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IN THIS ISSUE

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ABOUT THE COVER: *Detail from* The Essential Geography of Oregon, *by David Imus, recently recognized as a 2018 Honorable Mention by the* Atlas of Design. *To see more of David's work, visit imusgeographics.com.*

LETTER FROM THE EDITOR

In the early months of 2018, for the first time in fifteen years I found myself preparing to teach cartography to a group of undergraduate students. As is typical when preparing for a semester, especially after such a long time away from teaching a particular course, I was reviewing my materials and refreshing them based on the advances in cartographic knowledge that had been made in the intervening years.

As part of this process, I found myself returning repeatedly to the rich materials I have encountered in my various interactions with NACIS members, including articles published in *CP*, presentations I attended at the Annual Meeting (the most recent of which are conveniently **archived on YouTube**), and of course, the beautiful maps designed by many of our members, including those found in volumes I–III of the *Atlas of Design*.

I have tried to imagine how I could possibly deliver a high-quality learning experience for those undergraduate students without this virtual support from so many NACIS members, and I simply cannot. I have learned so much from all of you over the course of my career, and in turn I can now use that knowledge to inspire and help students develop into tomorrow's cartographers. So I express my gratitude to each of you who has participated in the life of NACIS in some way, large or small. I hope you have all been able to also take away something of value from your interactions with other NACIS members.

As 2017 is now a wrap, I would like to thank those individuals who served as peer reviewers for submissions to *CP* that received final decisions in 2017. In a world of increasing demands upon our time, the gift of your attention to helping our authors to do the best job possible in presenting their work is truly appreciated.

Jan Brus
Bill Buckingham
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Martin von Wyss
Xingguo Zeng

I would also like to acknowledge the excellent support I receive from *CP*'s Assistant Editor, Daniel Huffman, my section editors (Mathew Dooley, Alex Tait, Terri Robar, Fritz Kessler, and Mark Denil), and *CP*'s Editorial Board (Sarah Battersby, Raechel Bianchetti, Cynthia Brewer, Matthew Edney, Sara Fabrikant, Bernhard Jenny, Patrick Kennelly, Mark Monmonier, Ian Muehlenhaus, Michael Peterson, Anthony Robinson, and Robert Roth).

Without each of their contributions, *CP* would not be the high-quality publication that you see today.

In *CP* 89, you will find two *PEER-REVIEWED ARTICLES*. The first, by Nadia Panchaud and Lorenz Hurni, presents a usability evaluation of a geoportal that was designed to help novice map prosumers make better-designed maps. They identified some guidelines that could be helpful to those designing other geoportals, or considering ways to help users learn some cartographic design principles while using a mapping platform. In the second article, Carl Sack surveys the current state of teaching web mapping in North American universities, providing an overview of what is being taught, how web mapping theory and skills are taught, and what challenges and barriers to teaching web mapping exist in different institutional contexts. He provides a set of ten learning objectives that could be used to support teaching web mapping.

In the *PRACTICAL CARTOGRAPHER'S CORNER*, Lauren Tierney of National Geographic extends her NACIS 2017 conference presentation and updates a previously published description of how she and her team developed "The Melting of Antarctica." In her contribution, she reviews briefly some historical National Geographic efforts to map the continent, and walks us through the process for creating both the print and digital versions of this compelling map. We see the team's design thinking and iterative process, as well as the rethinking that was needed to produce an animated version of the map. Enhanced by video of her NACIS presentation and the video version of the map, this is one *PRACTICAL CARTOGRAPHER'S CORNER* contribution that you will not want to miss!

While Antarctica may certainly seem otherworldly to many of us, Zachary Bodenner's contribution to *VISUAL FIELDS* presents several of his maps of true otherworlds. His piece explores his maps of fantasy worlds, which harness illustration techniques that help evoke the sense of these places, thereby drawing the reader further into the stories they both drive and support.

Four book *REVIEWS* round out *CP* 89. Robert Hickey reviews *Atlas Obscura*, a title that presents a selection of the world's travel treasures, and in which maps primarily play a supporting reference role. Marcy Bidney's review of *Treasures from the Map Room* evaluates a book that presents treasures of a different sort: historic maps from the Bodleian Library at Oxford University. Tom Koch and Amanda Tickner each review a book presenting materials to support a cartographer learning to use ArcGIS Pro, Esri's latest desktop GIS application. While *Making Spatial Decisions Using ArcGIS Pro: A Workbook* was generally positively reviewed, with Amanda Tickner noting that the book supports learning how to make decisions in addition to learning software tools, Tom Koch found a decided lack of a decision-making perspective in the volume he reviewed, *GIS Tutorial 1 for ArcGIS Pro*, deeming this lack a fatal flaw of the book.

On that note, I invite you to dig into and explore the rich content presented in this volume of *CP*.

Amy L. Griffin
Cartographic Perspectives Editor

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PEER-REVIEWED ARTICLE

Integrating Cartographic Knowledge Within a Geoportal: Interactions and Feedback in the User Interface

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Custom user maps (also called map mashups) made on geoportals by novice users often lead to poor cartographic results, because cartographic expertise is not part of the mapmaking process. In order to integrate cartographic design functionality within a geoportal, we explored several strategies and design choices. These strategies aimed at integrating explanations about cartographic rules and functions within the mapmaking process. They are defined and implemented based on a review of human-centered design, usability best practices, and previous work on cartographic applications. Cartographic rules and functions were made part of a cartographic wizard, which was evaluated with the help of a usability study. The study results show that the overall user experience with the cartographic functions and the wizard workflow was positive, although implementing functionalities for a diverse target audience proved challenging. Additionally, the results show that offering different ways to access information is welcomed and that explanations pertaining directly to the specific user-generated map are both helpful and preferred. Finally, the results provide guidelines for user interaction design for cartographic functionality on geoportals and other online mapping platforms.

KEYWORDS: geoportal; web cartography; usability evaluation; user interaction; interface design; interactive cartography

INTRODUCTION

Geospatial datasets are abundantly available nowadays thanks to technological advances in data capture, storage, processing, and distribution, as well as to the democratization of (online) cartography. Geoportals and online mapping platforms offer an appropriate means and environment for publishing, displaying, and distributing geospatial data. However, datasets are often uploaded onto those platforms in raw form or with minimal thought given to their symbolization. The map mashups created by novice users on those platforms tend to produce results of low cartographic quality because no cartographic knowledge or professional cartographer is included in the process (Harrie, Mustière, and Stigmar 2011) and because the different datasets have been symbolized on an individual basis and thus are not optimal for combination.

Cartographic principles have been gradually formalized and integrated mostly within standalone tools (e.g., Color Brewer for color schemes [Brewer and Harrower 2013] and the subsequent similar "brewers," for map symbols and type [Schnabel 2007; Sheesley 2006]) and sometimes in small ways within geoportals aimed at the larger public. Yet, most cartographic knowledge is neither easily accessible nor well integrated within online platforms on which the public creates custom user-generated maps.

Our motivation in this work is to aid casual mapmakers in making better user-generated maps within online mapping platforms, by offering them functions based on cartographic principles. Concretely, our aim is to design and evaluate an interface and related user interactions for cartographic functions. These functions rely on cartographic concepts such as figure-ground and color contrast to improve the overall visual hierarchy and legibility of the map mashups.

Due to the nature of cartographic knowledge and the target audience of geoportals, there are specific challenges. First, a lay audience might hold a very different conceptual model than trained cartographers of how a map and its contents are organized. Moreover, individual conceptual models among the lay audience are much more variable. Second, cartographic knowledge is made of principles, guidelines, and a certain amount of subjectivity, and thus it is necessary to communicate the flexibility of that knowledge. Furthermore, it is unclear what types of interaction best support the introduction of cartographic knowledge to geoportal users in the context of the specific maps they will create. There are also open questions regarding how to design interactions that are based on cartographic knowledge and allow the discovery of such knowledge by casual mapmakers. Concepts of usability and human-centered design can help answer these questions, but there is a need to test concrete design implementations to gain a deeper understanding in the context of cartographic applications.

The first objective of our research was to explore relevant design principles to support the integration of cartography-related user interactions, and to implement them in an existing geoportal. Second, we investigated the different types of user interactions that were implemented, evaluating them in regard to their usability and appropriateness for cartographic functions and knowledge. Finally, we derived interaction design guidelines from these evaluations.

For the usability test, an existing geoportal and a framework offering smart cartographic functions were used. This geoportal allows the creation of map mashups from its available data and its cartographic functions; it also helps to improve the quality of the mashups by checking for appropriate content based on map types, by optimizing the drawing order of the layers, and by improving the visual hierarchy (Panchaud, Iosifescu Enescu, and Hurni 2017). The functions also explain choices to users; these kinds of explanations should not stay hidden, but should be open to the user, and capitalized on by integrating them within the workflow and the wizard GUI (graphical user interface). A wizard is a type of user interface that guides users through a sequence of defined steps to perform a task or solve a problem. They are also called "assistants" and are widely used in most operating systems.

FUNDAMENTAL CONCEPTS AND RELATED WORK

How MAP READERS interact with maps and mapping platforms can be better understood by looking into fundamental concepts such as human-centered design and usability. Based on those fundamental concepts, previous researchers have already gained insights and set best practices specific to designing maps and interactions on mapping platforms for an improved and more user-friendly experience.

HUMAN-CENTERED DESIGN AND USER DIVERSITY

Previous research and best practices overwhelmingly show that the comprehension of the users' needs and expectations is crucial for designing optimal user interactions (Roth and Harrower 2008). Such comprehension is central to the concept of "human-centered design" (HCD), also known as "user-centered design" (UCD), popularized as early as 1988 and defined by Norman (2013, 8) as an "approach that puts human needs, capabilities, and behavior first." The HCD approach has led to significant advantages such as improved usability of GUIs and tools, fewer errors during use, and faster learning times (Norman 2005).

With the emergence of the HCD/UCD doctrine, several sets of principles were developed to support its implementation. In Figure 1, we present here the core ideas of HCD with Shneiderman's (1987) eight golden rules, Norman's (1990) original seven principles, and Norman's (2013) revised seven principles.

The diagram reveals overlaps and differences among the principles lists. Common to all, constraints are described as a tool to help guide the user through possible interactions and prevent the use of functions that are not available at certain points. Additionally, actions should be easily reversible, so that users can undo potential mistakes and feel free to explore the interface without fear of making an error. Feedback about user actions and the state of the system is also cited as crucial for a positive user experience.

Important concepts unique to Norman's (2013) principles are affordances and signifiers. Affordances are the relationships between object appearances and the capabilities of the users: they help the users determine their possible interactions with the object. Some affordances are

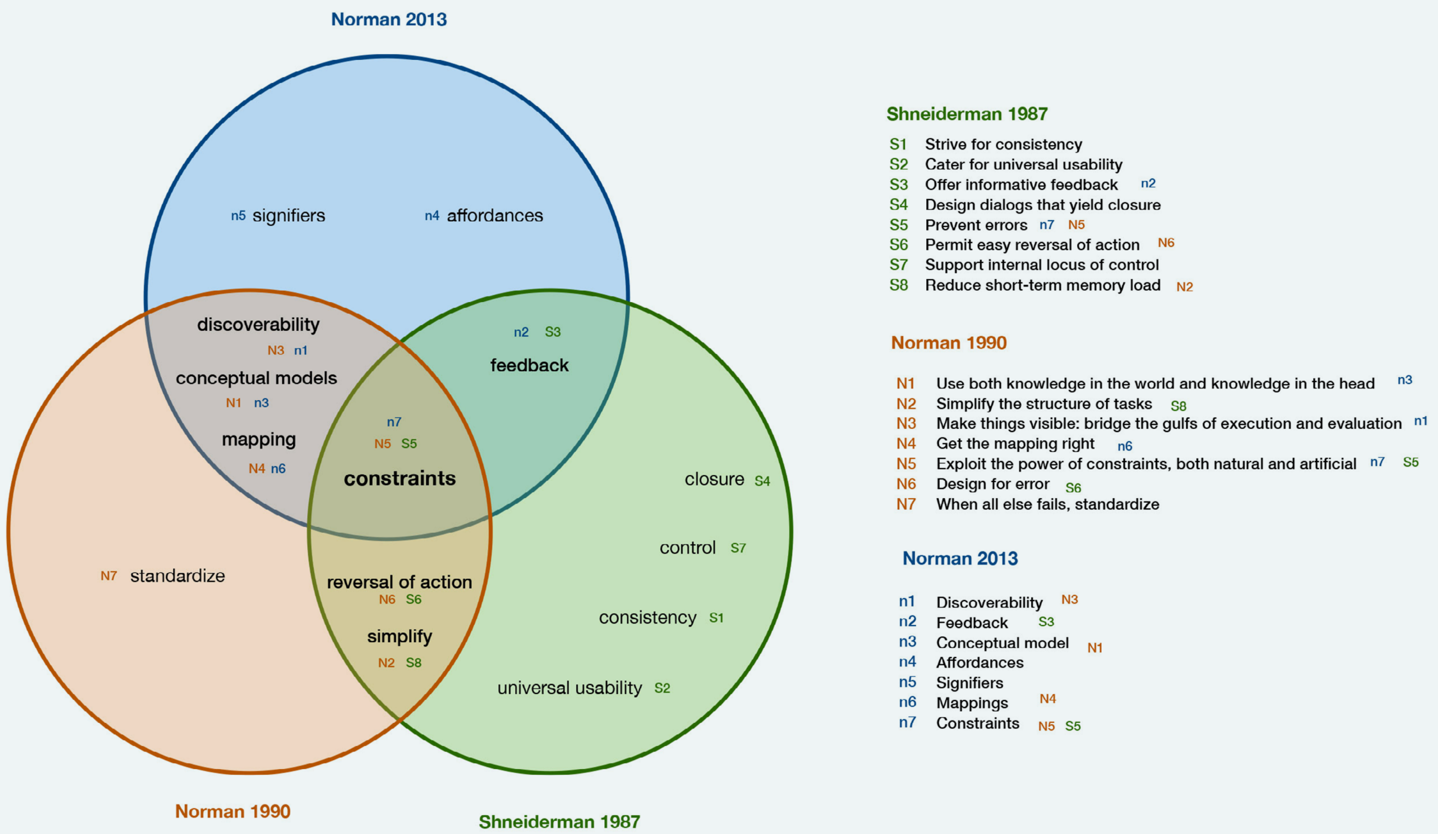

Figure 1. *Overlaps and differences between the different lists of principles for human-centered design.*

perceivable and act as a signal. When they are not perceivable, additional signifiers are needed; they are clues that convey how to use the objects (Norman 2013). They aim to reduce the number of settings and icons that need to be learnt before using the system by making them intuitive, easy to remember, and logical (linked to Norman's principle of "mapping" — N4/n6 in Figure 1), and they help to reduce short-term memory (STM) load (S8). Consistency (in interface design, but also in sequences of actions and terminology across the system) also supports the reduction of demands on STM and lets users focus on the content of the application and problem solving instead of on interface comprehension (Shneiderman and Plaisant 2005).

In the context of interfaces for geospatial data and visualization, it means that the interactions built into the GUI must make sense and be intuitive: for instance, users should not spend time deciphering the icons and buttons (Timoney 2013; see principle S8 in Figure 1). Additionally, understanding the user context and providing direct controls to the user are critical steps to preventing errors (Haklay and Nivala 2010; see S7).

While the above-mentioned principle lists give valuable insight into HCD, Gould and Lewis's (1985) framework offers a more comprehensive approach and is the most widely adopted (Haklay and Nivala 2010). The three core principles are: (1) an early focus on the users and tasks, (2) the use of empirical measurements to evaluate the design, and (3) an iterative process. The first point deals with the importance of the user's goals and tasks as the drivers for the design. Moreover, it implies that characteristics, behavior, context of use, work, and environment should be considered as well. Then, only through empirical measurements (e.g., the user's reactions and performance) can one evaluate whether there are improvements from the prototype to the final version. Finally, the design process should go through several iteration cycles of design, test, measure, redesign, etc., as often as necessary (Gould and Lewis 1985).

As seen above, the HCD approach is supported by a large body of work demonstrating the importance of carefully considering the needs, capabilities, and preferences of the target audience in designing interactions. In the context of map mashups, as opposed to traditional cartography, the map user is also often the mapmaker (Roth 2013) and thus the user has a double profile of needs and expectations which have to be taken into account.

Often the designers of online mapping environments regard their users as homogeneous, but group and individual differences exist. For instance, Slocum et al. (2001) mention expertise, culture, and age among several other characteristics, while Fairbairn et al. (2001) also refer to the users' expectations, experience, competences, and preferences. These various user differences lead to multiple user perspectives, and thus treating them as a monolithic group is inadequate (Haklay 2003); it is considered best practice to acknowledge different user skills and knowledge, especially between experts and casual users (Fairbairn et al. 2001; Jenny et al. 2010), as well as differences among laypeople themselves (Meng and Jacek 2009; Shneiderman and Plaisant 2005).

Consequently, there is no "one size fits all" interface (van Elzakker and Wealands 2007), but even so, aiming to cater to universal usability can help (Shneiderman and Plaisant 2005; see S2 in Figure 1). Suggestions from previous work are to design methods of interaction that can be adapted to the end user in terms of complexity (Slocum et al. 2001; Fiedukowicz et al. 2012; Jenny et al. 2010) and to provide flexibility in unfamiliar situations (MacEachren and Kraak 1997). Increasing interface complexity or its degrees of freedom can render tasks more difficult for users and thus alienate them (Slocum et al. 2001; Jones et al. 2009; Andrienko and Andrienko 2006).

USABILITY AND BEST PRACTICES

The success of an interface also depends on how well it supports the user's interactions with the application. The concept of usability is central to such success and is defined in the ISO 9241-11 standard as the "extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" (as quoted in Resch and Zimmer 2013, 1019; and He, Persson, and Östman 2012, 89). Van Elzakker and Wealands (2007) describe effectiveness as achieving goals with accuracy and completeness, efficiency as minimal resource expenditure, and satisfaction as comfort of use and a positive attitude. Additionally, Nielsen (1993) defines usability with the help of five attributes: learnability (the system is easy to learn), efficiency (a high level of productivity should be possible, once the system is learnt), memorability (easy to remember), errors (low error rate and easy recovery), and satisfaction (pleasant to use).

The cascading information-to-interface ratio is another approach to adapting to different user profiles (novice or new users vs. advanced or regular users) by providing increasing levels of complexity in the interface (Roth and Harrower 2008). This consists of a multi-layered interface and can help fill the divide between novice and advanced users (Roth 2013). By showing only the most important parameters at first and the more complex ones on demand, one can offer a simple interface at first sight for the novice user, while allowing the advanced user to access the complexity of the system as well. It is similar to "progressive disclosure," which hides parameters until they are actually needed (Wardlaw 2010).

Even though complex interfaces allow different users the flexibility to take cartographic actions in different orders, the productivity paradox has led interface designers to constrain the interface by reducing the number of cartographic functions or the degree of flexibility in order to increase productivity (Roth 2013). Other works pertinent to cartography likewise support the idea of constraining the interface for improved user experience (Dou et al. 2010; Keehner et al. 2008; Jones et al. 2009).

Previous work also offers key, concrete insights about interface characteristics that support improved usability. Interfaces should be consistent and systematic (Roth 2012); offer a small visual footprint (Roth and Harrower 2008); make important components visible; offer smart and adaptive functions (MacEachren and Kraak 2001); use appropriate metaphor as well as provide sensible default values depending on the context of use (Cartwright et al. 2001); use interface controls that feel most natural or intuitive (Harrower and Sheesley 2005); and avoid irrelevant interactivity and inconsistencies in information feedback (Jones et al. 2009). Additionally, windows should be reused and their number limited, and the same information should not be displayed in different places (Lauesen and Harning 2001). Also, pop-up windows should be avoided because users do not like them for several reasons (interruption, occlusion of the screen, require action to go back to the main window) and tend to close them right away without looking at the content (Resch and Zimmer 2013). To prevent further user frustration, interfaces should display warning messages and block unsupported actions early as well as allow users to save the state of the system or its results (Jenny et al. 2010). Redundant functionality, irrelevant interactivity, and inconsistencies in information feedback are also problems to take into account. Finally, implementing conventions that are used on popular websites can prevent the users from being surprised or confused at the results of the interaction. Such an example would be the double-click zooming used by Google Maps, an interaction that many users expect in other map applications (Wardlaw 2010).

The role of symbols and icons must not be underestimated, and their design should aim at clarity and accuracy, easy and correct interpretability (thanks to affordances and signifiers), and visual feedback when in use (Resch and Zimmer 2013). Even though the data-ink ratio (Tufte 1983) should be high to limit the footprint of the GUI, an overly minimalist icon design might not offer enough clues to allow the users to deduce its functions (Roth and Harrower 2008).

Finally and most importantly, Beaudouin-Lafon (2004) advocates designing interaction instead of interfaces because the interface is only a means, whereas the goal is to provide user-system interactions of high quality. Roth (2013, 64) defined cartographic interactions as "the dialogue between a human and a map mediated through a computing device." Thus the interface is of the utmost importance in optimally supporting the dialogue of cartographic interactions.

ASSISTED MAP DESIGN PROCESS

Beyond issues of usability and human-centered design, one should also consider how the dialogue between the user and the application is designed, and how it is able to capture the users' needs and contexts, and translate them into map specifications (data layers, map scale, symbology, etc.) that the application can handle.

Collecting user preferences via textual menus is difficult, and providing map examples or samples can help the process (Balley et al. 2014) and allow the users to better express their needs. Then, the challenge is to be able to infer appropriate map specifications from the user requirements. Balley et al. (2014) mention two different approaches: either following a static reasoning process using rules after having gathered the requirements, such as in the work of Forrest (1999); or reconciling cartographic constraints and the user's preferences in an iterative process, as used by Christophe (2011) for designing map legends.In the field of assisted map creation, there have been different attempts to organize and formalize cartographic knowledge and to put it at the disposal of a larger public using a graphic interface, including expert systems (Forrest 1993) or assistance for on-demand map creation via web services (Jolivet 2008). The gathering and formalizing of cartographic principles from experts and best practice map series is a common thread. The framework behind the interactions that are tested in this paper follows from this previous work, but focuses on functionalities for laypersons creating map mashups, and with a logic fundamentally independent from the application in which the data are visualized. The framework also relies heavily on semantic information, in the form of metadata about the meaning of the geospatial content, to deal with cartographic constraints. For instance, semantic metadata allow differentiation of roads from rivers from administrative boundaries. These distinctions enable the definition of finer cartographic rules and constraints in the framework.

GRAPHICAL USER INTERFACE AND INTERACTION DESIGN

The GUI is the access point to the functionality of any application and thus if not properly designed, it can hamper the use of the even the best application. A clear, well-thought-out concept and several rounds of design iteration are often needed before reaching an optimal interface.

EXISTING GEOPORTAL AND FRAMEWORK

For this study, we made use of an existing geoportal GUI as our starting point; as compared to starting from scratch this offers both design opportunities and constraints. First, there are benefits to using an existing framework and design that has already gone through several design iterations: the foundation is solid. At the same time, it gives the chance to perform yet another iteration on the general GUI design. However, there can also be some constraints as the technologies used are fixed and there might be limitations to what an existing framework can do.

Our geoportal is built on a traditional, three-tier architecture leveraging databases to serve maps via web map services (WMS) and a custom-built SVG GUI.

Service-driven cartographic visualization has proven its potential (Iosifescu-Enescu, Hugentobler, and Hurni 2010; Iosifescu et al. 2013), however the same functions could also be coupled to a vector tile-based architecture with styling on the client side. Cartographic principles are integrated within the geoportal via cartographic functions that help the users when they create their own maps with the geoportal content. This includes checking whether the selection of layers is appropriate for a specific map type, re-ordering the layers to prevent unwanted overlaps, and a function which improves the mashup's visual hierarchy by modifying the style of the background layers (for more information, especially concerning issues with map mashups, see Panchaud, Iosifescu Enescu, and Hurni [2017]). We decided to provide a background style function because a recurring issue found in map mashups from geoportals is the fact that most layers are symbolized in saturated color schemes matching a foreground style definition. As the functions mimic different parts of the cartographic workflow, a natural design choice for their integration is to use a wizard, allowing the user to go through the decision points of the map design process step by step.

We began by redesigning the GUI with input from a usability study done on a sibling project using the same GUI framework (Kellenberger et al. 2016). The GUI redesign also used principles derived from the literature and best practices that were not respected in earlier design iterations; project-specific needs also played a role. The common aspect to the changes was the optimization of the GUI's visual footprint: most of the space should be given to the map, and the GUI should not be cluttered in order to give enough space to the important features (Figure 2). Furthermore, some interface features that were lacking consistency were redesigned to offer a smoother and more consistent user experience.

