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From User Input to Augmented Tourist Map Design: A User-Centred Workflow

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Abstract:

Augmented Reality (AR) technology is becoming increasingly relevant in spatial applications, offering new ways to support exploration and navigation by overlaying digital information onto real-world environments. This is particularly relevant in tourism, where mobile devices are widely used and AR has growing potential to enhance the visitor experience. As this technology develops, AR maps offer both new opportunities and challenges for cartographic communication. AR maps are often considered a promising means of extending printed cartographic products with digital content while retaining the familiarity and broad overview of paper maps (Reilly et al., 2006). In this paper, an augmented map is understood as a printed map extended with a virtual layer of geographic information viewed through AR. Since the value of tourist information products depends on their usefulness to end users, the application of AR in tourism cartography should be guided by user-centred design (Roth et al., 2017; Roth, 2019). However, research on AR maps has often remained technology-driven, with strong emphasis on tracking and rendering (Cheng et al., 2022). A similar pattern has also been noted in AR research more generally, where user evaluation frameworks are still developing (Dünser et al., 2008; Choong et al., 2022; Graser et al., 2024). As a result, a practical methodological gap remains in translating user needs and preferences into concrete cartographic design decisions.

This paper presents a practical, user-centred cartographic workflow for developing an augmented tourist map through structured prototype design and expert refinement. Based on a case study of Croatian national park maps, it examines how requirements identified through user input can be translated into concrete cartographic design decisions. This paper addresses a methodological question: how can an augmented tourist map be developed through a traceable workflow in which user input defines the initial cartographic structure? The novelty of the paper lies not in proposing a new user-centred design model, but in showing how user input can be operationalised into cartographic decisions specific to an augmented tourist map, including content prioritisation, analogue benchmarking and the allocation of information between printed and virtual layers. Because the study focuses on cartographic communication, expert review was introduced as a formative checkpoint to assess and refine prototype clarity, consistency, and layer logic. It contributes a documented workflow for augmented tourist map development grounded in user-centred cartographic design.

The workflow consisted of three connected stages. First, a questionnaire-based user needs assessment examined content priorities and pictogram interpretation to identify design implications for tourist maps. Responses from 132 participants were ranked using a composite weighted score derived from open-ended “most important” and “least important” answers, in which objects listed earlier received greater weight. This showed that tourism activities, transport, and food and beverage were the highest-ranked content categories on a tourist map. At the same time, pictogram comprehension was assessed through open- and closed-ended questions using the ISO 9186 67% threshold, showing that several symbols used on existing Croatian national park maps were not reliably interpreted without legend support. Together, these findings suggested two main design requirements: the map content should emphasise the categories users consider most relevant, while also reducing unnecessary symbol ambiguity (Cibilić and Poslončec-Petrić, 2025).

Second, these findings were translated into a controlled prototype design by converting the composite category ranking into a reduced content set and layer structure. Rather than reproducing the full and often inconsistent content range found on existing park maps, the selected object categories were grouped into three priority tiers to support controlled distribution of information. All categories in the highest tier were retained, while one representative category from each lower tier was added, resulting in a reduced but balanced content set of five categories overall. Two matched stimuli were then developed: an augmented map prototype and an analogue tourist map that served as a familiar benchmark. The analogue map provided a stable cartographic reference condition, helping to guide decisions on content, symbolisation, and the distribution of information between printed and virtual layers. To preserve comparability and reduce symbol variability, both stimuli used the same standardised pictogram set together with the same POI categories, scale, layout

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logic, and overall content density. The main difference concerned the presentation mode and the distribution of selected objects between printed and virtual layers. The analogue stimulus contained the full selected set on a printed tourist map, whereas the augmented map stimulus used a printed base map along with a virtual layer displaying the remaining objects as pictograms aligned to the map surface. In this way, augmentation was treated as a cartographic design decision rather than a purely technical addition. The virtual content was intentionally kept simple, using static 2D pictograms aligned to the map surface to focus the design on map structure, clarity, and the relationship between printed and virtual information.

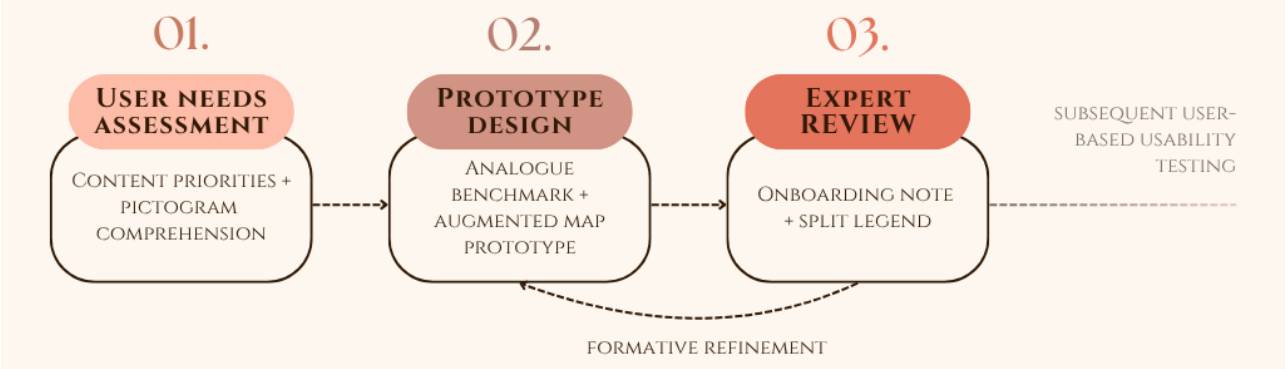

Figure 1. Three-stage workflow for augmented tourist map development.

The third stage involved formative expert review. The augmented map prototype, along with its matched analogue benchmark, was evaluated by seven expert cartographers in individual think-aloud sessions using a semi-structured protocol focused on usability, cartographic principles, and cognitive load. Their observations were audio- and video-recorded, supported by researcher notes, and compiled into a refinement log that grouped recurring issues and linked them to specific design actions. In this workflow, expert review served as a formative checkpoint to assess and refine prototype clarity, consistency, and layer logic. For the augmented map prototype, experts agreed that users should more clearly understand that additional information appears when the device is pointed at the map, leading to the addition of a short onboarding note on the printed base map. A second key refinement concerned the legend structure. Experts recommended a clearer separation between printed and virtual symbol explanations, resulting in a split legend structure: printed symbols remained on the paper map, while virtual symbols were presented in a fixed on-screen legend. Other refinements addressed local readability and spatial association, including the adjustment to symbol placement.

The presented case demonstrates that expert review can serve as more than a final check of cartographic quality. When used formatively, it helps stabilise the development of an augmented tourist map by improving interpretability and strengthening the distinction between printed and virtual layers. The proposed workflow shows that user-centred cartographic design can be documented as a practical and traceable process, rather than being treated as implicit design intuition. For cartographic practice, this offers a systematic approach to augmented tourist map development in which user input shapes the initial map structure, while expert feedback refines prototype clarity and the relationship between printed and virtual information. The resulting augmented map provides a basis for subsequent user-based usability testing.

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