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Techniques, challenges, and opportunities in mobile thematic map design for data journalism

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ABSTRACT

Maps are increasingly read on mobile devices. Mobile maps necessitate specific design considerations to improve readability and user experience. Little research has focused on how to design mobile thematic maps, in contrast to reference maps. Data journalism represents a common way that the public encounters mobile thematic maps. This paper characterizes the design techniques and challenges associated with mobile thematic cartography in the context of data journalism. Through interviews with 18 expert news cartographers, I show that teams of data journalists are increasingly aware of mobile users, but face numerous constraints when designing for these users. They face time constraints, the need to design for both desktop and mobile, and must reach vast general audiences, meaning they often practice simultaneous design over mobile-first design. News cartographers have also reduced their use of interactivity, which reduces complexity related to designing for both desktop and mobile. This work shows that news cartographers solve mobile thematic map design challenges through iterative design processes that draw from years of expertise, not a strict set of guidelines.

KEY POLICY HIGHLIGHTS

- News cartographers currently design mobile thematic maps based on generalized best practices, but are uncertain what choices do and do not work for their readers
- Many news cartographers design maps simultaneously for desktop and mobile, rather than prioritizing one over the other
- News cartographers are decreasing their use of interactive maps, given that they expect news readers want to consume information as fast as possible
- News maps are produced under time constraints that can be limiting on creativity and novelty, and without time for user testing

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Thematic maps; mobile maps; data journalism; cartographic design; structured interviews

1. Introduction

Mobile devices are part of daily life, and individuals today are more likely to read the news on mobile devices than on desktop displays or paper (Walker, 2019). Maps, too, are consumed in mobile apps and browsers, necessitating mobile-specific design considerations (Abraham, 2019). However, most research on mobile map design has focused on reference maps, navigation maps, and maps that use location-based services, which focus on wayfinding or identifying points of interest (POIs) (Lee, 2022; Roth et al., 2024). Mobile *thematic* maps, despite their wide use in data journalism, are understudied in academic cartography. Thematic maps show the distribution of one or several geographic phenomena across the landscape; common examples include choropleth and proportional symbol maps. While responsive design that considers both web and mobile platforms is important, I argue for mobile-first thematic map design as a research priority (see Bartling et al., 2022; Roth et al., 2024 for related research agendas). In this article, I begin addressing this need by characterizing the current and future state of mobile thematic cartography in journalism. I describe past research in these areas and follow with results from interviews with data journalists that reveal their workflows and visions of the future of mobile thematic map design.

There is limited literature at the intersection of mobile cartography, data journalism, and thematic mapping. Research exists on these subjects individually, or at the intersection of two of these subjects (for a partial list, see: Abraham, 2019; Chittaro, 2006; Fish, 2021; Gedicke & Haunert, 2023; Gorte & Degbelo, 2022; Ledermann, 2023; Lee, 2022; Muehlenhaus, 2014; Prestby, 2022; Roth, 2013; Schiewe, 2017; Segel & Heer, 2010; Song et al.,

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2022; Wallace, 2016). However, studies that combine all three areas are less common. Until recently, most studies which exist have focused on literature review and theoretical positions (Bartling et al., 2022; Roth et al., 2024). Hoffswell et al. (2020) and Kim et al. (2021) both studied responsive design in data visualization, but the maps made up only a small portion of the larger studies. Recently, Oesch et al. (2025) studied mobile thematic maps through a user study with news audiences. Schöttler et al. (2025) studied responsive thematic maps with design experts from multiple disciplines. My work expands on previous studies through direct engagement with data journalists.

Despite limited guidance on mobile thematic cartography, cartographers at news organizations must design thematic maps for mobile interfaces anyway. These individuals apply best practices from previous training and learn on the job. News cartographers are not isolated from technological and design progress, and they have communities they learn from on social media platforms and through societies and conferences. These communities are key mechanisms by which thematic map design evolves. To expand what is known at the intersection of thematic cartography, mobile cartography, and data journalism, I address the following research questions:

(1) What ideas, challenges, and techniques have been associated with mobile thematic map design in the context of data journalism?
(2) What ideas, challenges, and techniques do news cartographers currently practice when designing mobile thematic maps in the context of data journalism?
(3) How do news cartographers envision future ideas, challenges, and techniques for mobile thematic map design in the context of data journalism?

To answer these questions, I synthesized themes from related work and conducted structured interviews with 18 news cartographers. These interviews elicited current practices and encouraged participants to develop interface mockups to envision future designs. In the following sections, I characterize previous work relevant to mobile thematic map design for data journalism, describe the methodology for interviews with news cartographers, and derive answers from collected evidence for each research question.

2. Background

In this section, I review previous work at the intersection of mobile cartography, thematic mapping, and data journalism. While each of these areas has received attention in the literature, work that intersects all three is limited. Here, I place recent work into six categories related to mobile thematic news cartography: 1) responsive and mobile-first design, 2) screen size, orientation, and resolution, 3) generalization and complexity, 4) post-WIMP (windows, icons, menu, pointer) environments, 5) technical accessibility, and 6) individual accessibility.

2.1. Responsive and mobile-first design

Responsive design is a browser-based method to dynamically change the layout of a webpage based on the user's device (Marcotte, 2014). It relies on a fluid grid which changes at set breakpoints (mobile, tablet, desktop). With audiences increasingly accessing maps on non-desktop devices, cartographers have recommended creating maps using responsive design principles (Ricker & Roth, 2018), which is particularly important in the news industry (Schiewe, 2017). Maps are more difficult to design for multiple screens, in contrast to text or other graphics, since they embed set spatial relationships.

Following the principles of inclusive design that recommend designing for the most constrained users (D'Ignazio & Klein, 2020), cartographers have begun to embrace mobile-first map design (Horbinski & Cybulski, 2018). However, in a 2020 study (Hoffswell et al., 2020), most data journalists still designed desktop-first. Shifting to mobile-first is not simple, since cartographers have developed best practices for desktop maps to take advantage of large, multi-window screens operated by a mouse (Roberts, 2007). Since non-map elements like text, annotations, and legends often accompany maps, these elements may be rearranged along with the map to allow the entire layout to function better on mobile (Schöttler et al., 2025).

User experience is a key element of responsive design, as designs should translate fluidly to all devices (Roth, 2017). Some scholars have begun to examine mobile alternatives for thematic maps, which may appear as traditional choropleth maps on desktop, but change to choriented maps (Gorte & Degbelo, 2022) on mobile (Figure 1), allowing users a readable experience no matter the device. Alternatively, real-world constraints may force cartographers to prioritize their primary users. For example, Loeffler et al. (2021) describe the design process for their app *Flyover Country*, whose users are airplane travelers. While the app can be downloaded on a computer, users are more likely to use their phones on airplanes, and the app therefore prioritizes the mobile experience.

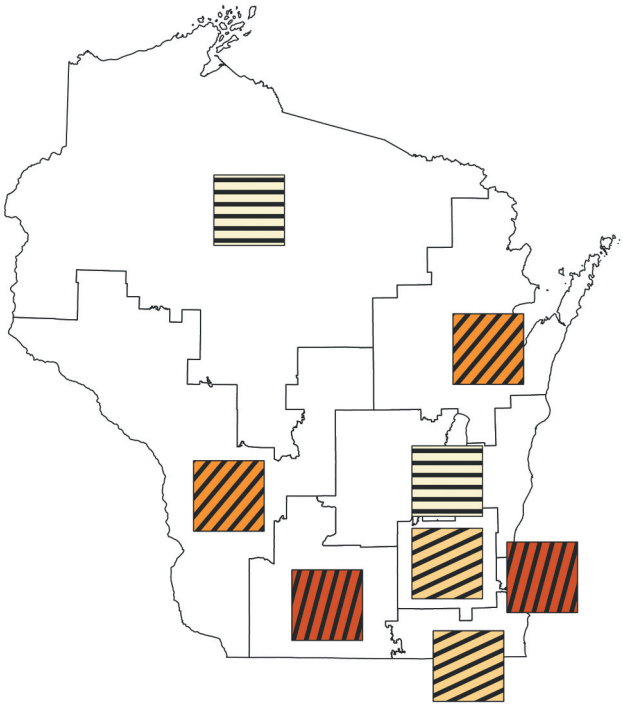

Figure 1. A choriented map which uses an equal sized square for each region and encodes information twice, through color and orientation, modeled after Gorte and Degbelo (2022).