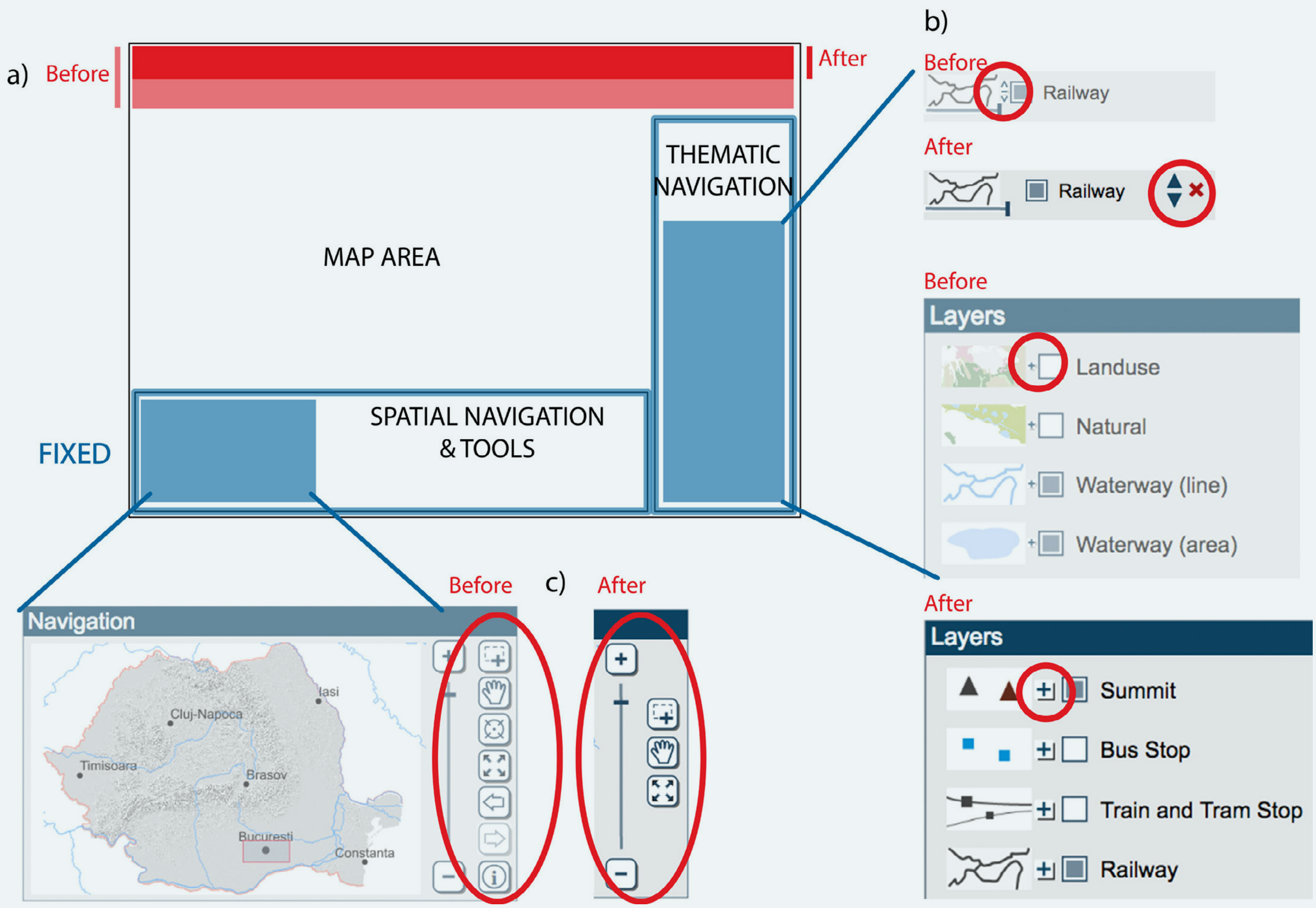

Figure 2. *Examples of design changes to the geoportal GUI. (a) The large banner at the top served no important purpose and thus it was made thinner. (b) Important functions had icons that were too small and many users did not notice them; their size was more than doubled with the new design. (c) Icons linked to unused functions and interactivity were removed.*

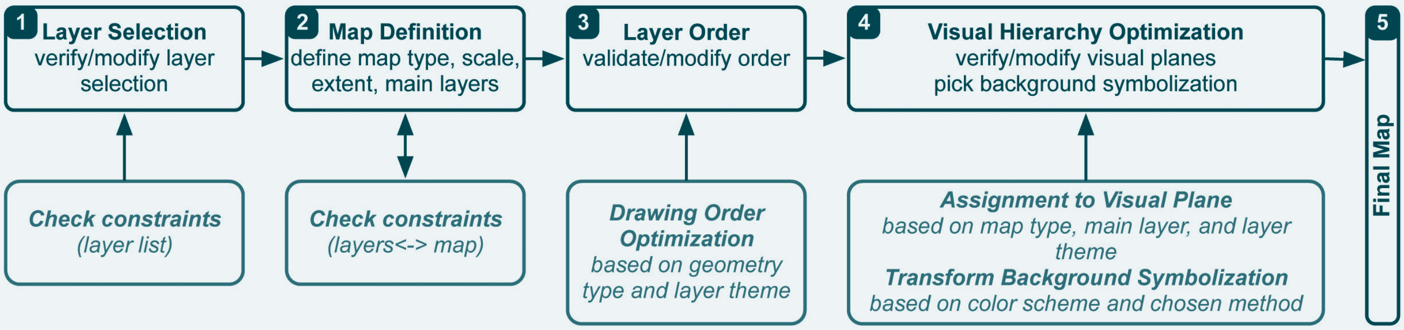

Figure 3. Workflow concept of the wizard. The top row shows the steps the users go through; the bottom row, the cartographic functions operating in the background.

WIZARD INTEGRATION

As mentioned earlier, a wizard was used to organize the geoportal's cartographic functions meaningfully. A wizard should be able to capture the user's requirements in an efficient manner with a minimal number of clicks, while offering a pleasant user experience. We integrated cartographic functions within the GUI over two major design iteration cycles. The first design iteration included organizing the cartographic functions and interactions into steps to offer a smooth wizard workflow. Our different steps were: (1) layer selection, (2) map definition, (3) layer order, (4) visual hierarchy, and (5) final map. Figure 3 shows the steps and how they related to the cartographic functions. The selection of layers occurs at the beginning because the users were familiar with selecting layers as a first step before downloading them (as this was a pre-existing geoportal function). Steps 2, 3, and 4 check user parameters against map content and offer to optimize different aspects of the map. To add support for thematic mapping (i.e., classification method and color scheme selection) would require an additional step between 3 and 4. In traditional cartographic workflows, there would be a step to pick symbols; however, as the symbology modifications in step 4 rely on the existing layer styles where the symbols are defined, there is no need for symbol selection in this specific application.

The second design iteration cycle led to the development of a dual GUI, allowing for a "geoportal" mode and a "wizard" mode. Common elements are kept from one mode to the other (e.g., map view, reference map, and navigation tools), while specific elements come and go as the user switches between the geoportal GUI and the additional features of the wizard. Going from one mode to the other

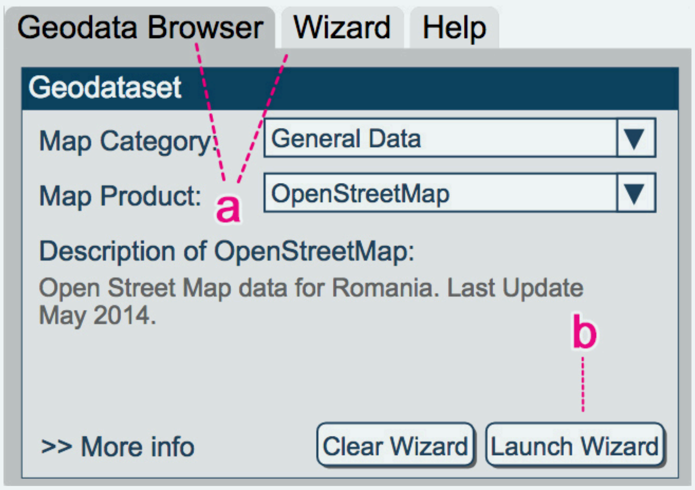

Figure 4. *Part of the GUI showing the switch between geoportal and wizard modes using a tab system (a) and direct access to the wizard (b).*

is always possible thanks to a tab system (Figure 4a) and there is a large "Launch Wizard" button in the geoportal mode (Figure 4b).

INTERACTION LEVELS

We organized information flows going from the wizard to the user in several levels based on the type, complexity, and depth of information provided. This cascading type of organization of the interactions helps with providing crucial information at first sight in the interface with little noise, while providing access to more detailed information on demand. Complex information about the inner workings of the cartographic functions is available for advanced or curious users, but does not clutter the interface unnecessarily for the other users. Table 1 breaks down the

Levels	Definition	Design implementation
Level 0: Interface content	Parameters and textual content available at first sight in the interface.	Part of GUI at first sight.
Level 1: Hints	Give hints regarding simple content or technical aspects. Give information about the interface parameters.	Tooltip concept.
Level 2: Input explanations	Explain concepts related to input parameters of the cartographic functions.	Links to additional content in the message window.
Level 3: Warnings and errors	Raise issues while the cartographic functions are working and checking parameters.	Small icons and popup windows.
Level 4: Output explanations	Explain the results of the cartographic functions that have been accomplished on a specific map and layer combination.	Depends on the complexity of the explanations. Either as tooltip or additional content.

Table 1. *Interaction levels.*

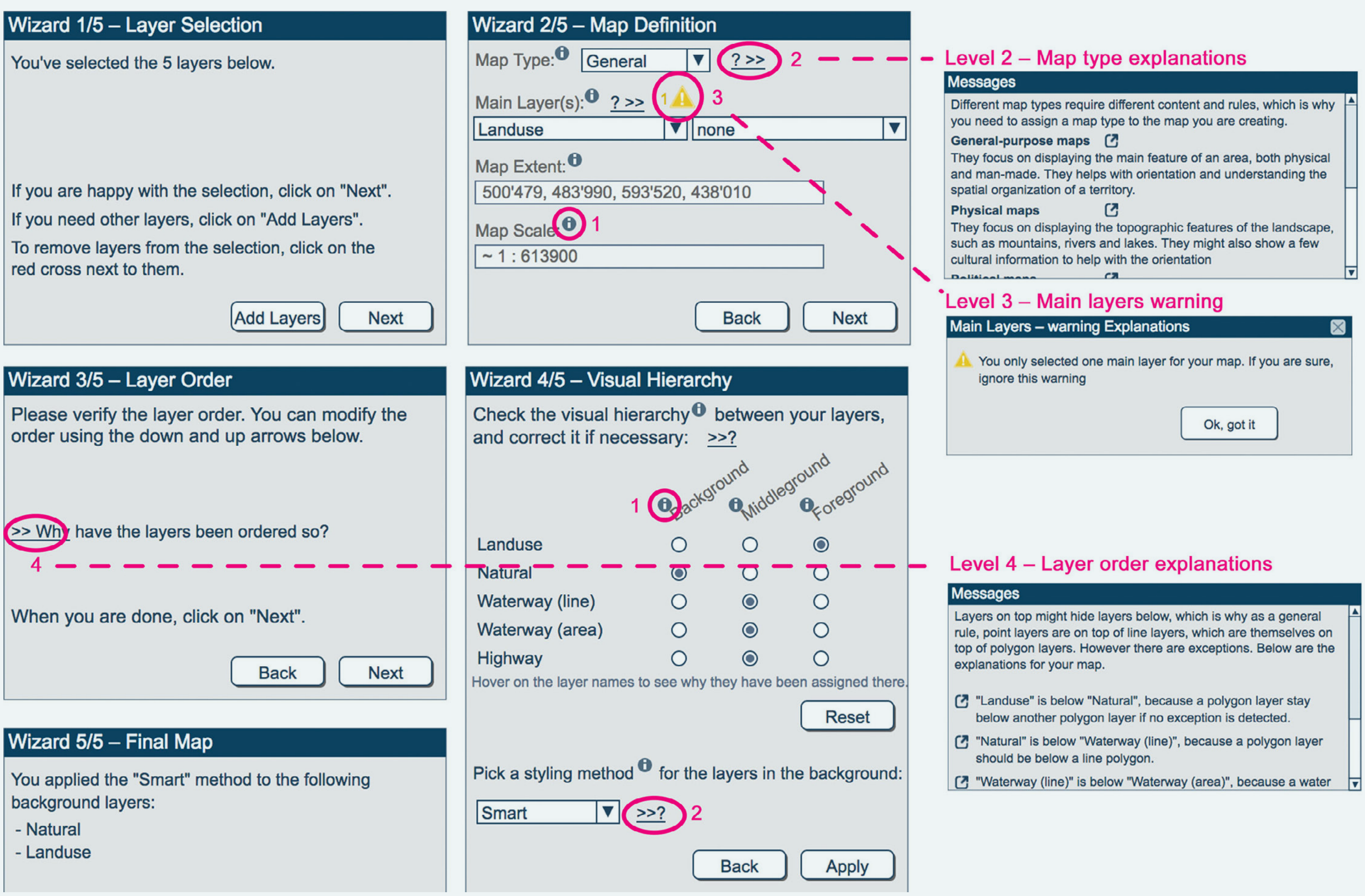

Figure 5. *Wizard steps and examples of different interaction levels.*

levels, while Figure 5 provides examples of the information cascade.

- **Level 0** represents the text and parameters visible at first sight in the interface and includes parameter names, selection options, basic instructions, back and forward buttons, and window titles. They are designed with traditional UI objects, such as checkboxes, radio buttons, and dropdown lists, and thus are very easy to understand because they are familiar to the large majority of computer users.
- **Level 1** interactions provide brief additional information about the parameters and cartographic terms in the wizard. They are accessible via tooltips.
- **Level 2** interactions provide additional content or concept-related knowledge about the cartographic functions and explain the importance and role of parameters. If one already knows about the concept or content, or is not curious about the inner workings of the cartographic functions, one can choose not to interact with this information.
- **Level 3** interactions consist of warning and error messages due to incompatible parameter values that might require the user to take action. Warnings do not prevent the user from going to the next step, whereas errors messages do.
- **Level 4** interactions are detailed explanations about the wizard action presented after the action is completed. Depending on the complexity of the functions, we used different integration strategies: from tooltips to additional text and image content in a dedicated window.

ERROR AND WARNING CONCEPT

There is an important conceptual difference between a warning and an error message. A warning conveys a cautionary message about something that might be wrong or that is missing. When no action is taken upon receiving a warning, the system can go on and assume sensible default values. Thus warnings should be discreet, and not hamper the progress of the system to the next step or break the user's flow of thoughts.

An error message, by contrast, is much more critical and should capture the attention of the users and instruct them to act in order to remediate the problem. Without action and modification of the parameters, the system cannot go on. Thus the design and implementation choices for the error messages must make them much more noticeable than the warnings.

When a user changes a parameter involved in a compatibility check, the check is run in the background and an icon appears next to the parameter if a warning or an error is found (see Figure 6). At this stage, nothing prevents the user from continuing to tweak parameters within the same wizard window. However, when moving on to the next window, if any error message is not resolved, a pop-up window will appear and block the process while explaining the problem and suggesting corrective actions (see Figure 7). Once the issue is solved, the user can move to the next step.

Figure 6. Examples of error and warning icons.

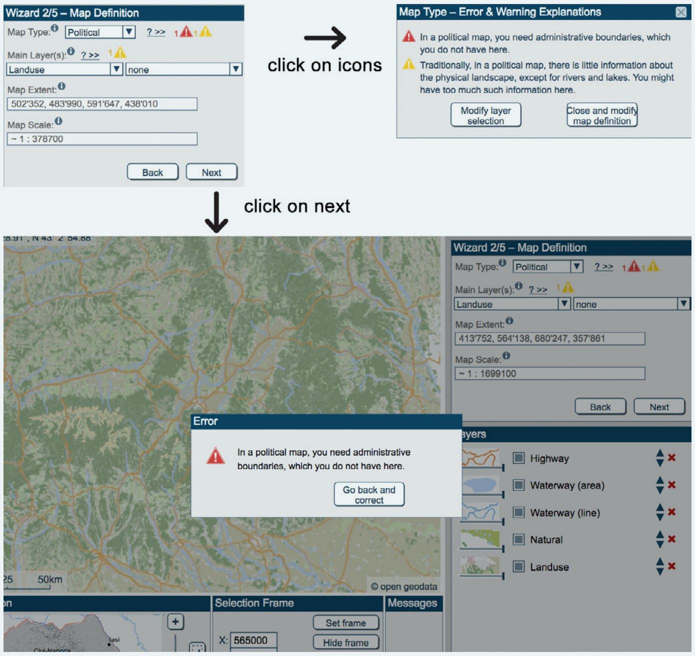

Figure 7. Behavior of the interface when an error is present.

USABILITY TEST

We conducted a usability test, focused on the users' behavior with the tools that were developed as well as on the design choices. More specifically, we tried to identify whether users found the wizard functionality to be helpful and efficient and how frequently they looked at the explanations and warnings while using the tools.

DESIGN

Participants

In total nine participants were recruited for the usability study: four women, five men. All were either working or studying at the university level, but none were active or trained in the field of cartography. Their participation was voluntary and they were not compensated. All participants use maps (digital and paper) at least once a month, while five of them used maps several times a week or more often. Their primary map use was for wayfinding and route planning. They also used maps for research and teaching purposes and during their hobbies (e.g., hiking, travelling, and out of curiosity). The number of the participants was chosen in order to cover different levels of familiarity with geoportals: three participants had never used a geoportal, three had used them a few times, and three used them often.

Tasks

A scenario and a series of tasks were developed for the usability test. The scenario was specified in such a way that the opportunity to use each function arose at least once. There were different types of functions present in the interface: some performed cartographic tasks and others provided additional information about the functions or cartographic principles. It was not necessary to use all the tools to complete the tasks from the scenario. However, this allowed us to observe whether the participants used tools or not, in which way, and with what frequency.

The scenario was as follows: "*You want to create an overview map of the Brașov region with the natural parks to have an idea of the protected areas of this region*."

Then, more detailed tasks and instructions were given to the participants. The tasks were chosen to follow the workflow of the wizard: (1) select layers, (2) verify and/or adjust the map definition parameters, (3) verify and/or adjust layer order, (4) verify and/or adjust the visual hierarchy, and (5) pick a new symbolization method for the background layers.

The goal of this scenario was to cover basic cartographic tasks that a layperson might undertake and that are found in some form on many public geoportals (data selection and combination, spatial extent definition, and simple modifications of the symbolization). The exact scale for the map was not explicitly specified; participants could zoom in more or less depending on their interpretation of the scenario.

Procedure

Before starting, the goals and procedure of the usability test were explained to the participants. Then, the usability test consisted of a familiarization phase, the actual test, a questionnaire, and a structured interview. During the scripted introduction, we explained the project, the tools developed, and the goals of the usability study to the participants. Then, the participants had a guided familiarization time with the geoportal and wizard. Afterwards, the participants received the scenario and tasks to accomplish. Their screen, mouse movements, and clicks were recorded during the test, while notes were taken during the structured interview. Next, the participants were given a survey consisting of (1) a User Experience Questionnaire (UEQ; Laugwitz, Held, and Schrepp 2008); (2) a workload estimation with the NASA Raw Task Load Index (RTLX; Hart and Staveland 1988); (3) general feedback questions; and (4) a demographic information questionnaire. The UEQ allows a quick assessment of the user experience of interactive products, whereas the RTLX helps assess the user's perceived cognitive workload while using the wizard system as a whole. The structured interviews at the end allowed us to gather qualitative information about design choices and the participants' impressions.

RESULTS

Usage of cartographic functions

Figure 8 shows how much time each participant spent on the different tasks during the test, as well as how they approached the test. For instance, participants D and E read the instructions carefully and then went straight to the tasks without much exploration, maybe because they were

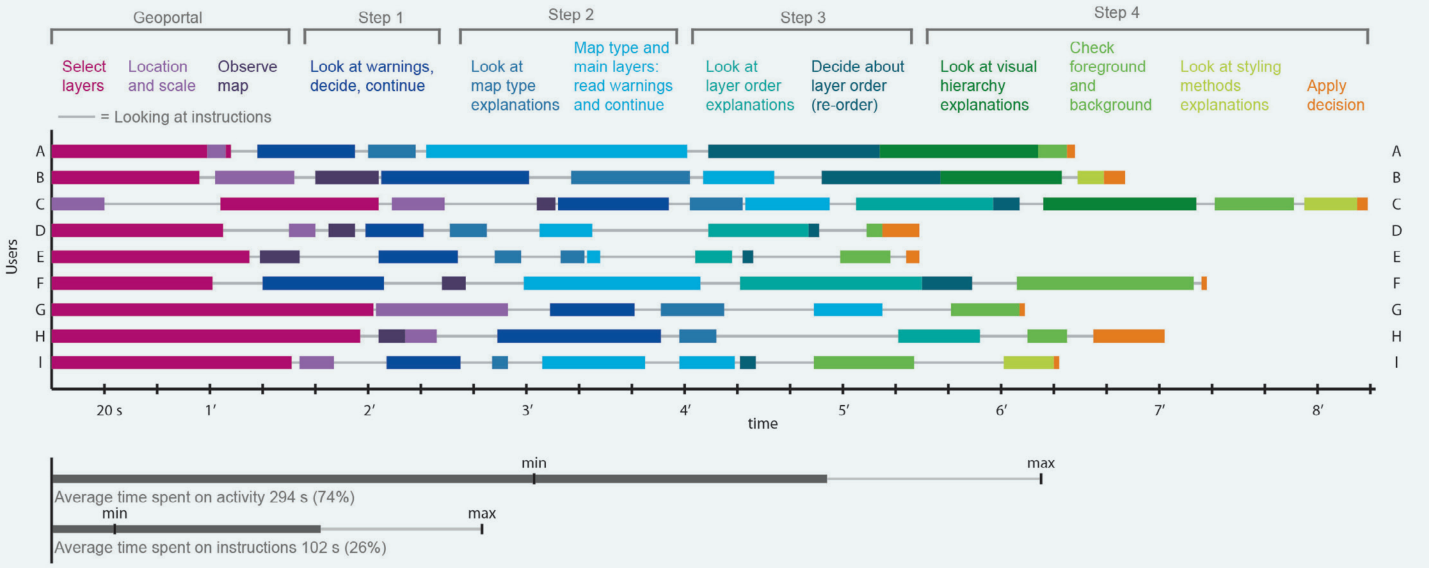

Figure 8. *Time spent on each task or function. Note: the start point is the participant's first interaction with the geoportal.*

familiar with geoportals and needed less time to complete the tasks; whereas participants A, B, and F spent less time on the instructions and much more on exploring the different functions and options of the wizard. It is notable that none of the participants used all the possible functions and explanations (Figure 9). Generally, and not surprisingly, the more functions or help used, the longer the participants spent on the geoportal. The general explanations about the main concepts and the warnings were used 53% and 74% of the time, respectively.

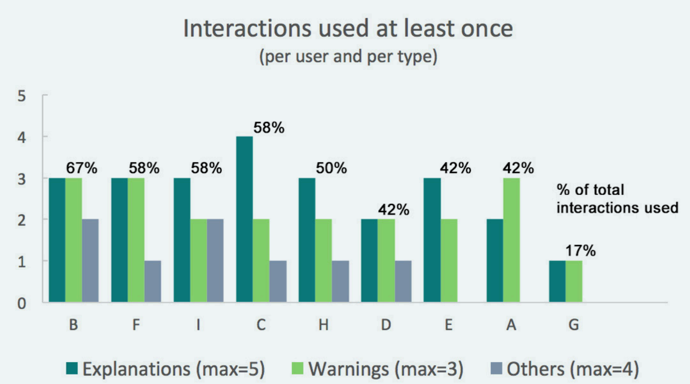

Figure 9. *Number of interactions encountered or used at least once by each user, based on type (general explanation, warning explanations, and others).*

Due to the fact that the scenario and defined task were precise, the participants reached similar end results during the test. They all managed to create the map according to the scenario. We show in Figure 10 one example of a map

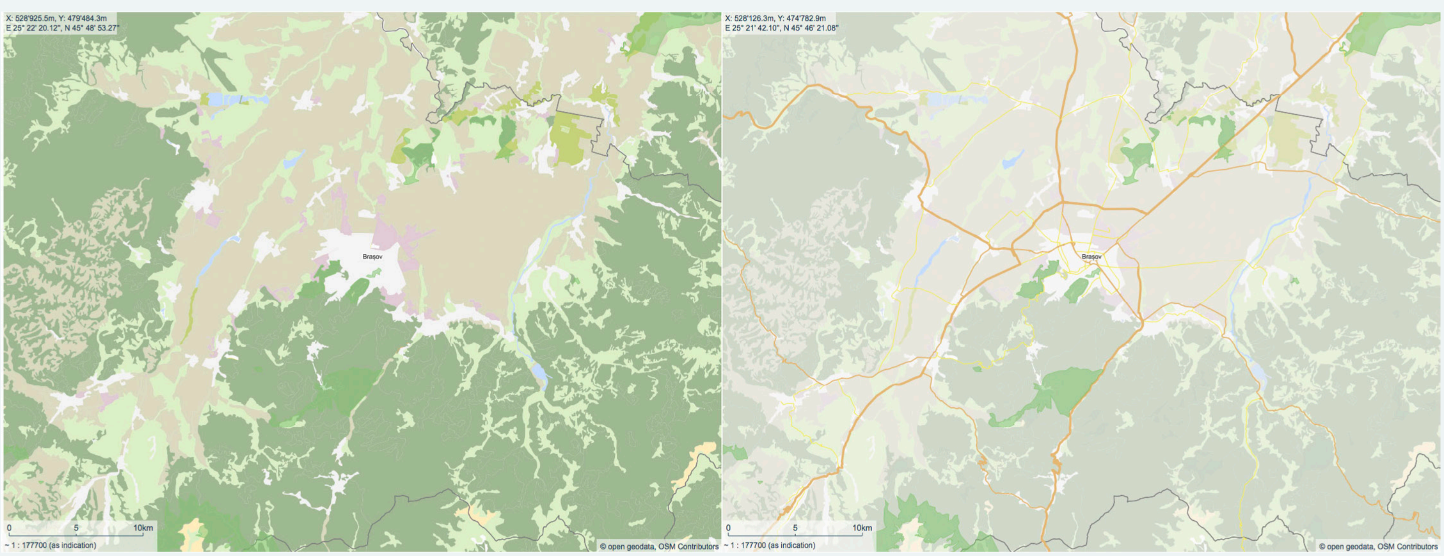

Figure 10. *Example of an initial layer selection by the participants (left) and end result after the use of the reorder and background functions.*

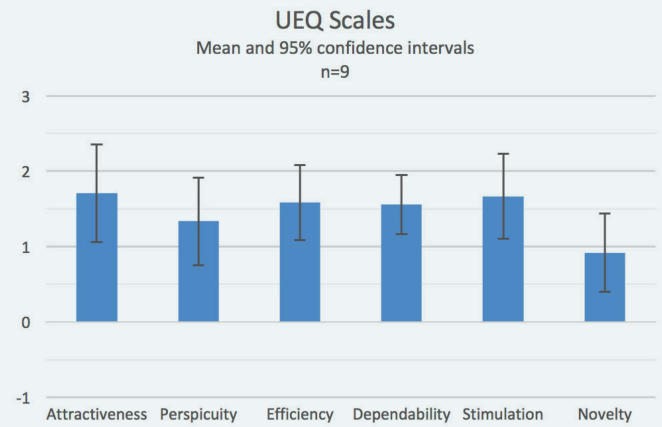

Figure 11. *User experience evaluation. Mean and confidence intervals of the UEQ scales.*

before & after the layer re-ordering and background modifications. Layers that were initially hidden, such as the road network, are no longer hidden and the strong background layer of land use has been de-emphasized. These changes improved the legibility and comprehension of the map by providing a clearer visual hierarchy of the map content and prevented unwanted feature overlaps.

