

Expert Perspectives on the Design and Use of Learning Materials for  
Neocartographic Interfaces

by

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## **Chapter 1: Introduction**

### **1.1 The Problem**

The ability and desire for humans to map is not new to society. The general public long has been able to sketch its own maps, whether on a cave wall, in the dirt, or on paper. It is the technology used to make maps—and the general public's access to this technology—that has changed (Harrower 2008). At the start of the digital age, the functionality needed for cartographic design only was accessible by expert professionals, tucked away in complex and expensive software packages (Wood 2003). However, there are a growing number of online, in-browser applications that enable the general public to produce and share their own maps. The production of maps by the general public, or *novice* mapmakers, using the web increasingly is described as neogeography, or, in the following *neocartography* (Turner 2006).

These emerging mapping tools present a potential issue, however: expert users of cartographic software historically have had formal training in the domains of cartography or GIS, while the general public likely has no such training in map design. While it is true that anyone can produce and share a map, there is a difference in quality of the maps produced by trained cartographers compared to those produced by the general public. In order to successfully create a map with a neocartographic interface, the mapmaker must possess knowledge of the functionality included in the interface, knowledge for making use of these functions in sequence, and—specific to cartography—knowledge about designing a map that communicates effectively. Thus, an emerging research topic in cartography is not

cartographic design itself, but the design of learning materials that assist novice mapmakers with learning how to use online neocartographic interfaces.

## 1.2 Purpose

The design of learning materials varies greatly across neocartographic interfaces and there has yet to be best practices established within the discipline. Learning materials vary not only in type (e.g., tutorials, tooltips, forums), but also in time of implementation, integration into the interface, type of knowledge supported, and type of media used. There are some emerging commonalities across neocartographic interfaces, such as an overview of the functionality included in the interface and a description of the basic procedures for making use of this functionality. However, domain knowledge of cartographic design rarely is supported, a topic that scholars agree is important for effective learning materials.

Learnability and usability issues have been well-researched in the discipline of human-computer interaction (HCI) (see Haklay 2010). However, cartographic interfaces present unique challenges to learnability and usability, as the user must possess a deep understanding of cartographic principles in order to produce a well-designed map that communicates information effectively and truthfully. Domain topics in cartography include projections, linework generalization, data classification, representation methods, and visual hierarchy, among many others. The quality of a map is a direct result of the mapmaker's knowledge of these cartographic principles. By supporting cartographic domain knowledge within neocartographic interfaces, the usability of the interface and the quality of resulting maps can be improved to support a novice user group.

The purpose of this research is to identify common and best practices in the design of learning materials within cartography, with a specific focus on neocartographic interfaces and novice mapmakers. To date, there has been minimal research on the topic of learning materials within the discipline of cartography (see Robinson et al. 2011 for a brief review). As indicated above, filling this gap is becoming increasingly important given the boom of online mapping tools targeted towards a novice audience. To address this gap, my research aimed to elicit *expert* opinion and viewpoints about the following research questions, serving as a foundational starting point for future work towards these questions:

- (1) Do learning materials improve the usability of neocartographic interfaces designed for the general public?
- (2) Are there existing best practices for designing learning materials in cartography? If so, what are they?
- (3) Are there certain contexts, user groups, or types of knowledge that determine if one type of learning material is better suited than another?
- (4) How should domain knowledge of cartographic principles be supported in neocartographic interfaces?

### 1.3 Scope and Limitations

To answer these questions, I conducted a series of semi-structured interviews with experts in online cartography. Experts recruited for the interview study included individuals who have designed learning materials for neocartographic interfaces and individuals who teach and research online, interactive mapping using these learning materials. Ten experts in total participated in the interview study, serving as representatives of their company or department in order to understand the overall institutional approach to the design of learning

materials. The interviews allowed me to establish a baseline regarding how experts view the design of learning materials for neocartographic interfaces, given the dearth of recommendations currently found in the literature. This initial sketch of design best practices serves as a foundation, identifying several paths forward regarding learning materials for subsequent study in neocartography.

This thesis proceeds with four additional chapters. In Chapter 2, background on the topics of neocartography and learnability are provided, as well as an overview and synthesis of the kinds of learning materials provided in popular neocartographic interfaces. The interview protocol and analysis procedure is described in Chapter 3. The ten interviews were transcribed and analyzed using a 46-part coding scheme following tenets of qualitative data analysis. Results of the interview study are presented in Chapter 4. Final thoughts on and future directions for research learning materials are provided in Chapter 5.

## **Chapter 2. Background**

There is great potential for neocartographic interfaces to provide learning materials to aid the general public in designing maps. Such learning materials come in many different forms and support a wide range of tasks and types of knowledge. By researching the current landscape of learning materials used by neocartographic interfaces, we can better understand how to help support the general public in producing higher quality maps.

### 2.1 Neocartography and Designing for Novice Mapmakers

This research is motivated by the large-scale shift in the production and sharing of maps due to Web 2.0 developments, or the use of the Internet as a platform atop which diverse datasets and services can be flexibly combined in creative ways (O'Reilly 2007). Web 2.0 technologies reopened the process of mapmaking to everyone, a process previously reserved for those with specialized cartographic or computer skills. The production of maps by the general public using the web increasingly is referred to as *neocartography*. The term ‘neogeography’ was coined by Turner (2006: 3), describing it as “people using and creating maps on their own terms,” and subsequently has been repackaged as ‘neocartography’ to emphasize the role of maps and mapmaking (Kraak 2011). The formalization of neocartography was heavily influenced by Google Maps, an in-browser user mapping service released in 2005 that allowed the user to create, publish, and share web maps (Gibson 2006). The platform is most notably known for the push pin map mashups that users can create with the Google Maps interface, and which now widely populate the web (Wallace 2011). Google Maps became well known because they provided an intuitive and easy way for *novice*

users—or those without formal training in cartography—to create and interact with maps online (Miller 2006). Thus, the ‘new’ or ‘neo’ aspect of neocartography is the provision of mapping interfaces—or *neocartographic interfaces*—for novice users.

This distinction between ‘experts’ and ‘novices’ has been part of a pivotal debate that precedes the popular application of Web 2.0 technologies for neocartography (e.g., Wood 2003, Koch 2004, Carter 2004, Olson 2004). On one hand, Wood (2003) and Koch (2004) argue that novice mapmakers are more pervasive than trained cartographers, and that this ratio has held true from historic times into present day. Furthermore, novice mapmakers often produce influential maps that are made without academic cartographic knowledge (Wood 2003, Demaj and Field 2012). On the other hand, Carter (2004) and Olson (2004) acknowledge that many people are making maps without expert knowledge in Cartography, but domain cartographic knowledge ultimately improves the quality of a map and its ability to communicate effectively. Cartwright (2012) warns that, because of a lack of applied cartographic expertise, many of the maps now being created by novice mapmakers in this Web 2.0 era are of poor design and often are unusable. Although experts and novice mapmakers alike are able to produce and share online maps, knowledge learned within the domain of cartography still is seen as critical in influencing the quality of the final product.

Due to the high availability of neocartographic interfaces, the question arises of how best to support novices who have not been trained in cartographic design or in the use of mapping software. There has been limited empirical research to-date on the differences between expert and novice mapmakers in the context of neocartography, with most research instead emphasizing a very different expert versus novice distinction in the context of exploratory geovisualization tools. As an example, MacEachren (1994) suggested that a gap

exists between expert and novice mapmakers in the complexity of their interactions and the subsequent insight gained from these interactions. An expert user interacts with the map to generate and test hypotheses, as well as to check their interpretations in order to reach comprehensive conclusions (MacEachren and Kraak 1997). Conversely, it is assumed that novice users engage superficially in hypothesis testing and do not glean as much insight from the interactive map as their expert counterparts (McGuinness 1994). Most subsequent work in interactive cartography and geovisualization therefore assumes, and thus designs for, an expert user group. While the above mentioned research focus on geovisualization and exploration rather than neocartography and map creation this divide between novice and expert users is probable.

Given the increased pervasiveness of novice mapmaking through neocartography tools, it is important to consider the usability and utility of a mapping interface for both expert and novice mapmakers who possess varying skill sets. User interfaces, map-based or otherwise, are characterized by their utility and usability in the fields of human-computer interaction and usability engineering. *Utility* describes what the user can do through the functionality of the interface (i.e., usefulness), whereas *usability* describes how well a user can make use of that functionality (i.e., ease-of-use) (Grudin 1992). Usability comprises five main components: (1) learnability (the ease of first learning the interface), (2) efficiency (the ability to use the interface productively once learned), (3) memorability (the ease of remembering how to use the interface when returning after a gap in usage), (4) errors (the frequency of and recovery from errors), and (5) satisfaction (the user's individual reaction to the interface) (Nielsen 1993). While all five components of usability are considered in the following, my focus in this thesis is on learnability, or the difficulty in learning a system

before the user can begin to accomplish his or her tasks. Nelson (1993) identifies learnability as the most fundamental component of usability, since the first experience a user has with an interface is that of learning how to use it.

There is a tradeoff associated with usability and utility: as the utility of an interactive map increases, the usability typically decreases (Grinstein 2003, Robinson et al. 2011). One possible way to overcome this tradeoff is to increase the user's skill level through learning materials, effectively improving both the utility and usability of the interface for that user (Roth et al. 2009). For instance, Andrienko et al. (2002) found in the context of interactive cartography that users are more receptive to novel interfaces when they are provided with sufficient introductory demonstrations and explanations about how to use the new tools. Thus, by improving the learnability of neocartographic interfaces, it may be possible to overcome the skills gap between novice and expert users.

## 2.2 Learning Materials and Minimalist Instruction

Given that learnability is an essential component of interface usability, particularly with novice users, it follows that the provision of learning materials is essential for neocartography and should be considered as a part of designing a neocartographic interface (Peddie 1992). It is suggested that *learning materials*, such as tutorials, demonstrations, tooltips, and documentation, can assist novice mapmakers and first time users in carrying out tasks when they encounter a new interface (Roth et al. 2009).

Much of the existing research on the design and development of learning materials has been in the area of online or e-learning. Online learning materials provide instruction for users within a browser and often are accessed through a learning interface (Shneiderman and

Plaisant 2010). *Learning interfaces* impart communication cues that are transferred between learners and the learning interface (Lohr 2000); therefore, learning materials should not be confused with the neocartographic interface about which the user is learning. Lohr (1998) developed a framework describing four kinds of questions a learning interface supports: (1) provide learner *orientation* (introduction to the interface topic), (2) provide *navigational assistance* (knowledge of user's current progress in the overall learning process), (3) provide *instructional strategies* (suggest the best method for user interaction with the learning interface), and (4) provide *instructional feedback* (knowledge that the user is doing the right thing)..

More recently, Khan (2005) expanded Lohr's (1998) work by associating the four ways in which learning interfaces support learnability through the broader cognitive processes behind learning. Drawing from Mayer (1993), Khan identifies three cognitive learning processes: (1) *selection* (noticing the critical information), (2) *organization* (chunking or sequencing information), and (3) *integration* (assimilating or associating information). According to Khan, orientation questions are associated with the cognitive process of selection, navigational assistance questions are associated with the cognitive process of organization, and both instructional strategy and instructional feedback questions are associated with the cognitive process of integration (Table 1). Together, Lohr's and Mayer's frameworks provide insight for designers of learning materials on how to best support the learner's cognitive process.

Cognitive process involved	Anticipated learner questions (Lohr, 2000; Lohr, 2003)
Selection (noticing the critical information)	<p><b>Anticipating the following <i>orientation</i> questions:</b></p> <ul style="list-style-type: none"> <li>• What is the topic of learning?</li> <li>• How do I begin learning?</li> <li>• What is the learning climate?</li> <li>• What is the breadth of this environment?</li> <li>• What, in general, is expected of me in this learning environment?</li> <li>• Do I feel comfortable welcome in this environment?</li> </ul>
Organization (chunking or sequencing information)	<p><b>Anticipating the following <i>organization</i> questions:</b></p> <ul style="list-style-type: none"> <li>• What is the depth?</li> <li>• Where am I in this process?</li> <li>• Can I mark where I am?</li> <li>• How do I go back?</li> <li>• What do I do now?</li> <li>• What do I do next?</li> <li>• When am I finished?</li> <li>• How do I get out of this?</li> </ul>
Integration (assimilating or accommodating information)	<p><b>Anticipating the following <i>instructional strategies access</i> questions:</b></p> <ul style="list-style-type: none"> <li>• How do I interact with this instructional strategy?</li> <li>• Can I get more/less information? More or less examples?</li> <li>• Can I skip this information?</li> </ul> <p><b>Providing interactive feedback</b></p> <ul style="list-style-type: none"> <li>• Am I doing the right thing?</li> <li>• Am I right/wrong?</li> <li>• How did I end up here?</li> <li>• Can I undo what I just did?</li> <li>• Can I customize this?</li> </ul>

Table 1: Lohr (1998) & Mayer's (1993) cognitive process framework (after Khan 2005: 326)

Shneiderman and Plaisant (2010) state that, though designers should strive for intuitive user interfaces that are transparently usable, there will be a need for supplemental learning materials to assist the user as the digital interface grows in complexity. They go on to enumerate several important ways in which the design of learning materials (described as 'help tools') vary. First, learning materials differ by the type of knowledge about which they instruct, differentiating among *semantic knowledge* (a factual description of the interface and its various components), *syntactic knowledge* (a step-by-step guide walking through the process or procedure for using the interface), and *pragmatic knowledge* (domain information on appropriate uses of the tools). Learning materials also differ in the way they are coupled

with the interface, and can be provided in an external document or website, embedded internally into the interface itself, or, if internal, updated to the user's current interaction context. Learning materials may be designed for review before entering the interface, as a quick overview at the very beginning of an interaction session, or as a reference throughout interaction. Further, these learning materials can be provided in multiple different media formats (e.g., text, graphics, audio, animations, video), and even may be extensible, allowing users to contribute or edit additional learning modules. Finally, the interface may offer staffed support, providing personal training and assistance via phone consultation, email, or forums.

As a result, Shneiderman and Plaisant (2010) organize and characterize learning materials by six dimensions: (1) *type of knowledge* (semantic, syntactic, or pragmatic), (2) *degree of integration* (external, internal, context-aware), (3) *time of intervention* (before, beginning, throughout), (4) *media format* (text, graphic, audio, video, animation), (5) *extensibility* (the ability for the user to add or alter information), and (6) *human support* (in person, phone, email, community forum). The Shneiderman and Plaisant matrix allows for analysis and review of learning materials not only by type, but into larger, more generalizable design terms. Thus, the matrix provides a useful framework for comparing learning material design strategies across neocartographic interfaces (see Section 2.4), to the end of establishing best practices.

While learning materials can reduce user frustration and increase the usability of an interface, as stated above, it has been found that users rarely review learning materials in full (Redish 2007). Instead, users prefer to use the interface until they require assistance, and then only read the sections that assist them with accomplishing the specific task(s) they had

difficulty achieving. *Minimalist instruction* embraces the fact that users would prefer to jump in and begin accomplishing tasks, rather than first reading detailed learning materials (Carroll 1998). Carroll and Rosson (1987) call this the paradox of the active user, in that users can save themselves time if they made an effort to learn the system, but they ultimately seldom do so. Carroll's minimalist instruction theory is anchored around four key heuristics: (1) support an action-oriented approach (encourage and support exploration), (2) anchor the tool in a task domain (i.e., in pragmatic knowledge), (3) support error recognition and recovery (a component of usability), and (4) support task-oriented reading of brief instructions (i.e., through chunking and sequencing). Minimalist instructions are designed explicitly for the novice user to enable them to rapidly learn how to use a novel interface. By understanding how novice users interact with learning materials, designers can improve the learnability of an interface, and thus improve its usability.