2.2. Screen size, orientation, and resolution

Mobile devices are smaller than desktop devices, presenting size-specific constraints for map design. Mobile phones vary in size and aspect ratio, and phones are getting larger and more elongated (Abraham, 2019). Mobile devices can be held in portrait or landscape orientations; however, most users default to portrait views (Sunardi et al., 2023). Mobile devices typically have higher resolutions than desktop systems, which cartographers may take advantage of (Coltekin & Reichenbacher, 2011).

Ricker and Roth (2018) compiled a table of constraints in mobile map design, including size-specific constraints like *map layout*, *generalization*, *symbolization*, *typography*, and *available map elements*. Individual data observations must be large enough to be read, while also fitting on the screen with other information (Ledermann, 2023). These elements must also have clear affordances as static or interactive for mobile devices (Stevens et al., 2013). Given the range of differences between screen size, orientation, and resolution between mobile and desktop devices, some maps and other visualizations may need to be designed or significantly modified for each platform (Kim et al., 2021; Lee, 2022). For example, landscape-oriented landforms may need to be displayed using portrait projections, like the transverse Mollweide projection (Roth et al., 2024). Adapting maps and other data visualizations for multiple screen orientations is typically more challenging than adapting other elements, like text and images (Hoffswell et al., 2020).

2.3. Generalization and complexity

Since mobile devices have smaller screens than desktop devices, map information may need to be generalized. The process of generalizing information is well-established in cartographic (Brewer & Buttenfield, 2007) and data journalism (Cairo, 2016) workflows. Cartographers *smooth*, *simplify*, *aggregate*, and *symbolize* data, often designing at multiple scales and levels of detail (Weibel & Dutton, 1999).

Some generalization-related recommendations intended to support mobile navigation map design (Ricker & Roth, 2018) are relevant to thematic mapping: *include only relevant information*, *simplify the basemap*, and *increase the default size*. Often, maps and other data visualizations have a hierarchy of information, so the least important elements can be cut for mobile (Hoffswell et al., 2020). Depending on the story, one strategy to represent thematic data on mobile devices may include scrollytelling (Stolper et al., 2016), a technique frequently used in story maps (Song et al., 2022) (Figure 2). These maps extend beyond one screen height and include multiple maps and other visualizations, with scrolling as the primary user input.

Cartographers may use generalization to support user attention and retention, as complex information may be difficult to understand, particularly for general news audiences. General audiences may be presented with known information rather than interfaces that encourage exploration and hypothesis development (MacEachren, 1994). Users also interact with mobile devices in varied environments (Reichenbacher, 2001), and generalization may be necessary to tailor attention to avoid safety concerns in the real world (Roth et al., 2018). Distracting physical environments can increase the cognitive load of users, which is only exacerbated by design constraints related to small screen sizes (Griffin et al., 2024).

2.4. Post-wimp environments

WIMP (windows, icons, menu, pointer) elements found on desktop computers are not fully replicable in mobile devices (van Dam, 1997). Maps designed for desktop devices take advantage of large screen sizes and multi-window dashboards, with users pausing to hover over or click on map features (Muehlenhaus, 2014), allowing

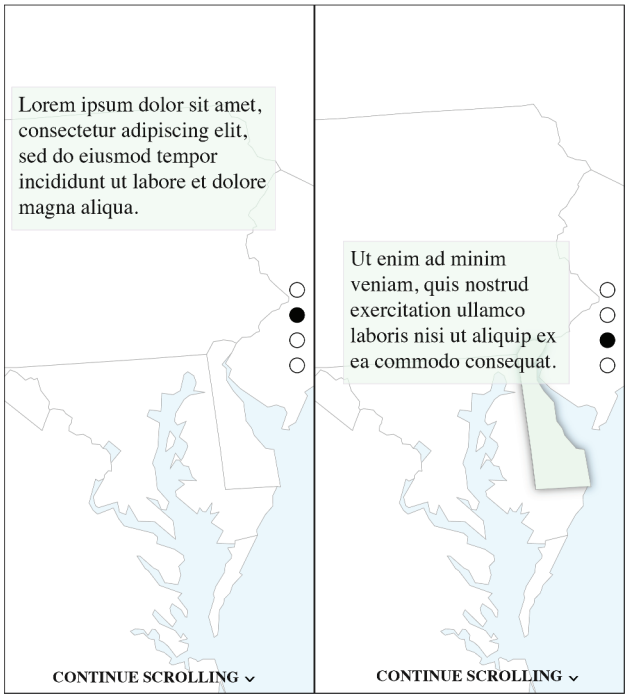

Figure 2. Two panels of a scrollytelling story. In the first panel, text appears over a basemap. After the reader scrolls, different text is exposed and an element is highlighted. A dot is highlighted in each panel to indicate how far the reader is in the story.

cartographers to take advantage of hover-specific design choices such as highlighting (Robinson, 2011).

Mobile devices are *post-WIMP* environments, offering different forms of interaction. Mobile-specific interactive affordances include *multi-finger touch*, *double-tap*, *rotate*, *tap and hold*, *AR/VR capabilities*, *location-based services*, and feedback through *vibration and sound* (Muehlenhaus, 2014). Some features are available on all devices, such as scrolling, though scrolling and reading may be conducted at a faster speed on mobile versus desktop devices, meaning the same action may have different controls and behavior across device types (Keib et al., 2022).

Given the differences between WIMP and post-WIMP environments, cartographers that develop responsive maps should consider each device type (Roth, 2017; Schiewe, 2017). For example, clickable elements that can be placed anywhere on a desktop may need to be moved lower on the screen to access with thumbs for mobile devices in a technique called bottom navigation (Loeffler et al., 2021). Other news stories use slippy maps, which display multiple levels of information through zooming and panning, filling the screen on a mobile device. Some touch-based features may need to be disabled to prevent *scroll-jacking*, an issue where the screen stays locked in place when the user tries to scroll, as the panning interaction for the map and the scrolling interaction for a story directly conflict with each other (Bostock, 2014).

2.5. Technical accessibility

Mobile devices are used in numerous environments and maps must display with slow internet connections, in different lighting conditions, and on devices with limited memory and processing power. Maps with heavy memory and processing requirements may leave behind and marginalize users with older phones (Roth et al., 2024).

Although widespread cellular coverage and generous data plans are common in many parts of the world, many individuals still face bandwidth limitations or have limited ability to pay for excess data; therefore, cartographers should maximize information efficiency (Coltekin & Reichenbacher, 2011; International Telecommunication Union, 2021). All mobile users face areas with limited connectivity, like the subway, so efficiency benefits extend to all readers. Even small lags in loading may cause users to click away from a story (Norman, 2013).

To mitigate loading issues, web designers may cache or preload elements (Loeffler et al., 2021), which also saves battery power. Batteries also drain quickly in bright outdoor environments, particularly if a map does not have sufficient contrast (Han et al., 2021). Stevens et al. (2013) described design recommendations from Apple cartographers, explaining they maximize figure-ground relationships and use established, meaningful colors to ease reading in sunny and distracting environments.

2.6. Individual accessibility

In addition to technical differences, cartographers should also accommodate individual differences. Following principles of inclusive design (D'Ignazio & Klein, 2020), content that is accessible to users with permanent differences will also help individuals who experience temporary or situational differences. Differences in visual abilities make up 78% of the information visualization papers on accessibility (Wimer et al., 2024), though limb differences and cognitive differences should also be considered.

Colorblindness is the most common visual difference considered in cartography, however high contrast maps are also important for individuals who have low vision. Thematic maps for blind and other visually impaired readers have been studied in the context of tactile maps

(Cole, 2021), though blind readers of digital maps may require alt text or ARIA labels that support screen readers.

Simpler maps, such as static or scrollytelling maps, may be more accessible for users with differences in abilities. More simple maps may work better for mobile users in general, who spend less time on maps than desktop users (Schiewe, 2017). Individuals with no use of their arms may require a screen reader, making complex interactive maps inaccessible. Other individuals may only be able to use one limb or hand, which must simultaneously hold the phone and perform all interactions. In addition, as part of the natural aging process, most individuals will see a reduction in motor abilities, potentially suggesting a reduced ability to interact with (Yu & Chattopadhyay, 2020) or read (Kovanen et al., 2012) maps.