User Experience Questionnaire

The UEQ is based on 26 pairs of opposing adjectives, which are then averaged into six scales: *attractiveness* (overall impression), *perspicuity* (how easy familiarization is), *efficiency* (whether tasks can be solved without unnecessary effort), *dependability* (feeling of control during interactions), *stimulation* (how exciting and motivating), *novelty* (how innovative and creative). The scales range from -3 (extremely poor) to 3 (extremely good). Due to how the scale scores are built and the fact that participants tend to avoid extremes, it is uncommon to observe values beyond -2 and 2. A value greater than 1.5 is considered to be a good experience.

The results in Figure 11 show all six scales have positive values, of which four scales are at or above 1.5: *attractiveness*, *efficiency*, *dependability*, and *stimulation*. The *novelty* scale receives the lowest score with a mean of 0.917: however, this score is above what is considered to be a positive evaluation (>0.8) and it is above the average value from the UEQ benchmark (see Figure 12). The benchmark has been set by combining 246 studies using UEQ result data from a broad range of products (business software, web pages, web stores, social networks). Thus comparing our results with the data in the benchmark helps to demonstrate the relative quality of our application compared to other products (Laugwitz, Held, and Schrepp 2008). Based on the individual scores of the *perspicuity* scale, the application is not perceived to be as easy (uncomplicated) as it could be (score of 1.1 for the pair), even though the score is above average when compared to the UEQ benchmark. Additionally, the confidence intervals at 95% also stay in the positive range.

Perceived Workload and Feedback

The raw scores of the RTLX in Figure 13 show that participants perceive the *physical demand* and the *frustration* as being low. The *performance* score is 1 for a perfect performance and 21 for failure, and with a mean of 5.33, it indicates that participants felt they achieved their tasks to a large extent. Score variations for *performance* and *physical demand* are small among the participants.

However, accomplishing the tasks is perceived as requiring a higher *mental demand*, which is not surprising because the wizard offers insights into complex cartographic

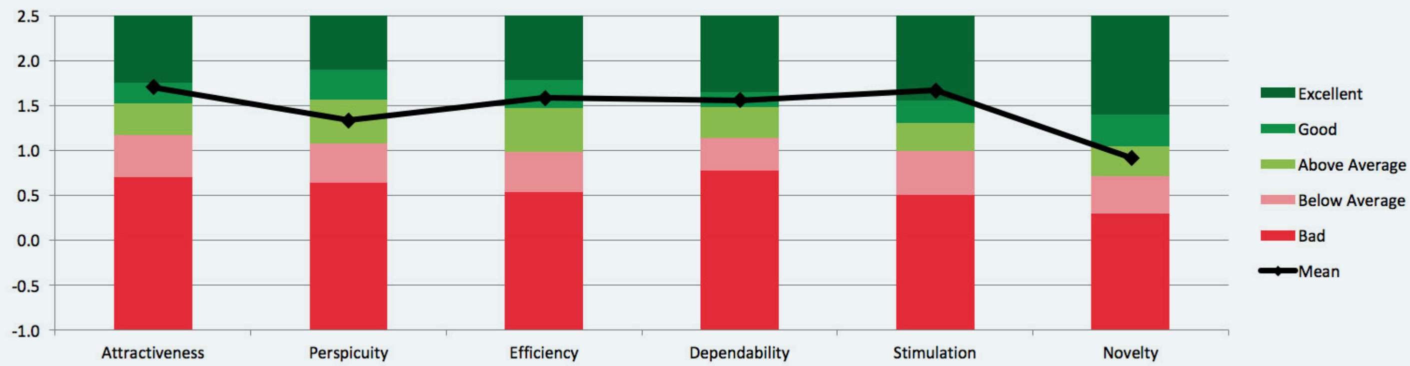

Figure 12. *UEQ Benchmark and usability study participant mean ratings. The scales are all above average, good, or excellent.*

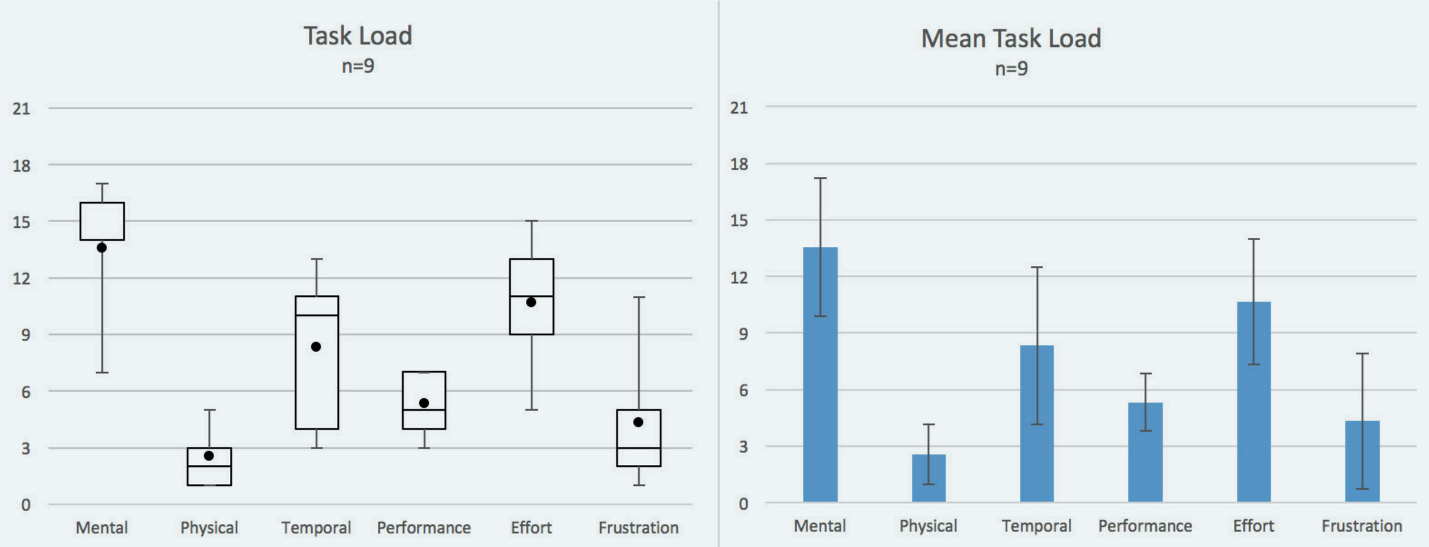

***Figure 13.** RTLX scores of perceived workload. Left: box-and-whisker plot displaying, the minimum, 1st quartile, median, mean (black point), 3rd quartile, and maximum. Right: mean and standard deviation for each RTLX scale.*

design processes and rules. The average *effort* required and the average *temporal demand* are just below the middle mark of 11. The *temporal demand* is the workload with the most dispersed distribution, which can be explained by the fact that time is subjective and because fulfilling the tasks could be achieved with or without spending time on the additional information and help provided.

From the UEQ, we saw that the application was perceived to be slightly complicated, but it did not lead to frustration or failure, as shown by the RTLX.

For the general feedback questions, participants had to answer the seven questions seen in Table 2 using a Likert scale of "Strongly agree" (=5) to "Strongly disagree" (=1). Due to how the questions were phrased (positive or negative), low or high average values can both be positive in meaning. Thus, the averages have been re-aligned from 1 to 5, with 5 being the positive meaning. The re-aligned scores were also used to create the clustered matrix seen in Figure 14. The clustered matrix shows three very positive participants (I, A, G), five positive participants (C, H, F, B, D), and one average evaluation from participant E.

The participants found the additional information about the cartographic functions helpful while also agreeing they were well integrated. The participants did not perceive they were making many mistakes, which corroborates the results of the RTLX regarding frustration, effort, and performance. Furthermore, the participants did not agree that the system was complex or cumbersome to use.

Question	Average	Re-aligned average
I found the system unnecessarily complex	1.78	4.22
I thought the system was easy to use	3.78	3.78
I found that the various functions were well integrated	3.89	3.89
I thought there was too much inconsistency in this system	1.78	4.22
I found the system very cumbersome to use	1.89	4.11
I found the additional information about the cartographic functions helpful	4.67	4.67
I thought that I was making many mistakes	2.33	3.67

***Table 2.** Average response to the feedback questions. Re-aligned scores: 5 = positive evaluation, 1= negative evaluation.*

However, their opinion was a little bit more split on statements about how easy the system is to use. They also disagreed with the statement about inconsistencies in the system and making mistakes, showing a positive evaluation of the wizard overall. Finally, while there is no correlation

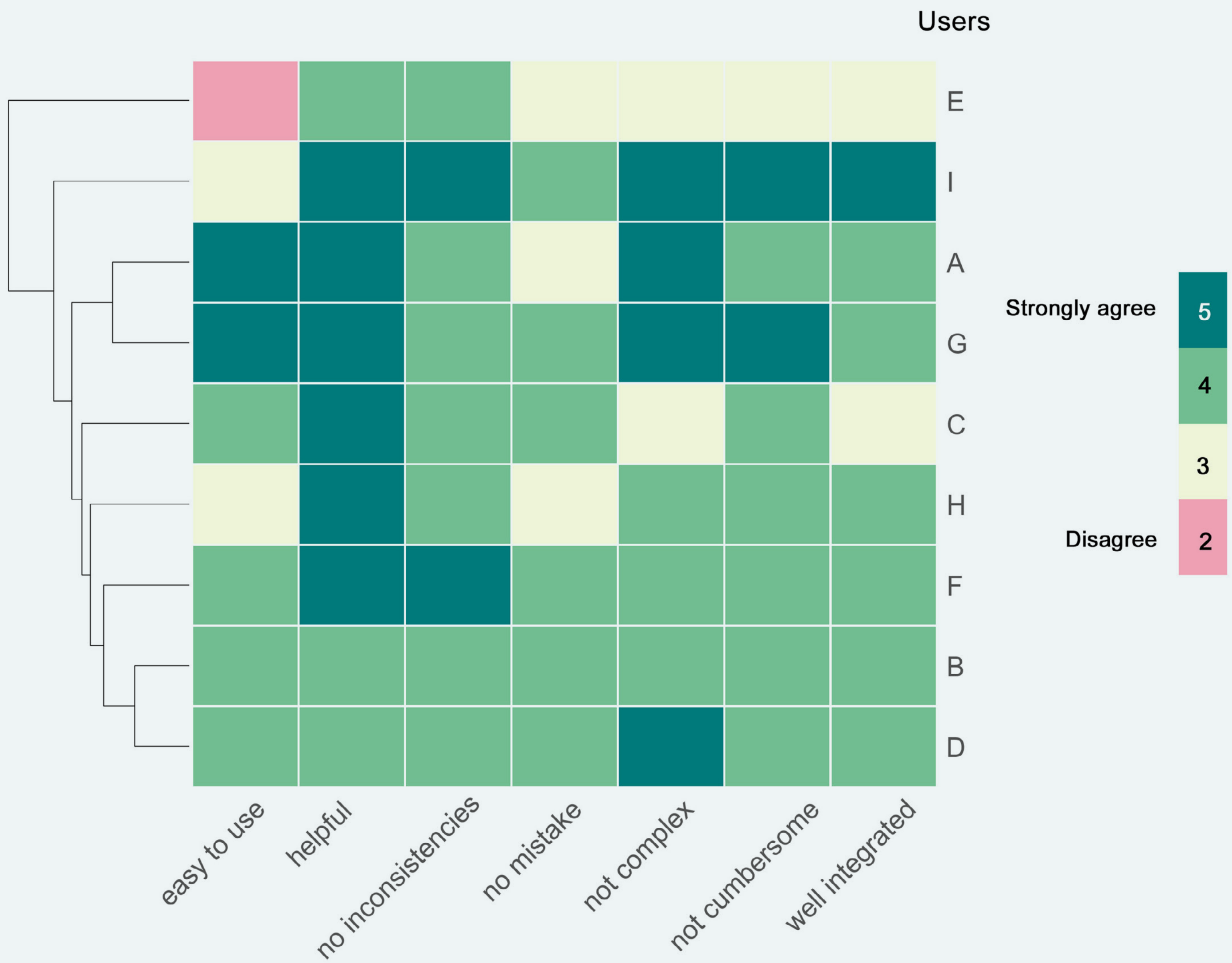

Figure 14. *Clustered matrix of the feedback scores for each user.*

between their evaluation and the time the participants spent on the system, the general feedback scores seem to be negatively correlated with how high the participants estimated their task load to be (higher general feedback score = lower task load estimations), with a Pearson correlation coefficient of -0.77 and p-value of 0.014. This fact is not surprising; however, with only nine participants, one should interpret this only as a marked trend.

The structured interview at the end allowed us to gather qualitative feedback and the reasoning behind participant choices or actions. We quickly review here the points that either were mentioned several times or that are of special interest. The reasons mentioned for giving positive feedback about the additional information mostly concerned the opportunity to learn more about an unknown field. Moreover, having access to the rationale behind the cartographic functions was appreciated, which might explain the high score of the helpfulness question. The participants explained the reason why they did not use a specific function that was accessible via an icon image and provided pictorial explanation: even though the icon was mentioned in the familiarization phase, the participants either did not realize it was an icon and/or were too focused on the text itself. This is clearly a design choice that needs further improvements. Suggestions for improvement were to change its color, or transform it into a link within the text. More generally, links and interactive features should be in a color that differentiates them from the rest of the interface, as several participants mentioned that interactive features were difficult to spot at first. Additionally, several participants commented on the lack of more significant feedback when a layer is added to the user-generated map as well as the absence of a sign that would indicate that the layer is already in the map. However, the implementation of the warning/error differentiation with yellow and red was well understood overall, especially in regard to the seriousness of the message being conveyed.

DISCUSSION

The usability test exposed both successful and flawed aspects of the interaction and GUI design, both in terms of understanding the wizard application and its actions and in terms of pure interface design. Moreover, it confirms some conclusions reached in previous work regarding interaction design for cartographic or geospatial online platforms.

The results revealed some misunderstanding of the language used within the interface. There appears to be a need for a short introductory section explaining the main vocabulary used. Beyond a clarifying role, it could also play the role of general documentation that can be used as a reference at any time. For instance, the term "map type," the different layer categories, and some other fundamental terms could be better explained. Additionally, there was some confusion among the participants as to the extent of the wizard actions. After certain warning or error messages, some participants expected the wizard to automatically correct some parameters, whereas the wizard was built to let the user decide about those cases because they are open-ended questions, and thus dependent on the user's purpose for the map. More specific feedback should be considered in certain cases to prevent any doubt. In addition, building auto-correcting functions should be incorporated into future developments.

Two weaknesses of the interaction design were uncovered. First, the conceptual understanding of the duality between "data browser vs. user-generated map" and how to add layers to the user-generated map was not optimal. The process could be better supported by providing better visual feedback when a layer is added to the user-generated map and to signal which layers are already in the user-generated map. This could be realized by shadowing or highlighting layers that are already present and by issuing a short, disappearing message stating when a layer has been successfully added to the map. Second, the icon that allowed the user to open an image demonstrating the text explanation was not well designed and participants did not realize it was an icon or were just too focused on the map and text to click on it. Thus, a redesign is more than warranted and one solution could either involve turning the icon into a link, using another color, or offering a miniature image with a function to enlarge it.

The tests also revealed some successes of our interaction concept. One of these was the frequent use of warning and error messages. These messages provided information about cartographic rules behind the constraints and modifications applied to user-generated maps. The participants applied an exploratory strategy, trying different options as a means to understand the explanations in relation to changes in the map parameters and in the map itself. As the changes were applied immediately to the map, the participants did not have to wait until the end of the wizard process to see how the parameters impacted their map. The messages, which are specific to the user-generated maps in question, are thus complementary to the general explanations: they deliver the same information but put it into perspective. It helps the participants to understand how the general rules apply to their unique, specific context. The distinction between warning and error messages was well understood, likely because it was built on known signifiers and familiar conventions by using red for error and yellow for warning.

The fact that participants found the additional information helpful and appreciated discovering something new has interesting implications for geoportals: not only does it support designing an optimal interface for helping the users create better maps, it also establishes the geoportal as an entry point for learning about cartographic design rules, as it does not require any specialized software or the need to deal with raw data.

When looking at the experience of individual users across the different scores and evaluation, there are a few interesting facts to highlight. The "worst" evaluation came from participant E, who was also the participant who spent the least amount of time on the geoportal and was one of the three who did not use all the different types of interactions. Participant C, on the other hand, spent the most time and gave an overall positive evaluation. Participants I and H, who gave the system the best evaluation, spent an average amount time on the wizard, but used a very different number of the interactions and functions. Interestingly, neither had used a geoportal before. Participant G is an outlier in their use of the interactions (only two types and 17% in total), however their general feedback score was one of the highest, and their RTLX score was the second lowest. Additionally, participants A and E used only two types of interactions and with a similar frequency, however, their general feedback and RTLX scores were very different from each other. Thus the amount of help used does not seem to be linked to whether the participants found the system user-friendly and easy to use.

Because the scenario for the usability test was structured, it allowed us to make sure the participants went through all the steps in order to better compare how they used the functions in terms of time spent on the functions and levels of information they access for each step. An unsupervised test would probably have led to different results and required an even lengthier debriefing to decipher the intentions of the different participants and why they did or did not perform certain tasks. Additionally, a larger number of participants would have been required as fewer variables could be controlled. However, our structure also meant that the participants had only marginal space for creativity in the map generation process. As the study focuses on geoportals, where creativity in regard to map content and styling is often limited compared to GIS or a drawing program, this constraint was deemed acceptable for the purpose of this work.

The results also show the emergence of different user profiles among the participants. It would support the assertion that the wizard can be used successfully without accessing each level of information, and that wizard users might benefit from the opportunity to choose between different interface designs with different levels of complexity. However, due to the relatively small number of participants, this suggestion must be considered carefully.

Finally, the interest in and high use of warning functions as a discovery tool suggests that because cartographic functions and knowledge are at times complex, participants found that having the map show what was meant (instead of text explaining what was meant) was valuable. Thus when building interactions with cartographic functions and knowledge, one should take care to provide the explanation not just in a "telling" form, but importantly in a "showing" form, such as within a sample map or an immediate change to the user-generated map. Learning by doing (and by seeing) seems to apply to the relation between cartographic knowledge and cartographic interactions.

CONCLUSIONS AND OUTLOOK

Our goal was to investigate the potential integration of cartographic functions and knowledge in an existing geoportal framework. After reviewing the state of the art in user interaction and usability, as well as our previous experience with mapping platforms, we built a model of interaction levels and showed different types of interactions with and feedback from the system to the users. Then, we tested the integration of smart cartographic functions and knowledge with a usability study. Insights gained through this study will help improve the actual platform and move towards a more hands-on approach to sharing cartographic knowledge. The main new geoportal design feature was testing interactions that provided immediate feedback about user actions in the user-generated map, rather than after going through several windows of parameters as is the case in a traditional wizard. Additionally, the choices the users made were always put in context, and the map and its contents were always visible and referred to in the wizard windows.

Feedback and the results of the usability study show that the overall experience with the cartographic functions and the wizard workflow was positive as proven by the enthusiasm of the participants, their curiosity about the cartographic content, and the different indicators regarding ease of use, task load, and qualitative feedback. However, it also revealed areas with potential for improvements, such as the implementation of the explanatory images and some unclear terminology.

From this work, we gather the following guidelines that are relevant for the integration of smart cartographic functions and knowledge into mapping platforms:

- The action and output of functions should be clear to the user.
- Help and explanations about the functionality should come in different forms and through different pathways (telling vs. showing and general vs. case-specific).
- Accommodating a diverse target audience is challenging, but providing several levels within the interface supports the tasks successfully.
- Providing users with ways to explore the content and knowledge by themselves and interactively should be favored, as it leads to a positive user experience.

This paper and its usability study show that implementing cartographic functionalities in geoportals with an open approach can be successful, enjoyable for the users, and not perceived as cumbersome. Cartographic wizards and similar approaches to integrate cartographic knowledge and functions should be considered in geoportals as a means to attract users, to offer sound cartographic visualizations of the geoportal data, and to further promote the platform.

Furthermore, there is still great potential for development in terms of interface/interaction design and cartographic functionalities. For instance, modules about color management and generalization levels could give more creative freedom to the users; they would be straightforward to implement because they rely on information about geometry, scale, and feature themes: information which is already present in the framework. Beyond enhancing the actual geoportal GUI based on the results of this study, our future work will focus on providing a more differentiated interface while keeping access to the additional cartographic knowledge similarly available. Additionally, developing smart functions that suggest corrections and apply them will be another priority. This is challenging because it requires the system to convey precise feedback to the user about what is being executed and why, without being too obstructive in terms of the user experience and a smooth workflow. Finally, providing a positive user experience and enabling the users to reach their goals should stay at the center of all these new developments.

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PEER-REVIEWED ARTICLE

The Status of Web Mapping in North American Higher Education

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Most maps are now consumed online, yet colleges and universities struggle to keep their cartography and GIScience curricula up to date with the use of modern web technologies. I present a qualitative interview study aimed at providing insight into current teaching practices, along with challenges that may hamper the uptake of web mapping technologies in the classroom. The study involved interviews with 20 instructors of web mapping courses at colleges and universities in the United States and Canada. Participants were asked about the overall vision for their web mapping courses, the scope of material covered, what specific topics are included, which web technologies they use and why, their preferred teaching pedagogy, and what challenges they have experienced. The results highlighted several strategies that cartography and GIS instructors can use to implement or increase the inclusion of web mapping in their curricula.

KEYWORDS: web mapping; higher education; teaching; JavaScript; coding; interactive maps; interviews

INTRODUCTION

Maps and mapping have changed drastically over the past decade or so. The invention of the smoothly interactive tile-based web map in 2005 heralded a major shift in public map consumption from paper to digital (Crampton 2010; Peterson 2014). Today, far more maps are consumed via the internet than in hard copy form. For example, Apple Maps served more than 5 billion map requests per week in 2015, and more than 4.6 million websites currently embed Google Maps (Jesdanun 2015; Built With 2017). Even most static maps that once would have been printed are now viewed as image or PDF files in the browser. In geography classrooms, web mapping is increasingly seen as a vital tool for supporting spatial thinking (Manson et al. 2014).

Creating web maps requires at least basic web development and programming skills, yet university geography departments lag in teaching these skills. Most cartography and GIS programs continue to focus on the use of push-button desktop software with little text-based coding instruction (Bowlick, Goldberg, and Bednarz 2017). The purpose of the research reported here is to better understand the current state of educational practice, as well as methods for expanding the teaching of web mapping in higher education. I report on an analysis of interviews with 20 instructors of web mapping courses regarding their teaching goals, tools, and methods. A basic understanding of web map infrastructure is necessary to interpret the findings of the study. Explanations of the technology and its impact on cartography in higher education follow below.

TECHNICAL BACKGROUND

The growth of web maps has been enabled by a series of innovations in internet technologies. All web maps make use of the internet's client-server architecture, wherein data are stored in files or a database on a host machine and transmitted by a piece of software (the server) to the user's web browser (the client) (Peterson 2008; Manson et al. 2014). The first web maps were simply static images of maps placed online as early as 1993, as soon as images could be displayed in a web browser (Peterson 2014). Interactive web maps, or maps that change in response to user input, were established shortly thereafter with the development of specialized map servers that could transmit specific geographic data or pre-rendered map images requested by the user.

During the 2000s, interactive web maps split between those rendered in formats native to the web browser and those developed for third-party browser plugins (Roth et al. 2014). In the former category, services such as MapQuest and TerraServer provided maps that the user could zoom and pan via interface buttons that would reload the web page with a new map view after each interaction (Peterson 2014). In 2005, Google engineered a major breakthrough with the launch of its Maps service, which relied on Asynchronous JavaScript and XML (AJAX) to load 256-by-256-pixel map image tiles as they were requested by the client, without reloading the entire web page (Peterson 2012). This afforded the user smooth, intuitive zooming and panning. This remains the most common type of interactive web map, often called a "slippy map." In addition, the Google Maps API, launched in 2006, allowed tech-savvy users to add their own data as marker or vector feature overlays atop a Google basemap, and retrieve information from features via pop-ups (Crampton 2010). Other commercial services and the open source OpenLayers API followed suit.