### 2.3 Types of Online Learning Materials

Currently no taxonomy exists that captures and organizes the complete solution space for learning materials. The following provides a review of commonly discussed learning materials from literature on human-computer interaction. In the review, nine commonly discussed learning materials emerged as most prominent: (1) tutorials, (2) startup tips and tours, (3) animated and narrated demonstrations, (4) wizards and brewers, (5) tooltips, (6) forums, (7) external help documentation, (8) annotated overlays, and (9) human support. Each is reviewed below.

(1) *Tutorials* are guided exercises demonstrating common tasks (Figure 1). Tutorials are useful because they motivate the user to practice tasks and become active in the

learning process (Shneiderman and Plaisant 2010). Tutorials provide comfort and ease of learning (Price and Korman 1993), but often are skipped by “aggressive learners” (Mirel 1991, as cited in Carroll 1998: 260). A minimalist instructional approach to tutorial design allows users to select which learning modules they would like to view and then complete them in the order of their own choosing. A minimalist instructional approach also means allowing users to define their own tasks, rather than support predefined ones, in order to mimic a more realistic usage scenario (Carroll 1998).

(2) *Startup tips and tours* contain informational content about the interface when a user first loads the interface (Figure 2). Startup tips provide a brief introduction to key functionality using balloon help (semantic knowledge), while startups tours walk the user through several steps for using the interface (syntactic knowledge). It is recommended that startup tips and tours only are shown the first time an interface is opened in order to avoid annoying expert users (Horton 2000).

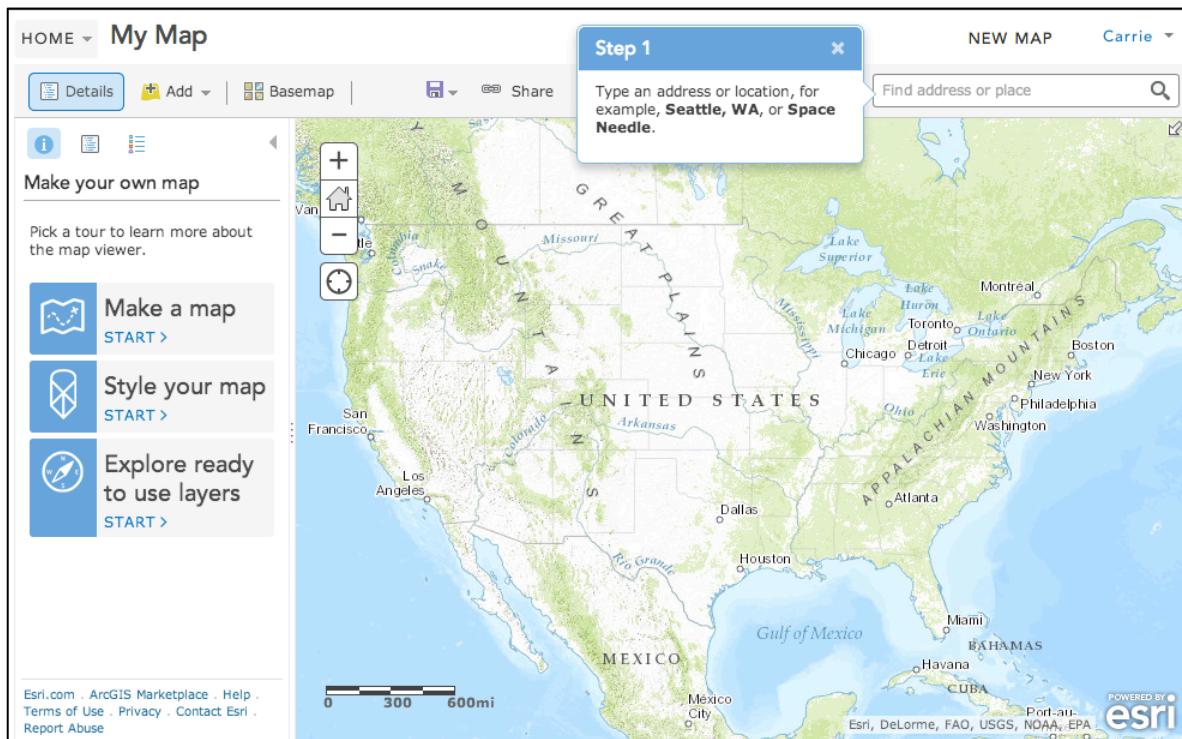


Figure 1: Interactive Tutorial of ArcGIS Explorer (Image captured June 2<sup>nd</sup>, 2014)

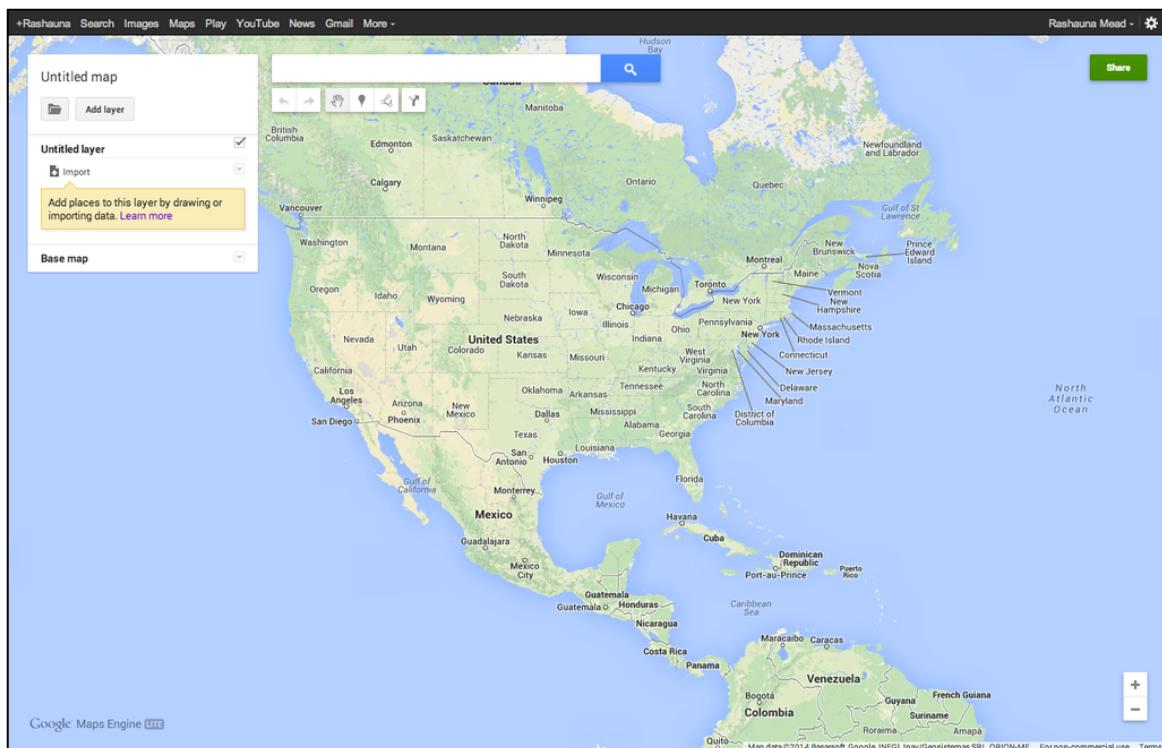


Figure 2: Startup Tip by Google Maps (Image captured March 5<sup>th</sup>, 2014)

(3) *Animated and narrated demonstrations* (Figure 3) comprise step-by-step procedures that explain the result of specific actions taken within the interface (Shneiderman and Plaisant 2010). This can be presented as an animation, an audio narration, or a video recording of a person using the interface. Animated demonstrations are well-suited for presenting syntactic knowledge and can be reinforced with textual or verbal explanations.

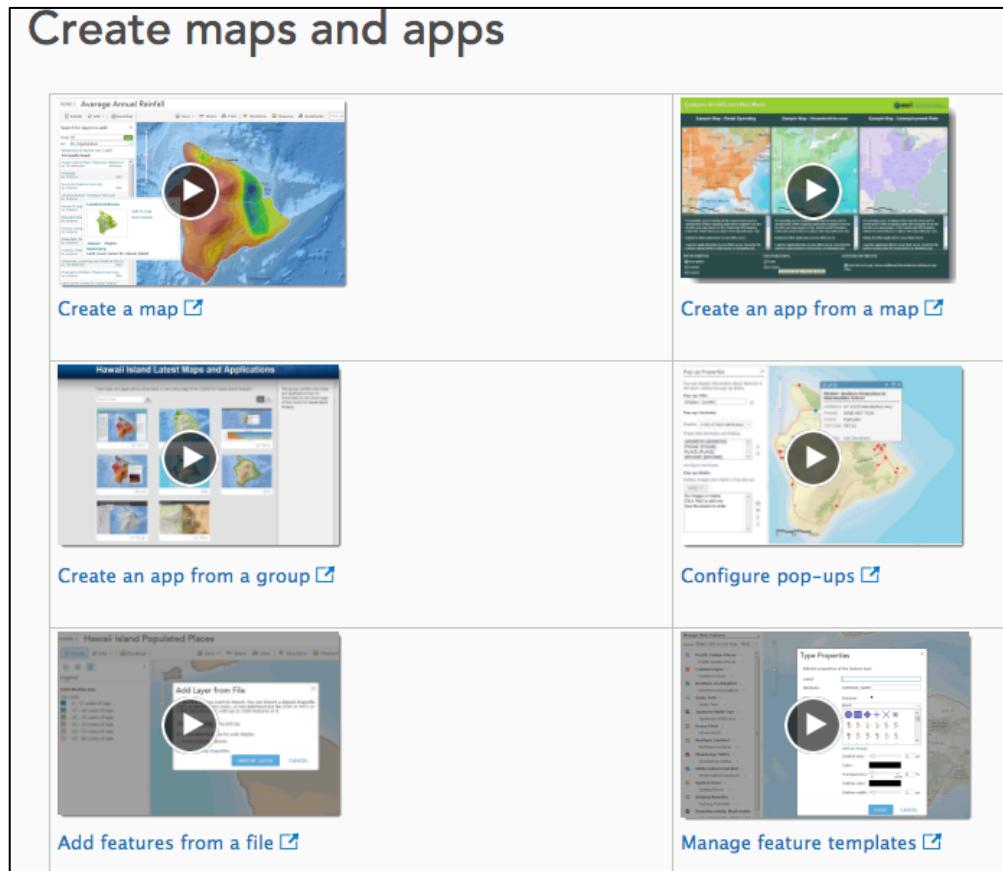


Figure 3: Video Library by ArcGIS Explorer (Image captured June 13<sup>th</sup>, 2014)

(4) *Wizards and brewers* (Figure 4) are single-purposed interfaces that walk users through relatively difficult tasks using a series of dialog windows and next buttons (Carroll 1998). Wizards support users in accomplishing actual work, but they inhibit exploration and experimentation as they offer a final solution based on user responses to a series of questions (Brewer 2003). Carroll recommends providing full explanations for each action completed by the wizard. In cartography, wizard-like solutions called ‘brewers’ have been proposed as alternatives that guide the user to a subset of viable design solutions, rather prescribing a single solution. Map-based brewers include ColorBrewer (Harrower and Brewer 2003), Symbol Brewer (Schnabel 2005), Isoline Engine (Roth et al. 2006), TypeBrewer (Sheesley 2007), ScaleMaster (Stryker et al. 2008), and the SymbolStore (Robinson et al. 2013).

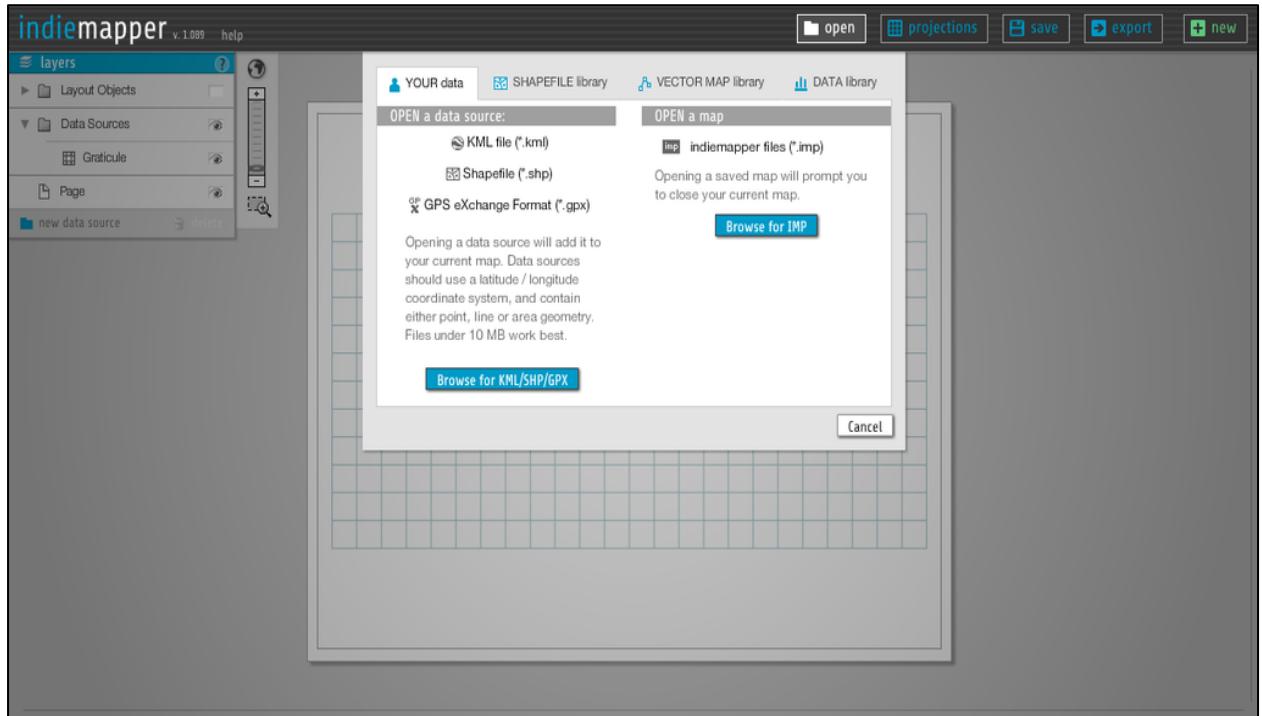


Figure 4: Wizard by Indiemapper (Image captured June 12<sup>th</sup>, 2014)

(5) *Tooltips (balloon help)* are popups providing brief conceptual information about the interface control beneath the pointer at that moment (Figure 5). Tooltips are useful because of their rapid feedback, convenience, and ability to provide information about a specific feature of interest (Farkas 1993, Carroll 1998). Placement of tooltips should be on the side or below the object, so that the tooltip does not obstruct the interface control it is explaining. The delay between the user pointing to a tool and the tooltip popping up should be no more than 0.5 seconds (Microsoft 2014). The popup should be removed either when the user scrolls away or after 5 seconds of hover.