3. Methods

To answer research questions two and three, I recruited expert cartographers at news organizations in the United States to participate in structured interviews and sketch interface mockups. In the following sections, I describe my research participants, interview design and procedure, and results analysis.

3.1. Research participants

This study was approved as exempt by the Penn State IRB under number STUDY00022852. The study was approved for implied consent. To be eligible for the study, participants had to within the past 2 years have employment that includes: 1) an element of maps and cartography and 2) work at a news organization. For this study, I recruited 18 participants employed at eight news organizations. I recruited participants through direct e-mails, additional e-mails from snowball sampling, and posts on a professional cartography Slack group. While there is not a clear mechanism to know the exact number of American news cartographers, the National Institute for Computer-Assisted Reporting (NICAR) conference, a prominent data journalism event, estimates that it has around 1,000 attendees per year (NICAR, 2024). Given that news cartographers make up a small proportion of all data journalists, the number whose work focuses on cartography is likely under 100, most of which are employed at around 20 to 30 large and midsize news organizations.

Prior to the interview, I asked participants to complete a demographics survey. Of the 18 participants, nine were female and nine were male. Thirteen participants were White, four were Asian, and one was White/Hispanic. Eleven participants completed an undergraduate and a Master's degree, two completed an additional certificate beyond their undergraduate degree, and five completed an undergraduate degree.

I also asked participants about their cartographic and journalism experience. Participants had an average of 7.89 years of experience in cartography (4–15 years). Participants had an average of 6.44 years of experience in journalism (1–16 years). Participants had been employed for an average of 3.12 years at their current employer (0.6–11 years). In their current role, participants work on map-related tasks always (5), often (10), sometimes (2), and rarely (1). Figure 3 provides an overview of participant responses, including the field of study and current employers.

3.2. Interview design & procedure

My interviews involved three parts: 1) a 45-minute structured interview on current practices in mobile news cartography, 2) a 15-minute interface mockup sketch task to propose a future design for a mobile map-based news story, and 3) a 15-minute structured interview based on the mockup.

The interview protocol followed a structured interview design (Kumar, 2014; Shadbolt & Smart, 2015; Suchan & Brewer, 2000). Structured interviews use the same questions for all participants, ensuring consistency in the topics discussed. Structured interviews are appropriate when the researcher has a clear understanding of the topic and when there are expected similarities across participants. In this study, a review of recent work provided a strong foundation for questions. My interview questions follow the six themes from the preceding review, with two additional categories added to understand general design and audiences.

For the second part of the interview, participants sketched an interface mockup for a new mobile-friendly thematic map, followed by a brief structured interview about their mockup. Interface mockups and other preliminary visualizations can help researchers and their collaborators discuss solutions to difficult challenges and generate multiple possibilities before full implementation (Kerzner et al., 2019). These mockups emerge without reference to previous tools, encouraging creativity without limitations imposed by current systems. Participants had 15 minutes to design a mobile interface that prioritizes thematic maps. I asked participants to include at least one map matching each of the following criteria: static, interactive, thematic, and at the scale of the United States. Subjects used Web Whiteboard to sketch their mockups, captured by a screenshot. They were prompted to address a subject area

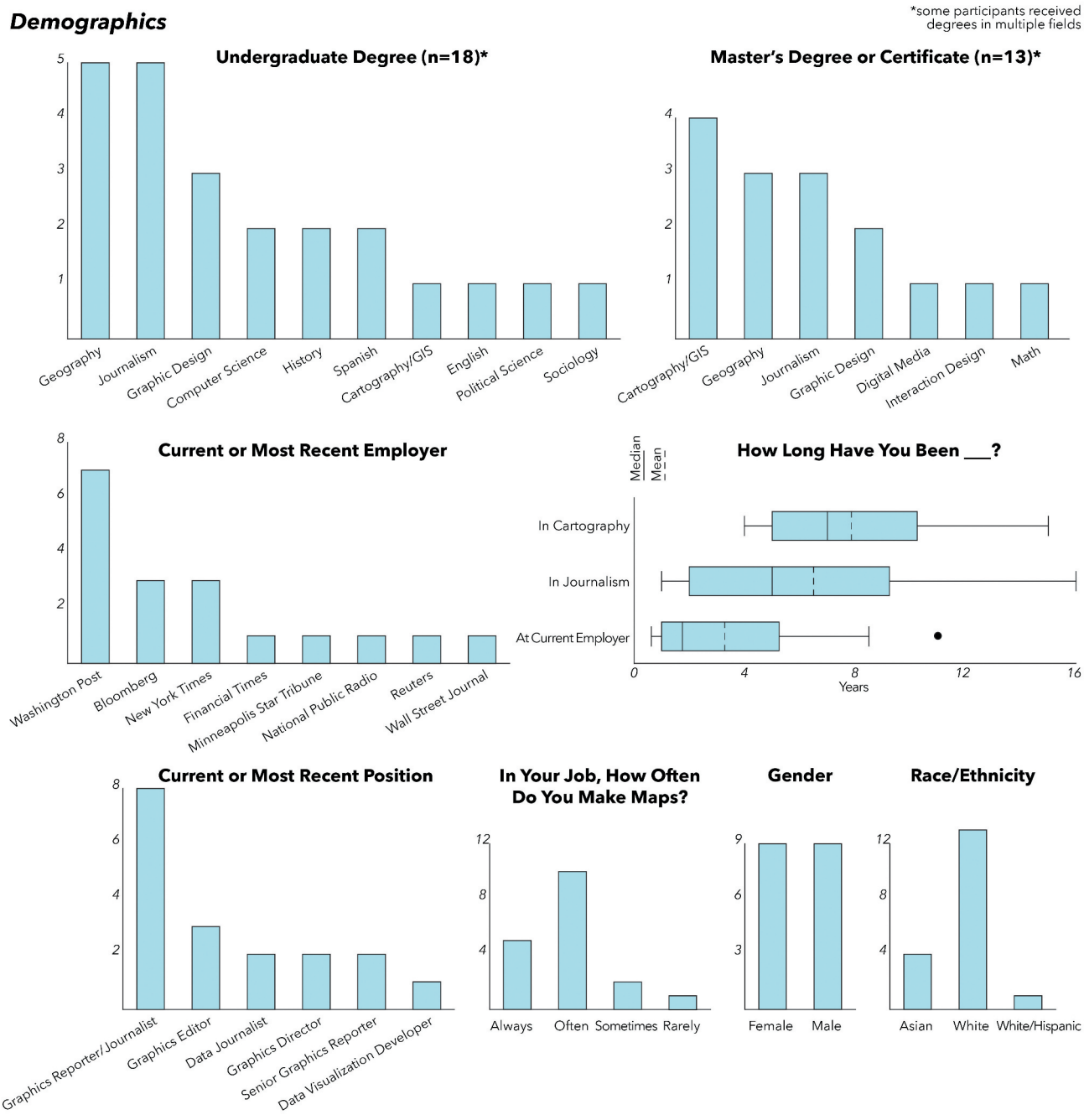

Figure 3. Participant demographics.

commonly found in news stories: weather and climate (Vujaković, 2014). Following this portion, I asked participants structured interview questions about their designs.

To refine my methodological approach, I conducted three pilot tests of my interview questions (one news intern, two PhD students); these responses are not included in the final survey. Based on these pilot tests, I added one interview question and restructured some questions for clarity.

Interviews were conducted on Zoom and limited to 75 minutes; a video and audio recording was captured of each. Screen sharing was enabled, allowing participants to point to elements on stories. See Appendix A for the full interview procedure and Appendix B for a summary of the results of questions that were omitted from the paper for non-surprising responses to limit length. For responses to all questions and interface mockups, the results are published in an open data repository: https://doi.org/10.26208/8XWG-ZW43.

3.3. Analysis

To analyze data collected from the structured interviews, I evaluated the responses to each individual question separately, given that all participants were asked the same questions. The coding scheme was imposed on the data by the themes used to structure the interview. The interview questions were organized into one of the six themes identified in the background portion of this paper (or one of two additional categories to capture general map design and audience), and results are reported by these themes. Given the presence of overlap across themes, in the discussion section I highlight results that intersect multiple questions. I evaluate the interface mockups primarily through the verbal descriptions given by my participants, referencing the screenshots as needed.

4. Results

Here, I summarize the results from my structured interviews and interface mockups, organized by theme.