The other type of interactive web maps commonly developed in the 2000s were those for third-party browser plugins such as Adobe Flash Player and Microsoft Silverlight (Peterson 2008). These were integrated into commercial software development environments and produced as binary executable files that ran once fully downloaded by the client (Roth et al. 2014). This strategy was advantageous for users with low bandwidth connections, providing smooth interaction without requiring constant communication between server and client. The graphics were also of superior quality to those that could be rendered directly in early web browsers (Jenny, Jenny, and Räber 2008).

However, browsers eventually caught up in their rendering and interaction capabilities. They developed universal support for the open web language standards of CSS (Cascading Style Sheets) for page styling, SVG (Scalable Vector Graphics) for vector image rendering, HTML5 for content layout, and JavaScript for programming tasks (Roth et al. 2014; also see Figure 1). Higher bandwidths also became increasingly prevalent in the developed world (Lienert et al. 2012; Nielsen 2016). Additionally, the World Wide Web Consortium (W3C) promoted a shift away from proprietary, third-party technologies toward

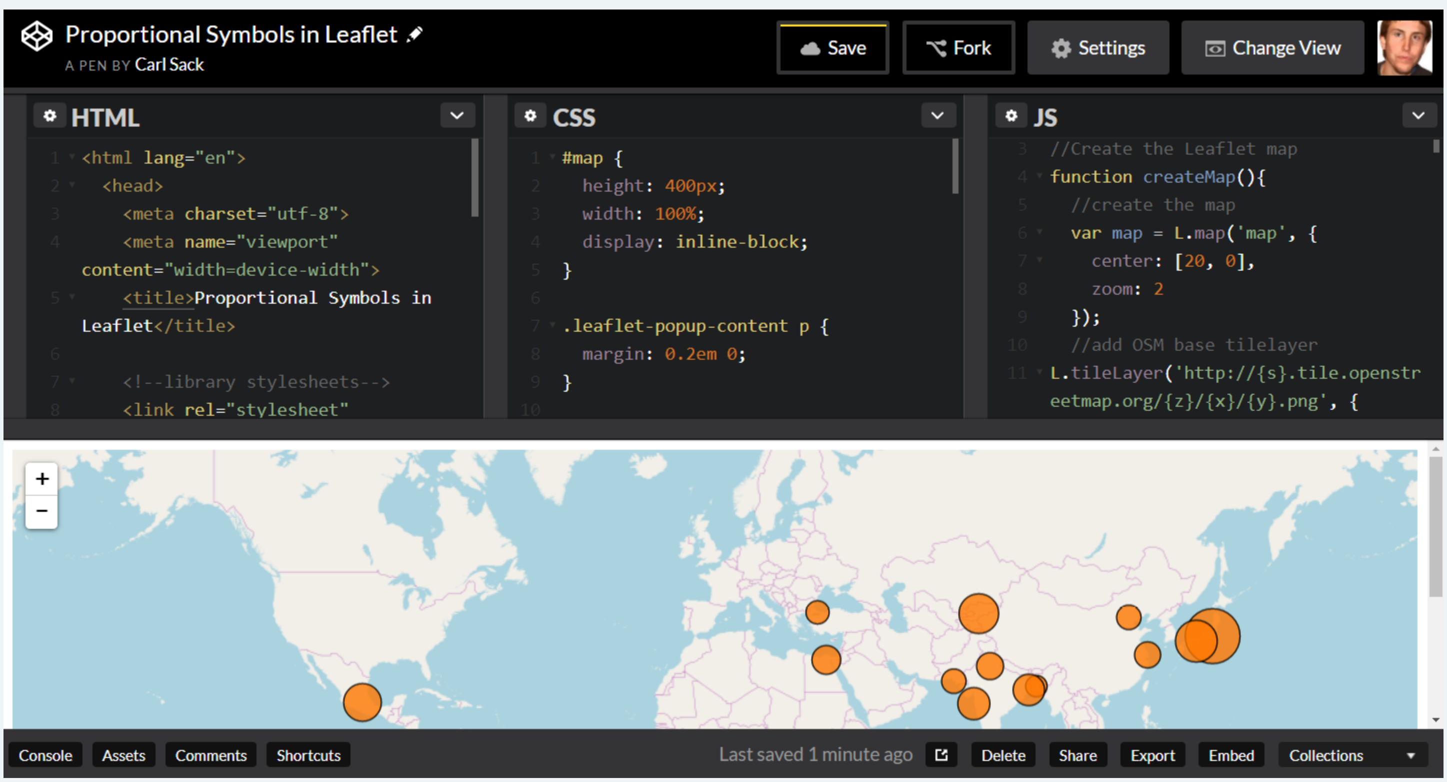

Figure 1. *Screenshot of an online web development application (Codepen.io) showing examples of the three basic open web platform languages: HTML, CSS, and JavaScript. The code contained in the three panels works together with external code libraries to generate the interactive web map at the bottom. The circles on the map are generated dynamically using the SVG graphics format (not shown as code).*

free and open source (FOSS) tools based on open web standards that ensured royalty-free use and modification (Lund 2017). In 2010, mobile device manufacturers announced they would discontinue support for third-party plugins in mobile browsers, precipitating the deprecation of these technologies in favor of sole reliance on open web standards (Jobs 2010; Adobe Corporate Communications 2015).

Concomitant with this shift has been a rapid growth in the diversity and flexibility of web mapping technologies. Open source JavaScript libraries such as Leaflet and D3, which consist of sharable and editable code to facilitate easier web map construction, have come into widespread use. Many commercial platforms such as Google continue cutting edge feature adoption (Peterson 2014). Full-stack web mapping and web GIS platforms—web applications that include both server- and client-side program components—such as Mapbox, CARTO, and ArcGIS Online have become more available, powerful, and usable, such that it is now possible to make and share a reasonably high quality custom web map and even perform advanced spatial analysis operations with a few mouse clicks in the browser (Kerski et al. 2012; Muehlenhaus 2014). Because these services rely on open web standards, the appearance and functionality of web maps created with them can be further customized by anyone with basic coding skills (Sack 2017).

HIGHER EDUCATION BACKGROUND

The shift to open web technologies in cartography has echoed a similar shift in higher education toward greater usage of web-based instructional technologies and resources (Bozkurt et al. 2015). Online education programs continue to grow rapidly, with 32% of all U.S. higher education students taking at least one distance education course and 15% taking exclusively distance courses in 2016, while overall higher education enrollment has declined annually since 2012 (Seaman et al. 2018). In the United States, community and technical colleges offering two-year associate degree programs, and universities offering four-year baccalaureate programs, receive a 34% share of federal government spending on workforce development (Fain 2017). Canadian universities likewise see much of their mission as training graduates to meet labor market needs (Davidson and Soubry 2014). With the rapid rise of information technology in all sectors of the economy, this job training looks increasingly web-focused as well as web-enabled (Atkinson 2016).

The number of distance education programs in GIScience is growing as universities aim to capitalize on the demand by working adults for professional retraining and flexible, location-independent course structures (Robinson and Nelson 2015). These notably include fully online degree programs in web mapping and GIS at The Pennsylvania State University, the University of Kentucky, and the University of Wisconsin–Madison, to name a few, which leverage web-based content management systems to combine written and multimedia content modules with real-time instructor support for student learning (Luo, Robinson, and Detwiler 2014). Such programs necessarily teach web mapping, as the web is their entire medium for instruction and assessment of cartography skills, but also recognize that interactive web mapping skills are currently in demand by employers and GIS professionals (UW–Madison 2017).

While these programs are on the cutting edge of web mapping education, a cursory review of course offerings listed on North American cartography and GIS program websites suggests that those offering courses in web mapping continue to make up the minority. Research into technology adoption in higher education suggests a range of possible factors, including the complexity of web technologies, resistance to change, lack of motivation, lack of institutional support, lack of faculty time and resources, and/or negative experiences in prior attempts (Moser 2007; Abrahams 2010). The New Media Consortium categorizes these challenges as "managing knowledge obsolescence" and calls for the establishment of "processes . . . for both technology and pedagogy discovery so higher education professionals can filter, interpret, organize, and retrieve information in an efficient and insightful manner" (Adams Becker et al. 2017, 23).

Nonetheless, there have been promising developments. With a recent update, the Geographic Information Science and Technology Body of Knowledge—the authoritative collection of GIScience education standards—now includes several web mapping-related topics, including *UX/UI Design Principles*, *Web Mapping*, *Virtual and Immersive Environments*, *Mobile Mapping and Responsive Design*, and *Usability Engineering* (UCGIS 2017). An increasing number of programs are integrating web mapping into their existing courses or creating new courses focused specifically on web mapping (Hermansen 2010). A critical mass of courses that would tip the scales toward universal adoption of web mapping in cartography and GIS curricula may not be far off (Abrahams 2010). My aim here is to hasten its arrival by increasing the awareness of the teaching strategies used by early adopters as well as the challenges they have faced in the process of learning to teach web mapping.

METHODS

The research study reported here consisted of one-hour interviews with instructors of web mapping courses at colleges and universities across the United States and Canada, conducted between August 2016 and April 2017. Potential participants were identified first by emailing faculty at institutions listed in the North American Cartographic Information Society's (NACIS) University Labs directory (**nacis.org/community/university-labs**). Additional potential participants were added based on recommendations of those who responded to the first round of emails. Finally, a general recruitment email was sent to the American Association of Geographers (AAG) Cartography Specialty Group listserv in advance of the 2017 AAG Annual Meeting.

Through this process, 92 potential participants were identified, of whom 22 agreed to an interview, a positive response rate of 24%. There was no noticeable correlation between those who responded and their geographic location, specialty, or institution type. Eighteen of those identified as potential participants responded but declined to be interviewed: four because they were not academic instructors, six because they did not currently teach web mapping, one due to lack of time, and seven for unspecified reasons. Twelve of those who declined forwarded the invitation or recommended colleagues who they thought would be better candidates.

Participants were considered to meet the study criteria if they had been an instructor of record for one or more courses that taught students how to create an interactive web map. Of the 22 interviews recorded, two were ultimately discarded because the participants did not meet the study criteria, resulting in a total sample size of 20. Of these, seven interviews were conducted in person at the NACIS and AAG meetings, and the remaining 13 were conducted by phone or video conference. The interviews were audio-recorded and transcribed in full.

A semi-structured format was used for the interviews, providing consistency in participant answers while allowing for more natural conversation and follow-up questions on themes that were of particular interest to participants (Bozkurt et al. 2015). The interview protocol included questions on

1. the background and training of the instructor;
2. the scope and sequence of topics covered by their web mapping course or courses;
3. the tools and technologies they relied on for teaching web mapping;
4. their attitudes toward proprietary and FOSS software;
5. their observations as to industry trends in web mapping technology and practice;
6. the extent to which they taught the class in person, online, or using a blended approach;
7. their use and creation of open educational resources;
8. their preferred teaching pedagogy;
9. successes and challenges they had experienced with teaching web mapping; and
10. any techniques they identified as "best practices" for teaching web mapping.

Interview transcripts were coded for qualitative data analysis using 26 descriptive codes across five categories of statements including the overall course context, technology used in the course, resources used in teaching the course, the course setting (i.e., whether in-person, online, or blended), the curriculum content, and teaching philosophy and experiences (Table 1). The coding scheme began as a list of 22 codes that were inductively revised and added to during transcript analysis and discussions between the two coders referenced below (Miles, Huberman, and Saldaña 2014). For each final code, the statements assigned that code were further grouped according to theme

Code	Description
Category: Course Context	
BACKGROUND	A statement about the instructor's education, training, or prior teaching experience
NAME	The name of a course
PROGRAM	A statement about the program context in which the course or courses is taught (e.g., degree type, prerequisite courses, etc.)
STUDENTS	A statement about the characteristics of a student or students in the course
SUPPORT	A statement about the extent or nature of support for the instructor from their program or institution
VISION	A statement about the social or academic role that the course is envisioned to fulfill
Category: Technology	
TOOL	A specific piece of software or hardware, a vendor, or a general category of technology
OPEN	A statement about the nature of open data or open source software
PROPRIETARY	A statement about the nature of proprietary software or data
MOTIVATION	A statement about why the participant prefers or does not prefer to use a particular piece or type of software
TREND	A statement about a trend of development in web mapping software over time
Category: Resources	
OER	A statement about open educational resources used or created by the instructor
TEXT	A purchased textbook or other commercially licensed resource
Category: Setting	
INPERSON	A statement about teaching in person
ONLINE	A statement about teaching online
BLENDED	A statement about using a mix of in person and online instruction
Category: Curriculum	
ORGANIZATION	A statement about the organizational structure of the course
SCOPE	A general statement about the range of topics covered in the course
TOPIC	A specific topic covered in the course curriculum
SEQUENCE	A statement about how topics are ordered or why they are in a certain order
OBJECTIVE	A statement regarding a desired function of the course
OUTCOME	An ability or result demonstrated by students who took the course
Category: Teaching	
PEDAGOGY	A statement about the instructor's teaching philosophy or techniques
EXPERIENCE	A statement about the instructor's overall experience in teaching web mapping or related subjects
CHALLENGE	A statement identifying a challenge the instructor faced in teaching web mapping
DEVELOPMENT	A statement regarding course development and/or revisions

Table 1. *Interview coding scheme.*

across all transcripts, with each theme's frequency and extensiveness recorded. These themes are presented in the Results section.

To validate the qualitative analysis, 25% of the transcripts (5 out of 20) were independently coded by two coders. The primary coder analyzed all 20 transcripts, while a secondary coder re-analyzed five of the transcripts to produce an inter-rater reliability score. The overall results produced a Cohen's Kappa score of 0.50, or moderate agreement (Hallgren 2012). This analysis included statements for which a code was generated by one of the two coders with no corresponding code given by the second coder. Excluding such one-sided codes produced a Cohen's Kappa score of 0.78, or substantial agreement.

Based on the results of the coding analysis, the codes VISION, SCOPE, TOPIC, TOOL, MOTIVATION, PEDAGOGY, and CHALLENGE were subjectively judged to contain the most salient collections of statements pertaining to the goals of the study outlined above. Themes from statements tagged with each of these codes were identified and tallied according to the frequency and extensiveness with which the theme recurred across all 20 transcripts. It is important to note that each interview received multiple (sometimes many) themes for each code, so these themes should not be considered mutually exclusive. Themes that recurred in multiple transcripts are reported in the Results section below.

RESULTS

The results of the qualitative analysis are presented below as a series of tables containing the themes for each code that were expressed in statements by two or more interview participants (i.e., were present in at least 10% of transcripts).

VISION

The VISION code was applied to statements about the big-picture social or academic role that the instructor imagined the course as fulfilling. VISION themes discussed by multiple instructors are reported in Table 2.

Frequency	Instructors	Theme
22	12 (60%)	Prepare students for future jobs
6	5 (25%)	Course fits the needs of the department/program
7	4 (20%)	Teach geographic thinking
6	3 (15%)	Improve general geospatial literacy
5	3 (15%)	Produce students who make better maps
3	3 (15%)	Course fills a niche that few other courses currently address
6	2 (10%)	Skills fit regional job market
3	2 (10%)	Provide add-on skills for non-GIS majors
2	2 (10%)	Elective course in GIS major/minor
2	2 (10%)	Course links geography to data analytics
2	2 (10%)	Course focus fits the dominant trend of GIS toward web-based applications
2	2 (10%)	Expose students to web mapping at a basic level
2	2 (10%)	Expose students to a variety of mapping tools they can use in future work

Table 2. *VISION themes expressed by two or more interview participants.*

Instructor visions mostly pertained to employable skills. The majority of web mapping instructors saw preparing students for future jobs as their major purpose in teaching the class. Related themes of meeting regional job market demand, providing add-on skills for non-majors, following trends in the GIS industry, and exposing students to tools they could use in their future work were each mentioned by two instructors. Five instructors taught the course because it fit the particular needs of their department or program, while three saw the course as filling an open niche. Four instructors saw web mapping as a useful way to teach students how to think geographically, and three each wanted to improve geospatial literacy and produce students who make better maps.

SCOPE

The SCOPE code was applied to statements about the overall range of topics or themes covered in the course. SCOPE themes discussed by multiple instructors are reported in Table 3.

The SCOPE code revealed clear divides in the depth to which instructors teach web mapping and whether it is the primary content of the course or a sidebar in a larger curriculum. Just under half of participants stated that their courses focused on a broader geography, cartography, and/or GIS curriculum into which they integrated web mapping skills. Eight participants said they exposed students to a wide variety of web mapping tools throughout the course. Seven stated that they maintained a heavy emphasis on teaching technical concepts, in keeping with the vision of web mapping as a career skill. Three reported that they sought to balance technical and design concepts, and three said they emphasized design heavily.

However, six reported going in a different direction entirely, using web mapping as a platform for encouraging students to think critically or explore a "big idea," and four said they used it to explore critical geographic theory. Although most participants considered programming an important web mapping skill, only three mentioned a focus on JavaScript coding, while four said they included no programming at all in their courses and three specified that they taught very little or only a very basic level of it. Three discussed covering geospatial data and three discussed teaching server-side mapping and GIS.

Frequency	Instructors	Theme	Frequency	Instructors	Theme
17	9 (45%)	Web mapping is integrated into broader course curriculum	3	3 (15%)	Application of tools to solve real-world problems
17	8 (40%)	Broad exposure to a variety of web mapping tools	5	2 (10%)	Web GIS
21	7 (35%)	Heavy emphasis on technical concepts over design concepts	4	2 (10%)	Cartographic design principles
15	6 (30%)	Geographic thinking/big concepts	4	2 (10%)	Introductory/basic level material
9	4 (20%)	Critical theory	4	2 (10%)	Web map design principles
8	4 (20%)	No programming	4	2 (10%)	Python-based
8	3 (15%)	Balance of technical and design concepts	4	2 (10%)	User experience/user interaction design
6	3 (15%)	Heavy emphasis on design concepts	3	2 (10%)	Basic introduction to cartography
4	3 (15%)	Not much programming	3	2 (10%)	Not highly technical
4	3 (15%)	JavaScript coding	2	2 (10%)	History of mapping/GIS
4	3 (15%)	Basic web mapping introduction	2	2 (10%)	Open source technologies
3	3 (15%)	Geospatial data	2	2 (10%)	Acquiring and using GIS data
3	3 (15%)	Server-side GIS/mapping			

Table 3. *SCOPE themes expressed by two or more interview participants.*

TOPIC

The TOPIC code was more granular still than either VISION or SCOPE, examining specific topics that were covered during units of the course curriculum. Participants covered a very wide variety of topics in their curricula, with almost every course seemingly unique. While this lack of cohesion could be judged negatively, one participant saw it as a positive, stating, "I would hate there to be a standard curriculum, so that everybody gets a very generic view of what cartography is. . . . The more variety, the better." Because this variety made for a great many separate themes, only those common to three or more participants are reported in Table 4.

Despite the lack of emphasis on coding in the SCOPE themes, the most frequently mentioned topic was a basic introduction to web languages and technologies. Geospatial web services was also mentioned as a topic by seven participants, while four each spoke more specifically about teaching how to either produce or consume these services. Crowdsourced data and volunteered geographic information (VGI) was also a common topic. Topics mentioned by fewer people included a mix of traditional cartography and GIS topics and topics more specific to web mapping practices.

Frequency	Instructors	Theme	Frequency	Instructors	Theme
16	7 (35%)	Introduction to web technologies/ code languages	8	3 (15%)	Scale
12	7 (35%)	Geospatial web services	8	3 (15%)	Cloud GIS
10	7 (35%)	Volunteered/crowdsourced geographic information	8	3 (15%)	Spatial analysis
13	5 (25%)	Web cartography	7	3 (15%)	APIs
10	5 (25%)	Accessing data	6	3 (15%)	Symbolization
7	5 (25%)	Cartographic design principles	5	3 (15%)	Web GIS
7	5 (25%)	Data processing	5	3 (15%)	Web map architecture
6	5 (25%)	Map projections and coordinate systems	5	3 (15%)	Vector tiles
5	5 (25%)	Color	4	3 (15%)	GPS data collection using mobile devices
6	4 (20%)	HTML	4	3 (15%)	Multiscale map symbolization/ generalization
6	4 (20%)	Map critique	4	3 (15%)	Interaction design
6	4 (20%)	Using Story Maps	4	3 (15%)	Data visualization
6	4 (20%)	Interface design	3	3 (15%)	Web feature services
6	4 (20%)	Publishing geospatial web services	3	3 (15%)	JavaScript
4	4 (20%)	Consuming geospatial web services	3	3 (15%)	Social media geodata
9	3 (15%)	Animation			

Table 4. *TOPIC themes expressed by three or more interview participants.*

TOOL

The TOOL code was the most granular of all, applied to a specific piece of software, hardware, general category of technology, or vendor name. Participants mentioned using almost 200 different tools. Table 5 presents all 68 tools that were mentioned by two or more participants.

One thing is clear from this analysis: ArcGIS Online is king. Sixteen out of 20 participants made use of it to teach web mapping skills. Other Esri products are distributed throughout the left-hand side of the table, showing that vendor's current dominance in the web map marketplace. Thirteen participants mentioned Esri tools in general, ten discussed using ArcGIS Desktop/ArcMap, nine each used Story Maps and ArcGIS Server, seven used the Collector mobile app, five each used Esri's Web AppBuilder, JavaScript API, and web application templates, four mentioned Esri as a vendor, and three used Esri feature services. Half of participants (10) used Mapbox, making it Esri's top competitor as a proprietary web mapping service supplier; five also mentioned Mapbox Studio, that vendor's flagship web mapping interface. In the same category, Google Maps was used by eight participants, with its API taught by five, and various other Google products gaining a few mentions each. CARTO was used by seven, with its Builder application and API each mentioned by two. Leaflet, the most widely-used open source web mapping API, was taught by seven participants. Six participants used QGIS, an open source desktop GIS platform.

Many participants also covered web languages in their courses. HTML and JavaScript were mentioned by 12 and 11 participants, respectively, while CSS was mentioned by

Freq.	Instructors	Theme	Freq.	Instructors	Theme	Freq.	Instructors	Theme
93	16 (80%)	ArcGIS Online	7	5 (25%)	Web map service (WMS)	8	2 (10%)	Geoserver
52	13 (65%)	Esri tools	7	5 (25%)	Web feature service (WFS)	8	2 (10%)	OpenLayers
27	12 (60%)	HTML	5	5 (25%)	KML	7	2 (10%)	Python
61	11 (55%)	JavaScript	22	4 (20%)	GitHub	6	2 (10%)	HTTP
36	10 (50%)	Mapbox	14	4 (20%)	Adobe Illustrator	5	2 (10%)	URL
32	10 (50%)	ArcGIS Desktop/ArcMap	13	4 (20%)	Esri	5	2 (10%)	Vector tiles
36	9 (45%)	ArcGIS Server	11	4 (20%)	APIs	5	2 (10%)	Twitter API
22	9 (45%)	Esri Story Maps	6	4 (20%)	GPS	4	2 (10%)	Learning management systems (LMS)
14	8 (40%)	Google Maps	6	4 (20%)	Excel	4	2 (10%)	Canvas LMS
45	7 (35%)	CARTO	4	4 (20%)	XML	4	2 (10%)	Git
43	7 (35%)	Leaflet	15	3 (15%)	TileMill	4	2 (10%)	Survey123 for ArcGIS
16	7 (35%)	Preexisting web map applications	14	3 (15%)	Google Earth	3	2 (10%)	Shapefile
13	7 (35%)	ArcGIS Collector	11	3 (15%)	Amazon AWS	3	2 (10%)	TopoJSON
7	7 (35%)	Mobile device	6	3 (15%)	Instagram API	3	2 (10%)	CARTO Builder
15	6 (30%)	QGIS	6	3 (15%)	OpenStreetMap	3	2 (10%)	Notepad++
11	6 (30%)	CSS	5	3 (15%)	Google Fusion Tables	3	2 (10%)	Microsoft Windows
9	6 (30%)	Web browser	5	3 (15%)	Geospatial web services	2	2 (10%)	Course website
20	5 (25%)	Google Maps API	4	3 (15%)	Google My Maps	2	2 (10%)	YouTube
19	5 (25%)	ArcGIS API for JavaScript	4	3 (15%)	Esri feature service	2	2 (10%)	Google
16	5 (25%)	Mapbox Studio	4	3 (15%)	jQuery	2	2 (10%)	ColorBrewer
12	5 (25%)	GeoJSON	3	3 (15%)	Tableau	2	2 (10%)	Web server
9	5 (25%)	Web AppBuilder for ArcGIS	9	2 (10%)	OGC web services	2	2 (10%)	CARTO API
8	5 (25%)	ArcGIS Web Application Templates	8	2 (10%)	Google tools			

Table 5. *TOOL themes expressed by two or more interview participants.*

six. Of web standard geospatial data formats, GeoJSON was used by five participants, and KML and XML were each used by four. Geospatial web services were also popular, with WMS and WFS each mentioned by five and the broader category of OGC services to which those belong discussed by two. Two participants mentioned teaching students about vector tiles, which are used by Mapbox and Google for their tile services (and can now be produced by Esri's ArcGIS Pro and ArcServer). While no one specifically mentioned raster map tiles, three participants mentioned using TileMill, an open source desktop application that creates them.

MOTIVATION

The MOTIVATION code was applied to statements regarding why the participant chose to use a particular tool in their course. The 42 themes in Table 6 provide context for the prevalence or absence of tools listed in Table 5.