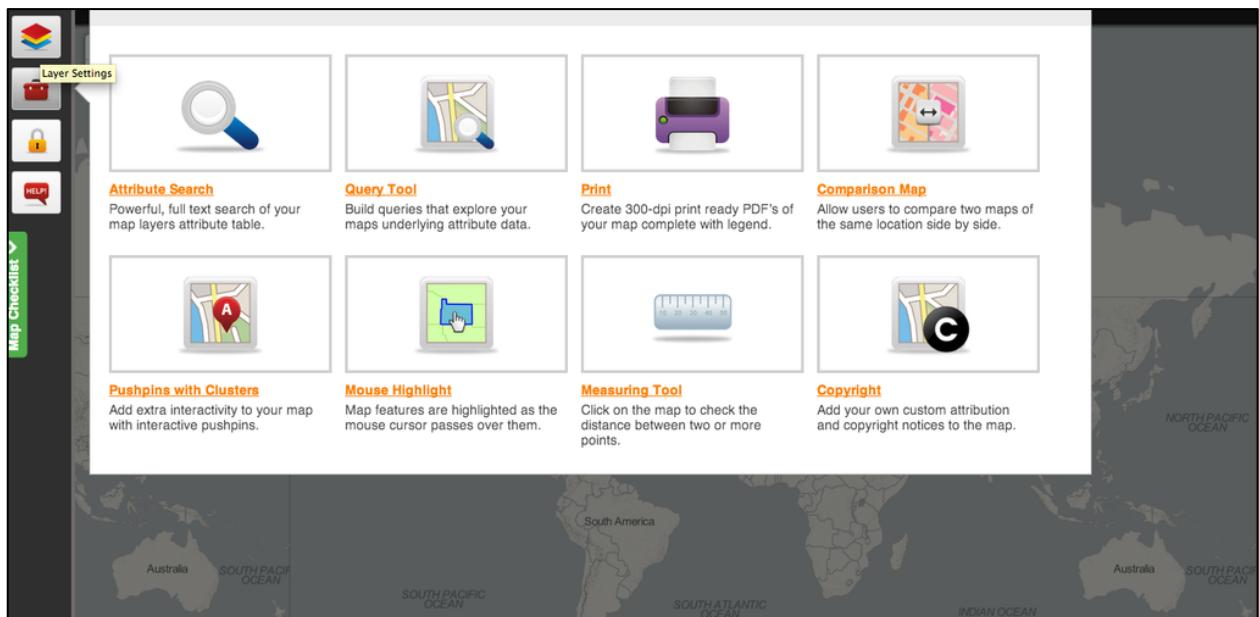


Figure 5: Tooltip by Mango Map (Image captured June 8<sup>th</sup>, 2014)

(6) *Forums* allow users to garner help from an established user community (Figure 6). These learning materials allow users to ask fellow users detailed questions about the interface, as well as to respond to the questions of other users (Shneiderman 2010).

Forums are integrated into a website, whereas the related news groups deliver emails as means of communication (Horton 1990).

(7) *Documentation* (Figure 7) is much like a user manual and often uses hypertext to link specific topics (Horton 1990). Documentation must be well written, developed early in the interface design process, follow standardized guidelines that match interface guidelines, and provide users a way to give feedback (Shneiderman and Plaisant 2010).

Figure 6: Forum by Batchgeo (Image captured March 5<sup>th</sup>, 2014)

**FAQ**

Have a question? You've come to the right place

We've done our best to compile a comprehensive list of Frequently Asked Questions. They are broken up by category and listed below.

- [10 Most Asked Questions](#)
- [Products](#)
- [Style Editor](#)
- [API Keys & Authentication](#)
- [Account & Billing](#)
- [Technologies](#)
- [CloudMade General](#)

**Style Editor**

**Q. What is the Style Editor?**

**A.** The Style Editor is a web-based online tool for creating your very own style of a map using verified OpenStreetMap data. It allows you to customize the appearance of the map, to show objects such as roads and buildings in different colors or emphasize different aspects of the data. Create a map that's just right for you, it takes only a few minutes! Best of all you don't have to start from scratch, because there are already pre-defined professional styles in the Style Gallery that you can start from. After you create your customized map style, you can embed it on your website or in your web or mobile application. CloudMade will host the tile images and keep them up-to-date for you.

**Q. How do I get started?**

**A.** Login into the Style Editor by opening <http://maps.cloudmade.com> and clicking on the Edit Map Style tab in the upper right. If you haven't already got a CloudMade account, then take a minute to create one so you'll be able to save your changes. Take a look at some of the styles that have been already available in the Style Gallery. You can see how the map styles look in the preview dialog. Styles are divided into the five categories: All Styles, Featured Styles, New Styles, Cloudmade Styles, and My Styles. You may need to wait for the few moments for the map styles to be loaded. With these categories, you can preview all styles from CloudMade DB to choose the best one as a draft to create your own.

**Q. What is special about the base styles?**

**A.** CloudMade's base styles provide a range of interesting variations of map styling designed by professional cartographers. You can use them as they are, but if you want to work with the style editor to create your own map style, you must always start by 'cloning' one of the existing base or community styles. Various aspects of the style cannot be changed within the Style Editor, and can only be controlled by selecting a base style. This includes POI icons, text positioning and road widths.

**Q. I want to edit an existing style.**

**A.** If you want to make changes to an existing style:

1. Clone the style:
  - select a style from [here](#)
  - press "Clone Style" from the right bottom
2. Add your changes to it:
  - select an object on the left panel
  - select features (line color or width) from the right panel
  - click "Refresh map with your changes"
  - press "Save this style" button

Your newly edited style is saved on your account.

**Q. How do I see the new color choice in the map display?**

**A.** Click the "Refresh the map with your changes" button, and wait a few moments while the map is re-rendered for you. Bear in mind all changes in Style Editor require you to Refresh the map to see them on the screen. Tip: make multiple changes before selecting Refresh to save re-rendering time.

Figure 7: FAQ documentation by CloudMade (Image captured March 5<sup>th</sup>, 2014)

(8) *Annotated overlays* (Figure 8) provide information about the scope and location of the interface's functionality upon the user's first entry, and often give insight regarding how to interact with the application (Bedford 2014). A noted benefit of annotated overlays is that they allow the user to gain an overview of interface functionality without trial and error learning (Cornett 2011). The design of these tools should be short and to the point in order to allow users to jump into use of the application as soon as possible (Bedford 2014).

(9) *Staffed Support* (Figure 9) is as highly valuable to a user as it is customizable to their needs; however it also is highly expensive to provide (Shneiderman and Plaisant

2010). This support can come in the form of phone support, email, in person demos or trainings, or live chat (Roth et al. 2013).

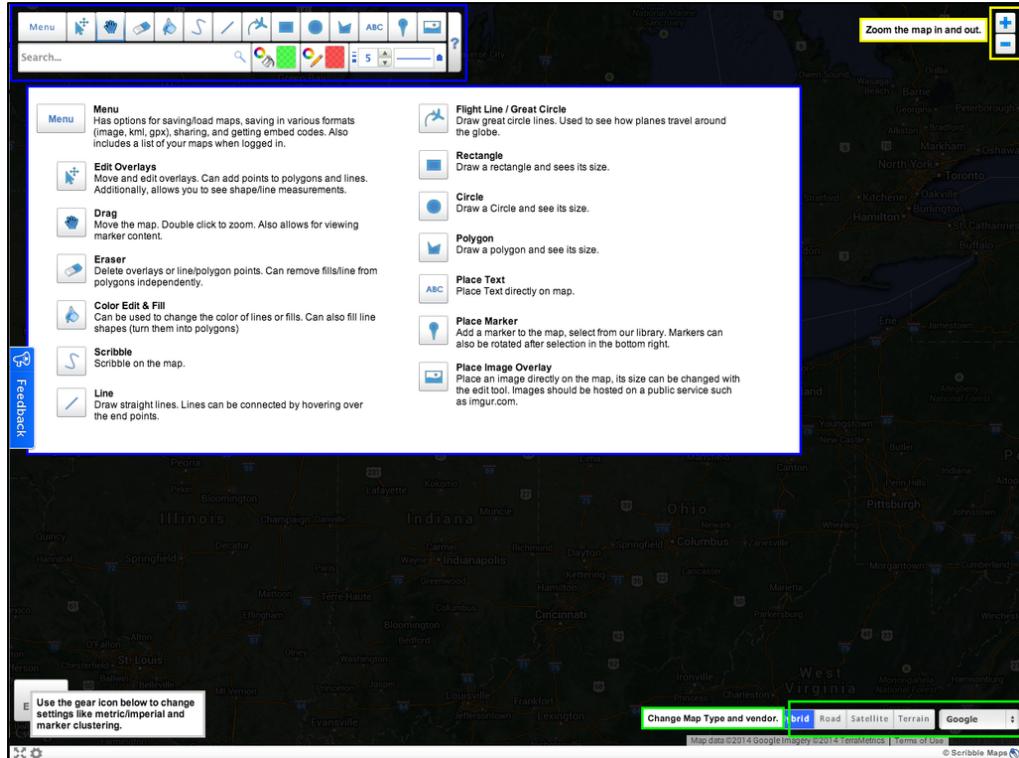


Figure 8: Annotated overlay by Scribble Maps (Image captured March 5<sup>th</sup>, 2014)

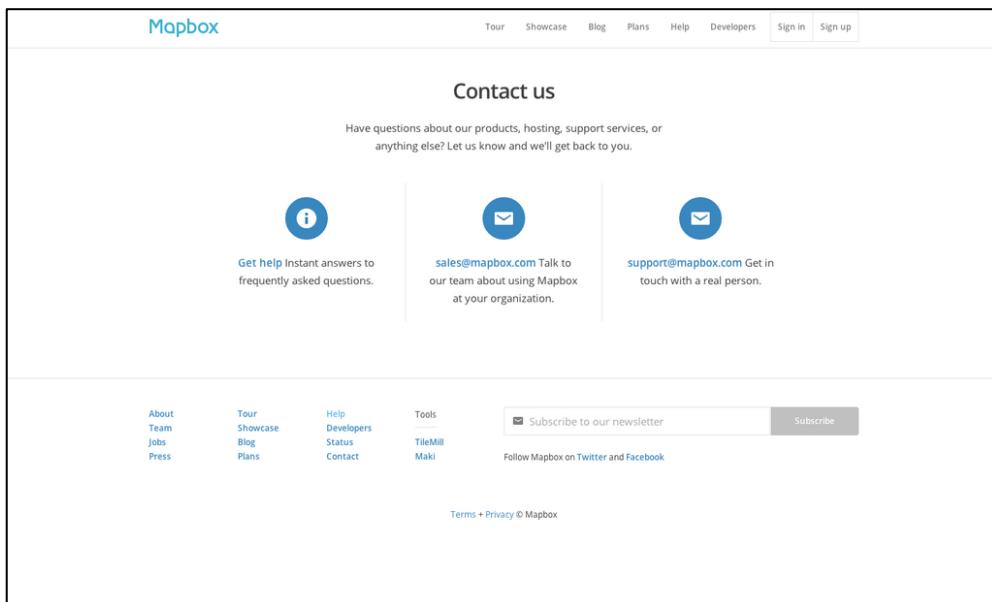


Figure 9: Staffed support by MapBox (Image captured March 5<sup>th</sup>, 2014)

## 2.4 Current Landscape of Learning Materials Supporting Neocartography

Leveraging the above review, I completed a survey of available neocartographic interfaces to understand the current landscape of learning material design for neocartographic interfaces. All surveyed learning materials were created for web applications that enable public users to create their own maps with their own datasets. Further, these neocartographic interfaces allow novice mapmakers to publish their maps either directly from their browser or to download the finished map for sharing in another file format. At the time of writing, there were a limited number of neocartographic interfaces that met these requirements, although the ability to edit and export spatial data in-browser is growing.

In total, learning materials from ten neocartographic interfaces meeting the above criteria were included in the survey: (1) ArcGIS Explorer Online, (2) Batchgeo, (3) CartoDB, (4) Cloudmade Editor, (5) GeoCommons, (6) Indiemapper, (7) Mango, (8) Map Engine, (9) Mapbox, and (10) Scribblemaps. Table 2 provides a critical comparison of these learning materials according to Shneiderman and Plaisant's (2010) six dimensions of learning materials introduced in Section 2.2 and the nine types of learning materials introduced in Section 2.3.

	Type of Learning Material	Type of Knowledge	Degree of Integration	Time of Intervention	Media Format	Extensibility	Human Support
ArcGIS Explorer Online	Tutorial, Startup, Demonstration, Tooltip, Forum, Documentation, Staffed Support	Semantic, Syntactic, Pragmatic	External, Internal	Before, Beginning, Anytime, Context-Aware,	Text, Graphic, Video	Open, Closed	Forum, Email, Phone, Live Chat
Batchgeo	Demonstration, Tooltip, Forum, Documentation, Staffed Support	Semantic, Syntactic	External, Internal	Before, Anytime, Context-Aware	Text, Graphic, Video	Open, Closed	Forum, Email
CartoDB	Tutorial, Startup, Demonstration, Tooltip, Forum, Documentation, Staffed Support	Semantic, Syntactic, Pragmatic	External, Internal	Before, Beginning, Anytime, Context-Aware	Text, Graphic, Video	Open, Closed	Forum, Email
Cloudmade Editor	Documentation, Staffed Support	Semantic, Syntactic	External	Anytime	Text	Open, Closed	Forum
Geo-Commons	Startup, Wizard/Brewer, Demonstration, Forum, Documentation	Semantic, Syntactic, Pragmatic	External, Internal	Before, Beginning, Anytime, Context-Aware	Text, Graphic, Video	Open, Closed	Forum
Indiemapper	Wizard/Brewer, Tooltip, Forum, Documentation	Semantic, Syntactic, Pragmatic	External, Internal	Before, Anytime, Context-Aware	Text, Graphic	Open, Closed	Forum
Mango	Demonstration, Tooltip, Documentation, Staffed Support	Semantic, Syntactic	External, Internal	Anytime, Context-Aware	Text, Graphic, Video	Closed	Email
Mapbox	Tutorial, Startup, Tooltip, Documentation, Staffed Support	Semantic, Syntactic	External, Internal	Beginning, Anytime, Context-Aware	Text, Graphic, Animation	Closed	Email
Map Engine	Tutorial, Startup, Demonstration, Tooltip, Forum, Documentation	Semantic, Syntactic,	External, Internal	Before, Beginning, Anytime, Context-Aware	Text, Graphic, Video	Open, Closed,	Forum
Scribblemaps	Tooltip, Documentation, Forum, Overlay	Semantic, Syntactic	External, Internal	Before, Anytime, Context-Aware	Text, Graphic, Video	Open, Closed	Forum

Table 2: A survey of learning materials in ten popular neocartography interfaces according to the nine types of learning materials reviewed in Section 2.3 and the six dimensions described by Shneiderman and Plaisant (2010) in Section 2.2. (Survey completed June of 2014)

The survey exposed several patterns and conventions in the provision and design of learning materials in support of neocartography. All of the reviewed neocartographic interfaces include at least two different types of learning materials, while ArcGIS Explorer Online and CartoDB provide seven forms of learning materials reviewed in Section 2.3

(range=2-7). Regarding the types of tools provided, documentation (10/10) and tooltips (9/10) commonly were found across the surveyed neocartographic interfaces. Other common types of learning materials included forums (7/10), demonstrations (7/10), staffed support (6/10), startup tips (5/10), and tutorials (4/10). Wizards or brewers were observed twice (2/10), while overlays only were observed in Scribblemaps (1/10).

Regarding the type of knowledge embedded within the learning materials, semantic knowledge (i.e., a description of the interface) and syntactic knowledge (i.e., procedural steps for using the interface) were provided in all ten (10/10) neocartographic interfaces. However, pragmatic knowledge (i.e., domain knowledge of cartographic principles) only was found in four (4/10) of the interfaces, with only three (3/10) supporting pragmatic knowledge beyond basic glossary terms (ArcGIS, CartoDB, Indiemapper). As discussed above, the lack of pragmatic or domain knowledge is potentially problematic for neocartography, given the novice user group.

All ten (10/10) of the reviewed neocartographic interfaces provided an external form of learning materials, most commonly in the form of external documentation and external video demonstrations. Nine (9/10) of the neocartographic interfaces included internal, embedded help, with seven of these interfaces including at least one context-aware solutions (as tooltips). All of the interfaces (10/10) allowed access of some form of learning material at anytime during use of the interface, with seven (7/10) having special learning materials for review before use and four (5/10) having special learning materials for introduction at the beginning of use.

Regarding the media format, all ten (10/10) surveyed neocartographic interfaces employed text-based learning materials in some way, while nine (9/10) included graphics in

the form of screenshots or illustrations. Videos (6/10) and animations (1/10) were observed in seven of the ten interfaces and ranged from a few seconds to upwards to ten minutes. None of the reviewed neocartographic interfaces provided audio-only learning materials.