4.1. General design process

4.1.1. Map design workflow

Most participants begin map design by gathering and cleaning data or sketching a mockup. Some participants asked themselves questions, including the type of graphic, the level of interactivity, the key takeaway, the role of the map in the story, and the timeline. Two participants have "been encouraged recently to design first for mobile because it's a majority of our readers" (P1), and *some* begin with multiple simultaneous artboards. Multiple participants indicated the use of tools: one typical workflow includes the combination of QGIS, Adobe Illustrator, and AI2HTML (an open-source tool data journalists use to convert multiple sizes of Adobe Illustrator artboards into HTML content) for static maps. A workflow for interactive maps involves mapping templates like DataWrapper or Flourish, which seamlessly display content across multiple device sizes.

4.1.2. Map design inspiration

Most participants mentioned other news organizations as inspiration, including national and international papers, mid-size organizations, and data visualization websites. Some participants look up specific subjects (e.g. flooding) to understand how it has previously been mapped, while others described a more casual exploration by scrolling through social media. Many participants also look in their organization archives since they may be able to "adapt templates or code that people have used in the past" (P1). Outside of news sources, participants drew inspiration from navigation services like Google Maps. Five participants referred to general mobile phone use as inspiration, and one said, "I'm looking at what am I seeing on TikTok that's capturing my attention. What am I seeing on Instagram or whatever I'm scrolling through" (P17). From non-digital sources, participants were inspired by historical maps, transit maps, and art.

4.1.3. Design standards

Many participants explained their organizations relied on internal best practices more than formal standards. The only recurring formal practice was type size. Participants noted most design guidelines existed to expedite the mapmaking process and to ensure consistency at their organization, as opposed to mobile-specific benefits. One participant explained "interactive-wise," maps are more likely to be similar because "coding is difficult and time consuming . . . by default you get these standards because people just copy the code because it's a lot faster" (P16). Some participants at larger organizations noted non-graphic journalists occasionally make their own simple maps. These individuals follow organizational templates closely, while experts "are mostly working on pieces that can benefit from breaking the rules" (P17).

4.1.4. Thematic map type

Most participants said the scale of the data mattered more to mobile design than the type of thematic map. They noted "there's design things you can do" to mitigate many issues, including "have it broken up into different parts . . . maybe you have state maps in mobile. You can have a toggle that'll take me to Colorado, take me to this" (P9). Two of the most common map types, choropleth and proportional symbol, were mentioned often, and equally mentioned as good, neutral, and bad. As examples of good design for mobile devices, participants mentioned cartograms, arrow maps, bar charts, and redundant encoding. As examples of bad design for mobile devices, participants mentioned arrow maps, dot density maps, and heat maps.

4.2. Mobile and responsive design

4.2.1. Desktop-first

To make a desktop-first design work on mobile, most participants discussed modifying the layout without changing information: moving map details (inset, labels, orientation), splitting the map in half or using

orthographic globe-like views, and displaying the data as small multiples. Three participants included excess information; as described by one participant, "I designed in a very wide frame, but the map labels were concentrated to the center . . . on desktop, you got this very big landscape feel. But then when you went to mobile . . . it was just cropping out that extra terrain" (P9).

4.2.2. Mobile-first

To make a mobile-first design work on desktop, three participants simply enlarged the information. Two occasionally designed mobile-sized maps for desktop. In one organization, "breaking news stuff operates on a smaller art board" (P5) and another has "a desktop option that is half width . . . we call it a related media item" (P8). Overall, most other changes were small: adjusting the zoom and viewport, resampling the raster, using an oblique angle, adding labels and hillshade, and moving scrolling text. One participant did not have an example, but broadly stated mobile-first "in general is a lot easier to do because you're going from a small amount of space to a larger amount" (P11). Four participants rarely designed mobile-first maps.

4.2.3. Change in mobile over time

Participants think about mobile design now more than they used to, with some only recently considering it at all. Specifically, participants have begun to consider visibility of small regions, labeling needs, number of interactive elements, vertical space, and smaller files sizes. Some participants said practice over time has allowed them to produce mobile maps more efficiently, while others credited the invention of better tools like DataWrapper and AI2HTML.

4.3. Screen size, orientation, and complexity

4.3.1. Landscape orientation

To handle landscape geographies on mobile devices, participants may rotate the map, though some specified this choice may confuse some audiences. Of participants who chose to rotate maps, most said less familiar geographies were better to rotate, since readers were less likely to notice. However, a few participants suggested more familiar geographies (e.g. the continental U.S.) were better to rotate because their familiarity supports greater readability. Cutting and cropping was also a common strategy used by participants, including cropping out less important data, "three globes-three orthographic projections – that go all the way across" (P17), additional insets, and moving information off the map.

4.3.2. Data and design complexity

Although asked as two separate questions, most participants did not distinguish between data and design complexity. One participant said data and design are "intertwined because you can use design tools to . . . make data that feels complex a little less apparent" (P14). Participants may change the scale or orientation, remove extra symbols, move information onto multiple maps, and reduce the number of classes on a choropleth map. Two participants said large datasets (i.e. hundreds of earthquakes) may lead them to display only the most essential information for mobile devices, but participants were mostly opposed to the notion of removing data. One participant explained that in data journalism, reducing complexity is "something we do on a regular basis. But it's not necessarily just because of mobile, we do that for overall reader comprehension" (P17).

4.3.3. Audience assumptions

Participants assume a simple design works best to retain mobile readership. They assume mobile audiences have short attention spans, so "you just have to be kind of limited in what you're asking the reader to do because this is something that they're just jumping into" (P15). Additionally, mobile readers are seen as more distracted because they may be "reading something . . . walking down the street, on the train, maybe it doesn't have their full attention" (P3). Because of audience limitations, news cartographers have "reduced the amount of interaction we put on any of our data viz or maps because we presume [less interaction]" (P8). Participants were in favor of simple forms of interaction like scrolling, including displaying multiple static maps through methods like scrollytelling, which works on all devices.

4.4. Post-wimp environments

Many participants rarely implement interactivity that differs between desktop and mobile, such as hover. As P15 explained, "the bar for interaction in the story is really high actually . . . the interaction things that I use, I want them to be super intuitive." After tracking buttons, P10 realized, "nobody actually clicks those buttons . . . interactives take a lot of energy, resources, and time, but the payback is not always there." If hover was necessary on desktop, it would become a tap on mobile. However, desktop devices are also limiting because "there's a lot of things that if we were only designing for mobile, we might do, but since we also need to make it for desktop, it can be kind of challenging" (P1). Participants suggested a few non- or low-

interaction alternatives to hover and tap: a scroll to reveal information, a search box, and annotations instead of tooltips. Participants were more likely to implement complex interactions based on other mobile apps, like Google Maps (multi-finger zoom and pan), Instagram (tapping on the right side of the screen for "next"), and "swiping from side to side . . . mimicking a Tinder dating app" (P12).

4.5. Technical accessibility

4.5.1. Static versus interactive

Participants noted a few practical constraints to interactive maps: limited time to make one for breaking news, someone with skills to make one is not available, and some stories do not have complex data to justify one. P7 suggested, "the balance of visuals that are explanatory versus exploratory on news stories is probably like 95–5 . . . the vast majority of news things should be on rails." Most participants said the usefulness of interaction depends on if it adds value to the story. They balance the additional time required with the knowledge that some users will never interact. A third of participants were most likely to use interactivity for ego-centric data where "people can look at their specific area. That's the case where it's going to be much more helpful" (P9). A third of participants rarely create interactive maps themselves.

4.5.2. Device and computing power limits

To ensure interactive maps load efficiently and without high demands from devices, participants minimize file size, preload elements, and compress data. Some participants remove map elements or make an interactive map static for mobile viewers. Some participants test on older physical devices or slower connections. Occasionally, participants may design stories that require higher-than-average computing power, but these visuals are more relevant when the piece is part of an experience, such as scrollytelling stories, where "having the map move as the reader scrolls was something that brought something new and different to the piece versus a static map" (P9). For static maps, participants might preload the page, initially load lower resolution maps, or compress map images. Static maps also last longer than interactive maps; when showing an interactive example from 2018, P17 said "God, I hope it still works . . . please work, it's old." Participants shared that part of the reason that interactive maps may become deprecated faster is because the code used to develop them is written quickly and sometimes imperfectly.