Two somewhat conflicting motivations occupy the top two positions in the table, with nine participants each. These themes demonstrate the tension between providing students with experience in industry-standard Esri products and exposing students to a wide variety of alternative tools

Freq.	Instructors	Theme	Freq.	Instructors	Theme
21	9 (45%)	Industry standard tool that students are likely to encounter in future jobs	4	3 (15%)	Department/program tradition or inertia
19	9 (45%)	Expose students to a variety of web mapping tools that may be useful in their future work	4	3 (15%)	Tool excites students
16	8 (40%)	Ease of use	4	3 (15%)	Tools provides valuable job skills
16	6 (30%)	Tools integrate into a full stack that addresses all course needs	3	3 (15%)	Lack of instructor time to explore possible alternative tools
8	6 (30%)	Tool is easier to use/teach than alternatives	5	2 (10%)	The tool demonstrates a particular topic well
8	5 (25%)	Free/no cost	4	2 (10%)	Tool makes accessing data easier for students
8	5 (25%)	Tool is popular/common	4	2 (10%)	Tools do not require programming skills
7	5 (25%)	Instructor is familiar/comfortable with tool	3	2 (10%)	Aesthetics of the tool
10	4 (20%)	Accessible to students	3	2 (10%)	Matches instructor's skill level/expertise
6	4 (20%)	Knowledge of tool is desirable to potential employers	3	2 (10%)	Tool provides an important web mapping component or concept
6	4 (20%)	Tool is covered by an institution-wide site license at no additional cost	3	2 (10%)	Tool provides a platform students can use to access another tool
5	4 (20%)	Interface is highly usable	3	2 (10%)	Tool enables students to easily create and learn about custom map tiles
5	4 (20%)	Tool enables students to gain transferrable skills	2	2 (10%)	Students can examine the inner structure of the tool
5	4 (20%)	Tool fits with instructor's ethical/ideological orientation toward open source	2	2 (10%)	Instructor saw a demonstration using the tool
4	4 (20%)	No time in course for exploring alternative tools	2	2 (10%)	Tool is fun/amusing
4	4 (20%)	Tool enables students to collect data in the field	2	2 (10%)	Prior relationship with software vendor
6	3 (15%)	Tool is powerful	2	2 (10%)	Web mapping is more accessible/approachable than desktop mapping software
5	3 (15%)	Instructor likes the tool	2	2 (10%)	Tool provides opportunity for remote collaboration
5	3 (15%)	Students are already familiar with the tool or its ecosystem	2	2 (10%)	Tool provides useful features for learning coding
5	3 (15%)	Students want to learn tool	2	2 (10%)	Tool enables data visualization
4	3 (15%)	Tools work well for particular course needs	2	2 (10%)	Prior/alternative tool was deprecated

Table 6. *MOTIVATION themes expressed by two or more interview participants.*

they may encounter in the future, thus encouraging adaptability. Notably, each approach sees itself as preparing students for future jobs.

Another broad, motivating theme was tool usability. Eight participants preferred using tools that are easy for both students and the instructor to figure out, and six similarly felt that the tool they chose was easier than the alternative tools they could have used. Six participants liked using tools that could integrate into a full stack of GIS technologies; this applied specifically to Esri products. Five participants each discussed tool popularity and their own familiarity with the tool.

Cost was an additional factor. Five participants expressed the need to use tools that were free, although this did not

Freq.	Instructors	Theme	Freq.	Instructors	Theme
20	13 (65%)	Final projects	4	2 (10%)	Open-book/repeatable online quizzes
21	11 (55%)	Hands-on/active learning	4	2 (10%)	Students engage in group discussion
9	8 (40%)	Students modify templates	4	2 (10%)	Students are encouraged to explore
7	6 (30%)	Students complete tutorials and exercises independently	4	2 (10%)	Curriculum addresses multiple learning styles
7	5 (25%)	Field data collection with mobile app	3	2 (10%)	Do not use lengthy lab assignment instructions
5	5 (25%)	Online discussion boards	3	2 (10%)	Balance between theory and practice
8	4 (20%)	Video tutorial/demonstration included in lesson	3	2 (10%)	Students choose which tools to use to complete an assignment
7	4 (20%)	Peer assistance encouraged	3	2 (10%)	Web maps are included as examples in lecture
4	4 (20%)	Simple/straightforward activities	3	2 (10%)	Traditional weekly lab periods
4	4 (20%)	Later exercises build on earlier topics	3	2 (10%)	Each assignment has learning goals/objectives
4	4 (20%)	Students find their own data for assignments	3	2 (10%)	Instructor teaches how to copy and paste code
8	3 (15%)	Peer critique	3	2 (10%)	Instructor assists students remotely using email, phone, and/or videoconferencing technologies
7	3 (15%)	Projects are open-ended	2	2 (10%)	Course gives students resources to pursue additional skills on their own
6	3 (15%)	Content should be fun	2	2 (10%)	Activities require multiple pieces of software to complete a task
6	3 (15%)	Students must figure out a solution through independent research	2	2 (10%)	Activities demonstrate the utility of GIS
5	3 (15%)	Instructor uses software/service problems as a learning experience	2	2 (10%)	Course includes traditional lectures
3	3 (15%)	Additional readings are assigned	2	2 (10%)	Course balances lecture and lab activities
3	3 (15%)	Deconstructing existing web maps	2	2 (10%)	Instructor demonstrates code examples
3	3 (15%)	Instructor directs students to online tutorials and resources	2	2 (10%)	Instructor focuses on design principles
3	3 (15%)	Students receive open-ended assistance during lab periods	2	2 (10%)	Students critique existing web maps
3	3 (15%)	Regular weekly or semi-weekly lab assignments	2	2 (10%)	Students engage in critical thinking and reflection
3	3 (15%)	Lectures are kept brief	2	2 (10%)	Students make a web map from beginning to final product
6	2 (10%)	Topics are carefully sequenced	2	2 (10%)	Students choose a topic of interest for their final projects
5	2 (10%)	Guest speakers are invited	2	2 (10%)	Bloom's Taxonomy
4	2 (10%)	Lecture material is posted online	2	2 (10%)	Instructor uses sandboxes to teach coding

Table 7. *PEDAGOGY themes expressed by two or more interview participants.*

necessarily also mean open source. The cost advantage of using a tool already covered by Esri's institutional site license was mentioned by four as a reason for choosing their tools. Interestingly, only three participants stated that the tool was chosen because it fit the needs of the existing course, and two each said that it demonstrated a particular topic or provided an important web mapping component or concept.

PEDAGOGY

The PEDAGOGY code was applied to statements about teaching philosophy, techniques, or methods used by the participant. This included but was not limited to statements using the name of a formal pedagogical model (e.g., Bloom's Taxonomy, active learning, etc.). Table 7 lists 50 pedagogical themes expressed by two or more participants.

Active learning was a key pedagogical approach discussed by participants. Eleven participants directly stated that they made their assignments active and hands-on, while 13 required their students to complete an independent final project at the end of the course to apply the skills and concepts they had learned throughout the semester. It was common practice to assign students existing web map templates to customize, with eight participants employing this strategy, while six said they had students work independently on assignments during lab periods.

Real-world applications were also seen as important. A quarter of participants (5) reported using Esri's Collector mobile app to have students collect location-tagged data outdoors on personal devices and upload that data to the ArcGIS Online platform, thereby demonstrating field data collection and processing workflows. Four participants reported requiring students to find their own data, keeping assignments relevant to their interests.

Several participants discussed different methods of content delivery through online learning management systems, used regardless of whether the class was primarily taught in person or online. These methods included hosting online discussion boards (5), generating video tutorials (4), posting lecture material online (2), and hosting open-book and repeatable online quizzes (2). Collaboration was also used frequently; multiple participants encouraged peer assistance (4) and/or integrated peer critique into project assignments (3). Several emphasized simplicity or enjoyment, including straightforward activities (4), keeping lectures brief (3), and keeping the course content fun (3).

CHALLENGE

The CHALLENGE code was applied to statements regarding what was hard or difficult about the course, for the instructor, for students, or both. Since modern web mapping technologies are both relatively new and technically complex, some challenge is to be expected. Highlighting the challenging areas may indicate where strategies should be developed for workarounds or improvements to instructional technique. Table 8 lists 31 themes, distinguishing whether each theme was primarily a challenge to the instructor, to the students, or to the course as a whole.

Unsurprisingly, given the rapid pace of change in web mapping technologies, most instructors (12) found keeping up with those changes difficult. Many discussed the implications of rapid change as well, including finding the necessary time to update their course curriculum (10) and finding the time to maintain and build their own technology skillsets (5). Two participants mentioned specific disruptions to their planned course content caused by unforeseen software changes just before or during the time when the course was offered.

For students, according to half of participants, the most difficult aspect of web mapping to learn was coding, particularly in JavaScript. Six reported that it was difficult to find adequate time to teach coding, while five discussed the paradoxical difficulty of teaching JavaScript skills to a set of students who do not necessarily enter the course with adequate background in general computing, and three saw this as a cause of students' difficulties learning the material. Four participants discussed their own lack of expertise in web mapping as an impediment to teaching it. Other challenges were more technical in nature, such as the difficulty of setting up and maintaining an in-house web server for the course (5), a lack of institutional support for required software (4), and outages in web services that were relied upon to teach the course (3). The latter theme particularly came up in interviews conducted after a worldwide outage of Amazon Web Services, which powers thousands of major websites and services, including the ArcGIS Online platform.

Freq.	Instructors	Theme	Freq.	Instructors	Theme
31	12 (60%)	Instructor: Keeping up with technology changes	5	2 (10%)	Students: Finding required data
20	10 (50%)	Students: Coding/JavaScript	5	2 (10%)	Instructor: Course revisions required by software changes
18	10 (50%)	Instructor: Time to update curriculum	4	2 (10%)	Instructor: Solving student problems
12	6 (30%)	Instructor: Instructional time required to teach coding	3	2 (10%)	Students: Completing tasks independently
9	5 (25%)	Instructor: Teaching computer science skills to students with little background	3	2 (10%)	Instructor: Balancing theory and skills
8	5 (25%)	Instructor: Server setup and maintenance	3	2 (10%)	Instructor: Student use of incompatible browsers or operating systems
8	5 (25%)	Instructor: Time to build or maintain own technical skills	3	2 (10%)	Instructor: Time requirements of teaching online
7	4 (20%)	Instructor: Lack of expertise in web mapping skills	2	2 (10%)	Instructor: Time required by students who struggle
5	4 (20%)	Instructor: Institutional software support	2	2 (10%)	Instructor: Time constraints of program
4	4 (20%)	Instructor: Low student motivation	2	2 (10%)	Students: Git/GitHub
5	3 (15%)	Students: Lack of prerequisite skills	2	2 (10%)	Students: Disruptions from software changes
4	3 (15%)	Instructor: Limited time in course to teach web mapping tools	2	2 (10%)	Course: Web service data or usage limits
3	3 (15%)	Course: External web service outages	2	2 (10%)	Students: Understanding cloud data storage
2	3 (15%)	Students: Software use and problem solving	2	2 (10%)	Instructor: Choosing which tools to teach
6	2 (10%)	Course: Limited bandwidth	2	2 (10%)	Instructor: Assessment and grading
5	2 (10%)	Instructor: Providing clear instructions to students			

Table 8. *CHALLENGE themes expressed by two or more interview participants.*

DISCUSSION

THE CURRENT STATE OF WEB MAPPING EDUCATION

The interview study revealed a great deal of variety but also some consistent patterns in course offerings. The participating instructors overwhelmingly saw web mapping as a career skill, and teaching it as necessary to prepare students for the current GIS job market. Some also viewed teaching these skills as enabling inquiry into broader critical and geographic questions. However, even those who stressed this aspect of web maps were clear on their overall purpose in teaching. One instructor exemplified their vision thusly: "By focusing on web mapping, by returning the explicit focus to spatial information and visualization . . . then we can really hone in on what makes geography and geographic thinking special, and the skills that my students have that their competitors don't in the job market or anywhere."

In terms of the overall scope of topics in participants' courses, four general threads emerged: *web mapping alone*, *web GIS*, *critical geography with web mapping*, and *web cartography*. Some instructors taught courses focused on web mapping as the exclusive subject matter of the course. However, this accounted for fewer participants than anticipated. In some cases, the course was focused on GIS or web GIS, with web mapping considered a subset of the technical skills curriculum. Several other participants saw web mapping as a gateway to geographic thought, critical theory, and/or "big concepts," in keeping with Manson et al. (2014). Finally, some introduced web mapping within traditional cartography courses, where the focus was primarily on visual design.

Enabling web technologies, data, and *design* ranked as the most taught topic areas. While a couple of participants included no coding at all in their web mapping courses, the majority saw a basic understanding of HTML, CSS, and JavaScript as vital, if challenging, to impart to students. Many included working with geospatial web services, which demonstrate how data layers and maps can be shared in real time across networks. However, managing the necessary server software, whether in-house or in the cloud, was frequently described as a challenge. Data—downloaded from traditional sources, collected in the field, or crowdsourced—and cartographic design are core components of web maps and were likewise key course topics.

In the market for teaching tools, Esri continues to exert dominance. While some interview questions were intended to prompt participants to reflect on the difference between open source and proprietary software and why they would use one over the other, most participants' answers showed this to be an amorphous divide. By far the more relevant division was between Esri and non-Esri software. Participants highlighted the need for tools to be *free*, *easy to use and teach*, and *relevant to students' future jobs*; for most, the type of software license was of minor or no concern.

Esri's ArcGIS Online platform provides a full suite of scalable tools and applications that cover virtually every component of web mapping architecture. At its basic, free tier, the software includes a hosted web mapping service with an accessible graphic interface. For client-side development, Esri provides an open-source JavaScript API, easy-to-modify application templates, and open access to many of its web services for non-profit use. Subscriptions to more advanced spatial analysis, data collection, and hosting capabilities are fully covered by the vendor's educational site licensing and thus entail no cost to instructors. Esri's desktop software, used in almost every introductory GIS course, is increasingly integrated with its online platform. Instructors stressed convenience, good documentation, vertically integrated applications, and absence of any additional cost as reasons for sticking with Esri, in addition to the vendor's continued dominance in the industry.

Nonetheless, there are downsides to Esri software that led some participants to consider other options. ArcGIS Server was frequently highlighted as difficult to set up and maintain. While templates are available for beginners to modify, the Esri JavaScript API is more complex than some open source mapping APIs. Some participants disparaged the lack of cartographic design guidance in ArcGIS Online. A couple rejected Esri software out of ideological adherence to free and open source. But the most frequently stated reason for using non-Esri software was simply to expose students to a wide variety of web mapping tools that they might encounter in the workplace. "I don't want [students] to know about just one thing, or one set of tools," opined one participant, "I want them to know about all kinds of tools out there, so they can be well equipped for whatever job position they happen to be going into."

In terms of pedagogy, hands-on active learning was seen as critical to student success. Several participants expected students to come up with their own data, or otherwise tried to make the learning relevant to students' interests. These are basic principles of constructivism, the philosophy that the role of the instructor is to assist students in building their own knowledge structures around the material (Foote 2012). They seem obvious in the case of a technical skillset such as web mapping, which operates at the uppermost, "create" level of Bloom's cognitive taxonomy, requiring students to synthesize concepts to produce an application (Anderson and Krathwohl 2001). Most instructors provided an exercise in creation via an end-of-term final project. What was not as expected was the prevalence of certain teaching techniques enabled by online learning management tools, such as hosting ongoing discussion boards and posting written and video tutorials for students to review. In particular, some participants commented on finding unanticipated benefits to posting lecture material and demonstrations online, such as increased comprehension among students for whom English is a second language, and the ability of all students to review the material and uptake concepts they may have missed during the class session.

The two greatest challenges in teaching web mapping were, unsurprisingly, teaching students how to code and keeping up with rapid technology changes in the industry. Most participants' courses are offered by a geography department or closely related discipline, so few students come to them with advanced computer science skills or programming experience (with some exceptions). There seemed to be consensus among participants that a single term is simply not enough time to turn beginners into coders at a higher than cursory level. Nonetheless, while a couple of participants avoided teaching any code, most considered basic knowledge of web languages important, even in courses with a broader scope such as web GIS. Several participants asked students to modify existing templates as an approachable way to learn some basic web development concepts.

With the available teaching tools changing quickly, many participants struggled to find time to update course materials as well as their own tool awareness and skillsets given other teaching and research commitments. Most software vendors and open-source projects will continue to support older versions after a new release, but those instructors who chose to use more innovative or cutting-edge products sometimes found themselves faced with acute disruption when a vendor chose to discontinue development of the selected tool. Further, the growing importance of interconnected cloud services may have promoted a false sense of security, as even the most trusted e-services were proven vulnerable to technical failure during the time period when interviews were conducted. Several participants had their courses disrupted on February 28, 2017, when Amazon Web Services—which hosts ArcGIS Online—suffered a major outage caused by human error, knocking those tools offline (Del Rey 2017). Taken together, these factors require web mapping instructors to be nimble and adaptable to change, while also maintaining technology blog subscriptions and attending technical conferences.

RECOMMENDATIONS FOR TEACHING WEB MAPPING

Based on the interview study results discussed above, it is clear that there are a variety of ways of integrating web mapping into geography, cartography, and GIS programs of study, and that the ultimate goal of each is to integrate spatial thinking with computational thinking and technical skills. The GIScience and Technology Body of Knowledge entry on Web Mapping (Sack 2017) lists ten learning objectives, which are organized according to the revised Bloom's Cognitive Taxonomy (Anderson and Krathwohl 2001; Table 9). These objectives were informed partly by the research I report here as well as prior research into web mapping course development (Sack and Roth 2017). All ten objectives should be included in new courses with a focus on web mapping, while critical

Learning Objective	Level in Revised Bloom's Cognitive Taxonomy
Identify examples of static, animated, and interactive web maps	Remember
Explain client-server network architecture	Understand
Explain how a tiled map mashup is created	Understand
Use a geospatial web service in a map or GIS project	Apply
Identify the source of data, representation, and animation or interaction in an example web map, and the roles played by each	Analyze
Critique the usability of existing web maps, including visual design choices, user interface, and interaction affordances and feedbacks	Evaluate
Determine a web map's intended purpose and assess its use of visual hierarchy and interaction based on that purpose	Evaluate
Design, construct, and publish an interactive web map	Create
Format the styling, text, layout, image resolution, and file type of a static map so that it can be included in a well-designed web page	Create
Publish a web map service or web map tile service	Create

Table 9. *Web Mapping Learning Objectives from the GIS&T Body of Knowledge entry on Web Mapping, organized according to Bloom's Cognitive Taxonomy.*

geography, cartography, and GIS courses may choose a subset to integrate.

The learning objectives in Table 9 form a measurable baseline of skills that students in web mapping courses should have at the end of the course. This sample is not intended as a comprehensive list of all possible learning objectives for web mapping and operates at the scope rather than the topical level of abstraction. Web mapping instructors should develop additional topical learning objectives that contribute to student success in this overall skill set. The depth of the curriculum depends on the course scope; broader-scope courses necessarily will not be able to accomplish as many web mapping objectives. A professional-level mastery of these skills will require multiple semesters of integrated coursework.

The pedagogy best suited to achieving these learning objectives is rooted in constructivism. There is little dispute in the literature and in the study results that active learning focused on real-world problems and applications is key to student success with web mapping. The constructivist principle of scaffolding and the open source principle of innovation based on manipulation of prior work can guide the assignment of learning activities, such as modifying existing web map templates (Schultz 2012; Balter 2015). Online learning management systems and robust web-based collaboration tools should be employed as central features of the coursework, not left out or treated as an afterthought. These tools reinforce both metacognition and collaborative troubleshooting skills that are essential to web development.

Support at the program and institutional levels is essential to the successful implementation of web mapping coursework. Information technology (IT) support staff must be willing to collaborate with instructors on making both client- and server-side web mapping tools available to students while maintaining network security. Before teaching a web mapping course, instructors should thoroughly plan what technologies will be needed and check with IT staff on the amount of notice required to install the software on institutional machines and what level of support can be provided during the course. Depending on the institution, instructors may need to be prepared to find creative workarounds involving cloud-hosted services if a desired tool cannot be made available to students. The choice of specific technologies used to achieve the web mapping objectives is much less important than emphasizing the adaptability and transferability of the design and development concepts involved in web mapping.

Given the pace of technology change, instructors must also make the case to their administrative and supervisory personnel for release time and funding to enable professional development and curriculum development. Given the rapidly growing importance of programming and web development skills to STEM careers, institutions and programs that wish to produce successful graduates must give instructional faculty the resources they need to develop these skills themselves and integrate them into cartography and GIS curricula.

CONCLUSION

Web mapping and coding skills are vital within the cartography and GIS career fields. Yet academic web mapping instruction remains in the pioneering phase, with relatively few institutions offering it in some form. Those that do offer it use a range of approaches that vary by scope of subject matter and depth of skills taught. Some instructors teach web mapping as a stand-alone subject, while others embed it within a broader context of GIScience, cartography, or critical geography theory. The former courses tend to go deeper into the technical skills, including a heavy emphasis on JavaScript coding, while the latter tend to include coding as a minor component or not at all due to the time requirements and lack of prerequisite skills in students. There are some exceptions to this trend, such as one interview participant who focuses heavily on technical skills but works in critique of the ontologies of geographic information and geospatial technology.

The newness of the field, the rapid pace of technology change, and the lack of prior experience with computer programming among the current generation of students pose major challenges for instructors of web mapping courses. Institutions have a major role to play in supporting the development of such courses, and given the demand for web mapping skills, it is in their interest to do so. Administrators can support instructors by lightening teaching loads to allow time for research, development, and updating of course materials, as well as providing funds for conferences and workshops. IT staff can help by dedicating time to working with instructors to install and configure necessary software, and by reducing lead time for new software requests as much as possible.

Despite the challenges, the participants interviewed for this study demonstrate that web mapping instruction is possible in a wide range of higher education settings given minimal instructor knowledge of the technology and a willingness to experiment. Web maps are no longer the maps of tomorrow; they are the maps of today. Training in web mapping technologies should be considered mandatory for future cartographers. The strategies exposed by this study should serve as inspiration for cartography and GIScience educators everywhere to develop courses that provide their students with these essential skills.

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How we Made "The Melting of Antarctica"

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The following is an updated edition of an article that originally appeared in Source*:* ***source.opennews.org/articles/melting-antarctica***.

For over 120 years, *National Geographic* magazine has been mapping Antarctica, maintaining a commitment to visually illustrating the complex processes that occur on this remote continent. The National Geographic Society's interest in Antarctica began in 1892, when it sent a small team of scientists to the southern continent to build on previous work by other explorers: Álvaro de Mendaña in 1567, Anthony de la Roché in 1672, and James Cook in 1772. Four steam whalers set off from Dundee in Scotland—an expedition that would result in *National Geographic*'s first map of Antarctica, by Dr. James Murray (Figure 1). This hand-drawn map was the first of over 50 maps of Antarctica and the Arctic to be featured in the magazine—making the poles one of *National Geographic*'s most heavily mapped geographies.

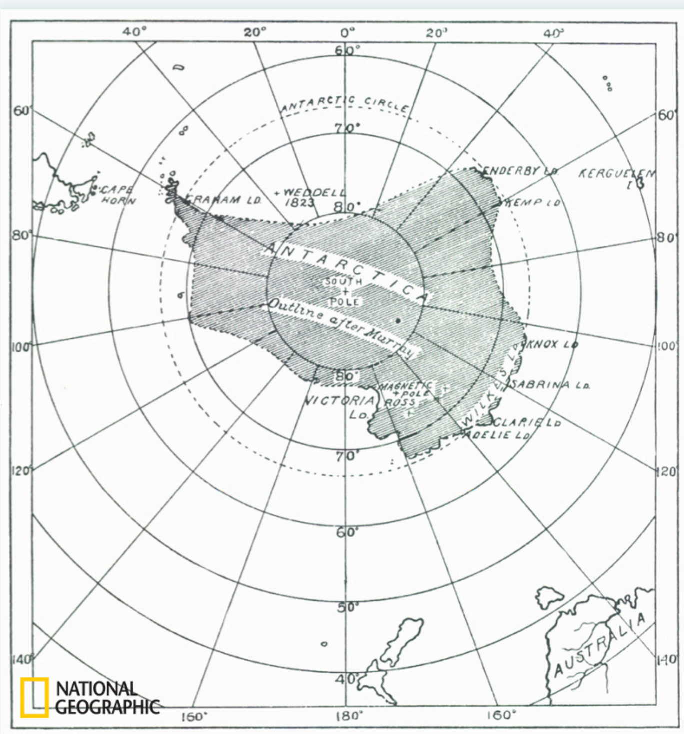

Figure 1. *"The Antarctic Continent," December 1894.*

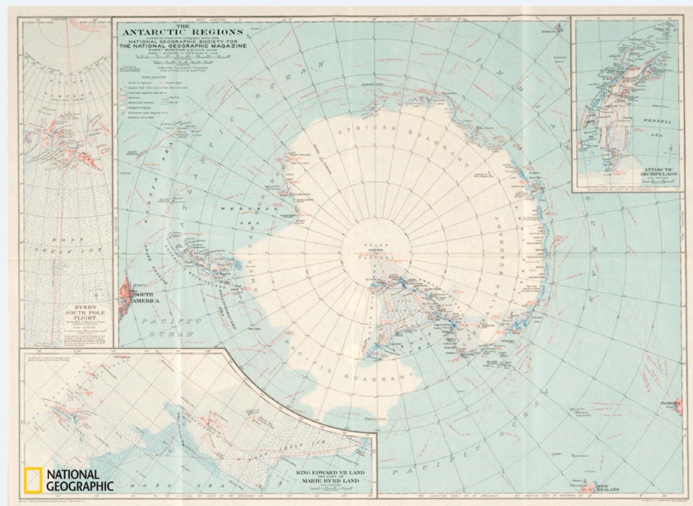

Figure 2. *"The Antarctic Regions," October 1932.*

National Geographic's first supplement map of Antarctica was featured in the October 1932 issue (Figure 2), and shows the significant progress that had been made charting the coastline since Murray's attempt 40 years prior. State of the art cameras brought unprecedented images of the great southern continent.