Six (6/10) of the reviewed neocartographic interfaces were extensible, allowing the user community to update and modify the learning materials. However, all ten (10/10) of the interfaces had at least one learning material that was closed, suggesting extensibility may be specific to a particular subset of learning materials. All ten (10/10) provided human support, seven (8/10) interfaces have forums and five (5/10) offer email support; ArcGIS Explorer Online was alone in provided live chat and phone support, in addition to their forums and email support.

The above survey characterized and compared the learning materials for ten neocartographic interfaces. I then used this survey to inform the question protocol and coding scheme for a series of interviews with experts working in neocartography (see Chapter 3), to the end of establishing several best practices in learning material design for neocartographic interfaces.

## **Chapter 3. Methods**

### **3.1 Participants**

Ten experts participated in an interview study to discover how learning materials are best designed for neocartographic interfaces targeted towards the general public. An individual was eligible for participation if he or she met one of three criteria: (1) he or she designed and developed learning materials; (2) he or she has researched the learnability of neocartographic interfaces in an academic setting; or (3) he or she has instructed the use of neocartographic interfaces in a classroom setting using the available learning materials.

Recruitment for the study was conducted through email, with contact information provided by gatekeepers or found on the website of the company or department. Due to the narrow subject of study—the design of learning materials for neocartographic interfaces—the sample pool was small, resulting in a relatively small sample of n=10. Following a semi-structured approach, interview questions were balanced between initial inquiries about the overall institutional practice at their company or department and follow-up probes about individual values and opinions. Therefore, each participant acted as a representative of his or her institution during the interview, revealing insight about the broader practice of neocartography and learning material design across sectors despite the relatively small sample. That said, the sample size of ten participants limit the findings to the specific context of expert views on learning materials for neocartography.

All ten participants (10/10) had experience designing and developing learning materials, with five (5/10) of those participants gaining this experience while designing one of the neocartographic interfaces surveyed in Section 2.4. Seven participants (7/10) had

studied learnability of neocartographic interfaces in an academic setting and four participants (4/10) had formal experience teaching neocartographic tools, allowing them to share insights from direct observation of students. One participant (1/10) held a pair of associate degrees, one (1/10) held a Bachelors degree, three (3/10) held a Masters degree, and five (5/10) held PhD degrees. Across the sample, seven participants (7/10) held at least one of their degrees in cartography or geography.

### 3.2 Materials and Procedure

The interview followed a semi-structured design, starting with a set of focused key questions, but having the flexibility to reorder questions and ask follow-up probe questions as needed (Roth et al. 2013). To keep the sample pool as large as possible, the method for conducting the interview varied based on participant availability: four interviewers were conducted in person (4/10), two conducted over the phone (2/10), and four via online videochat (4/10). Prior to the interview, each participant was provided with a PDF document providing an overview of specific learning materials that would be covered in the interview, drawn from the Section 2.4 survey. Whenever possible, this document included examples produced by the participant, or by his or her company. Distribution of example learning materials provided a common ground regarding the vocabulary used in the interviews—as many learning materials are referred to in various ways in an ad hoc manner—and stimulated an additional layer of discussion about concrete designs after initial impressions were provided. Appendix A provides of such PDF document as an example. I conducted all interviews, recording the discussion using an audio recorder for subsequent transcription and qualitative data analysis (see Section

3.3).

The interview protocol was organized into four sections: (1) background (i.e., the biographical information reported in Section 3.1), (2) HCI and usability (e.g., target users, interface learnability, and cognitive load), (3) learning material design (e.g., type of learning material, type of knowledge, degree of integration, time of intervention, media format, extensibility, and human support; see Table 2), and (4) final thoughts (further insights, overarching design recommendations, past and present trends). Table 3 provides the set of key questions used for the interviews. The interviews were designed to last no longer than one hour.

<b>I. BACKGROUND</b>	
1.	What is your current job title, or what title would best describe what you do?
2.	How many years have you been working and or doing research in this field?
3.	Describe your post-secondary education, listing the name of the degree, major, and/or certificate.
4.	Take several minutes to provide an overview of your job responsibilities as they relate to the design of mapping interfaces.
<b>II. HCI &amp; USABILITY</b>	
<b>Users</b>	
1.	Can you describe who your company or organization sees as its target user group or groups?
2.	Does your company address variation in skills or expertise in your target user group? Can you provide an example when your company designed a learning or help tool to account for expertise variance in the user group?
3.	Do the concepts of “neocartography” or “neogeography” affects the way your company thinks of its services?
<b>Usability</b>	
1.	Does your company have strategies for promoting the first-time learnability of its mapping tools? Can you provide an example?
2.	Does your company have strategies for promoting memorability of its mapping tools to avoid the user having to relearn the interface upon return? Can you provide an example?
3.	Does your company have strategies for reducing the cognitive load of the user, or the amount of information the user needs to memorize or remember to use the mapping tool?
<b>III. LEARNING MATERIAL DESIGN</b>	
<b>Type of Learning Material</b>	
1.	There are many ways to provide learning materials to users. Your company employ (review them from the PDF). What type of help and learning materials do you find the most effective, and why?
2.	What are the relative advantages and disadvantages of these learning materials? Are there reasons that you might choose one type of learning or help material over another, such as different user groups, different interface functions, or different mapping contexts?
3.	Please describe your company’s design process (workflow) from concept to finished product of learning materials. How does this relate to the design process of the mapping tool itself?
<b>Media Format</b>	
1.	Is there a form of media (text, video, interactive tutorial, graphic, audio) that your company finds to be the most effective for learning materials?
2.	What are the relative advantages or disadvantages of these different kinds of media for learning materials? Are there situations or reasons to choose one over the other (e.g., different user groups, different interface functions, different mapping contexts)?
3.	If learning materials were designed to use multiple forms of media, what combination has your company found to work the best?
<b>Degree of Intervention</b>	
1.	When designing learning materials, does your company integrate these materials into the tool itself or provide them as external or linked resources?
2.	What are the relative advantages or disadvantages to an integrated versus external approach to designing learning materials. Are there situations or reasons to choose one over the other (e.g., different user groups, different interface functions, different mapping contexts)?
<b>Minimalist Instruction</b>	
1.	Describe how your company thinks users engage with learning materials.
2.	How extensively do you think novice or beginning users make use of the provided learning materials? How is this different from expert users with training in cartographic design and GIS?
3.	Are your learning materials designed to encourage the user to jump around or are they intended to be read in order? Why?
4.	Provide feedback to users that they are using the interface correctly or incorrectly?
<b>Support of Knowledge</b>	
1.	How does your company design for knowledge that pertains to identification of tools and their uses?
2.	How does your company design for knowledge that pertains to the processes that a user must carry out to produce and share a map?
3.	How does your company design for knowledge that pertains to cartographic domain such as best practices and methods?
4.	The majority of learning materials often help users with identification of tools and how to use them to produce maps. Cartographic domain knowledge is often not supported. Why do you think this may be? Should domain knowledge be supported?
<b>IV. FINAL THOUGHTS</b>	
1.	Do you have any recommendations for how to go about designing learning materials?
2.	Are there any common practices for designing help and learning materials that were used in the past and no longer seen as a good solution? If so, what were they and why are they no longer used?
3.	What do you believe are the common practices and guidelines used today in designing learning and help tools for cartographic interfaces?
4.	What trends and changes do you think we will see in the future in designing learning materials?
5.	Any final thoughts or advice that you have on designing and implementing learning materials for cartographic interfaces?

Table 3: The interview protocol

### 3.3 Qualitative Analysis

Qualitative data analysis (QDA) is a systematic approach to interpreting qualitative information and has been applied to reveal insights from interviews, on-site observations, and documents (Caudle 2004). When applied for the interview method, a QDA approach recommends the delineation of audio transcripts into their smallest semantic unit with subsequent application of a series of codes describing the content of these units.

The interviews were all audio recorded using QuickTime Player on a laptop computer and transcribed using a transcription service. The transcriptions were unitized at the statement level and coded using a 46-part coding scheme derived from the Chapter 2 background review (Table 4). The 46-part coding scheme was organized into seven larger themes common to the background review and interview discussions: (H) HCI & Usability, (U) Users, (T) type of learning tool, (S) Shneiderman and Plaisant's (2010) six dimensional matrix, (K) Khan's (2005) cognitive process framework, (C) Carroll's (1998) minimalist support, and (A) general in-house best practices. A final other (O) category was created during analysis to capture notable statements not captured by the above codes. Coding was not mutually exclusive by statement, meaning that multiple codes could be applied to a statement. A total of 937 codes were applied across the ten transcripts, resulting in an average of 93.7 codes per participant and the average mention of each code 20.37 times. Table 5 presents the frequency, extensiveness, and average of each code. Chapter 4 treats each of these code categories as a separate subsection, summarizing discussion using the synoptic style of reporting detailed by Monmonier and Gluck (1994) (Chapter 4).

<b>HCI &amp; USABILITY</b>		
H1	Learnability	A statement about the learnability
H2	Memorability	A statement about the memorability or cognitive load
H3	Errors	A statement about error prevention
H4	Satisfaction	A statement about user satisfaction
H5	Efficiency	A statement about efficiency of a learning or help tool
<b>USERS</b>		
U1	Neocartography	A statement regarding neocartography
U2	Expert	A statement about expert, those with previous cartographic or GIS training, users
U3	Novice	A statement about novice, or the general public, those without cartographic or GIS training, users
<b>TYPE OF LEARNING MATERIAL</b>		
T1	Tutorial	A statement about tutorials as learning materials
T2	Startup Tips/Tours	A statement about startup tips and tours as learning materials
T3	Demonstrations	A statement about animated and narrated demonstrations as learning materials
T4	Wizards/Brewers	A statement about wizards and brewers
T5	Tooltips	A statement about tooltips as learning materials
T6	Forums	A statement about forums as learning materials
T7	Documentation	A statement about documentation as learning materials
T8	Annotated Overlays	A statement about overlays as learning materials
T9	Staffed Support	A statement about staffed support as learning materials (including statements about Shneiderman & Plaisant's human support dimension)
T10	Example	A statement about the use of examples
<b>SHNEIDERMAN'S SIX DIMENSIONS OF LEARNING MATERIALS</b>		
<b>Types of Knowledge</b>		
S1	Semantic	A statement about the support of semantic knowledge
S2	Syntactic	A statement about the support of syntactic knowledge
S3	Pragmatic	A statement about the support of pragmatic (domain) knowledge
<b>Degree of Integration</b>		
S4	External	A statement about the integration of a help or learning tool as external
S5	Internal	A statement about the integration of a help or learning tool as internal
<b>Time of Intervention</b>		
S6	Before	A statement about a learning or help tool before the use of the online mapping tool
S7	Beginning	A statement about a learning or help tool at the beginning of the use of the online mapping tool
S8	Anytime	A statement about a learning or help tool at that can be accessed at any time
S9	Context-Aware	A statement about a learning or help tool that is context-aware
<b>Media Format</b>		
S10	Text	A statement about the use of text
S11	Graphic	A statement about the use of an illustration or image
S12	Animation/Video	A statement about the use of video or animation
S12	Audio	A statement about the use of audio
S14	Combination	A statement about the use of a combination of media
<b>Extensibility</b>		
S15	Open	A statement about the extensibility of help or learning tool being possible
S16	Closed	A statement about the extensibility of help or learning tool as not a possibility
<b>KHAN'S COGNITIVE PROCESSES FRAMEWORK</b>		
K1	Feedback	A statement about interface feedback to the user
K2	Instruction Strategies	A statement about user learning strategies and the use of help and learning tools
K3	Orientation	A statement about user orientation to the help and learning materials
K4	Navigation	A statement about how a user should use or navigate through the help and learning materials
<b>CARROLL'S MINIMALIST INSTRUCTION</b>		
C1	Order	A statement about learning materials designed to be read and used in order
C2	Subject	A statement about learning materials that are organized by subject
C3	Exploring	A statement about encouraging exploring
C4	Active	A statement about strategies for supporting active learning
<b>IN-HOUSE BEST PRACTICES</b>		
A1	Past	A statement about a common approach or tool used in the past for learning materials
A2	Present	A statement about a common approach or tool used in the present for learning materials
A3	Future	A statement about a common approach or tool used that learning materials
<b>OTHER</b>		
O1	Learning Styles	A comment about different user learning styles

Table 4: The coding scheme

CODE	NAME	FREQUENCY	EXTENSIVENESS	AVERAGE
<b>HCI &amp; USABILITY</b>				
H1	Learnability	10	6	1.67
H2	Memorability	10	7	1.43
H3	Errors	5	2	2.5
H4	Satisfaction	16	9	1.78
H5	Efficiency	21	7	3
<b>USERS</b>				
U1	Neocartography	27	10	2.7
U2	Expert	44	10	4.4
U3	Novice	77	10	7.7
<b>TYPE OF LEARNING MATERIAL</b>				
T1	Tutorial	38	9	4.22
T2	Startup Tips/Tours	22	8	2.75
T3	Demonstrations	59	10	5.9
T4	Wizards/Brewers	38	7	5.43
T5	Tooltips	34	10	3.4
T6	Forums	30	9	3.33
T7	Documentation	66	10	6.6
T8	Annotated Overlays	4	2	2
T9	Staffed Support	19	8	2.38
T10	Example	21	8	2.63
<b>SHNEIDERMAN AND PLAISANT'S SIX DIMENSIONS OF LEARNING MATERIALS</b>				
Types of Knowledge				
S1	Semantic	18	9	2
S2	Syntactic	38	10	3.8
S3	Pragmatic	53	10	5.3
Degree of Integration				
S4	External	20	9	2.22
S5	Internal	39	10	3.9
Time of Intervention				
S6	Before	1	1	1
S7	Beginning	1	1	1
S8	Anytime	2	2	1
S9	Context- Aware	5	3	1.67
Media Format				
S10	Text	16	9	1.78
S11	Graphic	13	8	1.63
S12	Animation/Video	54	10	5.4
S13	Audio	1	1	1
S14	Combination	5	4	1.25
Extensibility				
S15	Open	0	0	0
S16	Closed	0	0	0
<b>KHAN'S COGNITIVE PROCESSES FRAMEWORK</b>				
K1	Feedback	29	9	3.22
K2	Instruction Strategies	5	2	2.5
K3	Orientation	1	1	1
K4	Navigation	3	2	1.5
<b>CARROLL'S MINIMALIST INSTRUCTION</b>				
C1	Order	15	6	2.5
C2	Subject	10	6	1.67
C3	Exploring	7	4	1.75
C4	Active	29	8	3.63
<b>IN-HOUSE BEST PRACTICES</b>				
A1	Past	6	3	2
A2	Present	8	5	1.6
A3	Future	5	4	1.25
<b>OTHER</b>				
O1	Learning Styles	12	8	1.5
<b>TOTAL</b>		937	N/A	93.7

Table 5: Coding Results

## **Chapter 4: Results**

### **4.1 HCI & Usability**

The first category of codes indicated statements that pertained to the components of usability derived from HCI (H), and included five codes: (H1) learnability, covering statements about the ease of learning the neocartographic interface during first use, (H2) memorability, covering statements about the cognitive load of the user and the ease of remembering how to use the interface on repeated use, (H3) errors, covering statements about strategies to prevent user errors with the interface, (H4) satisfaction, covering statements about the subjective user experience with the interface, and (H5) efficiency, covering statements about the speed of using the interface and associated learning materials. The more frequently discussed HCI/usability codes included efficiency (average = 3.00) and errors (average = 2.5). Comments about satisfaction (average = 1.78) and learnability (average = 1.67) were offered less often, with memorability garnering the least discussion (average = 1.43).

Discussion regarding HCI/usability centered on the impact that learning materials have on the overall usability of the neocartographic interface. One participant noted that the learnability (H1) of neocartographic interfaces often is a concern for novice mapmakers because they simultaneous need to learn about cartographic design and how the interface supports cartographic design. This participant stated, “A common approach to improving the learnability [of the interface] is to provide learning materials.” A second participant indicated that the most conventional way of improving learnability is provision of a user manual or documentation, a statement that matches the Section 2.4 review. This participant went on to

recommend a solution for documentation, saying his or her preference is, “having levels of documentation where I can easily get into what I need...but at the same time for somebody who has no comfort level with this they say can start from the beginning.” Interestingly, this statement suggests that improving the learnability of a neocartographic interface is important for both experts and novices, but that the provided learning materials should be designed differently for these two user groups.