4.6. Individual accessibility

Many participants design with high contrast and color-blind-friendly colors, using alt text and ARIA labels as a fallback. One participant described a recent example "from a hurricane base map. One of the editors was asking if I can make the water more subtle than it was. And I brought up that most people are probably looking at it on their phone in the sunlight" (P16). Related to text size, two participants use a baseline larger text size, and two use REM (root-em, the size relative to the root element) as the unit of measure for text, as it is generally more adaptive. Two participants mentioned audiences with different accessibility needs are "another argument for not adding interaction where interaction is not necessary" (P8). Participants were more aware of how to design for users with vision differences than limb differences, and were uncertain how forms of accessibility that use keyboard tabbing translate to mobile. Some participants have an accessibility member on their team who answers these questions. In one case, this role caused a participant to "feel like . . . I'm a bit of a sheep and just doing what the [Digital Accessibility Center] people tell me to do . . . I don't know why I'm doing this" (P7).

4.7. Audience

4.7.1. Success

Most participants mentioned that according to their employers, page views and time spent as two of many factors in map success, but some said, "they are not measuring success on clicks" (P13). Many participants noted views and time cannot be solely attributed to the map, since it is part of a larger story. Within their organization, participants mentioned being noticed by higher ups or winning awards was important. Successfully bringing data from the wireframe stage to the production stage was also considered a success, although this success was measured subjectively by the news cartographer and their team, not the audience. On a personal level, participants were varied in what mattered most. For P16, "the big thing is always, like for [project], someone is using that in their 4th-grade class. That's the feedback that makes you happy." Other personal successes included causing emotional reactions, making real change in the world, and learning new skills.

4.7.2. User feedback

Participants said it was rare to receive map-specific feedback from audiences, and when comments do come in, it is difficult to distinguish meaningful critique

from complaints. More often than changing an already published story, participants took feedback into account for future stories, including colorblind-friendly designs, reduction in unfamiliar map orientations, and the addition of progress bars in scrollytelling stories. In an example of a minor change, "we published a world map that had labels . . . and someone wrote in and said a label is over where the majority of people in Canada live, so we moved it" (P1). Participants noted the main mechanism for feedback is from colleagues during map production.

4.8. Interface mockups

Following the structured interview, I gave participants 15 minutes to design a mobile-first interface mockup, followed by a 15-minute structured interview about the mockup. Participants were asked to center the story around weather and climate with the following checklist: two maps, one interactive map, one map at the scale of the United States, one thematic map, envision the future of mobile map design.

4.8.1. Static and interactive elements

For static maps, most participants drew either an entire or a partial view of the United States. For interactive maps, around half of the participants drew a zoom interaction based on a city typed in a search box or selected from a dropdown menu. Some participants envisioned novel interactions, including a carousel (interactive element to rotate between content) to toggle between datasets (Figure 4), a scrolling beeswarm (chart which shows all individual data points on one axis without overlap) of states (Figure 5), a magnifying glass to zoom in (Figure 6), and an option for users to submit their data (Figure 7).

4.8.2. Scale and orientation

Almost all participants began their mockups by displaying a map of the United States to show overall patterns in a north-up orientation, followed by one or multiple zoomed-in maps to look at data more closely. These locations represented either the most notable parts of the dataset or the user's location. Some participants made other choices including rotating the map 90 degrees, using a globe (to more accurately position Alaska and Hawaii), using a beeswarm chart, splitting the country into three parts, and displaying small multiples.

4.8.3. Thematic map types

Four participants used a choropleth map, three used an isopleth map, three used continuous raster data, two used vector arrows, one used a cartogram, and one used a proportional symbol map. Two participants displayed multiple weather datasets with thematic map types that varied depending on the dataset (Figure 4). Two participants displayed location data; one used polygons based on the size of a fire (Figure 8), and a second used dots colored based on severity. Three did not select a thematic map type.

Figure 4. Mockup featuring a zoomed-out map of the United States and a detailed map of the user's location. The data displayed is based on the user's location and the thematic map type is based on the data. The user can move the carousel to change the data.

4.8.4. Novelty and differences from current practice

A third of participants said they did not include anything novel in their mockups. Some participants created templates that parallel their current work (Figure 9). In more novel efforts, two participants designed maps with multiple weather datasets that once zoomed to the user's location would automatically display the most relevant weather type for that area. Three participants designed maps with more interactivity than normal. Other simple

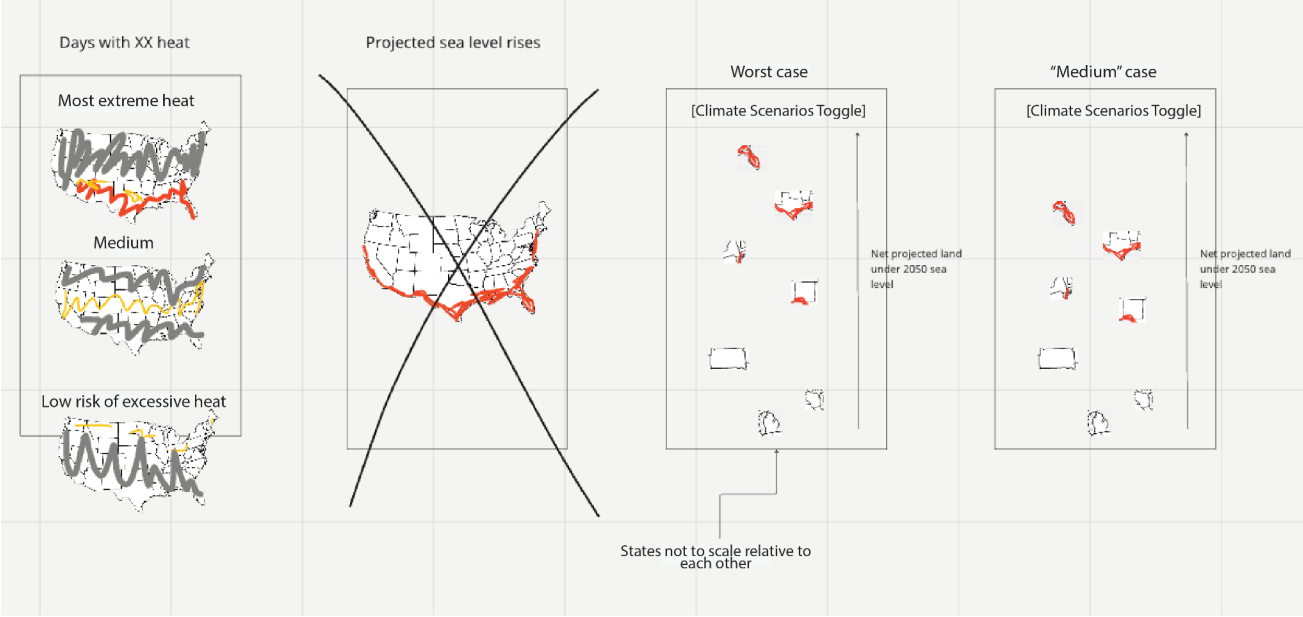

Figure 5. Mockup featuring a map which previews information at the scale of the United States, followed by a scrolling beeswarm of states taken out of geographic context. Beeswarm plots are similar to scatter plots in that they display information along one axis, but they avoid overlap of variables. A scrolling version of this plot had data that is contained beyond one screen length, requiring the user to scroll.

ideas include a rotated cartogram, a globe, a progress bar for scrollytelling, options for three recommended cities if users did not want to input their location, non-linear scroll and swiping, and a slider for time data. More complex ideas included feeling the heat of a location through the phone (Figure 10), a beeswarm of states on an axis (Figure 5), a magnifying glass on an otherwise static map (Figure 6), a custom color palette based on the user's preference, and a design where fire-affected areas look like a burnt napkin (Figure 8).

5. Discussion

5.1. Previous work in mobile thematic news cartography

To understand previous work in mobile thematic news cartography, I asked:

> What ideas, challenges, and techniques have been associated with mobile thematic mapdesign in the context of data journalism?

After reviewing previous studies, I found there is limited work at the intersection of all three areas, other than a few preliminary calls to action (Bartling et al., 2022; Roth et al., 2024), one empirical study in cartography (Oesch et al., 2025), and one in human-computer interaction (Schöttler et al., 2025). I draw out six themes that relate to mobile thematic cartography in the context of data journalism: responsive and mobile-first design, screen size, orientation, and resolution, generalization and complexity, post-WIMP environments, technical accessibility, and individual accessibility.