Among other excellent efforts in the following decades, in November 1971 the magazine published a single-page map with hand-drawn relief, with a perspective looking down the Antarctic Peninsula to the South Shetland Islands (Figure 3).

More recently, in September 2011, cartographers Ginny Mason and Stephen Tyson mapped Robert F. Scott and Roald Amundsen's expeditions to the South Pole in 1911–12 (Figure 4). The colors, texturing, and perspective truly place the reader in the frigid, harsh landscape alongside the explorers.

Today, the mapping tradition continues, with *National Geographic* actively pursuing its interest in Antarctica. In 2017, while at the magazine, I worked with senior graphics editor Jason Treat, and freelancer Stephen Tyson to create latest the installment of *National Geographic*'s Antarctic maps, highlighting the impact of climate change on the continent (Figure 5).

Figure 3. "Antarctic Peninsula," November 1971.

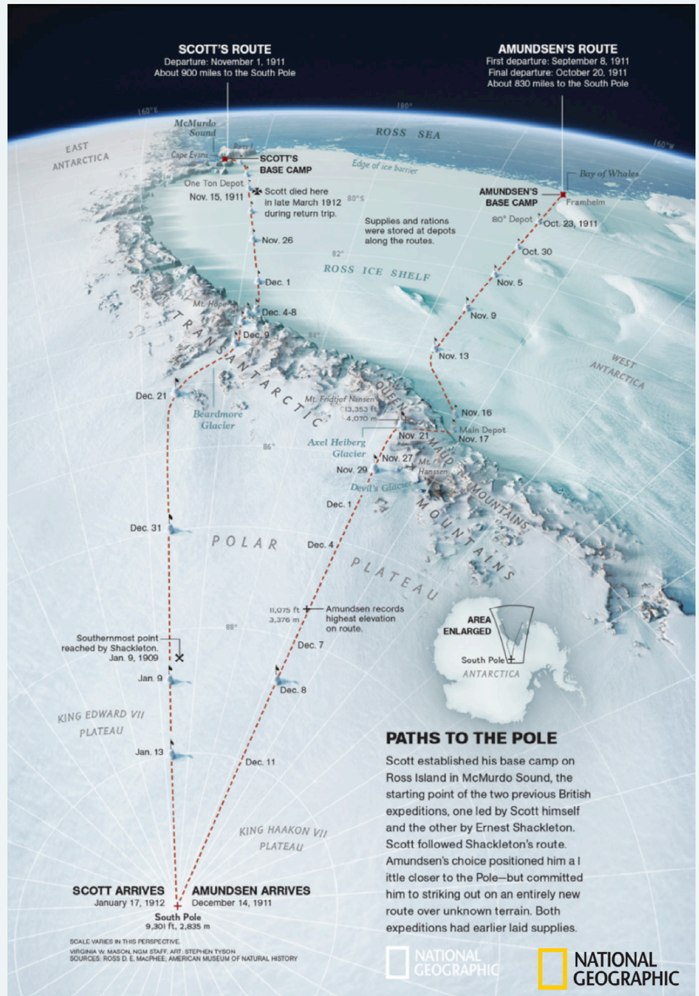

Figure 4. "Paths to the Pole," September 2011.

MAKING THE MAP

The creative process in the *National Geographic* magazine maps and graphics department involves an intensive process of multiple critiques, edits, adjustments, and tweaks over the course of weeks or months. And it all starts with a sketch. In January 2017, I drew up my first brainstorming sketch for our Antarctica map, to be published in the July issue of that same year. I remember making it during a meeting for another story I was working on (a map of the black-crested macaque's habitats on the island of Sulawesi in Indonesia—worlds away from Antarctica), with the sketch buried amongst the meeting notes. It's not the prettiest, but even the roughest sketch is critical to getting into the creative mindset needed to begin a project before getting locked down in the software.

I drafted several ideas, starting with a traditional top-down representation, then breaking apart the continent

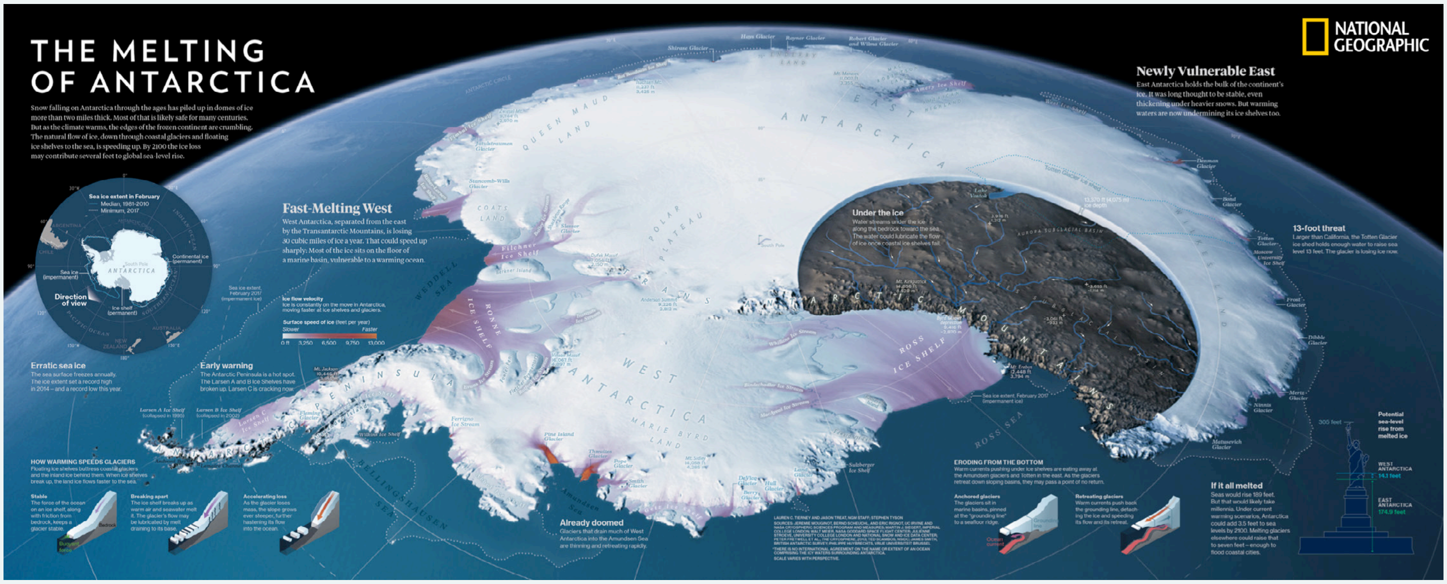

Figure 5. "The Melting of Antarctica," July 2017.

into two separate maps to experiment with explaining the dynamics of western vs. eastern Antarctica, and then experimenting with this method in perspective view for both sides of the continent.

These early options (Figure 6) were drafted to fit a full spread (about 10 by 12.5 inches), until we tried our luck drafting a double-gatefold spread (Figure 7) to pitch to our directors (for context, a double-gatefold is about 10 inches high and about 25 inches wide). This is not the sort of space that we frequently get for maps and graphics in the magazine. I began penciling a full-blown, perspective map of Antarctica that featured the full continent.

The directors loved the idea, and we got approval to move forward with the double-gatefold spread for the map.

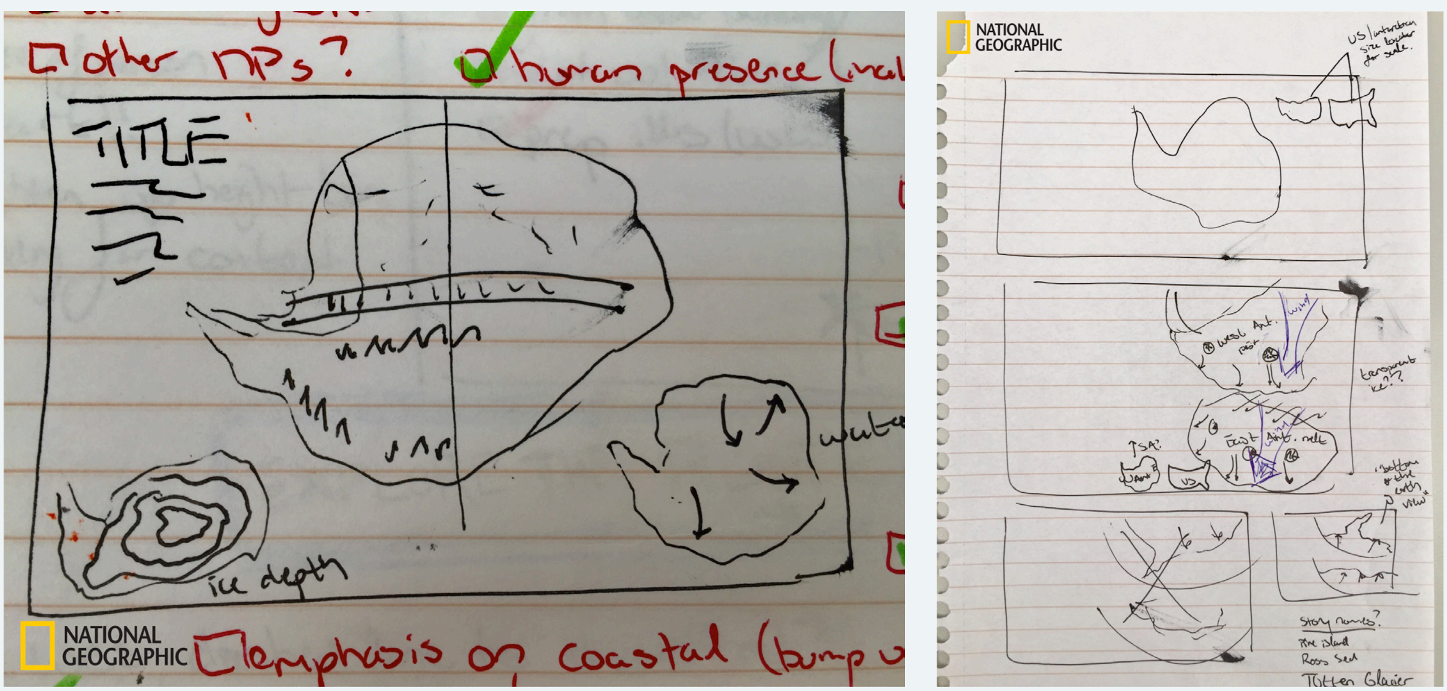

Figure 6. First (left) and second (right) rough sketches of "The Melting of Antarctica."

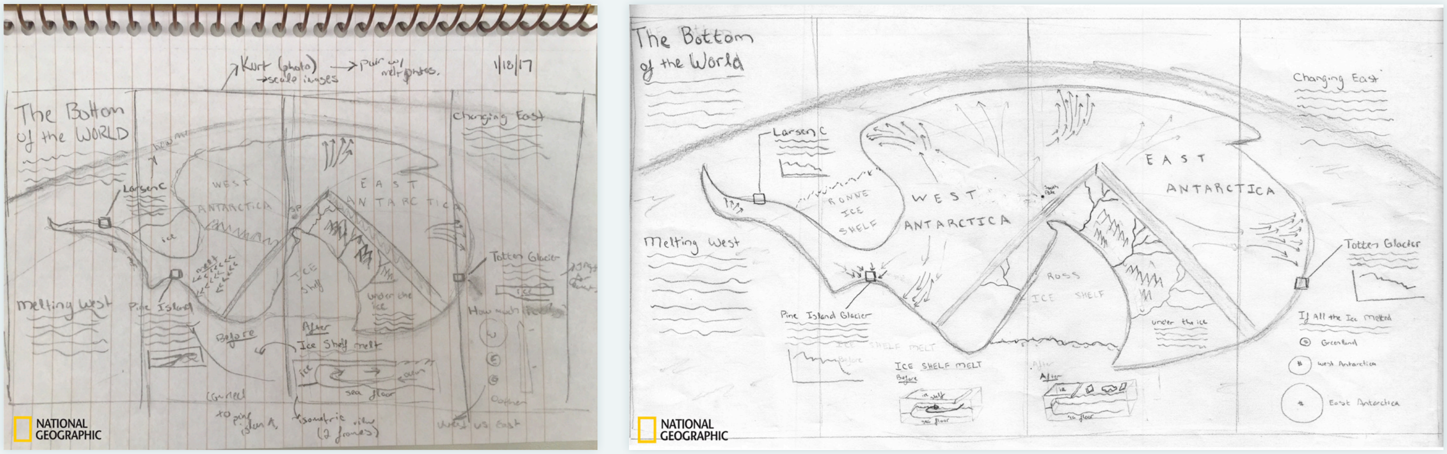

Figure 7. Initial sketches of a full double-gatefold layout.

Along with our layout, we also got approval for our main thematic elements. The four thematic goals of the map were to:

- compare the western and eastern sides of the continent, and how one is changing more rapidly than the other;
- demonstrate that ice is constantly on the move (referred to as "ice velocity") on the continent, and how some places have been speeding up more than others due to climate change;
- illustrate what's going on under the ice (subglacial rivers and lakes); and
- highlight how warming waters are changing the dynamics of the ice shelves that hold back the glacial ice on the continent.

With the layout and proposed thematic elements approved, we jumped into the software. I worked on the main map for the piece with Stephen, who used Maya to render the base map elements and Adobe Photoshop to fine-tune the 3D rendering. Our first step was to figure out which angle would communicate the vastness of the continent, and figure out the appropriate shape for the under-the-ice cutout. The early drafts, which were in greyscale, were commonly referred to by our creative director as "Death Star renderings" (Figure 8).

Once we got the angle of the perspective approved, we began to add color, draft the map notes, add small explainer graphics, and experiment with the locator map. My colleague Jason added graphics along the bottom of the spread, including a graphic of the Statue of Liberty to illustrate how much sea level would rise if all of the ice

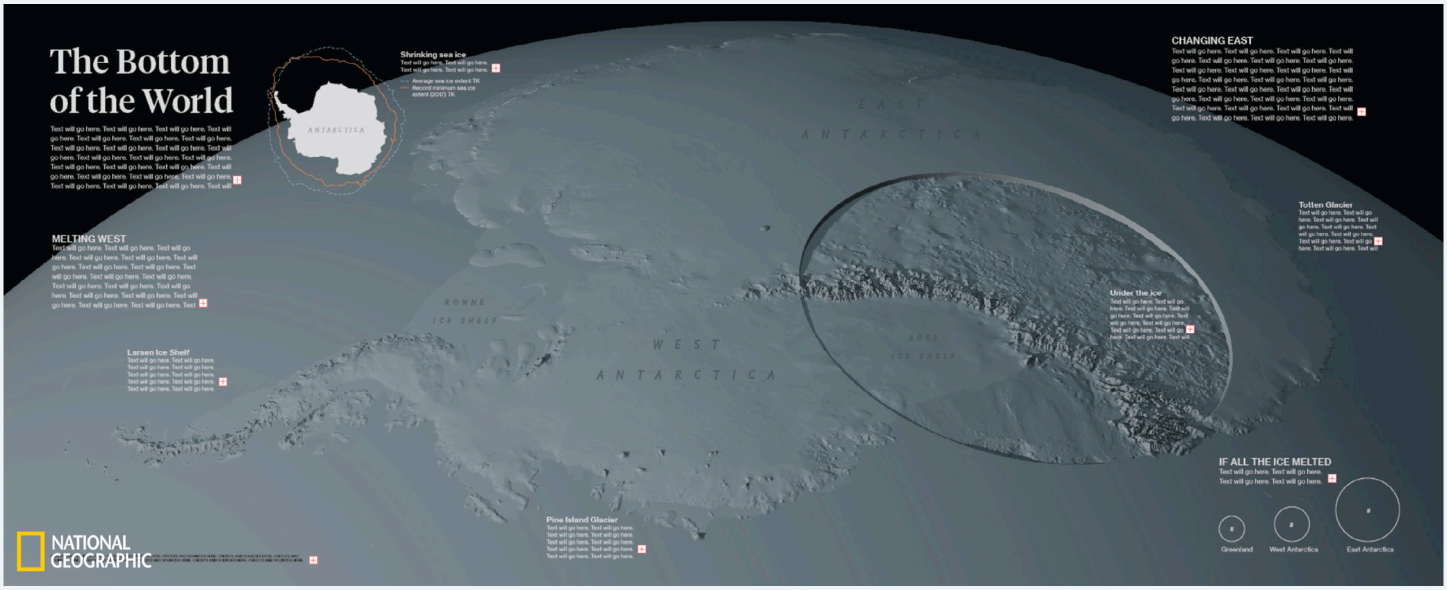

Figure 8. First render done in Maya.

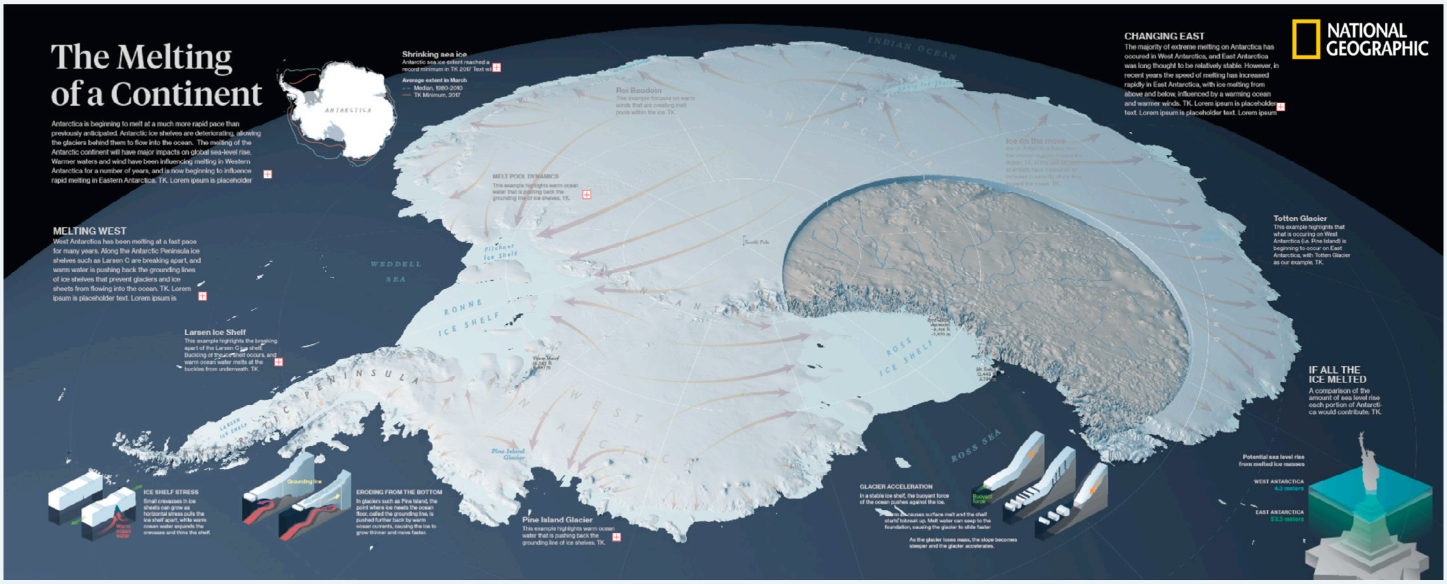

Figure 9. *Adjusting the thematic components of the map in Photoshop and Illustrator.*

on Antarctica were to melt—this provided context for the sheer quantity of ice on the continent (Figure 9). I also began to experiment with how to visualize the ice flow velocity, trying my luck with some colored arrows (spoiler alert: it didn't pan out).

We experimented with rendering the sea ice surrounding the continent, which, while beautifully depicted, made the map very busy and crowded (Figure 10). We also reminded ourselves at this stage that the goal of the map was not to recreate the entire landscape of Antarctica. The goal was to give a window into the dynamics of climate change on the continent, and to do this we needed to stay more on the "graphics" side of the spectrum, rather than the "rendering" side.

We opted for a line and slight tint boundary to give the extent of the sea ice. We expanded the locator map to show the average sea ice extent and the record low sea ice extent, which cleared space on the main map for the map notes and graphic elements and boosted the usefulness of the locator map.

To reach the final product we continued to fine-tune the map labels, graphics, and notes. The title went through three different versions, and we simplified the Statue of

Figure 10. *The addition of sea ice caused the map to feel crowded.*

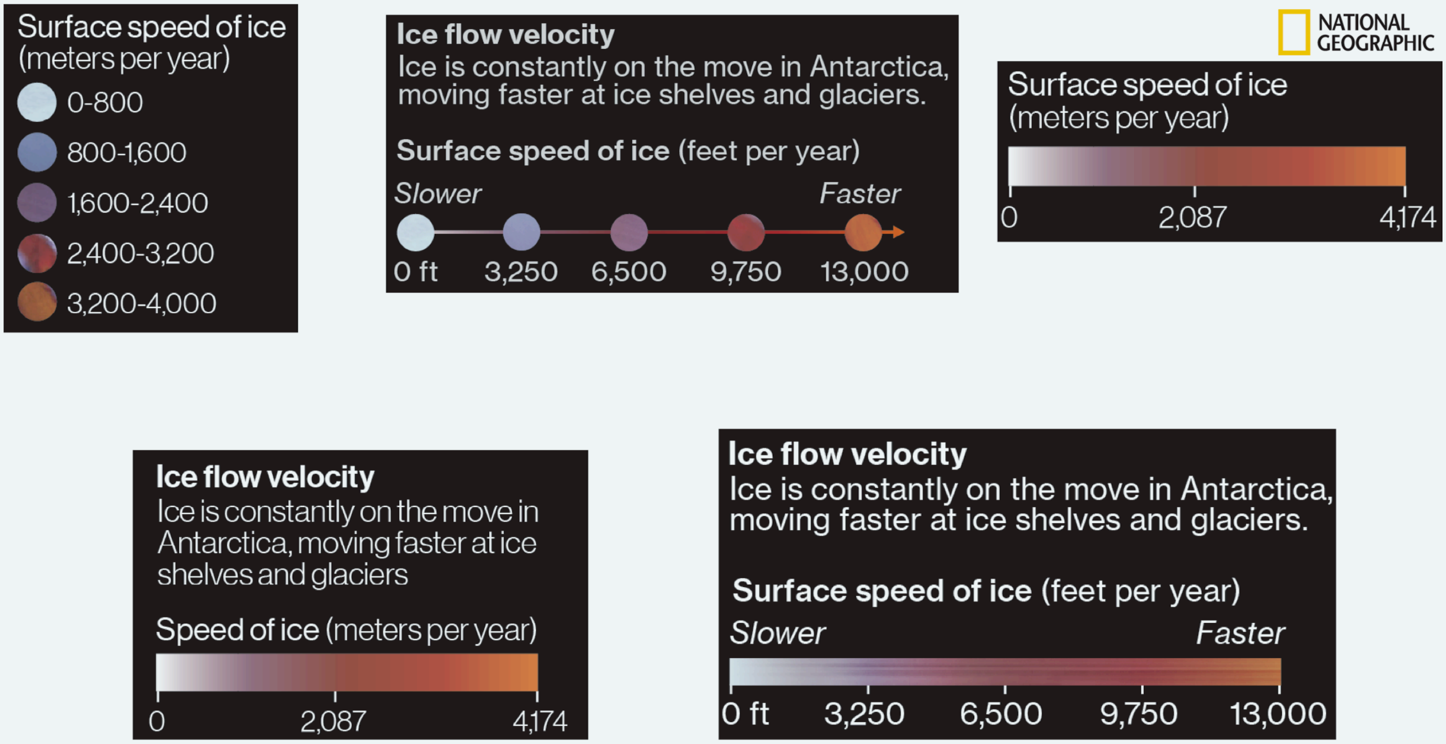

Figure 11. *Examples of different iterations of the ice flow velocity key.*

Liberty graphic to match the overall feel of the map. We blended the map labels in with the landscape, adjusted the lighting and shadows to emphasize volume of the ice, and adjusted the final purple-red-orange color ramp for the ice flow velocity.

ADJUSTING THE DETAILS

Each tweak, adjustment, and content change made a difference in creating the final piece. Some map elements went through many more iterations than others, including the map key and the arrows to emphasize ice flow velocity.

The key for the ice flow velocity went through many, many iterations (Figure 11; I estimate that we made 10 different versions). We began with a categorical version, and eventually evolved to a continuous ramp to emphasize the flowing nature of ice on Antarctica. As a final touch, we added the same streaking texture that appeared on the map to further drive home the connection between key and map.

For representing the ice flow velocity, we weren't fully confident that the streaking texture/effect alone would emphasize the movement of the ice, so we experimented with arrows on the edges of the ice shelves, where ice flows

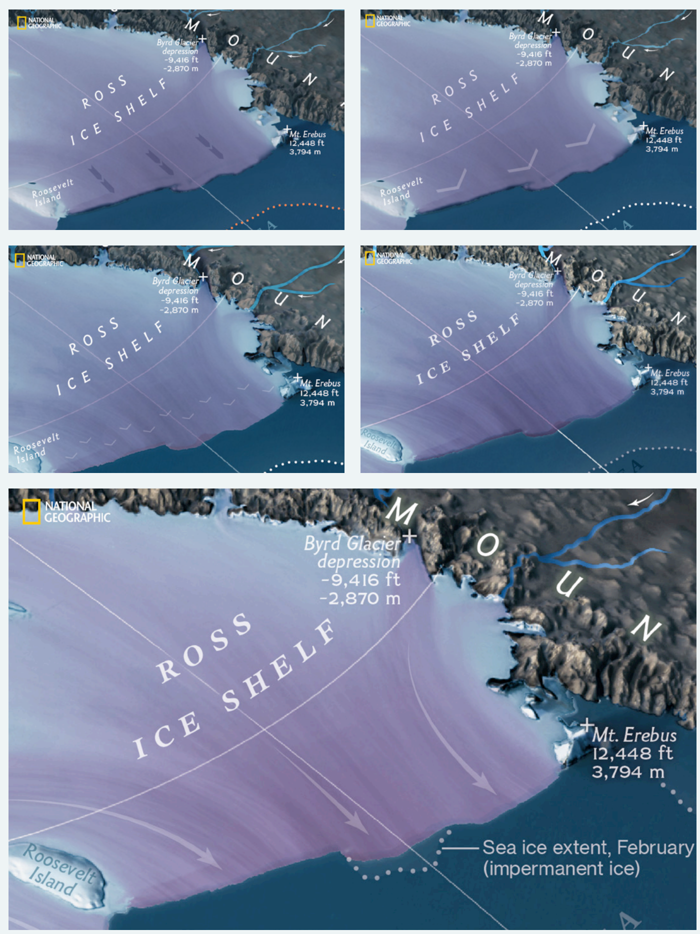

Figure 12. *Examples of different arrows to indicate movement of ice along the shelves.*

the fastest. We tried many varying versions: blocky arrows, blocky chevron arrows, big chevrons, lots of little chevrons, a brief period of no arrows, and then settled on a delicate, tapered arrow to subtly emphasize the flowing nature of the ice (Figure 12).