In HCI, memorability (H2) primarily is described as the ease in remembering the necessary steps in using the interface to achieve a given goal. However, when speaking about memorability in terms of the design of learning material, participants noted that there is an added cognitive load when separating learning materials from the interface as external documentation, making it sometimes difficult to remember the instructions from the learning material when returning to the interface. An additional example regarding cognitive load related to the mapping of ‘big’ datasets, with a participant stating that cognitive overload issues arise when mapping layers containing numerous items. Finally, chunking—a method in which information is broken down into smaller segments to ease the memorability—of text-based instructions into clear procedural steps often was cited as a way to ease the cognitive load when designing learning materials.

Participants primarily mentioned error reduction (H3) when discussing the design of interface feedback—or the messaging (via text, audio, visuals, etc.) given to the user about the state of the interface after using one of the controls—noting that carefully designed feedback is an important way to reduce errors. This topic of feedback is covered in more detail in Section 4.5 when summarizing statements about cognitive processes. Similarly, comments about satisfaction or dissatisfaction (H4) all were offered regarding specific types

of learning materials, and therefore are reported under their respective learning materials categories in Section 4.3.

Finally, efficiency (H5) commonly was discussed alongside the topic of integration (external or internal) and was measured as the time and effort needed to reach the desired information. Several participants stressed that learning materials that can be reviewed efficiently are preferred, with one participating stating that “[animated GIFs] work especially being that they’re super fast...you don’t even have to hit the play button,” and a second participant stated that tooltip phrasing “ has to be short...it has to be exactly the problem they’re dealing with.” Learning material solutions requiring more effort to review, and thus slowing down the user during interaction, were less liked by participants. Inefficient learning materials included video, with one participant offering “it is like watching the video...if you make me go through everything to get to what I want, I’m likely to get more frustrated and try to find a different avenue to get there,” and strict wizards, with a second participant stating “I think the rigid wizards don’t work well...[they] sort of gets up in your face and stops you from actually doing your work...[it] actually interrupts the workflow because it seems to think that it knows better...I think that’s the absolute worst case.” The importance of efficiency in learning materials was summed up by one participant, stating “I think people overestimate the amount of time that people are going to spend with that learning material...I think we think that this stuff is way more interesting than our users, so we overestimate [their interesting], which is kind of depressing...it just means we have to be really efficient and really fast.”

## 4.2 Users

The second category of codes identified statements about expert versus novice users, a core tension in neocartography. Three codes were included to capture comments about users: (U1) implications about neocartography broadly, (U2) comments about expert users, and (U3) comments about novice users. The topic of novice use garnered the most discussion (average = 7.70), followed by expert use (average = 4.40) and neocartography (average = 2.70).

When speaking about novice mapmakers (U3), one participant noted the importance of learning “what buttons to click” (i.e., semantic or syntactic knowledge) rather than learning how to apply these buttons for cartographic design (i.e., pragmatic knowledge). Participants noted that learning materials that are internal, such as startup tooltips and tours, were appropriate for novice users when the goal is providing semantic or syntactic knowledge (i.e., demonstrating “what buttons to click”). Providing pragmatic or domain knowledge was more complicated, and generally reserved for expert use only (U2). The difference between expert and novice users with regards to pragmatic knowledge was summed up well by one participant, who stated “An expert isn't someone who memorizes where all the buttons are...an expert is somebody who knows how to bring his or her knowledge to solve a problem, and it's really hard to educate people on that, on that higher level of do you know why you're doing this.” This participant continued, “Most [novices] just want to know what button to click next, and so there's always that tension I've noticed, you know, people are like, just tell me what to click.” Therefore, novice users are different from expert users in that they don't have the time or desire to learn this pragmatic knowledge.

Thus, a goal of learning material design for neocartographic interfaces (U1) is to deliver subtle pragmatic knowledge efficiently and in a format that is easy to learn. One recommendation for enabling users to make “good” maps without knowledge of cartographic design was to integrate pragmatic knowledge into a “smart” interface, or one that makes the design decisions for the user, or at least weeds out suboptimal options. A common example of such an approach is the map brewer, an option that is more enabling and exploratory than the inefficient wizard. As for teaching pragmatic knowledge, one participant suggested use of context-aware popups and quick tooltips integrated internally. As one participant stated, “my sense is that experts aren't going to go to tutorials and video tutorials first, so novices would probably want to start [with tooltips].” This participant went on to say that “Experts are probably like maybe look at the written external documentation.” Forums and examples also commonly were mentioned as oriented more towards experts than novices. Four different participants noted that designers of learning materials should not expect a user to become an expert through these materials, but rather support them with basic pragmatic knowledge so that they do not need to become an expert. In neocartography, the aim is not to make everyone a domain expert in cartography, but rather to support novices in creating their own maps.

#### 4.3 Types of Learning Materials

The third category of codes covered statements about the different types of learning materials (T) reviewed in Section 2.3: (T1) tutorials, (T2) startup tips/tours, (T3) demonstrations, (T4) wizards/brewers, (T5) tooltips, (T6) forums, (T7) documentation, (T8) annotated overlays, and (T9) staffed support. A tenth code was added to cover design

examples (T10), a commonly discussed method of learning used by experts. The most frequently discussed type of learning material was documentation (average = 6.60), followed by demonstrations (average = 5.90), and wizards (average = 5.43). Learning materials that also discussed in the interviews were tutorials (T1) (average = 4.22), tooltips (T5) (average = 3.40), forums (T6) (average = 3.33), examples (T10) (average = 2.63), startup help (T2) (average = 2.75), staffed support (T9) (average = 2.38). Annotated overlays (average = 2) were the least frequently discussed learning material, and was mentioned by just two participants.

Tutorials guide users through a particular process to reach a defined goal (T1). Participants noted that tutorials work well for conveying syntactic knowledge regarding a sequence of steps to complete to achieve a goal, and that tutorials work better for novice users than expert users. One participant stated, “There is a natural progression. Right? I mean, you start with a kind of tutorial-based things.” This participant went on to note that expert users, “don’t have patience to sit through a tutorial, and so, that’s also why this doesn’t work so well for like sort of these expert users, because they don’t want to sit through everything...as soon as you know bits and pieces all ready, then the tutorial is kind of, maybe it’s not the best format.” This participant noted this sentiment applies to video demonstrations as well. Further, a second participant noted that tutorials take a lot of time to complete and therefore require a large investment from the user. Referencing a tutorial approach taken by one neocartographic interfaces, this participant said, “Lessons 1, 2, 3. I count to 32nd but I was like whatever...I lost interest.” In comparison to using tutorials, a third participant suggested that examples (T10) are the better learning material to provide for experts, saying “But I’m too impatient for that, and so you know I’ll go look for an online tutorial, some kind

of way or another, but code examples are my favorite and just really being able to start trying something out.” The recommendations for tutorials overall were to chunk them into short instructions aimed at providing syntactic knowledge for getting novice users up and running with a new interface. If designed for expert use, avoid requiring the experts to step through modules on pragmatic knowledge that can be assumed already is known.

Startup learning materials can be provided within the interface as a single popup tip or, as one participant stated, as a “call to action” that steps the user through the interface as an interactive tour (T2). The feedback given about startup tips and tours was split on whether it was truly helpful or actually a hindrance to using and learning the interface. One participant supporting startup learning materials stated that the, “tour way of doing that works better, I think, because then you are actually in the interface and you can make it much more interactive, too,” and went on to say, “the things that I always like as a user is when people show me exactly in the interface where I'm going to be going...because then I can follow along really quickly.” Startup help has the advantage of being internal to the interface, and therefore does not have the memorability and cognitive load issues of external learning materials. As a second person stated, “When [startup tips and tours] are done well, they can be really nice and be in the interface itself ...so you don't have to flip to that other page.” Those that had trepidations about startup learning materials cited that they can annoy the user, with one participating stating, “I tend to get a little frustrated with those because they won't let me do what I want to do until I do the next step that they insist on, and I'm not necessarily a sequential thinker and so I tend to dismiss those more readily.” Design recommendations derived from the interviews about startup tips and tours included keeping them short, in the range of 1-6 steps, allowing the user to dismiss and reactivate them at any

time, and preventing them from automatically beginning upon repeated use of the interface.

Startup learning materials were not recommended for experts.

Animated and narrated demonstrations (T3) were used by participants in order to present syntactic knowledge. Most participants immediately thought of videos when probed about demonstrations. Participants used stronger language when discussing video demonstrations compared to all other types of learning materials. While acknowledging that others may find it useful, one participant stated “To be perfectly honest I hate video help, I won’t use it, I just don’t have time to wait for them to get to what I want,” while a second participant stated, “I kind of know that most people aren’t going to watch those, right, you know.” Video demonstrations often were viewed negatively due to the fact that it is hard to locate the information you want in a video without watching it in its entirety, a result of video demonstration being a passive rather than active form of learning. Participants also mentioned that the memorability of video demonstrations is poor, with one participant stating “videos and little animated things might go too fast,” and a second stating “Sometimes people aren’t very good at translating [the video demonstration to] something that’s similar, you know what I mean?” While acknowledging the negatives of video demonstrations, one participant noted that some learners may prefer videos and that “Things like video tours and some of those basic tools are to me, that’s for the novice user.” A second participant supported this idea that video tours are for novices, saying “Well, my sense is that experts aren’t going to go to tutorials and video tutorials first. So novices would probably want to start there.” Design recommendations given for video demonstrations to circumvent the perceived negatives included keeping them short, chunking them into small topics to make it easier for users to find and review what they want, and providing a transcript with the video

to let users read the demonstration rather than watch it. One participant offered that animated GIFs are a good solution for demonstrations because they efficiency start and replay the demonstration, they typically are short, and they can be combined with text to support multiple learning styles.

Wizards or brewers help novice mapmakers produce a map by stepping through cartographic design decisions (T4). Wizards were seen as a good solution for novice mapmakers, as they internally embed pragmatic knowledge on cartographic design into a neocartography interface. As one participant said, “I think that just really helps [novice users] understand what they're doing without having to refer to something external.” In particular, visual and kinesthetic learners may find the brewer option preferable for their learning styles. How, participants did identify drawbacks of wizards (mentioned above) and brewers. All ten participants stated that wizards and brewers can get too heavy handed and actually impede work, especially for expert users. As one participant stated, a wizard is “very linear but it's also very rigid, and the problem with that is that if you don't always go through the same sequence of steps” and continued to say that “the first time through, you're like, okay, this thing is really cool...but very quickly as your knowledge increases, often that step-by-step wizard really gets in the way.” Further, by imposing a sequential workflow, wizards and brewers can impede active learning by doing. Design recommendations to overcome the perceived negatives of wizards and brewers emphasized being able to dismiss the brewer at any time. As one participant stated, “not maybe making it permanently available at the beginning but not necessarily forcing a brand new user through it, if it's the kind of one that would like to dismiss it and you know just let me get started.” A wizard or brewer also

should make background information available to the user as to why particular design decisions are recommended in different design contexts.

Tooltips provide a short explanation of an interface control to which the user is pointing (T5). Tooltips are seen as standard, or as one participant termed “classic,” form of help. Tooltips were seen as the most efficient and easiest to ingest of the discussed learning materials, as one participant stated “it's just kind of keeping with the standard, and it's hopefully self-explanatory, but if not the little hover there can perhaps give a little bit extra detail,” and a second stated that they “give you just the thing you needed to learn at that moment, it's fast and it's learning in context.” While participants agreed that tooltips are a standard, useful form of learning support, two participants stated that tooltips are not necessary if interface transparency is achieved. Further, one participant brought up the important issue that tooltips the same way on mobile or touch devices as they do on desktops due to the lack of hover. It was recommended that tooltips be kept to short segments of knowledge because, as one person stated, “paragraph long tooltips are normally really annoying because they cover a lot of the screen.” Overall, participants agreed that tooltips always should be included in a neocartographic interface.

Forums allow users to post and respond to specific questions and can be a rich resource when there is an active community of users for the given neocartographic interface (T6). One participant supported sentiment, saying “I think it's really great when you can just have a community of people who can answer questions...that's a really good resource, a sort of help planning thing, but it's only achievable with a small number of products out there.” Due to the text format of forums, they are searchable and therefore allow for efficient identification of common user problems. However, one participant noted that forums can

become overwhelming for a novice user to navigate, particularly as the number of responses to a question increases. Further, this participant noted that novice users often do not know the correct vocabulary to use to search for a topic, stating that “There are so many unanswered questions because the questions are not phrased in a way that actually solicit a lot of response.” For these reasons, forums were recommended for supporting intermediate and expert users, and not advised for novice or first time use.

Documentation provides a level of depth and completeness not afforded by other types of learning materials (T7). Due to its ability to convey complex information, it is seen as an important type of learning material to provide for neocartographic interfaces, as one participant noted, “[It is] something where you can quickly see what this thing can do, and if you are struggling with something you can quickly do a search and find the solution.”

Participants stated that while documentation is helpful, it should be treated as something that will be referenced and not read in full. As one participant stated, “You’re not going to sit through 100 pages of documentation and just like sort of read it.” A second participant noted that motivated expert users are more likely to use documentation. Design recommendations for documentation included making it searchable, well-structured and organized and providing multimedia alongside the text. Well-structured documentation also should include a table of contents that can be skimmed. Endorsing documentation, one participant stated “subtitles and subheadings kind of get the sense of the range of the technology and everything that it has, just very briefly.” In this sense, documentation was considered an excellent way to show the full range of functionality of a neocartographic interface.

Annotated overlays point out the location of interface controls and provide a brief description of their functionality (T8). Only one of the surveyed neocartographic tools in

Section 2.4 employed overlays, and only two participants spoke about them in the interviews.

Overlays are found more commonly in a mobile environment, rather than a desktop environment, as an alternative to tooltips. Most existing neocartographic interfaces are designed for non-mobile use, which might explain the dearth of discussion regarding this type of learning material. One participant said that they are good for creating a common language for the neocartographic interface, educating the user about how to refer to the interface controls when using other learning materials. The second participant stated that, “Normally I dismiss them and then regret it, that would probably be best given a touch environment.” Therefore, it was recommended that the overlay can be activated and closed at any time during use, and not just available upon entry to the neocartographic interface.

Staffed support provides specific, specialized help that may not be available through other learning materials (T7). In the interviews, three forms of staffed support were discussed: (1) email, (2) phone, and (3) instant chat. Phone and instant chat were seen as “cool” because they could provide instant answers without needing to wait for an email response. Participants overall agreed that the user would find staff support as a positive, useful way to provide help, but that it would be overly taxing on the company and therefore not feasible in most contexts.

#### 4.4 Shneiderman and Plaisant’s Six Dimensions of Learning Materials

The fourth category of codes pertains to the Shneiderman and Plaisant’s (2010) six dimensions of learning materials (S). A total of sixteen codes were used to capture variation across these six dimensions. Three codes were included to capture the types of knowledge embedded in the learning material: (S1) semantic, (S2) syntactic, and (S3) pragmatic. Across

these types of knowledge, pragmatic was discussed the most frequently (average = 5.30), followed by syntactic (average = 3.80) and semantic (average = 2.00). Two codes were included to capture statements about the degree of integration: (S4) external and (S5) internal. Comments about internal integration were more common (average = 3.90) than those about external integration (average = 2.22). Four codes were included to cover the time of intervention: (S6) before use, (S7) at the beginning of use, (S8) at any time, and (S9) context-aware. Due to the fact that time of intervention is based on the given type of learning material, most participants comments regarding time of intervention were specific to individual learning materials, resulting in low frequencies overall (averages of 1.00, 1.00, 1.00, and 1.67 respectively), with these comments integrated into the discussion in Section 4.3. Five codes were included to capture statements about the media format: (S10) text, (S11) graphic, (S12) animation/video, (S13) audio, and (S14) a combination of media. Discussion about animation/video was much more common than the other forms of media (average = 5.4), followed by text (average = 1.78), graphic (average = 1.63), combination (average = 1.25), and audio (average = 1.00). Although two codes were included for extensibility (S15: open, S16: closed), the topic of extensibility was not discussed by any of the participants. Finally, codes for the sixth dimension—human support—were not included in the coding scheme due to overlap with staffed support (T9), revised in the previous subsection.

