

# Understanding how Designers Find and Use Data Visualization Examples

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**Abstract**—Examples are useful for inspiring ideas and facilitating implementation in visualization design. However, there is little understanding of how visualization designers use examples, and how computational tools may support such activities. In this paper, we contribute an exploratory study of current practices in incorporating visualization examples. We conducted semi-structured interviews with 15 university students and 15 professional designers. Our analysis focus on two core design activities: searching for examples and utilizing examples. We characterize observed strategies and tools for performing these activities, as well as major challenges that hinder designers' current workflows. In addition, we identify themes that cut across these two activities: criteria for determining example usefulness, curation practices, and design fixation. Given our findings, we discuss the implications for visualization design and authoring tools and highlight critical areas for future research.

**Index Terms**—Examples, visualization design, idea generation, interview study, qualitative research

## 1 INTRODUCTION

From knitting to web design to manufacturing, designers across domains rely on examples as sources of inspiration [24, 27, 39]. It is no surprise that visualization designers often look for relevant examples [10, 43] on galleries like BLocks.org [3] and Observable [13] and sharing communities like Tableau public [5]. We use the term “designers” broadly: while “designers” often refers to individuals who specialize in the profession of design, in our work this term refers to individuals who create any form of data visualizations for various purposes, including but not limited to journalists, data analysts, and UX designers. Little research has studied how these designers use examples in their work: what do they look for when exploring examples? What strategies do they use? How do they incorporate elements from examples into their own designs? How do examples inspire or hinder creativity? Understanding the role of examples in design workflows can inform the research and development of future visualization tools.

While others have studied the use of examples by designers in the context of engineering [11, 12] and graphic design [21, 22, 24, 39], the findings are not readily transferable to visualization. Engineering design often focuses on the development and performance of physical products, while graphic design is purely concerned with the visual representation of information. Visualization design, on the other hand, focuses on visually representing data so that it is easy to find and interpret patterns [55]. As a result, the design decisions made by visualization designers are both informed and constrained by the underlying data [56]. Furthermore, the metrics to evaluate a visualization design involves both objective measures (e.g., perceptual accuracy) and subjective criteria (e.g., visual appeal), requiring more balanced considerations in choosing and using examples.

In this paper, we attempt to address this gap in the visualization literature by investigating *how visualization designers use examples in their current practices*. We conducted 30 semi-structured interviews with 15 students (novice) and 15 professional (expert) visualization designers. To understand how designers find and use relevant examples, we asked our participants to describe how they sought out examples, how they determined if an example was useful or not, and how ideas were translated from examples to their final designs. Through qualitative

analysis of our interview data, we contribute core themes, patterns, and challenges centered on example-based visualization design activities.

Our analysis focuses on two major activities: *searching* for relevant examples and *utilizing* examples. We find that designers search for examples to not only find design ideas, but to gain contextual information about their data and target audience. Further, designers may adopt different strategies to search for examples depending on their experience, such as performing a targeted search to match a known design prior (i.e., a design idea they have in mind before search), versus an exploratory search to opportunistically identify new and interesting examples. We discuss how these variations in strategy lead to differences in tool selection and usage as well as in the challenges designers encounter while searching for examples.

We find that designers engage in three main strategies when using examples: 1) *select and merge* visual elements such as color schemes and glyph designs from multiple examples, 2) *replicate and modify* an example to suit design goals, and 3) perform *trial and error* on many examples to identify a desirable design. We discuss the tools used to implement the strategies, the role of example reuse in design, and the common issues designers face when using examples. We observe that designers select relevant examples based on their effectiveness and aesthetics, and often examine the trade-off between these two criteria. Finally, we examine existing practices and perspectives around example curation and design fixation, and discuss the challenges our participants face and their visions for ideal example search and utilization environments.

Through our findings, we suggest research opportunities to help visualization designers find new examples to spark their creativity, select useful examples relevant to their target use case, and reuse examples effectively.

## 2 RELATED WORK

In this section we provide summaries of related work across domains on the role of examples in idea generation, example search, usage, and selection patterns, as well as the impact of examples on creativity.

### 2.1 Idea Generation Using Examples

In general, idea generation for designers encompasses *Idea-Finding*, or a search for knowledge—new or old—that sparks inspiration for solutions to design problems [42, 58]. While idea generation is an integral part of the creative process, in practice designers struggle the most with coming up with new design ideas [42]. Smith et al. find that designers often engaged in deliberate information retrieval methods—either through search engines or past experience—to understand the problem domain in order to generate ideas [52]. Herring et al. similarly, find that designers seek inspiration through the active or passive search of examples, physical objects or analogies etc. [25]. Designers were also found to have a preference for visual artifacts over textual descriptions as sources of inspiration [22].