Figure 13. A map of Greenland from the January 1956 issue was inspiration for the golf flag symbol for the South Pole.

LOOKING TO THE PAST

We drew a lot of inspiration from historical *National Geographic* magazine maps of Antarctica and the Arctic. One of my favorite historical touches that made it into our map was the "golf flag" for the South Pole, inspired by an illustrated map of Greenland, published in the January 1956 edition of the magazine (Figure 13), and encouraged by the Director of Cartography at the time, Damien Saunder.

We also drew from the past for examples of cutaways at the poles, particularly a map of the route of the submarine USS *Skate* from the July 1959 issue (Figure 14), to explain what lies beneath the ice. This proved pivotal for representing the flow of water below the ice on Antarctica.

Through the process of looking to the past for inspiration we also saw that some of our ideas that we believed to be original had actually already been done in the past. For

Figure 14. *This "below the ice" map from the July 1959 issue was inspiration for the cutaway on "The Melting of Antarctica."*

example, our perspective view of Antarctica was not the first time the whole continent of Antarctica had been featured in perspective in the magazine (Figure 15).

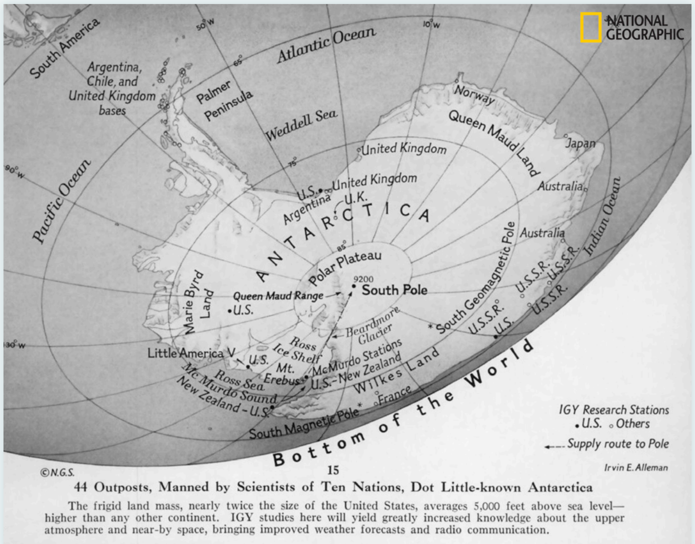

Figure 15. Another instance when Antarctica was portrayed in perspective view was in this July 1957 map of scientific outposts in Antarctica.

REACHING A DIGITAL AUDIENCE

After months of research, proof of concept tests, drafting, data wrangling, and designing, we sent the final version of the map to the printers, approximately two months before it would arrive at newsstands. We then turned our focus to the digital representation of "The Melting of Antarctica."

Jason sketched out the first storyboard sketch for the digital component to be flexible as either an interactive digital rollout or a video (Figure 16). After much discussion, we decided to go with a video. We wanted to try something different from the more common interactive projects in order to effectively translate a 25-inch-wide print piece to mobile.

For the video Jason and I teamed up with filmmaker Hans Weise and animator Jennifer Smart. We used renderings done by Charles Preppernau for the title and closing scenes. One of the biggest challenges of the digital version was staying true to the look and feel of the original print piece. We created all new maps and I styled them to match Stephen's texturing and lighting from the print

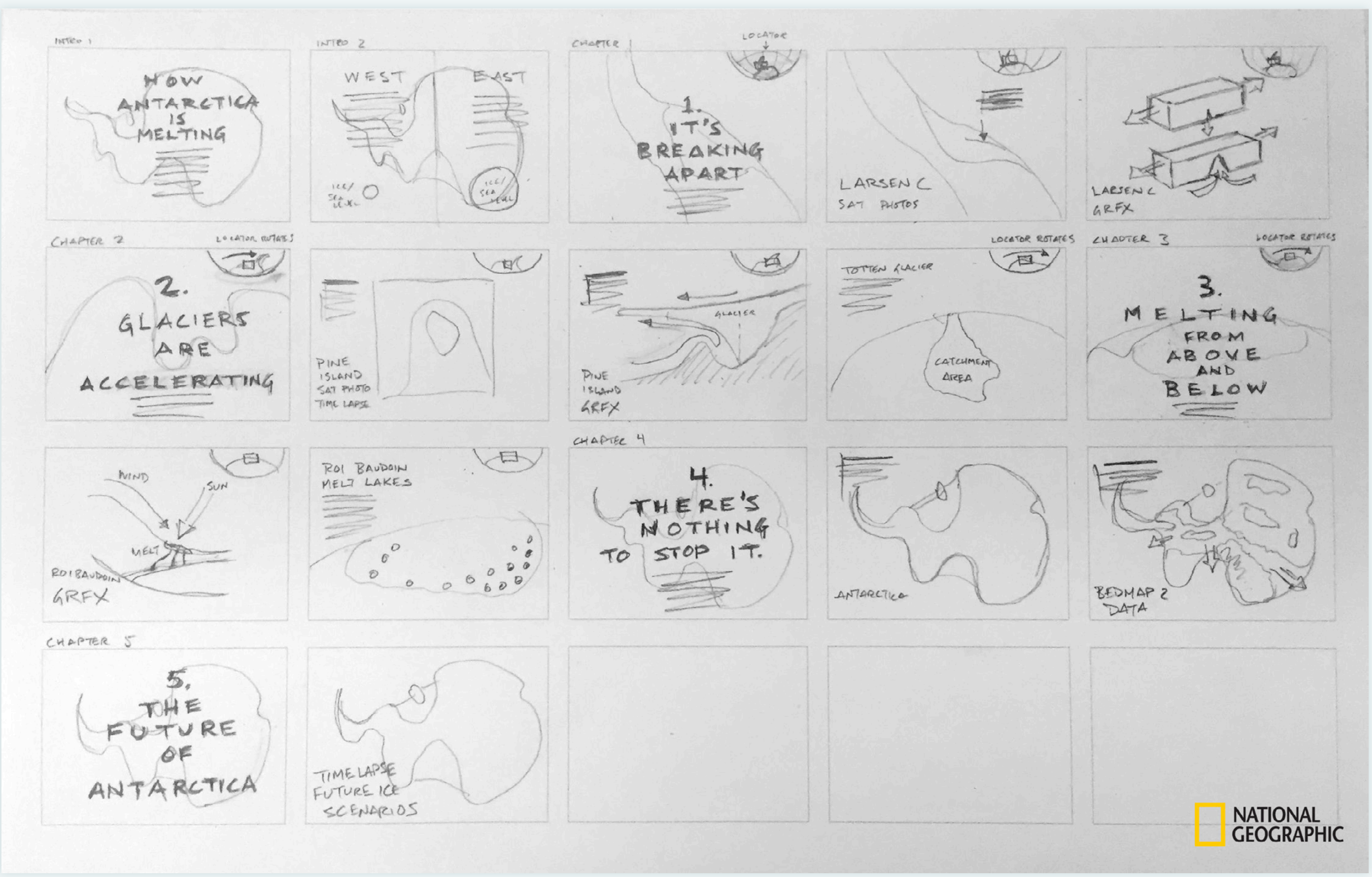

Figure 16. Initial storyboard sketch for the digital version of "The Melting of Antarctica."

piece. These new maps were needed for the video so that they could be used multiple times to communicate the different thematic elements and place the viewer at particular locations at different times in the video.

To generate the hillshade for this new map, I used the open source program Pyramid Shader (**terraincartography.com/PyramidShader**). I exported several different hillshades with different levels of generalization and slightly different sun angles. This gave the ice on the top-down map a greater sense of volume.

I brought the hillshade layers into Photoshop and used some tricks from Tom Patterson's illuminated shaded relief tutorial (**shadedrelief.com/illumination**) to build the relief for the map. I overlaid this on top of a satellite image of the continent, and adjusted layer transparency settings to get a final product that matched the feel of the original print version (Figure 17).

The final design of "The Melting of Antarctica," in both print and digital forms, required months of extensive fine-tuning of the map and graphic elements, as well as the incorporation of cartographic elements that drew from historic *National Geographic* maps of Antarctica, tying the map more closely with its predecessors. From initial concept to final design, it took over six months of planning, research, layout alteration, and cartographic fine-tuning to accurately communicate the effects of climate change at the bottom of the world.

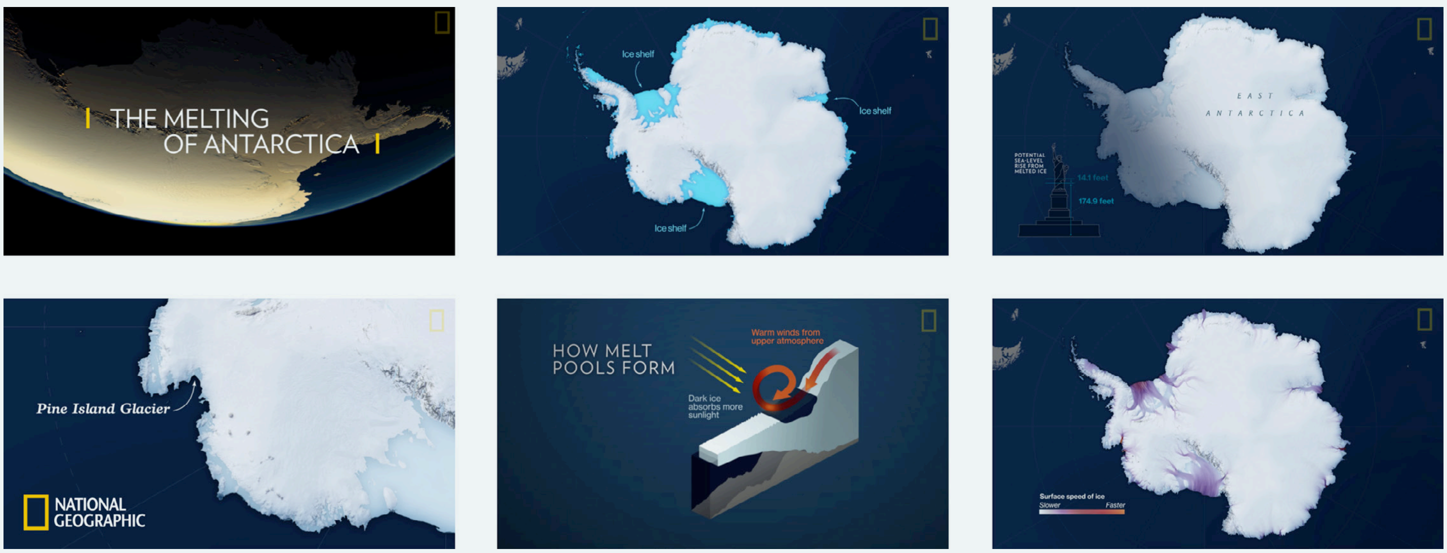

Figure 17. *Scenes from the final video version of "The Melting of Antarctica."*

"THE MELTING OF ANTARCTICA"

Click to watch the full video of "The Melting of Antarctica."

WATCH LAUREN'S PRESENTATION

Click to watch Lauren's NACIS 2017 presentation on the making of "The Melting of Antarctica."

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Mapping the Otherworld

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I started making fantasy maps just to see if I could. As a young cartographer whose only experience with mapmaking was in a university classroom, the possibility of making maps without using a GIS was somewhere far from the forefront of my mind. But through the a cyclical process of gathering inspiration and then practicing, I began to realize that fantasy maps represent a different way of approaching cartography. The maps themselves become part of a story, influencing plot and character development. In turn, the maps are altered to fit the story in a creative feedback loop that culminates with the completion of both narrative and graphic works. For consumers of

The Isle of St. Jezebeth

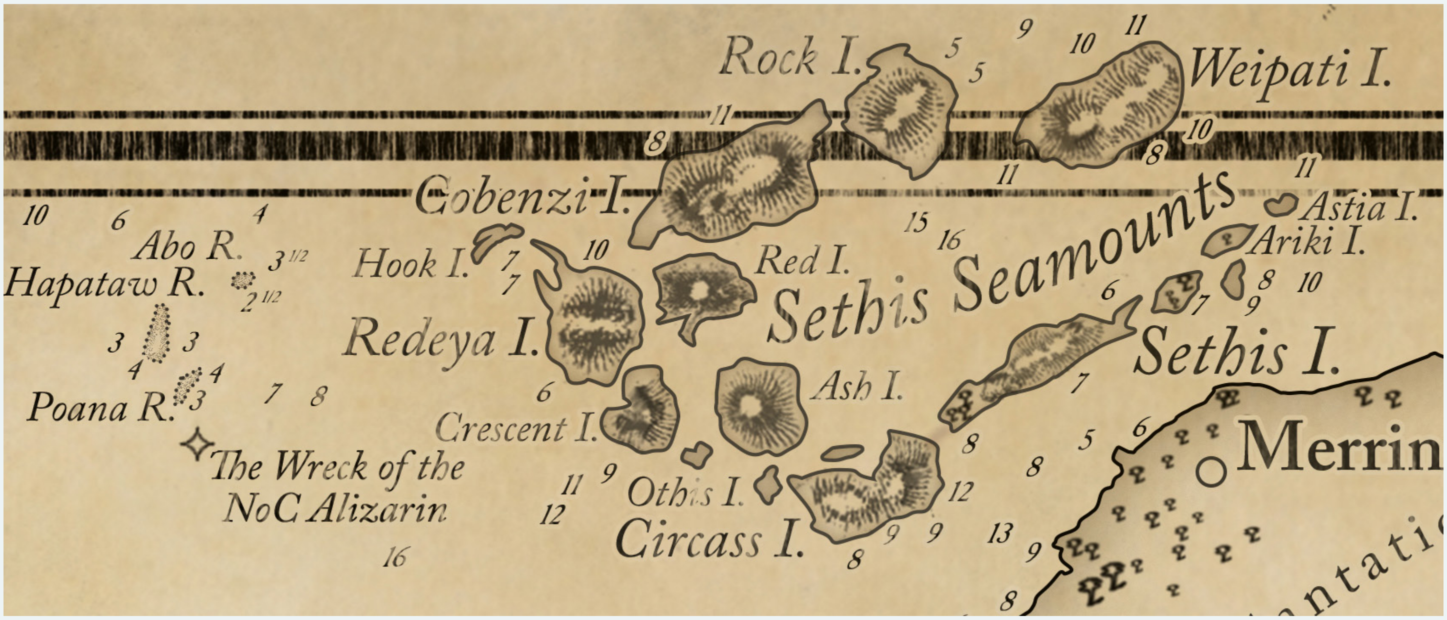
fantasy literature, film, or games, a map can be as valuable as the text of the story itself. In a setting that is necessarily opaque, maps can grant insights into the people, places, and ideas that are critical to otherworldly stories. Here are just a few examples of fantasy worlds I have created over the years.

THE ISLE OF ST. JEZEBETH

The native peoples of St. Jezebeth once considered their island, named *Noelani R'eo* in their native language, an oasis in a threatening sea—the end of the navigable ocean. To the east it is edged by sharp reefs with temperamental tides and jagged atolls that seem to appear from nowhere. Yet, the original settlers of the island saw fit to put down roots here. And why not? The island offers ample root crops to serve as a dietary staple, open shores for easy fishing to the south and west, and enough land to spread out while remaining one loose collective. *Noelani Re'o* seemed a fitting end to generations of seafaring and migration. There was not always peace among the various native peoples, but at least a communal sense of purpose united the island.

All of that changed with the arrival of the New Men from across the sea. In truth, they were explorers from the seafaring nation of *Cinza*. A sea captain named Zora finally made landfall after a handful of false starts and ships run aground on the serrated barriers west of the island. Discovering the wealth of natural resources before her, Zora returned to her home country and ushered in successive waves of settlers, who brought conflict, trade, and ultimately conquest to the island, now named after the Cinzan saint of splendor. What Zora, and all the men and women who followed, could not predict was that an unassuming plant, found high in the uplands of *Noelani Re'o* would contain an otherworldly force capable of threatening *Cinza* and its neighboring nations. Primordial forces deep below the island, funneled to the plant through the fertile volcanic soil, will soon ignite the ambitions of *Cinza*. But no such boon comes without cost, and soon that nation will be forced to reckon with the consequences of its imperial ambition.

The Isle of St. Jezebeth (detail)



The Isle of St. Jezebeth (detail)

AZRAGHAEL

Azraghael is a continent on the verge of a radical scientific breakthrough. Universities routinely churn out brilliant scholars, artists, and philosophers. Aided by a new sorcery that allows a mage to place text on a scroll using only their mind, scholars in *Jementah* have begun a sweeping program aimed at spreading once-hidden knowledge. Thanks to the perfect confluence of physical resources and spells that distill the night sky into transportable instruments, navigators from *Cinza* have expanded *Azraghael's* collective knowledge of the skies, seas, and storms. Magic facilitating long distance communication and the flow of information has helped many of the nations of *Azraghael* to develop networks of scientific communities.

Still, *Azraghael* is not Eden. It is a patchwork of shifting alliances, a mottled quilt of historical conflict and marriages of power that are complicated by these recent scholarly advances. The barbarian tribes of *Tuon* are a looming threat. *Hezhe* marshals for war against *Jahora*, putting the security of these southern nations' staple rice crops in jeopardy and threatening the food supplies of their desert neighbors. And a growing demand for luxury resources spurs coastal nations into overseas expansion, conquest, and extraction. Across the sea, the nation of *Cinza* arrives on the shores of a previously uncharted island, returning to *Azraghael* with fascinating discoveries that could usher in prosperity across the continent—or spell its downfall.

The Isle of St. Jezebeth (detail)

Azraghael

Azraghael (detail)

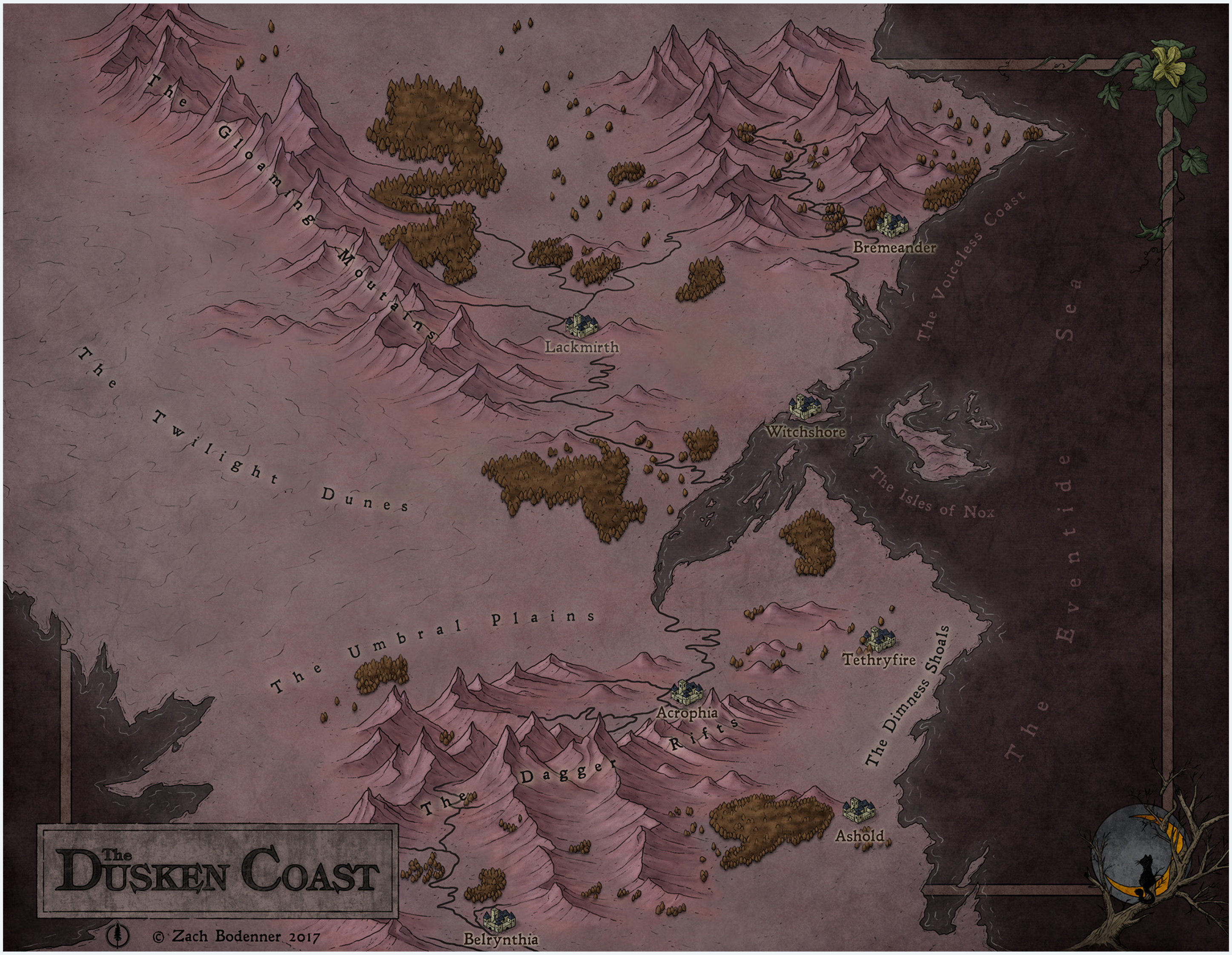
Azraghael (detail)

THE DUSKEN COAST

The Dusken Coast is a land of gloom, perpetual twilight, and paranoid intercity tension. Its cities are remote, confined by the grim and lifeless Twilight Dunes to the west, and endless Eventide Sea to the east. The stretch of coast is rugged, with jagged peaks, dense forests, and broad expanses of little but dry, craggy ground and barely arable soil. Rainstorms are rare, but the clouds never seem to part over this foreboding and unpleasant land.

Days of excess and prosperity are but a remembered dream, living on in the lore and decaying infrastructure of once-mighty cities. Whitewashed walls have aged into musty, stained relics. Civic structures crumble, and few, if any, statues have survived the intermittent periods of iconoclasm. Wars between cities have been bloody and never conclusive. Legacies of espionage, sabotage, and dark magic have poisoned the minds of each city against the others. The citizens of *Belrynthia* have not forgiven the mages of *Acrophia* for delivering a plague of insects that destroyed valuable timber resources. Is *Acrophia* not responsible for the decline of *Ashold* as well? *Bremeander* will forever blame soothsayers in *Witchshore* for saltwater migration up their life-sustaining river.

The Dusken Coast (detail)



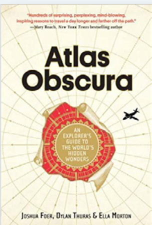
The Dusken Coast

This place is bleak, and the future holds promise only in the mind of the unreasonable optimists. Whispered prophecies spoken at a hermitage deep in the *Gloaming Mountains* tell a story of a great hero who will unify the Dusken Coast after one final, bloody conflict. Of course, everyone knows that prophecies never come to pass.

Visual Fields focuses on the appreciation of cartographic aesthetics and design, featuring examples of inspirational, beautiful, and intriguing work. Suggestions of works that will help enhance the appreciation and understanding of the cartographic arts are welcomed, and should be directed to Section Editor Matt Dooley: **mapdooley@gmail.com**.

The Dusken Coast (detail)

ATLAS OBSCURA



By Joshua Foer, Dylan Thuras, and Ella Morton

Workman Publishing, 2016

470 pages, $35.00, hardcover.

ISBN: 978-0-7611-6908-6

Review by: Bob Hickey, Central Washington University

Unlike the subjects of other reviews I have written, *Atlas Obscura* is neither a textbook nor a normal book. It's more of a very selective encyclopedia.

As such, it isn't something one normally would sit down and read—nor is it something I would assign to a student.

That said, it was great fun to flip through, and it's something I'll reference before future trips!

So, what is it? *Atlas Obscura* is a compendium of 600 odd, weird, different, obscure, spectacular, and gross places you can visit—with a few random lists tossed in to break things up. Is it subjective? You betcha. Is it comprehensive? By no means, but it *is* something to supplement your Lonely Planet guide with little or no overlap. For those who travel, it's fun both to look for places already visited and to find new hangouts.

The book is organized first by continent, then subdivided geographically; it also has a special topical index in the back.

Because there is no good way to describe the incredible variety of places it presents, I'll organize and highlight a few of my favorites. First is the Globe Museum in Vienna. I've been there—it's pretty much porn for map nerds. Original Mercator globes are the top attractions.

If we consider "cultural" sites, the "can't miss" selection includes: the UTA Flight 772 Memorial in middle-of-nowhere Niger; the Bordello Museum in Wallace, Idaho; Yamamoto's Bomber in Papua New Guinea; the African Renaissance Monument in Dakar, Senegal (twice as large as the Statue of Liberty!); and, of course, Carhenge in Nebraska.