Three types of knowledge are required to learn and use a neocartographic interface successfully: semantic, syntactic, and pragmatic. Participant discussion suggested that different learning materials are best purposed for different types of knowledge. Participants agreed that semantic knowledge (S1) is best achieved through interface transparency and minimalist instruction, but as one participant noted, “I don’t think it’s possible to have 100

percent transparency with an interface when you're dealing with specialized functionality."

Learning materials regarding semantic knowledge therefore become increasingly important as transparent usability diminishes. One participant noted that tooltips are the best learning material for delivering semantic knowledge, as the tooltip can provide the name of the interface control and brief description about what it does it with limited effort.

Participants noted that semantic knowledge is key to acquiring syntactic knowledge (S2), as once users know the names of the provided interface controls, they then can find more in-depth information about processes and workflows for using the functionality to reach a goal. This participant stated, "As soon as you know what the name of a tool is, then it's very easy to gain whatever knowledge you need to work with it." Tutorials, brewers, and startup tips and tours were suggested as good solutions for supporting this syntactic knowledge due to their ability to outline steps in a clear effective manner.

Discussion about pragmatic knowledge (S3) had the widest variation in participant responses, both in how best to deliver this kind of knowledge as well as complex issues surrounding pragmatic knowledge and novice mapmakers. Pragmatic knowledge, in the context of this study, pertained to domain knowledge of cartography. Expressing the importance of providing learning materials on pragmatic knowledge, a participant stated, "I think that's actually a crucial point, I mean, if you talk about sort of my philosophy about mapping, I think that it's often why there's so many bad examples of maps because domain knowledge is such a well, you know, you can just click around a whole bunch and then you get a map, and then that's why we see so many of these God-awful examples of maps." Due to the ability to "click around" and make a map, many users may not even realize that pragmatic knowledge about cartographic design can improve their result. Such a lack of

awareness then might explain why many designers feel that novice mapmakers do not even care about acquiring pragmatic knowledge. Participants viewed a map brewer as the best way to provide pragmatic knowledge. Additional suggestions included video demonstrations, external documentation, and a context-aware tooltip to alert the user of pragmatic knowledge as it applies to current interactions. Four of the participants stated the sentiment that people should be able to make “bad maps” and break “rules” of cartographic design, but learning materials should be available if the user would like to learn more about cartographic design.

The location of learning materials can either be internal (S4), embedded within the neocartographic interface, or external (S5), found on a separate page or in a separate document. Participants preferred internal integration, with one participant stating that when learning can be done while using the interface, it is considered a “win.” As web technology has advanced, it has become easier to integrate learning materials into the interface through “slick interactive tours” context-aware tooltips, and brewers. Such internal solutions were seen as a benefit, with one participant noting “I think the inline stuff is nice because it’s kind of, it’s using the live system itself, as opposed to having to refer to something else that is external.” However, it may be impossible to include more complex, lengthier information internally, with one participant suggested that, “if it requires say more than two or three sentences, I’d move it to outside the interface.” This sentiment was reinforced by another participant, who said, “Well again, the integration is creating a more complex interface, so as long as it’s done well and it doesn’t get in the way, it works.” The general recommendation emerging from the discussion on integration was to embed the learning materials inside the interface whenever possible, but move them to external pages when the information included in the learning material grows too long or complex.

Four media formats were discussed in the interviews: text, graphic, animation/video, and audio. Participants positively responded to text (S10), with one participating stating that text is “greater because you can search it” both within the learning material, and then more broadly using a search engine on the Internet. It was noted that the ability to search text allows users to quickly locate the information that they are seeking, improving efficiency. As noted above, participants recommended chunking text into “bite size” pieces that are easier to navigate through and skim. However, one participant noted that, “I think the general trend has been from less words to more words, or less words and more pictures.” Participants supported the use of graphics (S11) because they can provide annotated screen captures of the user interface in combination with textual explanations. As one participant stated, “Like an annotated image that tries to explain the UI of it for you, that combination is great.” Video or animation (S12) was the most frequently discussed media format, with much of the discussion overlapping the discussion of demonstrations (T7) above. As described in the prior subsection, most of the discussion on video demonstrations was cautionary, with one participant stating “So they watch a 5-minute video and don't get any resolution, they just get kind of ticked.” However, a different participant did note that “videos are really effective, visually stimulating.” Only one participant commented on audio (S13), remarking that they have never seen an audio-only solution for learning materials. Most of the discussion regarding media format considered multiple formats in combination (S14), allowing for full support of different learning and media preferences.

#### 4.5 Khan's Cognitive Process Framework

Khan's (2005) cognitive process framework (K) comprises four topics: (K1) instructional feedback, (K2) instructional strategies, (K3) orientation, and (K4) navigation. The primary topic discussed related to Khan's framework was the feedback (average = 3.22). Discussion was limited about instructional strategies (average = 2.50), navigation (average = 1.5), and orientation (average = 1), with only one or two participants commenting on each of these topics.

Instructional feedback, when applied to neocartographic interfaces, describes the messaging provided by the interface to the user after an interaction (K1), and typically gives an indication if the interaction was correct completed or not. Feedback was seen by participants as essential for supporting novice users of neocartographic interfaces. Discussion on feedback for learning focused almost entirely on giving novices warnings against interactions. Feedback warning fell into two categories, critical or fatal errors (primarily syntactic knowledge) and times when the user may be breaking cartographic conventions (primarily pragmatic knowledge). Speaking about these two categories, one participant said, “one of them would be they're doing something that's just not going to work right, and it's going to break the process or the data isn't formatted right, so you need something back saying hey, this isn't actually numbers, that's pretty critical.” This participant went on to say “On the other end, it's like what they're trying to do with any map flow is to kind of tell people how to make correct maps right now.” Design recommendations between “fatal” errors and “cartographic” errors differed. As for fatal errors, strong feedback was suggested, a popup tip that appears in the middle of the screen and explains, as one participant said, “in plain English” what the error is and how to fix it. For cartographic errors, popup tips should

be subtler. Speaking about cartographic feedback with popup tips, one participant said, “This could be annoying, maybe arresting their behavior with a popup is too strong,” while a second said the popup tip should not “freeze your whole thing, but you click on it and maybe sort of pops up for like for five seconds, but lots of notifications would make them useful to people, but not annoying.” Thus, the design of fatal feedback should be strong and corrective, while the design of cartographic feedback should be subtle and suggestive.

Participants noted three axioms that serve as the foundation for an overall instructional strategy (K2): provide information about how to interact with learning materials, provide information about knowing which parts of the learning materials are essential and which can be skipped, and provide information about how to find additional information outside the scope of the learning materials. Participants noted that a clear entry point into both the interface and the learning materials is needed, which can be reinforced through startup tips. One participant suggested that instructional strategies can be reinforced by, “have some sort of expandability...If you want to have a broad topic let me expand into to get to the sub areas.” This allows users to see what is available upon first entry into the learning material, while enabling them to “drill down” to the specific information that supports them while actually using the neocartographic interface. This is mirrored in several of the few comments regarding orientation (K3) and navigation (K4), as suggestions included providing a broad list of topics or “table of contents” in order to allow users to gain an overview of what is available and quickly navigate to a learning material of interest. Finally, one participant, mimicking statements about the text media format above, noted that a search function can greatly improve the navigation of learning materials.

#### 4.6 Carroll's Minimalist Instruction

Carroll's (1998) minimalist instruction describes strategies for supporting active learning (C), or learning by jumping into a new interface and exploring, rather than spending a large amount of time learning a system upfront. Four codes were included to capture input about minimalist instruction: (C1) order, identifying statements about learning materials designed to be read and used in a sequential or methodical order, (C2) subject, identifying statements about learning materials that are organized by subject or domain task, (C3) exploring, identifying statements about encouraging open exploration prior to reviewing materials, and (C4) active, identifying statements about encouraging active learning. Within this category of codes, the greatest amount of discussion was on active learning itself (average = 3.63), followed by order (average = 2.50), exploring (average = 1.75), and subject (average = 1.67).

The process in making a map is not sequential. Accordingly, participants noted that learning materials should be organized by subject first (C2), and then ordered sequentially within subject (C1). As one participant stated, "I think it should be organized by what you're doing at that moment...So, yeah, by subject matter, then it should be linear" following this comment with "I don't necessarily want to go through step by step unless the topic I'm looking up requires a step by step [solution]." Concerns over learning materials that are ordered sequentially were greatest with tutorials, with one participant stating "I tend to get a little frustrated with those because they won't let me do what I want to do until I do the next step that they insist on and I'm not necessarily a linear thinker and so I tend to dismiss those more readily." Supporting this combined subject then order solution for organizing learning

materials, a participant said, “I really feel it’s sort of step one, step two sort of stuff as an intro...But, it is really useful also to have kind of ‘pick out what you need’ type of help.”

Interestingly, several participants suggested that support for exploration (C3) and active learning (C4) actually might be more important for novice rather than expert mapmakers. A participant highlighted this report, “So if you’re a novice you’re not going to spend potentially more than 10 or 15 minutes playing with this tool before your end result.” An interface that allows the user to jump in immediately and complete work was seen as ideal. Several of the learning materials—such as documentation and video demonstrations—were labeled as “passive” and therefore considered ineffective for supporting active learning. Recommendations for supporting exploration and active learning included providing a small example that the user can modify, provide outlets to “play” within the interface, and mimic exploration though short interactive tours and tutorials.

#### 4.7 In-House Best Practices

The final category of codes collected participant opinions on in-house best practices in the use and design of learning materials for neocartographic interfaces (A). Three codes were included under this category: (A1) past best practices, (A2) present best practices, and (A3) future trends. Although overall discussion was limited regarding best practices, past best practices were spoken about the most frequently (average = 2.0), followed by present best practices (average = 1.60) and future trends (1.25).

In the past (A1), participants stated that user manuals were common. As one participant noted, “Every piece of software used to come with a, you know, sometimes 3 or 400 page heavy user manual and it was very linear and it was very much set up like a

textbook.” However, technological changes presently (A2) allow for interactive tutorials which, “[seem] to be much better, much better, faster.” As mentioned above, context-aware tooltips that are embedded internally to the interface also have become standard. Regarding present practices, one participant noted that, “Video tutorials and hands-on demonstrations... You know, I think that's kind of the norm now but it's also very user-friendly and approachable.” Interestingly, animated GIFs were viewed by some participants as a thing of the past, but by others as an emerging trend in learning material practice (A3). Taking the latter perspective, one participant stated that animated GIFs are making a comeback due to the transition away from the Flash plugin and towards the open web platform. Other future trends include greater inclusion of context-aware solutions and heavier reliance on startup tours. Commenting on the expansion of new technologies, one participant stated, “And now we have many more options and I think you've liked picked out quite a few and having got that entire range is, I think, part of the solution.”

## **Chapter 5: Summary and Future Directions**

### **5.1 Summary of Results**

This research sought to discover the current landscape of learning materials in neocartography and, through this exploration, began to describe best practices in designing and using materials for neocartographic interfaces. To this end, I aimed to answer the following questions:

- (1) Do learning materials improve the usability of neocartographic interfaces designed for the general public?
- (2) Are there existing best practices for designing learning materials in cartography? If so, what are they?
- (3) Are there certain contexts, user groups, or types of knowledge that determine if one type of learning material is better suited than another?
- (4) How should domain knowledge of cartographic principles be supported in neocartographic interfaces?

In this thesis, I made three contributions to address these questions: (1) I first completed a review of relevant literature in cartography, HCI, and usability engineering regarding the design and use of learning materials, (2) I then compared a set of ten contemporary neocartographic interfaces and their learning materials according to the frameworks and recommendations from the literature review, and (3) finally, I conducted expert interviews with the designers of these neocartographic interfaces and associated learning materials, as well as instructors who use them in a classroom setting, to capture contemporary practice and opinion about key themes and trends identified in the background

review. This work serves as an initial characterization of best practices regarding the design and use of learning materials for neocartographic interfaces according to expert views, serving as a formative foundation for further research. Insight towards each of the four research questions is summarized below.

*(Q1) Do learning materials improve the usability of neocartographic interfaces designed for the general public?*

In this research, the usability of neocartographic interfaces was examined by the heuristics of learnability, memorability, error prevention, and efficiency. When speaking about the usability of neocartographic interfaces, participants in the interviews noted that it is the overarching goal to achieve interface transparency, which does not rely on the review of learning materials. However, due to the diverse kinds of the knowledge (semantic, syntactic, and pragmatic) required to make use of a neocartographic interface, participants agreed that interface transparency is not always possible. Learning materials are important for filling the usability gap when transparent usability cannot be achieved. One important way in which learning materials improve usability is through immediate and internal instructional feedback, which prevents ‘fatal’ errors and potentially avoids ‘cartographic’ errors, although in a more subtle way. Participants agreed that the efficiency in accessing and reviewing learning materials is key, with participants suggested an organization of learning materials by subject and a chunking of learning materials in “bite-sized” pieces. Overall, the interviews reminded that it is not the goal to convert novice users into experts, but to provide just enough instruction to allow novices to use the interface (i.e., to make it usable for them).

*(Q2) Are there existing best practices for designing learning materials in cartography? If so, what are they?*

The literature review on cartography, HCI, and usability engineering revealed several relevant frameworks for conceptualizing the design and use of learning materials (Section 2.2) and multiple recommendations for designing specific types of learning materials (Section 2.3). The expert interviews expanded on this body of knowledge for neocartographic interfaces specifically supporting novice users, which, as reviewed in Chapter 4, pose a unique set of challenges due to their complexity and domain specific knowledge. Both overarching and learning material type-specific design recommendations emerged. Based on the expert feedback, I offer eleven best practices in the design and use of learning materials for neocartographic interfaces; Table 6 provides a more detailed review of recommendations for each of the nine types of learning materials introduced in Section 2.3:

- (1) Give users control: Following minimalist instruction, users often are excited to jump in and explore the interface, and therefore should be able to dismiss learning materials that intervene before starting an interaction session or at the beginning of first use (e.g., startup tips and tours, demonstrations, annotated overlays). Forcing users to step through unneeded or unwanted learning materials limits their sense of control over the interface, and likely will annoy and frustrate them, hindering learning.
- (2) Enable access at any time: While it is important to allow users to skip learning materials at the beginning of the session, it also is important that they know how to access them when needed. Learning materials therefore should be accessible at any time, and the control for accessing them should be clearly marked in the interface.

- (3) Focus on internal integration: While external learning materials, such as documentation, are useful for expert users, novices will benefit from an emphasis on internally embedded learning. Internal learning materials are more efficient and reduce cognitive load, improving memorability.
- (4) Chunk information: Memorability further is improved by breaking apart instructional content into decodable pieces. Breaking apart text, videos, and tutorials into smaller pieces allows users to find the information they need more quickly and helps them recall the content with more ease, again lightening the cognitive load.
- (5) Restrict pragmatic knowledge for novices: Although essential for gaining expertise in cartography, pragmatic knowledge on cartographic design may not always be beneficial to a novice user. When providing knowledge, do so in a subtle, non-intrusive way and avoid impeding the workflow of the user.
- (6) Support non-sequential learning: Mapmaking is not a sequential process, and for this reason sequential or step-by-step learning materials such as tutorials and wizards may restrict exploration and active learning with a neocartographic interface. Organize learning materials by subject first, and sequential order second.
- (7) All users are different: Users have different learning styles, preferences, and levels of domain knowledge. Therefore, there is not one type of media format or type of learning material that will work for everyone. Use multiple media format and types of learning materials in combination to support a wider range of users.
- (8) Make searching easy: Searchability is valued because it allows users to efficiently find the specific information for which they are looking. Therefore, consider

providing a text alternative to multimedia learning materials, such as providing a transcription for video demonstrations.