5.2. The current state of mobile thematic news cartography

To understand the current state of mobile thematic news cartography, I asked:

> What ideas, challenges, and techniques do news cartographers currently practice when designing mobile thematic maps in the context of data journalism?

I conducted interviews with news cartographers to understand current practice in this area and synthesize those results here.

5.2.1. Mobile-first or desktop-first

Recent literature in cartography and related fields has pushed for mobile-first design with the assumption that mobile devices reflect a more constrained use case compared to desktop devices, and to address the rapid increase in mobile users (Horbinski & Cybulski, 2018; Roth et al., 2024). However, the news cartographers I interviewed are split on mobile-first or desktop-first workflows. Often, participants work on three artboards at once without prioritizing a particular screen size, a process referred to here as *simultaneous design*, an extension of responsive design. Hoffswell et al. (2020)

Figure 6. Mockup featuring a map of the United States situated within text. The user can press on any area of the country to zoom in with a magnifying glass, and the rest of the country remains as the background, as opposed to a traditional zoom.

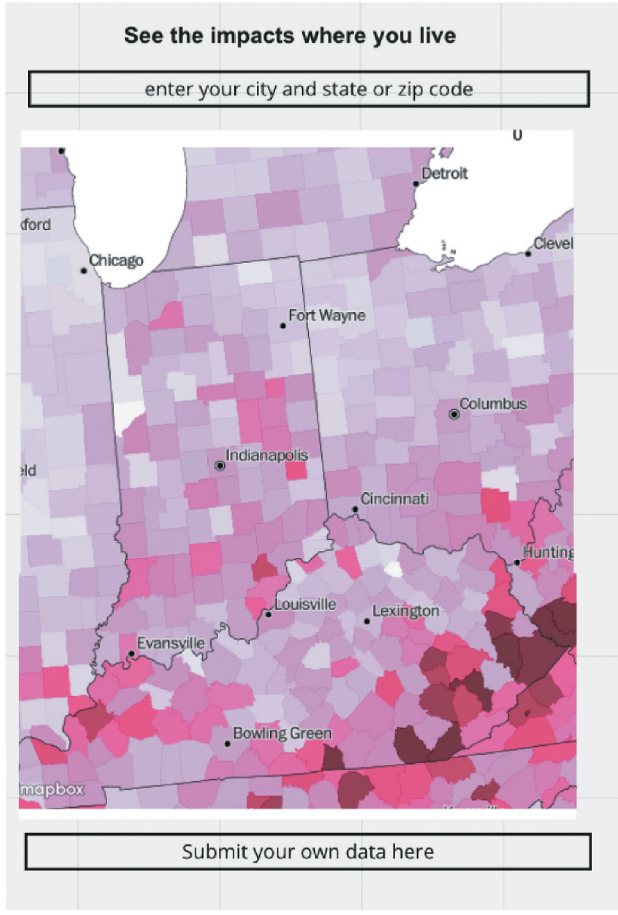

Figure 7. Mockup featuring a map which zooms in to the user's location. The user is then prompted to contribute their own data.

similarly discuss simultaneous editing, and like cross-platform design (Seffah & Javahery, 2003), simultaneous design considers multiple user experiences equally. In contrast, a few participants exclusively design desktop-first or mobile-first.

A common argument for designing desktop-first is as follows: "it's easier to cut than to add because when you're cutting you're taking away information that already exists, but when you add information, you have to pull it from somewhere" (P6). Additionally, some participants explained the reason they became cartographers was to design big, beautiful maps, and that mobile-first takes away some of this joy. However, some complex stories can take advantage of the mobile platform; one participant described an effective scrolly-telling story centering the Appalachian Trail, a long and skinny route.

In contrast, some participants advocated for mobile-first design. These participants explained that mobile audiences are increasing over time, an assumption confirmed by a survey conducted by Pew Research Center (Walker, 2019) and the Swiss news organization Neue Zürcher Zeitung (NZZ) (Oesch et al., 2025). Some stated mobile-first is a policy imposed by their employer. Other work on cartographic journalism reports similar findings (Schiewe, 2017; Wallace, 2016). Additionally, these participants argued the reverse of desktop-first advocates; to them, it is easier to add details for desktop after crafting a mobile-first map. When constrained for time, a small map can always be enlarged, and on desktop, it may look strange, but it will remain readable.

In news cartography, it remains necessary to design for multiple screen sizes. While academic literature favors mobile-first design, individual cartographers

Figure 8. Mockup featuring a map using burnt napkin imagery to demonstrate wildfires.

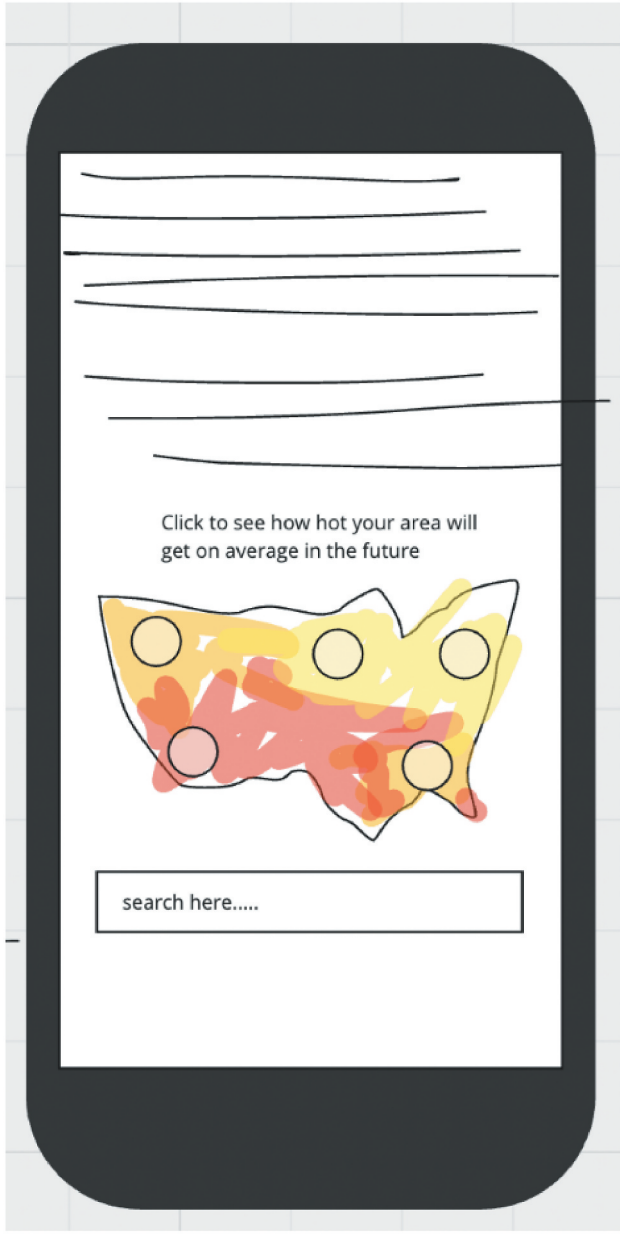

Figure 9. Mockup that parallels the participant's everyday work.

have preferences related to time constraints and it may be difficult for experienced cartographers to make a switch. New technologies have made it easier to practice simultaneous design across multiple artboards. One popular workflow includes processing data in QGIS and designing in Adobe Illustrator. AI2HTML, an open-source script developed by *The New York Times*, makes it easier to work across multiple Illustrator artboards and publish them online (Sam, 2018). DataWrapper and Flourish provide similar functionally for interactive maps across multiple screen sizes, and some organizations, like NZZ, have created their own in-house tools for this purpose (Oesch et al., 2025).

5.2.2. Content and responsive design

Responsive design is necessary for the fast-paced news industry (Marcotte, 2014). While someone *can* design different maps for mobile and desktop users, participants in this study were mostly opposed to giving mobile and desktop readers different experiences. Instead, participants cut supplementary information and shift content around to fit on mobile without changing essential information; rearranging non-map elements is also a strategy employed by participants in other work on responsive thematic maps (Schöttler et al., 2025). The information on most news maps is already simplified for public consumption and little else can be generalized.