Moving on to Ma Nature, check out: the falcon hospital in Abu Dhabi; the crooked forest in Poland; the bioluminescent firefly squid of Toyama Bay; Costa Rica's sloth sanctuary; and Archie, a giant squid at the Natural History Museum in London (or the colossal squid at the Te Papa Museum, New Zealand).

If body parts are your thing, Galileo's middle finger can be viewed in Florence. Then, there's the Museum of Death in Hollywood. But the epic choice would be the Musée Fragonard (Paris) – where a fair-sized troop of flayed bodies can be viewed. While there, be sure not to miss the horseman of the apocalypse: a deceased rider flogging a dead horse.

For the straight up odd stuff, I'll begin where *Atlas Obscura* begins, in the United Kingdom with the Silver Swan, an automaton built in the 1770s. For pure excitement, you will want to see the pitch drop experiment at the University of Queensland; if you're lucky, you'll see a drop fall (it happens every 12–13 years). The longest operating light bulb (since 1901) can be viewed in Livermore, California, and the world's largest tesla coil resides in Makarau, New Zealand.

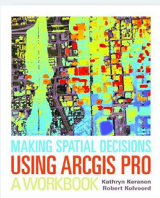
No list, though, would be complete without at least some of the places that most of us would recognize. These include places like Socotra Island (Yemen), Yosemite (California), Hobbiton (New Zealand), Batu Caves (Indonesia—where monkeys will try to steal your postcards. Trust me, watch out for them), the City of the Dead (Cairo, Egypt), or the Nazca Lines (Peru).

There are also the places you should *not* visit. Topping this category is North Sentinel Island (India)—a place where non-locals go to be attacked and/or killed. Seriously, just stay away. Ditto, Snake Island (Brazil)—even I, a lover of snakes, will take a pass on this one. For "tough to get to," check out the bust of Lenin at the South Pole of Inaccessibility (the spot farthest from the coast). You can round your list off with the infamous Sourtoe Cocktail in Dawson City, Canada. Yup, a cocktail with a dead (and well preserved in high-proof alcohol) human toe floating in your drink.

I've saved for last a couple of places that simply make you ask "why?": the Gopher Hole Museum in Canada and the Weeki Wachee Mermaids in Florida.

For those who have read this far, my advice is to buy a copy of *Atlas Obscura*. It's fun, interesting, and a potential travel guide to many places around the world. Sadly, though, it failed me in my first attempt at using it as a travel guide: there isn't anything listed in the Shetland Islands (where a friend of mine is going in January). My disappointment, however, was premature: a visit to their website (atlasobscura.com, where over 12,500 entries of even more odd stuff can be found) turned up four attractions in the Shetlands. I'm just about to email my buddy and bookmark the site!

MAKING SPATIAL DECISIONS USING ARCGIS PRO: A WORKBOOK



By Kathryn Keranen and Robert Kolvoord

Esri Press, 2017

376 pages, $69.99, softcover.

ISBN: 978-1-58948-484-9

Review by: Amanda Tickner, Michigan State University Library

Making Spatial Decisions Using ArcGIS Pro: *A Workbook* is the fourth in a series of GIS workbooks by Kathryn Keranen and Robert Kolvoord. Both authors have backgrounds in K–12 and higher education, and their experience is reflected in a text that is straightforward and approachable for audiences from high school on up. This new volume is consistent with others in the series, with a key difference being length: it is substantially longer, with more, and somewhat more extensive, exercises. While several of the exercises are essentially repetitions of those found in earlier series entries—they use the same structure and data to create similar outputs—the exercises have been updated to work in and with the ArcGIS Pro software.

ArcGIS Pro is relatively new, released in 2015, and, unlike earlier iterations of ArcMap, is a genuinely new piece of software. The tools are similar between ArcMap and ArcGIS Pro, but the workflow is very different between the two. In 2020, Esri plans to sunset the ArcMap desktop application in favor of ArcGIS Pro, and this workbook is a useful addition to the as-yet relatively scarce resources available to address this impending changeover.

The authors clearly assume that the reader will have some basic experience with both ArcGIS Pro and with GIS in general, assumptions that might seem to contradict the book's implied suitability as an introductory GIS text. However, in this reviewer's estimation, most of the exercises can be mastered with only the most basic understanding of GIS. Familiarity with mapping using ArcGIS Online, and access to an ArcGIS Online organizational account, are also assumed. Many modules, for example, involve accessing online data and while the process steps are given, familiarity and experience are helpful.

The workbook exercises are divided into nine modules, each with two projects. In general, the first project of each module has step-by-step instructions, while the second is less detailed but covers similar materials and processes. This is a nice pattern: the first project is very cookbook-like, while in the second, the user applies the tools without so much hand-holding, but still with guidance and a provided dataset.

The topics and themes vary in kind from module to module. An example of a more planning/government-type scenario (though not labeled as such) is "Module 1: Hazardous Emergency Decisions," which presents a scenario around a "homeland security" situation involving a chemical spill on a highway. It requires creation of a map of detour routes and relevant facilities within a certain drive time. There are also more environmentally focused scenarios, such as "Module 9: Forest Vegetation Height," which uses lidar data to observe and manage a forest area.

This variety of topics could be looked at positively (there is likely something relevant for everyone in one module or another) or negatively (many topics may seem irrelevant for users focused on a particular discipline). The lack of a consistent theme could be problematic for a course taught within a specific department, such as Fisheries and Wildlife, or Urban Planning. On the other hand, the range of topics might be useful in a more general GIS course, where getting an idea of the possibilities of GIS within many subject areas is helpful.

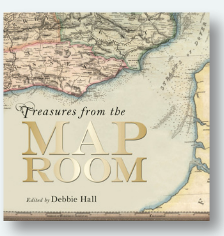
Working through the modules was generally straightforward: they follow a pattern of presenting the scenario, identifying deliverables to support decision making within the scenario, documenting and setting up the project, performing analysis, and sharing your results. However, sometimes it was not clear whether it was ArcGIS Pro or ArcGIS Online that was to be used. The tight integration between ArcGIS Pro and ArcGIS Online—a feature of the software—meant that the line between the two was occasionally a little confusing.

There is an emphasis on raster rather than vector-based tools in the workbook modules, which may not be satisfying for those who rarely use remote sensing or raster data. Vector-based tools are covered, but they just don't receive as much emphasis and coverage as the raster tools. Overall, however, tool coverage is good, and nearly all the basic GIS toolsets are included: network analyst, spatial analyst, raster calculator, creating composite images from remote sensing data, lidar skills, supervised and unsupervised classification, and using LAS data to make DEMs.

There was a good deal of repetition built into the exercises, and this was welcome—repeated tool use helps the process sink in. Additionally, the modules encourage documentation of the process via note taking, which they list as a deliverable. This is a good practice generally and it was nice to see it promoted in this workbook. Some of the other writing assignments, such as writing an incident report in the first module, felt extraneous. It is clear that the writing assignments were included as part of the book's mission to teach about using tools to make decisions, and the writing is a reflection of the synthesis of decision making and information gathering, but sometimes the tasks did not hit their mark. Without an instructor to evaluate and critique the written deliverables, the value of the writing exercises is unclear: they could easily be an important part of a course that includes using ArcGIS Pro, but how do they teach you to use the software? Still, the writing assignments can be easily skipped.

Making Spatial Decisions Using ArcGIS Pro would make a good textbook for an introductory general GIS course. The depth of the modules and the wide range of assignments, which include writing prompts, are clear and follow a textbook style. The Esri Press summary for the book lists high school, community college, and university instructors and students as being the audience for the book. This seems reasonable, as the workbook would make a fine textbook for anyone getting started with ArcGIS Pro at many levels of education. It also works well as an introduction to ArcGIS Pro for a GIS professional outside of a class. There are other online tutorials and books that function similarly to this volume, but *Making Spatial Decisions Using ArcGIS Pro: A Workbook* is a solid contribution to the small pool of ArcGIS Pro learning resources.

TREASURES FROM THE MAP ROOM



Edited by Debbie Hall

Bodleian Library, 2016

233 pages, $60.00, hardcover.

ISBN: 978-1-85124-250-4

Review by: Marcy Bidney, University of Wisconsin–Milwaukee

As the title suggests, *Treasures from the Map Room* is a book dedicated to showing us some of the treasures housed in the Bodleian Library map collections. The book is broken up into seven chapters, an Introduction, a List of Images and their sources, a nicely compiled bibliography, and an Index. The Introduction provides a brief history of the development of the Library's map collections, and each chapter focuses on a different type of map. These range from maps for travel and exploration, to maps of imaginary lands. Every chapter opens with an essay nicely tying together the topic with the maps and cartography. For example, the chapter on knowledge and science discusses how geographical knowledge was passed on through maps. There is a heavy bias toward British materials, both in the essays and the example maps, but that is only to be expected of a book focusing on the collections of the Bodleian.

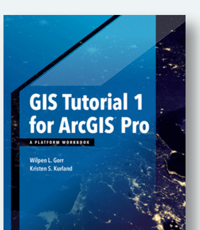
Highlights from the chapters include, in Chapter One ("Travel and Exploration"), an interesting comparison of two charts published by the Hydrographic Office of the Royal Navy showing the changes that occurred to the island of Krakatoa as a result of the catastrophic August 1883 volcanic eruption. Chapter Two brings us many excellent maps representing "Knowledge and Science." The standout example in this chapter come from the 1846 *An Historical Atlas in a Series of Maps of the World as known at different periods constructed upon an uniform scale and colored according to the political changes of the period* by Edward Quin. Readers familiar with this atlas know that it is a series of maps, each showing a more extensive world, as, over time, it became known to Europeans. The known world on the maps is light and beautifully colored, while the "unknown" parts of the world are shrouded under a dark cloud called "terra incognita." The author of this map's description in *Treasures from the Map Room* rightfully tackles the absurd notion projected by this atlas that the world outside of the European context was "unknown" until discovered by Europeans. Chapter Three covers "Pride and Ownership," highlighting the idea that maps can show pride in ownership, either of a place itself or of a map depicting a place. The highlight of this chapter is the image of a small portion of a tapestry map showing part of Worcestershire. This tapestry is one of a set of four, each measuring about 15 × 20 feet! The tapestries were created to decorate a house—a rare idea in the late 16th century.

In Chapter Four we find "Maps of War," which is a topic that cannot be ignored in a book such as this. The maps discussed show a variety of means for using maps in wartime. Of note in this chapter is the portion of a stunning map showing trenches along the front in World War One France. Chapter Five, "The City in Maps," shows the reader how cities have been mapped through the centuries. The real gem in this chapter is the panorama of London before the great fire, drawn by Dutch cartographer Claes Visscher. The details of buildings and in scenes of London life at the time are exquisite—seeing this one map in person should be on the bucket list of most map lovers. Chapter Six is all about "Maps for Fun" covering, for the most part, tourist maps. The standout in this chapter is the map of Yellowstone National Park in Wyoming. Its depiction of the park landscape, including the hot springs (viewed facing south from the Mammoth Hot Springs entrance), shows the park in its early years. Finally, in Chapter Seven we find maps of "Imaginary Lands" an interesting mix of maps of places that could have been, of places that were imagined to be, and of real places depicted as somehow symbolic.

The maps chosen to illustrate each of the chapter topics were thoughtfully chosen as representatives of the versatility and power that maps, and their meanings, can have. The reproductions are of high quality, and details are easily deciphered. When a map is too large to fit in its entirety on the page, either a well-chosen detail of the map is shown or the map is allowed to spill over onto the next page. *Treasures from the Map Room* successfully reaches its goal of showcasing the treasures of the map collections at the Bodleian Library at Oxford University with an interesting and thoughtful presentation. The reader gets a sense of each map and its historical importance, and a sense that the maps shown barely scratch the surface of the tremendous treasures to be found in the collections.

I would recommend *Treasures from the Map Room* for libraries who collect generally on cartographic history, or as a gift for lovers of maps and cartographic history.

GIS TUTORIAL 1 FOR ARCGIS PRO



By Wilpen L. Gorr and Kristen S. Kurland

Esri Press, 2018

470 pages $99.99, softcover.

ISBN: 978-1-58948-466-5

Review by: Tom Koch

INTRODUCTION

This latest instructional book from Esri Press is listed at $99.99. Like its many predecessors, it serves three functions simultaneously. First, it seeks to teach the basic mechanics of an Esri software product, in this case ArcGIS Pro. Second, it seeks to sell Esri itself with the implicit message that GIS *is* Esri. Forget the many, and in some cases splendid, programs with first-rate instructional materials available elsewhere at either a lower price (for example, Maptitude), or for free (like QGIS). Third, as a "platform book," this volume serves as an introduction to, and thus promotion for, a range of other, individually costly (if potentially useful) Esri programs and apps.

Purchasers of *GIS Tutorial 1 for ArcGIS Pro* are offered a free, time-limited, introductory subscription to the software. The basic annual cost for a single user is USD $1,300, a hefty price in a world where freebies like QGIS are multiplying. "Perpetual" licenses (which don't require annual renewal) are also available, with prices starting at USD $2,565, as are academic and corporate subscriptions for multiple users. Costs of the latter types are available only on request from the Esri sales force.

BASICS

Why someone would choose ArcGIS Pro ("ArcPro") over another program (even ArcGIS Desktop) is something we're never told in this tutorial, although Esri User Conference demos of ArcPro present a potentially powerful program with extraordinary functionality for the handling of large datasets. It's not an easy program to learn: its menus are complex and sometimes confusing, and its command structure, to put it nicely, is complex. Anyone interested in using it likely needs, therefore, both a tutorial and time to learn a completely new set of commands.

That tutorial is what this 470 page tome sets out to provide. It is divided into four separate Parts, each containing between three and five chapters. The first 123 pages (Part 1) are about "Using, making and sharing maps" on the ArcPro platform. It includes instructions on downloading data for the course's examples, basic ArcPro techniques, and a general discussion of "map design" and "map concepts for GIS projects." The text assumes the reader knows nothing about maps, GIS software, or much of anything pertinent to the lessons it presents (I'll explain that last bit in a minute).

The 162 pages in Part 2 of the book, "Working with spatial data," describe the general construction and utility of Esri geodatabases (a way to hold and stabilize multiple datasets, feature classes, tables, rasters, and other, more complex entities), and spatial data in general, as well as ArcPro procedures for geoprocessing, digitizing, and geocoding. The third Part is "Applying advanced GIS technologies" with 115 pages on spatial analysis, raster GIS, and 3D GIS in ArcPro, including data animations. Finally, Part 4 is titled "Managing operational systems with GIS." The tutorial projects in this part involve building a "Graffiti Mapping System" and a "Graffiti Mapping Removal System." The first analyzes patterns in infraction locations, and the second handles supervisory job tasking for clean-up crews. Since I'm not involved, at present, in either of these types of management activities, I didn't focus on these chapters.

Purchasers of *GIS Tutorial 1 for ArcGIS Pro* are first directed to a website where downloading of tutorial materials took 20 minutes on a relatively fast broadband connection. Installation run time for the downloaded .exe file was approximately fifteen minutes. The additional (and necessary) "assignments" download took a further 23 minutes and required about thirteen minutes of unpacking. ArcGIS Pro is significantly different from the company's principal product, ArcGIS Desktop, and those expecting an easy transition will be disappointed. The software itself has a somewhat daunting, complex, interface structure with multiple menus and dashboards that make for a steep learning curve, and also renders describing it the software challenging. All the controls are dynamic, so the reader has to get to the correct menu/sub-menu at the right time to find the option they need to select.

OVERVIEW

The book's type is generally quite small, especially what appears to be six-point type set on colored call-out boxes: a barely legible combination. I needed a magnifying glass to see the tiny menu icons embedded in the text. Finding anything in this book is difficult: there is no index, nor does the table of contents point the way if, say, a user wants to review specific protocols for changing a projection or adding a row to a database.

Like most Esri tutorials—for example, *GIS Tutorial for ArcGIS 10: Spatial Analysis Workbook* (Allen 2011)—the authors assume readers will have no previous knowledge of cartography or of mapping, either on- or offline. Thus, basics like coloration, resolution, scale, and spatial analytics are all offered as new material. It's hard, though, to imagine a neophyte going to this tutorial as a first experience in GIS. The question arises as to just what this book is supposed to be about: a tutorial for ArcGIS Pro, or a general introduction to GIS? A tutorial is normally limited to how to do something in a particular program. Trying to be all things to all readers only blurs the focus. Judged as an example of focused technical writing, it is clear that this volume was not written by experts in the trade.

That said, if one patiently follows the point-and-click instructions, one can, with practice, build a moderate competence in ArcPro. Some instructions are hard to follow, and in some places directions are unclear; but mostly, and with time, the tutorials can be more or less followed. I found it useful to create a set of short, "how-to" briefing notes as I worked through the book's examples. I will also admit that, while working through this tutorial, I modestly warmed to the program if not to this instructional volume. However, I still prefer my ArcGIS Desktop 10.4.

TUTORIALS

The tutorials evidence an arrogant and sometimes ignorant vacuity. We're told that "attributes play a major role in GIS," for example, and "Besides providing data needed to solve a problem or investigate spatial patterns, attributes allow you to search for useful information and mapped features" (19). The authors, both Carnegie Mellon policy and management academics—and authors of a previous Esri teaching book—should know better.

Attributes don't just "play a major role in GIS." They are the rows of data we collect and with which a stated problem is formulated; their organization and subsequent manipulation is the means by which a problem is addressed. Attributes don't let you search for "useful information." One can search for an individual datum, but as information theorists since Shannon (1948) have insisted, *information* is what we build in a specific context with the data we purposefully collect (Koch 2017b). Maps organize and project a set of selected "attributes" in an attempt to build information from data rows.

It is difficult to engage with, or care much about, the tutorial exercises because we are never told either the problem or the context. Take Tutorials 1.1–1.6, for example (33–46). We open a map that includes 14 symbolized layers that may have something to do with the accessibility of healthcare for citizens in the city of Pittsburgh and the surrounding Allegheny County, Pennsylvania. This *could* be an interesting, and even exciting, example of GIS analytics *if* we knew what the problem was, why these map layers were chosen, and why we were making this map.

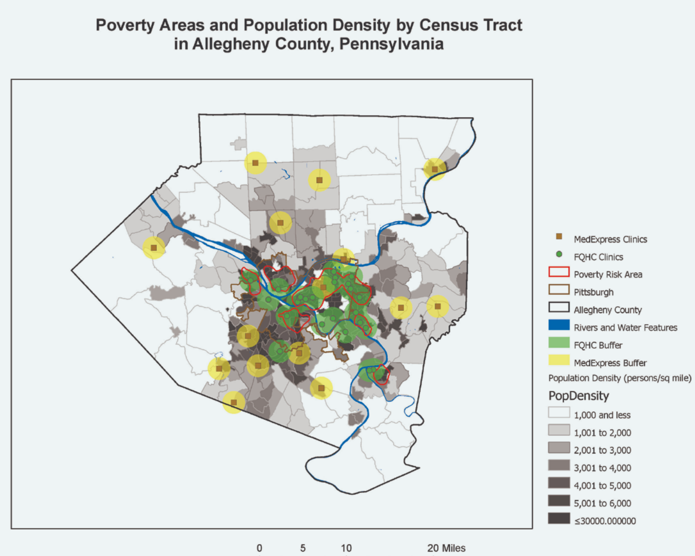
Besides basic Pittsburgh-area geographies (city streets, county boundaries, rivers, and water features), layers include the locations of two different types of clinics (one private and one apparently publicly funded, sort of, maybe), poverty levels, and population density. Nowhere is there a problem statement: maybe this is about locating private clinics, maybe it is about healthcare; I don't know.

Whatever it *is* about, we also likely need to know the location of area hospitals whose emergency rooms serve as *de facto* clinics for millions of America's uninsured persons (EMTALA 1986). We might also wish to include ethnicity in the mix of variables: because the racial divide in the United States, and especially older cities like Pittsburgh, is often a critical determinant in the provision of health care and in the likelihood of a citizen having health insurance (for a review see Koch 2017b, Chapter Eight).

Worse, two of the layers describe buffers around the two different types of clinics. Both sets employ a one-mile radius, a size "commonly used," we are told, to determine accessibility to grocery stores in urban areas. "You can safely assume," the authors declare, "that what works for grocery store accessibility also works for health care facilities" (12).

Say what?

The term "grocery store" may describe anything from a large chain megastore (think Loblaws) to a small-time



This is a map from a tutorial with various layers describing something—we're never told what—about health clinic accessibility in Pittsburgh, PA.

local greengrocer. Across this range of providers, some will have fresh produce and some will not; some will overcharge for days-old bread and vegetables and others will have lower cost, fresher produce. Is the consumer walking, driving, or dependent on public transit? If they are driving, is there parking (at what cost?), and, if not, is there public transit available?

Location analysts spend their careers on this kind of problem. There is a huge literature on the location of both "food deserts," mostly in poor neighborhoods, and "food oases" where wealthier folk get the best quality produce at the best prices. Literally hundreds of papers have been written about these issues in the US public health literature (Story et al. 2008), health geography journals (Walker, Keane, and Burke 2010), and elsewhere. There are even articles dedicated to the *mapping* of food disparities (Phillips 2011). Nowhere in those literatures did I find anyone stating that a simple, one-mile buffer around any and all types of food outlets serves to answer any question.

The literature on health clinics and their availability is similarly complex, if not more so. All clinics are not the same. Some are run by physicians and some by nurses or nurse-practitioners. Some will have diagnostic equipment (EKGs, EEGs, ultrasound, for example) that others lack. Some will be able to handle complex infectious disease and trauma injuries. Others . . . not so much.

Clinics are not simple and fungible. One size does not fit all. Do these two different clinic classes presented by the authors have different levels of competence and service? Can they be accessed by public transportation? Who knows? This is the type of management-speak arrogance that assumes mapmakers are mindless drudges (Wood 2002) who should just draw without question whatever data an employer or supervisor gives to them (Koch 2017a). It's also an example of oversimplified thinking that ignores a problem's real complexity to embrace simplistic formulations.

DISCUSSION

I've used one or another version of Esri software since 1996. Their new ArcGIS Pro program has potential, and some power users may find it their go-to GIS, especially if they prefer to work online. I am also an Esri Press author: they published both editions of my *Cartographies of Disease* and recently co-published my *Ethics in Everyday Places*. So I'm loathe to write a review that wholly dismisses one of their publications or any of their products. However, this book is an example of everything that is wrong with GIS when conceived as a mechanical, point-and-click exercise in which the mapmaker is assumed to be a mindless functionary. Its approach is shot through with the kind of magisterial, management-style assumptions that lead to poor analysis, faulty conclusions, and shoddy map making. Perhaps it could be used as an example to students of the kinds of clueless managerial oversight they can expect to encounter in their careers. Certainly any class of bright undergraduates could, given the opportunity, use the text's substantial failings to critique this kind of problem presentation. It would be a simple thing for the class to think up five problems to be considered based on the materials provided for Tutorials 1.1–1.6. I suspect too, that they'd also suggest other data sources to focus one or another problem more clearly.

To be fair, the authors Gorr and Kurland aren't technical writers. They're academics focused on public policy, management, and enterprise data analytics. That said, every chapter should start with a statement: "Here's the problem we want to address." It would be followed by a short description of the reasons specific datasets were collected and how they bear on the problem. After that, some remarks on the mechanics of making a simple map *about* something (coloration, resolution, scale, etc.) would make sense: why, for example, this projection rather than another? Later chapters in this volume deal with spatial analytics, and to deal with that we need to know the problem, what it is we are trying to argue or understand. Only then can the analysis become an intellectual rather than a robotic exercise. That, in turn, would add focus and clarity to the point-and-click instructions.

If the editorial focus of Esri Press were on how we use maps to consider problems and on what maps do, rather than on the software the company sells, we might get tutorials that were also terrific contributions to the literature-at-large. We might even have software that didn't become, with every iteration, less intuitive, more complex and ultimately more expensive. Alas, volume by teaching volume, Esri seems to be moving away from that mission. They didn't do it with this overblown book, and that is just too damn bad.

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The general format is: Name of author(s). Year. *Title in Italics*. City of Publication: Publisher Name.

Robinson, Arthur H., Joel L. Morrison, Phillip C. Muehrcke, A. Jon Kimerling, and Stephen C. Guptill. 1995. *Elements of Cartography, 6th Edition.* New York: John Wiley & Sons.

Articles in Periodicals: Author's or authors' names as in *Books,* above. Year. "Title of Article." *Title of Periodical,* volume number, page numbers, DOI if available. Follow punctuation and spacing shown in the following example.

Peterson, Michael. 2008. "Choropleth Google Maps." *Cartographic Perspectives* 60: 80–83. doi: **10.14714/CP60.237**.

Articles in edited volumes: Name of author(s). Year. "Title of Article." In *Title of Edited Volume*, edited by [Editor's or Editors' names, not inverted], page numbers. City of Publication: Publisher's Name.

Danzer, Gerald. 1990. "Bird's-Eye Views of Towns and Cities." In *From Sea Charts to Satellite Images: Interpreting North American History through Maps*, edited by David Buisseret, 143–163. Chicago: University of Chicago Press.

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Cartography Associates. 2009. "David Rumsey Donates 150,000 Maps to Stanford University." *David Rumsey Map Collection*. Accessed January 3, 2011. **http://www.davidrumsey.com/blog/2009/8/29/david-rumsey-donates-150-000-maps-to-stanford**.

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A Plan of the City of New York and its Environs. P. Andrews, sold by A. Dury in Dukes Court, St. Martins Lane, surveyed by John Montressor, 1775.

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Cartographic Perspectives

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