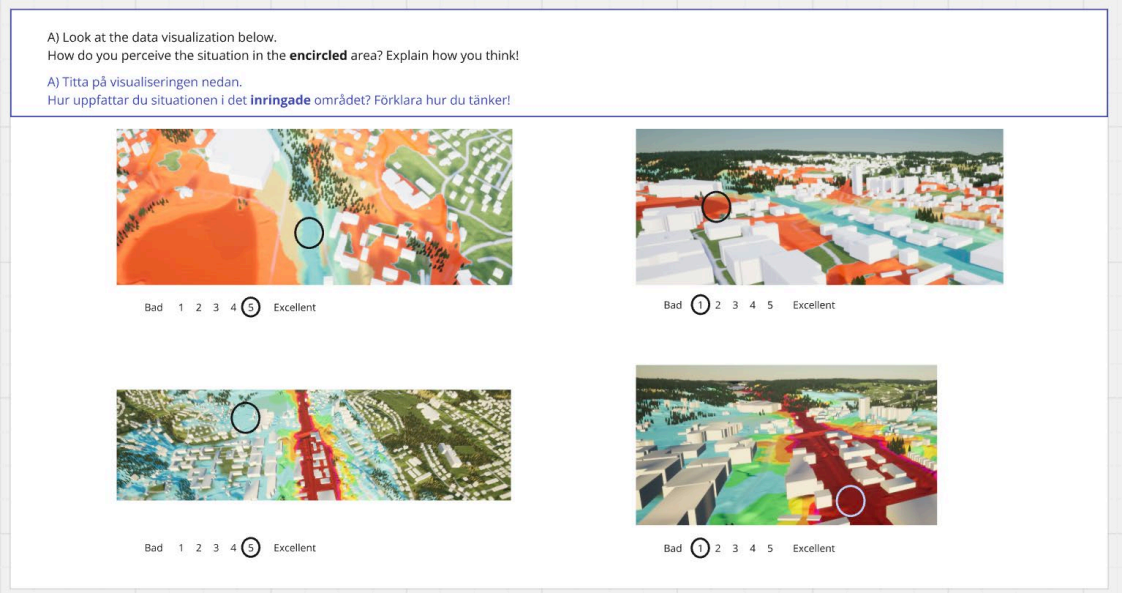

Figure 2. Example of exercise: Interpretation of colour.

Professionals were targeted who previously participated in one of our research workshops or focus group discussions and thereby had an expressed interest and competence in visualization. Out of 31 invitations, 8 respondents participated belonging to public sector (5), private sector (2), and academia (1), with work experience ranging from 2 to 11 years in their fields, within the areas of environmental and social sustainability, health, architecture, BIM, data analytics and/or digital twins.

The interviews were performed online using Microsoft Teams and the digital collaboration platform Miro for the exercises. The sessions were held in English and lasted between 30-45 minutes. Upon consent, the sessions were recorded and transcribed.

Results were grouped per exercise to highlight similarities between participants and numeric values were summarised in line graphs. The answers were analysed to identify challenges of existing visualizations.

3. Results and discussion

This study explored how urban planning professionals perceive and interpret data visualizations in 2D and 3D, and what design choices are most effective for conveying complex spatial information. The results highlight the importance of colour, contrast, and customization in effective visualization.

Participants preferred high-contrasting and colourful heatmaps, especially when combined with subdued background modes. This finding is consistent with (Słomsla-Przech et al, 2021), who emphasize the importance of colour in the perception of our surroundings. Icons and symbols were more intuitively understood than colours, particularly when based on well-known standards, supporting Hawkins et al. (2009). This suggests that the use of standardized icons and symbols can facilitate the interpretation of complex spatial data.

The study emphasizes the need for adaptable and user-friendly 3D-models, allowing users to filter and select information according to their needs. Participants called for customizable functionalities, such as the ability to filter levels of information, show or hide data layers and select how information is presented (text or pictograms). This is in line with the work of Cao et al. (2020), who highlight the importance of visualization in facilitating problem-solving and cognitive processes in urban planning.

The study also reveals challenges of visual communication that omits explanatory legends. Participants required annotations or a legend to correctly read heatmaps and their values. Two participants considered the context and terrain morphology of the visualized landscape to gain understanding, one had a colour deficiency. This suggests that meaning can be gathered from diverse elements composing and image yet utilizing explanatory legends can facilitate the interpretation of complex spatial data, particularly for users who are not familiar with the visualization techniques used.

The set-up of the interviews, with focus on feedback through guided exercises around visual material, proved to be an efficient way to gather data on perception of visualizations. One important realization was that many participants were not used to thinking about the visual representation of material in their work, making it necessary to vary between different levels of information in describing the task. Even though participants were unused to evaluation through exercises, the method extracted a broad variation of comments and reflections and boosted their creativity. The film-clip derived more interest and answers than the images, which can be supported in research by e.g., Castro-Alonso et al (2019), stating the benefits of dynamic over static visualizations for learning.

4. Conclusion

This study gathered insights from professionals who use visualization in their work, and was a test of a design research method, where participants could bring in their expertise. This is a small interview study, nonetheless it indicates the complexity that needs to be considered when designing information visualizations of qualitative data. More user-friendly, interactive and adaptable 3D-models were called for to handle high complexity in urban planning. These models should incorporate multiple information layers and offer customizable functionalities to support informed decision-making. Participants also raised the need for guidelines and best practices on how to visualize data, pointing out the need for standards for data visualization. The findings contribute to the MiljöVis-research project, aiming to visualize environmental and social parameters in large-scale 3D-models. Ultimately, the study underscores the necessity of further design research to refine visualization practices, particularly for qualitative data, in urban planning.

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Biographies

Fabio Latino, research engineer with background in urban planning, engaged in scientific data visualization. He brings experience in visualization of digital twins for cities, spanning from user study to concept development for data visualization and interaction in 2D and 3D. He is coordinator for the Gothenburg node of InfraVis.

Beata Stahre Wästberg, associated professor and senior researcher, explores the use of visualization as a tool for analysis, communication and dialogue in urban planning processes. Her research focuses on the challenges of visualizing invisible parameters, such as air quality, sound and social factors, in 3D-city models.

Monica Billger, full professor in Architecture and Visualization, conducts research on perception of light and colours in digital environments as well as serious games to support urban planning processes. She is the director of InfraVis, the National Research Infrastructure for data visualization.

Liane Thuvander, professor in Architecture and sustainable building, works with co-creation, integration of social and environmental aspects in digital twins, and knowledge implementation in practice. Her research focus is on development of methodologies for spatial value mapping linked to visualization strategies to support stakeholder dialogue and decision-making in urban transformation.