A few participants did note scenarios where desktop users would be given additional information. One described a story where desktop users saw all recent earthquakes as proportional symbols, and mobile users saw only the largest ones. As rationale for different experiences, one participant expected desktop

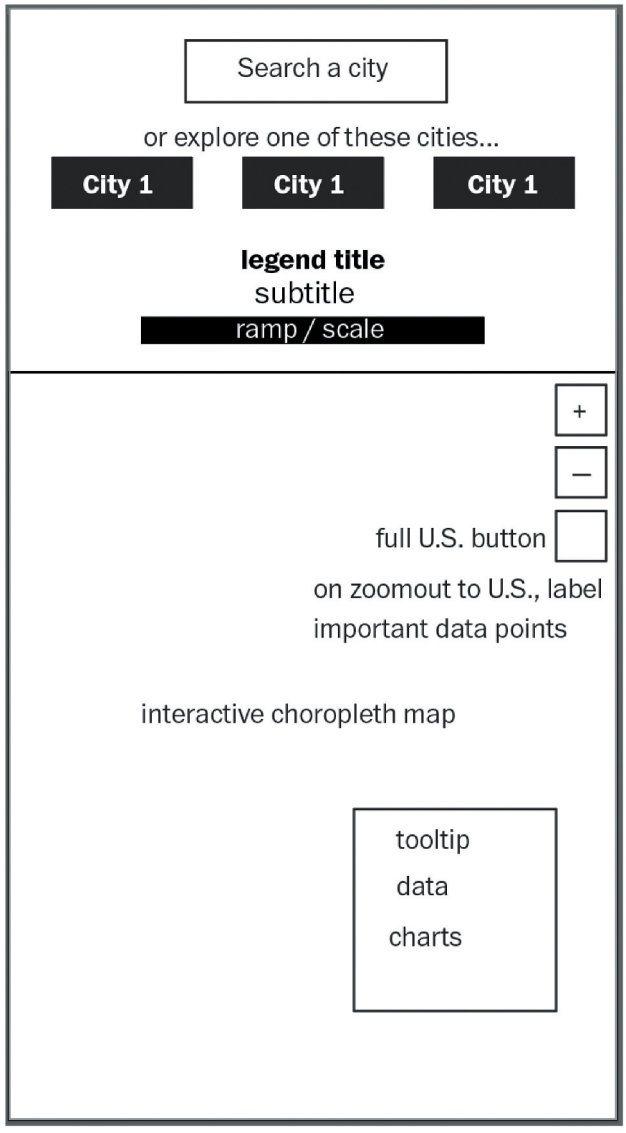

Figure 10. Mockup featuring a map of heat in the United States where users can tap on a dot and feel the temperature through their phone. For mobile accessibility, the search bar is at the bottom.

users to be less distracted and spend longer on a story, warranting more information. The mobile experience may need to be glanceable and viewed quickly (Blascheck et al., 2019; Holcombe, 2009). This idea relates to MacEachren's (1994) cartography cube, which theorizes that public audiences might be presented with known information via static interfaces, compared to private audiences who may seek to interactively uncover new knowledge. This framework does not discuss modality of interaction, however as described by P14, and echoed by others, "I do feel like people interact more with a desktop version more so than mobile."

Some academic work has conceptualized new thematic map types that may be easier to read on mobile devices (Gorte & Degbelo, 2022). However, news cartographers reported using established thematic mapping techniques, like familiar choropleth and proportional symbol maps, on mobile devices, relying on core cartographic design skills to ensure readability. Beyond basic conventions, some cartographers experimented with cartograms, which have become popular in election mapping (Houtman, 2022). Cartographers also make modifications to common map types, like reducing the number of classes on a choropleth map or redundantly encoding information through size and color.

5.2.3. Expert knowledge and freedom

Though many news cartographers use templates and reuse code, news cartography is a specialized job that requires expert knowledge and creative solutions to difficult challenges. Prescriptive design guidelines and standards do not reflect the complexity of news cartography, although Schöttler et al. (2025) report that their participants are anxious about the lack of design guidelines. Some larger organizations have templates to guide non-cartographers for quick maps, but the creative and data-intensive maps are produced by professional cartographers without organizational standards.

As an example of an expert task, participants discussed how they decide to rotate or split a map for a mobile device. Participants said rotated unfamiliar geographies will go unnoticed, while familiar geographies are readable even when rotated. However, moderately familiar places cause the most confusion when rotated and should be avoided. Participants in a different study on responsive thematic maps suggest rotating maps should be discouraged (Schöttler et al., 2025), suggesting this technique may need additional research. Relatedly, more cartographers are splitting maps into halves or thirds. However, this work must be approached with care. One cartographer described wanting to split a map of closed abortion clinics in the United States. However, one clinic moved from North Dakota into Minnesota when laws changed, and their border occurred along the split, so it was instead rotated to preserve this essential data point. One method to improve the readability of world maps, proposed by Oesch et al. (2025), suggests splitting continents so they are stacked on top of each other. This method has been empirically proven to help more participants correctly identify a variable of interest, compared to the baseline. Therefore, despite some drawbacks, splitting the map may be useful in news cartography.

The freedom to rely on expertise is supported by most news organizations, since most cartographers are not exclusively tied to metric-based assessments of their work. While news organizations could measure success

through page views, many participants said success is more often measured by having the story noticed by their supervisors or winning awards. However, for stories that require only simple maps, satisfying the goal of the story is sufficient. One participant said during idle news weeks, success was tied to giving a cartographer the chance to learn a new skill, emphasizing that their organization supports creativity. While creative experts who envision designs that Fish (2021) would call "vivid" are employed in these jobs, most news maps are produced under time constraints, limiting creativity.

5.2.4. Scrollytelling and interactive map design

Interactive maps require additional effort to work smoothly on mobile and desktop devices, since each has affordances that do not exist on the other (Muehlenhaus, 2014; van Dam, 1997). "There's a lot of things that if we were only designing for mobile, we might do, but since we also need to make it for desktop, it can be kind of challenging" (P1), including multi-finger touch and capabilities for AR and VR. Reliance on interaction is decreasing; as described by P3, "10 years ago, data viz was a lot more . . . button centric . . . it was data viz that catered to other data viz people and not to your average reader." Similarly, P12 explains, "we're relying more on static maps but in a way that is visually impressive . . . people have done really long Illustrator maps that simulate interactivity."

When maps are interactive, technical elements must work across devices. Scrolling is a simple interaction that can be performed on any device (Stolper et al., 2016). Some desktop interactive maps use hovering for tooltips, which must become a tap on mobile. Mobile users may need an extra alert to click, while desktop users may simply "brush" over the feature (Becker & Cleveland, 1987). News cartographers sometimes use more complicated interactions like search boxes, dropdown menus, or pan and zoom (Roth, 2013), although space becomes a constraint on mobile. Greater density on mobile devices may lead to reduced discoverability of information (Kim et al., 2021).

In addition to technical elements, cartographers must consider whether users will interact at all. Participants believed mobile users scroll quickly and are unlikely to perform interactions, an idea that is also suggested by Schiewe (2017). Desktop users, too, are expected to have limited attention spans, and while interaction rates may be higher than mobile, "we don't put anything in a hover that is important. If it's crucial for the reader to know, then we try not to. And this goes for desktop too" (P8). P16 called overall interaction rates "abysmal . . . like 40–50% or something, less than you'd want."

The choice to provide interaction requires a cost–benefit analysis. For repeat designs, code can be copied from earlier work. Novel features take longer to implement. Because of the additional time it takes to make an interactive map, "you'd probably be amazed at how shoddy a lot of the stuff was put together" (P16). Static maps also typically last longer than interactive maps. Audience matters, too; breaking news stories have a broader user base who likely will not interact, while a cartography-heavy investigative story may have a more attentive audience. Egocentric stories, which tell the user something about themselves, are also likely to drive higher interaction rates.

Data from my interviews suggests the main form of mobile thematic map interactivity in journalism is now scrolling. Oppositely, participants in a study by Schöttler et al. (2025) were not opposed to using interactivity for mobile thematic maps. However, their study included participants beyond data journalism, suggesting some results may be domain-specific. My participants said a few other mobile interactions have exciting potential for future map designs in news cartography. Some interactions may draw from other apps, such as right-tap for "next" as in an Instagram story or swiping as done on dating apps like Tinder. Additionally, future maps could take advantage of connections to smartwatches or phone cameras. However, alternative designs have risks, such as questions about how the message of the visual is maintained for readers despite its new format; most measures related to this issue are subjective (Kim et al., 2021).