(9) Use consistent vocabulary: Users first must acquire semantic knowledge before they know how to search for syntactic and pragmatic knowledge. Therefore, developing a straightforward and logical naming system of the interface controls is important for novice users. This vocabulary then should be consistent across the neocartographic interface and all provided learning materials.

(10) Design two kinds of feedback: Feedback about critical errors that ‘break the map’ is essential and should be corrective in nature to help the user overcome the error. Feedback about cartographic design decisions should be given in a subtle way and offered as a suggestion, rather than correction.

(11) Support active learning: Learning by doing, or active learning, is the primary method by which a user will learn an interface. This remains true for first time, novice users. Design the interface to allow users to see immediate successes within the interface, providing learning materials only after they run into problems.

*(Q3) Are there certain contexts, user groups, or types of knowledge that determine if one type of learning material is better suited than another?*

Design best practices for learning materials are strongly linked to context, user groups and type of knowledge. Table 6 provides a summary of best practices by type of learning material. Participants in the interviews commonly noted that, while that one learning material would benefit an expert, it would perhaps annoy, frustrate, or impede the work of a novice, and vice versa. For example, while brewers can aid a novice user greatly, they might slow

down an expert user. In contrast, while forums are an excellent resource for expert users to gain answers to specific, in-depth questions, forums can become overwhelming and frustrating for novice users that do not yet know how to ask a question properly or be able to make sense of the provided responses. It was the consensus that tutorials, startup tips and tours, and wizards/ brewers are excellent learning materials for novice users, while forums, documentation, and examples are generally better for expert users. Tooltips were seen to have no negative impact on experts and therefore should be universally included. Annotated overlays are useful replacements for tooltips in the context of mobile design.

There are three types of knowledge can be supported by learning materials: (1) semantic, the name and purpose of a tool, (2) syntactic, the process or processes to produce a map, and (3) pragmatic, domain knowledge specific to cartography about design principles. From the interviews, it emerged that some learning materials may be better suited for one type of knowledge over another. For communicating semantic knowledge, it was found that tools that are internal to the interface are best, such as tooltips, annotative overlays, and startup tips and tours. Tutorials, startup tours, demonstrations, and wizards were considered useful for acquiring syntactic knowledge due to their ability to establish and explain a workflow. Approaches for supporting pragmatic knowledge are summarized in the final research question.

Type of tool	Pro	Con	Recommendation
Tutorials	<ul style="list-style-type: none"> <li>- Effectively supports syntactic knowledge</li> <li>- Establishes a common language</li> </ul>	<ul style="list-style-type: none"> <li>- Expert users may get frustrated, as they do not want to be forced to review material they already know</li> <li>- Takes time and investment</li> </ul>	<ul style="list-style-type: none"> <li>- Should be short and “bite size”</li> <li>- Internal to the interface is ideal set-up, if possible</li> <li>- Consider providing examples rather than full tutorials for expert users</li> </ul>
Startup Tips and Tours	<ul style="list-style-type: none"> <li>- Interactive tours perform well because they internally show users where things are in the context that people will actually be using the tools</li> <li>- Provides an entry point for using the interface</li> <li>- Lightens the cognitive load, as user does not have to exit the interface to learn material, then remember what was learned upon return to the interface</li> </ul>	<ul style="list-style-type: none"> <li>- Can prevent work</li> <li>- Can annoy the user</li> <li>- Usually in a sequential format, but mapmaking is not always sequential</li> </ul>	<ul style="list-style-type: none"> <li>- Should be short: within a suggested range of 1-6 steps</li> <li>- Allow the user to dismiss help at any point</li> <li>- Allow for the recall of startup help at any point</li> <li>- Limit startup help to the first few times of use, at which point, limit to request only</li> </ul>
Animated and Narrated Demonstrations	<ul style="list-style-type: none"> <li>- Effectively supports syntactic knowledge</li> <li>- Can help novice users gain familiarity with the interface</li> <li>- Excellent for visual learners</li> </ul>	<ul style="list-style-type: none"> <li>- Users cannot easily skip to sections they are interested in</li> <li>- Does not effectively support active learning</li> <li>- Memorability may be an issue. It can be challenging for a user to repeat an interaction that they viewed in a video outside of the interface.</li> <li>- Not for expert users</li> </ul>	<ul style="list-style-type: none"> <li>- Consistency in showing processes, and do not show them too quickly</li> <li>- Provide a back and/or slow-down function</li> <li>- Providing a written transcript with video can help to support a broader range of learning styles</li> <li>- Consider using GIFs to show short interactions</li> <li>- Keep demonstrations succinct</li> <li>- Break demonstrations into segments or chapters to help user locate information quickly</li> </ul>
Wizards and Brewers	<ul style="list-style-type: none"> <li>- Supports good mapping practices without requiring the user to have domain knowledge</li> <li>- Appropriate for novice users</li> <li>- Supports learning by doing for active or kinesthetic learners</li> <li>- Internal to the interface</li> </ul>	<ul style="list-style-type: none"> <li>- Can get too heavy-handed and hinder workflow</li> <li>- May feel rigid to the user</li> <li>- Can impede workflow for intermediate and expert users</li> <li>- After the first initial uses, some may get bored or tired of repeatedly going through rigid steps</li> </ul>	<ul style="list-style-type: none"> <li>- Include the ability to deactivate wizards</li> <li>- Allow for steps to be skipped</li> <li>- Provide domain knowledge to the user about decisions they made</li> </ul>
Tooltips	<ul style="list-style-type: none"> <li>- Efficient</li> <li>- In-context learning</li> <li>- Supports semantic knowledge</li> <li>- Helpful when interface transparency cannot be achieved</li> <li>- Supports interface exploration</li> </ul>	<ul style="list-style-type: none"> <li>- Not mobile friendly</li> </ul>	<ul style="list-style-type: none"> <li>- Short segments of text so as to not have long paragraphs that block the interface</li> <li>- Longer segments of text belong elsewhere</li> <li>- Consider always including them since there are no perceived negatives</li> </ul>

Forums	<ul style="list-style-type: none"> <li>- Provides high-level, specific support</li> <li>- Searchable</li> <li>- Works well for intermediate and expert users</li> </ul>	<ul style="list-style-type: none"> <li>- Must know how to ask a question first, which requires some domain and vocabulary knowledge</li> <li>- Novices may not be able to judge the quality of responses, and some responses may not be the solution they need</li> </ul>	<ul style="list-style-type: none"> <li>- Needs an active community</li> </ul>
Documentation	<ul style="list-style-type: none"> <li>- Searchable</li> <li>- Good for in-depth support</li> <li>- Skimming headings and titles can help teach users about the full breadth of functionality that is possible</li> </ul>	<ul style="list-style-type: none"> <li>- Novices may be overwhelmed by extensive documentation</li> <li>- Unlikely that it will be consumed in its entirety</li> </ul>	<ul style="list-style-type: none"> <li>- Include a search function</li> <li>- Keep information well-organized and structured so that users can locate the information they need</li> <li>- Quality writing is important for user readability</li> <li>- Support chunking of information with “bite-sized” paragraphs</li> <li>- Use graphics, videos, and GIFs to support multiple types of learners and to help break up the text</li> </ul>
Annotated Overlays	<ul style="list-style-type: none"> <li>- Works well for showing the location and a brief description of tools</li> <li>- Mobile friendly</li> <li>- Establishes a common language</li> </ul>	<ul style="list-style-type: none"> <li>- Too many items in the overlay can lead to cognitive overload</li> <li>- Users may dismiss annotated overlays right away and prefer to explore the interface, instead</li> </ul>	<ul style="list-style-type: none"> <li>- Needs to be recallable after dismissal</li> <li>- Be aware that the more items that exist on an overlay, accordingly decrease the users ability to recall the information</li> </ul>
Staff Support	<ul style="list-style-type: none"> <li>- Seen as a nice offer</li> <li>- Can provide user specific support</li> </ul>	<ul style="list-style-type: none"> <li>- Email support was seen to take too long to receive answers</li> <li>- Can be taxing on the organization</li> </ul>	<ul style="list-style-type: none"> <li>- Live chat or phone support can quickly provide users with the information that they are looking for</li> </ul>

Table 6: Design and use recommendations based on experts perceptions for different types of learning materials.

(Q4) How should domain knowledge of cartographic principles be supported in neocartographic interfaces?

Maps created by novice mapmakers often do not adhere to cartographic principles, which ultimately designate them as “bad maps” in the minds of expert cartographers. However, as stated two participants, the novice mapmaker is not to be blamed for what they do not know. Thus, a benefit of learning materials, when applied to neocartographic interfaces, is that they can help the user incorporate domain knowledge into their work,

allowing novice mapmakers to produce maps that more ethically and effectively communicate information.

The interview study generated two ideas for incorporating domain knowledge into neocartographic interfaces. The first was a “smart interface,” in which domain knowledge is integrated into the interface as a constraint on what the novice user can do in their map design, ensuring that the resulting maps meet cartographic principles. The second was provision of learning materials providing pragmatic knowledge in order to teach the novice user about cartographic principles, ultimately allowing them to make their own decisions in designing their maps. Recommended learning materials for communicating domain knowledge included tutorials, demonstrations, documentation, and even modified brewers that explain cartographic conventions as they recommend appropriate solutions. That said, it cannot be expected that novice users have the time or interest in becoming an expert in cartography. In this respect, neocartographic interfaces and their learning materials need to be designed not to convert novices into experts, but to make domain knowledge available when needed.

## 5.2 Limitations

Limitations of this study and its claims are linked to the small sample pool from which to recruit expert participants. Due to the relatively small pool of possible participants, the ultimate sample was small. A larger participant size would improve the validity of the above design recommendations. Another limitation was that the expert interviewees were speaking only from anecdotal experience about novice users and learning materials. A promising future research area would be to conduct research with novice users to see how they employ

learning materials when using neocartographic interfaces. Finally, there was a large UW-Madison Department of Geography connection (4/1), given the use of key gatekeepers at UW to identify potential participants; none of the participants were students, however. Because many participants shared similar background training, the elicited opinions and perspectives may not be completely representative of professionals working in neocartography.

### 5.3 Future Directions

As stated in the introduction this research sets out to serve as a foundation for future studies on learning materials supporting neocartographic interfaces. The above research findings and best practice recommendations serve as a jumping off platform for further research. Future directions would be to conduct both qualitative and quantitative studies with novice users to evaluate the claims and recommendations made in this research. A quantitative study measuring the usability of neocartographic interfaces that randomly assigns users a type of learning material would be one important way to reveal more detailed and quantifiable insight into the impacts learning materials have on the use of neocartographic interfaces. A follow-up qualitative focus group of novice users could gain deeper insight into the experience that novices have when first learning these interfaces. Future studies derived from the solicited expert perspectives in this study are likely lead to deeper insight regarding best practices are likely to provide a deeper insight into the design and use of learning materials.

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## Appendix A

# Learning and Help Materials Screenshots

This document contains screenshots of learning and help tools from online mapping websites. The screenshots were taken between February 2014 - July 2014. Some of the learning and help materials may have changed since the screen capture. This list is not meant to be comprehensive, but is instead meant to serve as a conversation piece around learning and help tools, and their design. You will find that the tools are organized by type of learning tool.

## Documentation

### IndieMapper Help

<http://indiemapper.com/app/learnmore/>

The screenshot shows the 'IndieMapper Help' page. At the top, there's a navigation bar with 'learn more' and 'table of contents' buttons. The main content area has a header 'Welcome To Indiemapper Help!' followed by a paragraph of text. Below this, there's a section titled 'General Map Making Topics' with a list of links. Further down are sections for 'Univariate Thematic Map Types' and 'Multivariate Thematic Map Types', each with its own list of links. At the bottom, there's a section titled 'Want to dig a bit deeper?' with a list of recommended textbooks. The footer includes 'INDIEMAPPER SUPPORT' and a link to 'indiemapper help'.

Welcome To Indiemapper Help! Here we share our insights and tips for making great thematic maps. Our goal is to cover the important concepts in cartography and flag the important decision points in the map-making process. As with many activities in life, there isn't always a single best answer in cartography, and in those cases we've tried to outline some of the pros and cons to different solutions. Indiemapper makes it easy to experiment - so don't be shy.

This help system is not meant as a replacement for a full textbook on cartography, rather it is a quick reference guide for those moments when you're stumped, unsure of what to do next, or unfamiliar with the terminology. While the recommendations on these pages are quick and not loaded with academic references, please appreciate that they represent a thoughtful synthesis of decades of map-making research.

**General Map Making Topics**

- [Level of Measurement: Nominal, Ordinal, and Numerical Data](#)
- [Standardizing Data](#)
- [The Basics of Data Classification](#)
- [Labeling and Text in Cartography](#)
- [Using Colors on Thematic Maps](#)
- [Univariate Maps versus Multivariate Maps](#)

**Univariate Thematic Map Types**

- [Choropleth Maps](#)
- [Proportional and Graduated Symbol Maps](#)
- [Dot Density Maps](#)
- [Non-Contiguous Cartograms](#)

**Multivariate Thematic Map Types**

- [Bivariate Choropleth](#)
- [Bivariate Cartogram](#)
- [Bivariate Proportional Symbols](#)
- [Value by Alpha](#)
- [Proportional Labels](#) (2 variables)
- [Colored Proportional Labels](#) (3 variables)

**Want to dig a bit deeper?** Have a look at a few of our favorite textbooks:

- Slocum et al. (2008) [Thematic Cartography and Geovisualization](#) (3rd Edition)
- Brewer, C. A. (2005) [Designing Better Maps: A Guide for GIS Users](#)
- Dent et al. (2008) [Cartography: Thematic Map Design](#) (6th Edition)

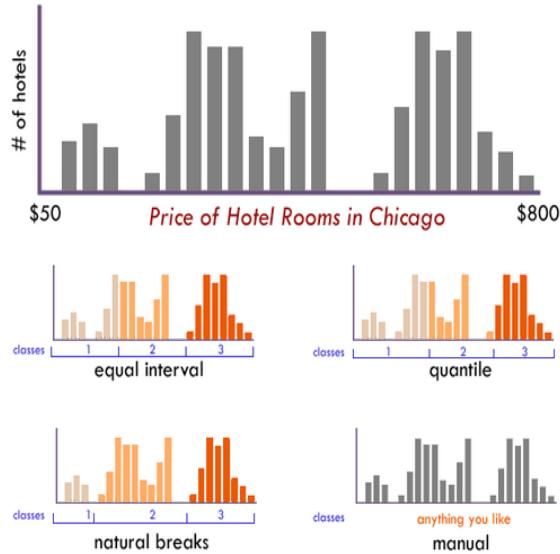
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**INDIEMAPPER SUPPORT**

[indiemapper help](#)

**Classification Method**

Just as there is no single correct number of classes, there is no single best way to classify your data into ranges. Look at the histogram (or scatterplot) to determine the 'form' of your observations. Above all else the goal of data classification is to put places with similar rates in the same class, and separate places with very different rates into different classes.



*The form of this histogram suggests that 3 or 4 data classes seem most appropriate. Lacking any other insight, the "dips/gaps" suggest natural places to break the data.*

**EQUAL INTERVAL** divides the data into equal size classes (e.g., 0-10, 10-20, 20-30, etc.) and works best on data that is generally spread across the entire range. **CAUTION:** Avoid equal interval if your data are skewed to one end or if you have one or two really large outlier values. Outliers in that case will likely produce empty classes, wasting perfectly good classes with no observations in them. Since the hotel data above doesn't have really large outliers, this is a data distribution that works well with equal interval.

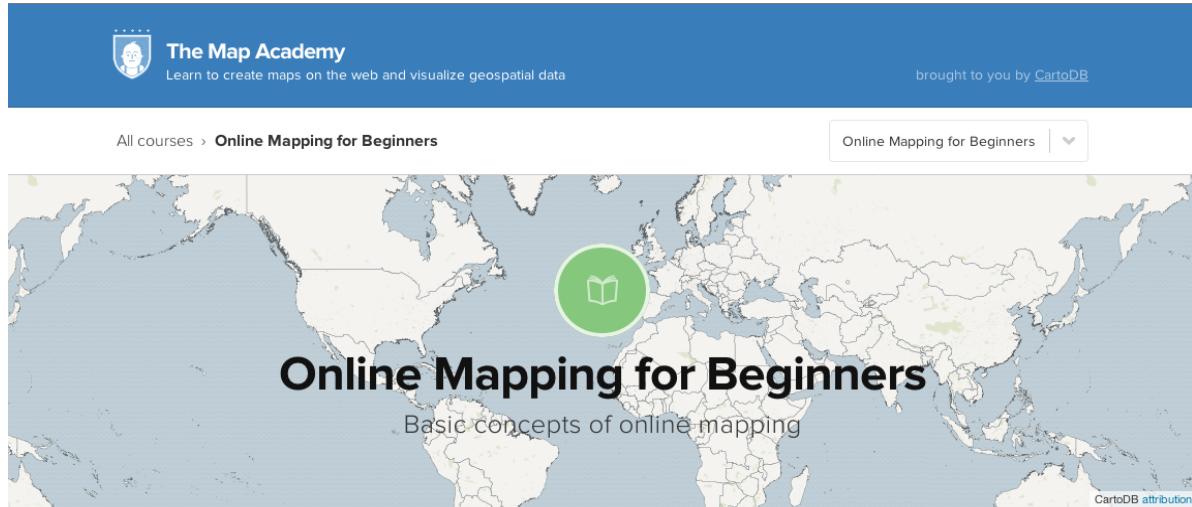
**QUANTILES** will create attractive maps that place an equal number of observations in each class: If you have 30 counties and 6 data classes, you'll have 5 counties in each class. The problem with quantiles is that you can end-up with classes that have very different numerical ranges (e.g., 1-4, 4-9, 9-250...the last class is huge). Quantile can also separate locations with very similar rates and group together places that have very different rates, which is very undesirable, so use the histogram to see if this is happening. **CAUTION:** In the hotel room example above, the quantile produced a questionable class break by lumping a portion of the third cluster back into class 2, despite it being much closer (numerically) to the other observations in class

**NATURAL BREAKS** is a kind of "optimal" classification scheme that finds class breaks that (for a given number of classes) will minimize within-class variance and maximize between-class differences. One drawback of this approach is each dataset generates a unique classification solution, and if you need to make comparison across maps, such as in an atlas or a series (e.g., one map each for 1980, 1990, 2000) you might want to use a single scheme that can be applied across all of the maps.

## Tutorial

### CartoDB Online Mapping for Beginners

<http://academy.cartodb.com/courses/01-beginners-course.html>



#### Lesson 1

Making your First Map

#### Lesson 2

Your First Choropleth Map

#### Lesson 3

Thematic Maps with Point Data

#### Lesson 4

Animated Maps with Point Data

#### Lesson 5

Multilayer Visualizations

#### What you'll learn

In this lesson, you will learn how to work with data tables to create interactive map visualizations. You will explore styling your map, adding multiple data sets, and experimenting with different ways to display your data, including animated maps. You'll learn how to share your new visualizations with friends, family, and the world.

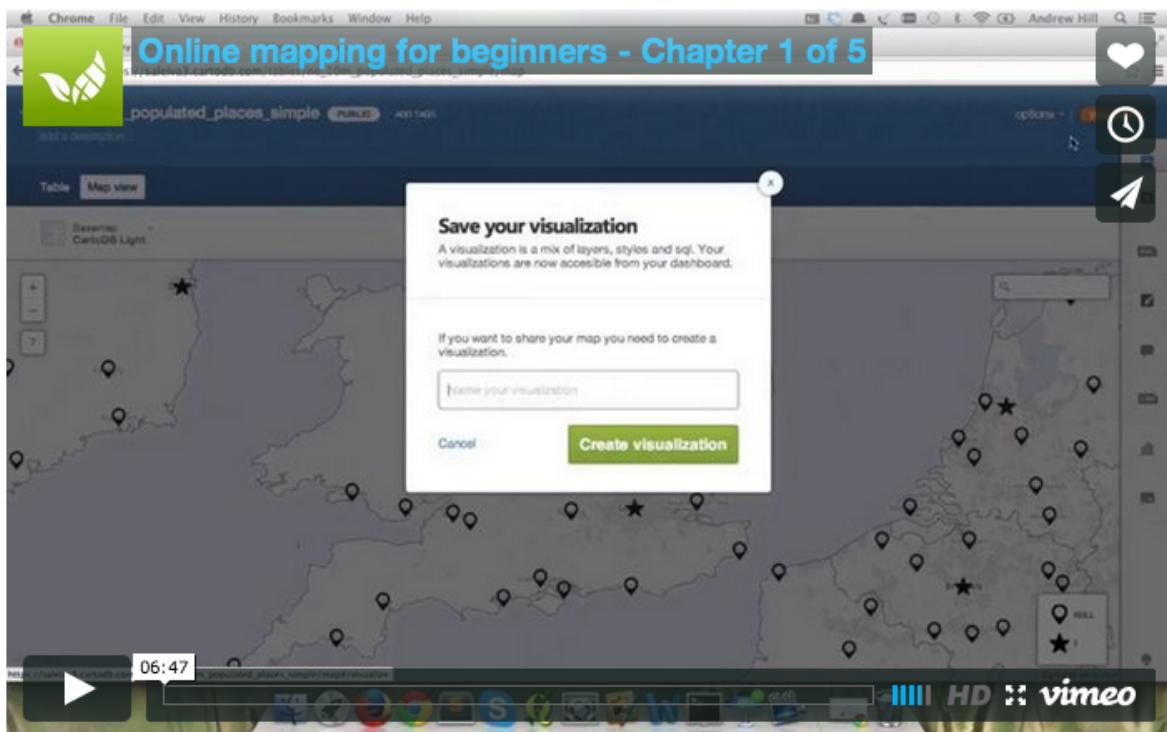
#### Prerequisites

- Reliable internet access
- A modern browser like Chrome, Firefox, or Safari
- Basic computer skills

## Demonstration

### CartoDB Video Help: Mapping for Beginners

<http://academy.cartodb.com/courses/01-beginners-course/lesson-1.html>



## Forum

### Google Maps Engine Users Forum

<https://groups.google.com/forum/#!forum/google-maps-engine-users>

The screenshot shows the Google Groups interface for the 'Google Maps Engine Users' group. The left sidebar includes sections for 'My groups', 'Favorites' (with a note to click a star icon to add it), and 'Recent searches'. The main content area displays the group's homepage, which includes a welcome message, a summary of 34 topics (99+ unread), and a 'Join group to post' button. It also features a 'About' section and a 'Welcome to the Google Maps Engine Users Group!' message. Below this, there's a section titled 'A few important points:' with several bullet points about communication guidelines. At the bottom, there are three recent posts: 'Create and update assets in V1 of the API' by Daniel Resnick (2 posts, 15 views, Jul 3), 'New Maps Engine API Tutorial!' by Jen Kovnats (4 posts, 336 views, Mar 11), and 'Launched: API access to larger vector tables and dynamic query capacity for Maps Engine customers' by Jen Kovnats (1 post, 161 views, Jan 22).

## Contact

### Mapbox: Email Support

<https://www.mapbox.com/contact/>

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### Contact us

Have questions about our products, hosting, support services, or anything else? Let us know and we'll get back to you.



[Get help](#) Instant answers to frequently asked questions.



[sales@mapbox.com](mailto:sales@mapbox.com) Talk to our team about using Mapbox at your organization.



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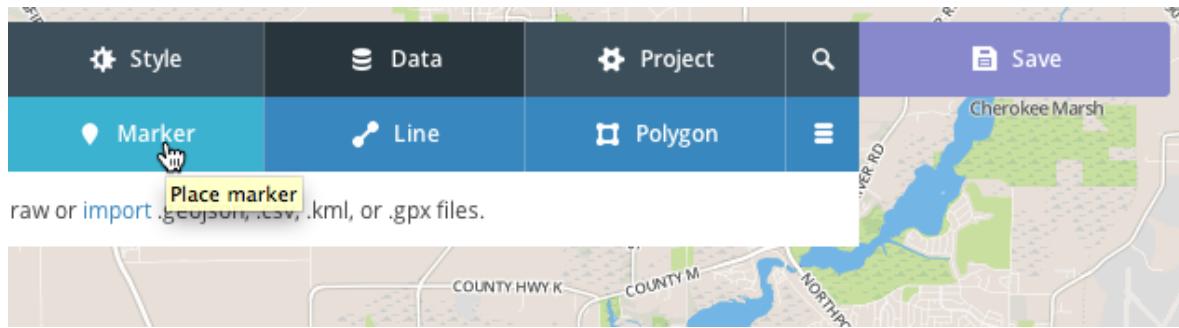
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## Tooltip

### MapBox: Place Marker Tooltip

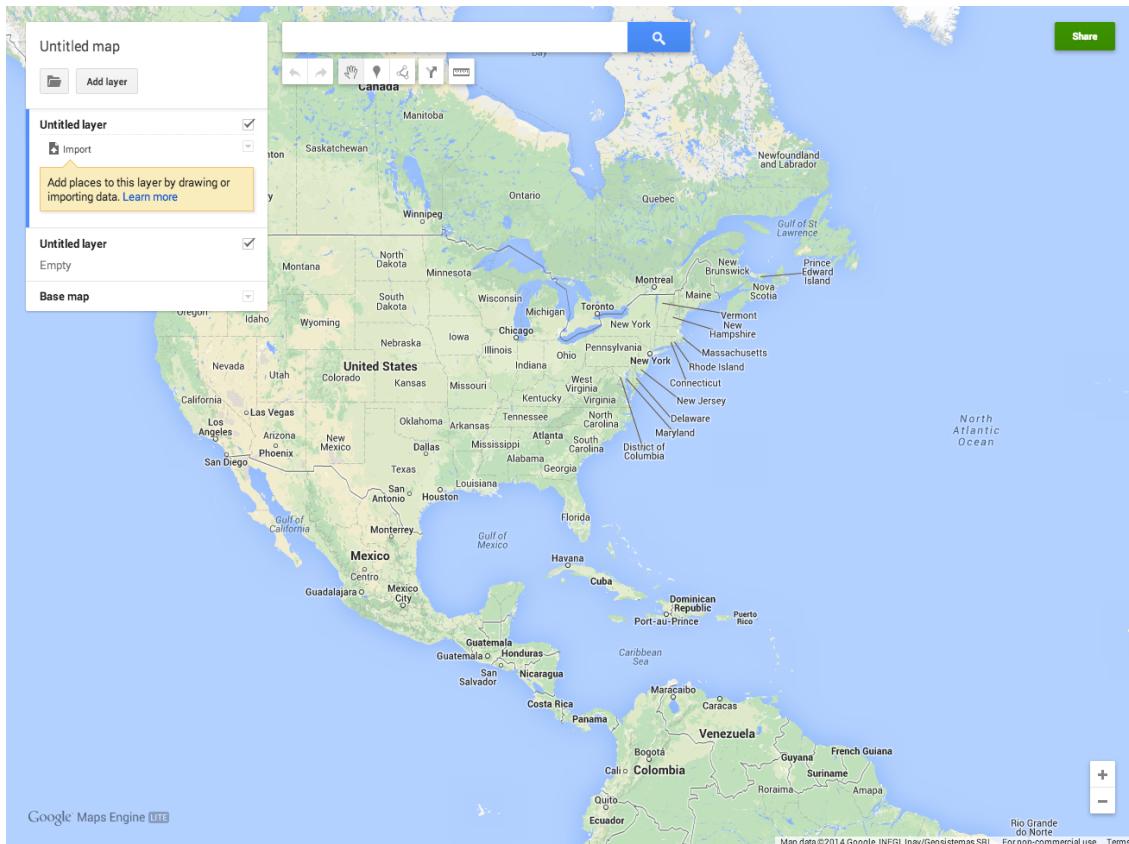
<https://www.mapbox.com/>



## Startup-Tip

### Google: Add Places or Import Data

<https://mapsengine.google.com/map/>



## Startup Tour

### ArcGIS: Interactive Tutorial

<http://www.esri.com/software/arcgis/arcgisonline>

HOME ▾ Example

Details Add Edit Basemap

Step 1

Type an address or location, for example, Empire State Building.

Seattle, WA

NEW MAP Carrie

Get Started

Pick a tour to learn more about the map viewer.

Make a map START >

Style your map START >

Explore ready to use layers START >

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HOME ▾ Example

Details Add Edit Basemap Share

Step 2

You can always add new points (also known as, features) or update existing ones. Click the Add button.

Make a map START >

Style your map START >

Explore ready to use layers START >

Location

Empire State Building - 350 5th Ave, New York

Not what you wanted?

Get Directions

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**HOME ▾ Example**

**Get Started**

- Search for Layers
- Browse Esri Map Layers
- Add Layer from Web
- Pick a tour to the map view
- Add Layer from File
- Add Map Notes **Make a map START >**
- Style your map **START >**
- Explore ready to use layers **START >**

**Step 3**

Let's add information to the map. Select **Add Map Notes**.

**Location**

Empire State Building - 350 5th Ave, New York  
Not what you wanted?  
Get Directions

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## Brewer

### IndieMapper: Map Brewer

<http://indiemapper.com/>

**indiemapper v. 1.089**

**layers**

**1 Choose a new layer to add**

one attribute    reference points, lines, and/or areas  
 multivariate    map labels

**2 Choose an attribute**

Nuclear Power Reactors ...  
Nuclear Power Reactors ...  
Nuclear Power Reactors ...  
Nuclear Power Reactors ...  
People

**3 Choose a map type**

Proportional Symbols **Choropleth**  
Dot Density  
Cartogram

**4 Standardize your data**

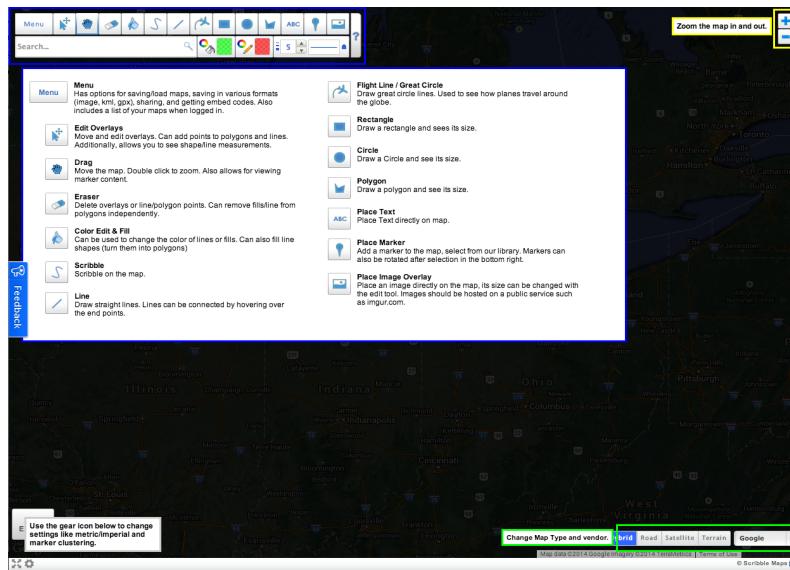
yes  no  
display current data  
Nuclear Power Reactors Opera...  
by: Nuclear Power Rea...

Cancel **Okay**

## Overlay

### BatchGeo: Tool Overlay

<http://batchgeo.com/>



## Feedback

### CartoDB: Error Feedback -No Georeferenced Data On Your Table

<http://cartodb.com/>