5.2.5. News cartography constraints and audiences

News cartographers expect their audiences to be general, and therefore interactions and content must remain simple. Similarly, Schiewe (2017) describes news audiences as both large and heterogenous. Additionally, news cartographers believed their readers are often distracted and not fully committed, meaning they may jump from the story at any time. Work on cognition in cartography similarly suggests that the distracting environments which mobile maps are viewed in lead to increased cognitive load, and therefore decreased ability to pay attention to the maps (Griffin et al., 2024). Cartographers may make design choices that reduce cognitive load. For example, novel map choices must be well-designed, as readers will leave if they are confused (Wardlaw, 2010). My participants discussed ideas to try new interactive techniques, but ultimately scrapped them given the anticipated lack of attention by readers.

The timeline of news mapping projects and the necessity for responsive design are tied together. News

cartographers work on tight deadlines and must ensure their maps can be read on any screen. Therefore, novelty, even if beneficial to readers, may not fit in a particular project. Academic studies on news cartography often focus on time-intensive pieces (Song et al., 2022). However, the opportunity to design these stories is a limited part of most news cartographers' jobs. While these stories gain the most recognition, most news maps must tell a story in one image on a tight deadline.

Reader responses are limited in news cartography. Organizations rarely have time to run user tests themselves and must rely on knowledge generated via other industries. A study by Oesch et al. (2025) combines the efforts of academics and data journalists and directly tests mobile thematic maps with readers who have opted in to user testing, a method which should be applied to additional studies in the future. However, general audiences are rarely deeply invested in the story, and few will comment on map-specific issues. A few cartographers received feedback on small issues like label placement or the desire for a progress bar in scrollytelling stories, but this is rare. However, news cartography provides an opportunity to test new ideas in front of large audiences. Novel techniques are often tested in creative stories, not via urgent breaking news, meaning the stakes are lower if an idea is unsuccessful.

5.2.6. Opportunities for growth

Accessible design and moving beyond incremental work are two major areas where further engagement at the intersection of journalism and cartography is necessary.

Making maps accessible to all the intended audiences is important, as readers should not be left behind due to differences in ability (D'Ignazio & Klein, 2020). These considerations include physical differences like limb and vision abilities, as well as device differences like larger text and old software (Wimer et al., 2024). Despite awareness of the need for accessibility advances, many participants described limited progress toward accessible mobile map design in journalism. Some participants mentioned care for vision differences including color blindness and low vision, providing alt text and ARIA labels. Others explained accessibility was reviewed by software or an accessibility expert on their team, suggesting not all cartographers have internalized principles of accessible design and it is not part of their workflow from the start (Kelly & Bosse, 2022; Roth, 2013). Participants were also limited in their awareness of mobile-specific forms of accessibility.

News cartographers may also benefit accessible design by moving beyond incremental work. When asked where they get inspiration from for mobile news maps, most news cartographers looked to previous work by their colleagues or other news organizations. This practice runs the risk of perpetuating the same few styles. While repetition can improve user experience, there is still room for novelty that prioritizes the user. Additionally, vividness achieved through novelty may make stories more memorable (Fish, 2021).

5.3. The future of mobile thematic news cartography

To understand future directions in mobile thematic news cartography, I asked:

> How do news cartographers envision future ideas, challenges, and techniques for mobile thematic map design in the context of data journalism?

I elicited interface mockups from news cartographers to assess future ideas in this area and synthesize those results here.

Participants were asked to prioritize novelty and imagine the future of mobile maps. A third of participants noted their mockups did not differ much from their everyday practice, and others made simple proposals for novelty. Additionally, the orientation and layout of the stories was consistent across participants. These results, considered with the time constraints faced by news cartographers, suggest that the news cartography field is not primed to create something new, instead using proven methods to impact readers without confusing them.

Participants were constrained to 15 minutes for these mockups, which may be too short of a time to develop novel ideas; however, this constraint also reflects the reality of a newsroom. Many participants used proven forms of interactivity, with ego-centric designs prioritizing the user's location. Other participants more novelly proposed ideas including: feeling the heat of locations through their phone, stylizing a wildfire map to look like a burnt napkin, and creating a fisheye-like zoom through a magnifying glass. While I hoped asking for a map on weather and climate would be generative (Kerzner et al., 2019), some participants felt stressed without more specific data.

6. Limitations

This study was designed following best practices from geographic research. However, due to research timelines and participant availability, limitations remain.

Participant diversity is a limitation of this study. The study focused on American news organizations,

missing representation from other countries. However, I still expect most results to be applicable to news cartography more broadly, just as the results from work by Oesch et al. (2025) conducted at a Swiss newsroom has relevance globally. Second, the sample was purposive, since there are a limited number of news cartographers. I first reached out to highly prominent news cartographers that I was aware of through conferences, social media presence, and prominence at major newsrooms. I also utilized snowball sampling, so some organizations are overrepresented as participants recommended their colleagues. I may have missed several talented journalists due to biases in these networks. While I reached out to individuals across the country and at multiple-sized news organizations, my sample was dominated by cartographers on the east coast and at large organizations. Only one participant works at a regional newspaper, and notably seven work at the *Washington Post*.

Another limit of this study was the structure of the interface mockup methodology. I gave participants 15 minutes to design a mockup of a news story 3 years in the future, asking them to consider a novel design focused on weather and climate. While some participants took advantage of this freedom, others felt lost without a subject, since their real jobs always involve specific assignments. Others mentioned they develop mockups in collaboration with colleagues, so designing alone was unfamiliar.

7. Conclusions and future directions

This article assessed the past, present, and future of mobile thematic cartography in the context of data journalism. It contributes to a growing area of cartographic research on mobile mapping (Abraham, 2019; Gedicke & Haunert, 2023; Gorte & Degbelo, 2022; Ledermann, 2023; Loeffler et al., 2021; Oesch et al., 2025; Roth et al., 2018; Yu & Chattopadhyay, 2020). Most prior work on mobile cartography prioritizes app-based or navigation maps, not browser-based or thematic maps found in journalism. This study helps define the key characteristics of mobile thematic cartography in journalism – perhaps the most likely place where the public will encounter thematic cartography.

Overall, my study focuses on mobile map design undertaken by expert cartographers, not the experiences of users. While academic literature promotes mobile-first design, in practice most cartographers choose what is easier in their time-constrained jobs. In news cartography, maps must be responsive across multiple device types, so the most appropriate practice may be simultaneous design (Hoffswell et al., 2020). Map data and design decisions remain an expert job as maps shift to mobile, especially since these decisions are often made quickly. Additionally, while occasional stories may include interactive elements, participants reported an overwhelming reduction in interactive maps for mobile devices. There is a need for additional studies outside of data journalism that assess mobile thematic maps to determine if these findings are more broadly applicable.

As news consumers increasingly rely on mobile devices, a few areas for future research become important. First, accessibility adaptations for mobile news maps are limited and require improvement. Second, when developing interface mockups, many cartographers expressed a desire for proven templates rather than novelty. While there will always be opportunities for in-depth map-based stories, most of the job of news cartographers is to produce fast, consistent designs. Therefore, academic studies may seek to optimize static mobile thematic map design. Given that opportunities for innovation are limited in newsrooms, academic research may be where innovation and user testing can occur. Third, news cartographers may wish to implement simple forms of user-centered design where possible, such as methods to track user behavior on mobile devices. Additionally, as mobile-first design becomes more common, research on mobile thematic maps outside of data journalism may reveal insights about user experience more broadly. Mobile user needs, especially as they differ from desktop user needs, is increasingly important to understand.

This study focused on the needs of news cartographers, so future studies that focus on the end-user perspective would complement this work. Understanding the process of developing mobile thematic news maps is central to future developments in mobile map research, leading to additional studies that center the needs of news cartographers so they can design accurate and effective maps to communicate complex and crucial information for our society. Additionally, the results of this study highlight that understanding the needs of mobile users is particularly important and understudied compared to desktop users, which has implications beyond data journalism. This study establishes the groundwork for future studies in data journalism and for mobile cartography more broadly.

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Data availability statement

The data that support the findings of this study are openly available in the Penn State Data Commons at https://doi.org/10.26208/8XWG-ZW43 and within the article and its supplementary materials.

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