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Manuscript received 31 Mar. 2022; accepted 15 Jul. 2022. Date of Publication xx xxx. 2022; date of current version 08 Aug. 2022. For information on obtaining reprints of this article, please send e-mail to: reprints@ieee.org. Digital Object Identifier: xx.xxx/TVCG.201x.xxxxxx

While extensive research into example use for ideation has been explored in fields like engineering and graphic design, to the best of our knowledge, how *data visualization designers* currently seek out inspiring examples has not been studied. We contribute to this body of knowledge by examining if visualization designers employ similar strategies to generate design ideas.

## 2.2 Example Search and Storage Strategies

Examples provide a visual framework for designers to understand problem domains, build, generate and validate ideas, and communicate to other designers [24, 39]. For example, knitwear designers use past designs and newly found examples to generate ideas and share trending styles with others [21]. Designers tend to use two strategies for finding examples: an *active search* where there is a deliberate search with a “target” example in mind [25]; and a *passive search* where the goal is to browse material to randomly find inspiration [8, 22, 24]. Miller et al. observe that the type of design activity and a designers job role influences the strategies and criteria designers use to find, store, and use examples. For example, web designers use examples to search for known solutions to a problem and to differentiate their designs, whereas industrial designers use examples to understand the domain [39].

While examples clearly influence how ideas are generated, finding relevant examples can be a challenge. The web is a popular resource for examples [24, 39], but designers often struggle to compose the right search queries [25, 54, 60] and search results may not contain any inspiring examples. As a result, designers are often forced to modify their keywords to diversify search results [24, 26, 47]. Past work has also found the opposite: that designers may seek out similar examples, restricting the diversity of their exploration [39]. Once relevant examples are found, designers tend to curate them into personal collections [30] as mood boards, design documents, electronic bookmarks or image libraries [24, 63].

A few tools aim to help designers find relevant visualization examples. Hoque et al. created a search engine to help users find relevant D3 designs by matching search queries to the visual style and structure of D3 visualizations [28]. Saleh et al. enable similar search capabilities by computing style similarities between low-level visual elements within infographics [48]. IdeaRelate provides users with relevant examples based on their conceptual distance from a users design idea [64].

Prior work identifies key strategies that designers use to search and store examples. Our current study clarifies how these strategies apply specifically to visualization design by investigating how visualization designers structure their search parameters to elicit design examples as well as how these examples are selected and used— independently or together—to generate novel design ideas.

## 2.3 Example Usage and Influence on Creativity

Examples directly influence the creativity of designers [35] and can be intentionally or unintentionally transferred into designs when people perform creative tasks [34, 36, 53, 57]. Sio and Kotovsky identify several factors that modulate the influence examples have on creativity [51], including (1) the *commonness* of an example which examines how familiar the example is to the problem domain [16, 44, 51]; (2) The *Timing* of introduction of examples [31, 40, 50] (3) *Number* of examples used in the design process [51]; (4) *Quality* of the examples [41] and (5) the *semantic* distance of example to the problem domain [12, 50].

Examples can significantly elevate creativity, and designers have been found to use examples to prime themselves towards thinking of certain ideas [6]. However, examples have also been found to inhibit creativity when designers prematurely fixate on certain ideas leading to unintentional transfer of ideas that are either wrong or unhelpful to the current problem solving task [17, 32, 45, 51]. This phenomenon is known as “design fixation” [29, 46]. Parsons et al. find that data visualization professionals employ various techniques to avoid fixation such as incubating themselves from the problem, seeking external input, and seeking inspiration in existing visualizations [43].

Our work examines example use across visualization designers through the lens of idea generation. We focus on what factors are signals for useful examples and how these ideas are transferred from examples to visualization designs as outcomes of the creative process.

## 3 METHODS

Our goal in this work is to understand the practices of visualization designers and how they find and utilize design examples. To this end, we conducted semi-structured interviews with both novice and professional visualization designers. In this section, we describe the selection criteria for participants and the study design.

### 3.1 Participants

To fully understand the role of examples in visualization design workflows, we needed to account for all levels of visualization design expertise. We recruited two groups of participants: students representing novice visualization designers, and professionals with industry experience in designing visualizations. We recruited participants from university and visualization conference mailing lists, online visualization communities (e.g., r/dataisbeautiful) and Twitter. A demographic survey was used to screen participants. To evaluate participants’ experience, we collected data on their occupation, past visualization projects, how often and how long have they been creating visualizations.

We recruited 9 male and 6 female student designers in our study. They self-report as students, and have created visualizations in an academic context (e.g., class projects) but not in a professional setting (e.g., [with] clients). 80% (n=12) of our student designers had between 1 to 4 years experience creating data visualizations, the remaining 3 students had between 3 months to 1 year experience. 53% (n=8) of these students report creating visualizations less than once a month, 33% (n=5) less than once a week and 12% (n=2) create visualizations weekly or daily. Their background ranged from domains like security or robotics to more diverse domains such as journalism and architecture.

We recruited 8 males and 7 females as professional designers for our study. All but one of our professional designers report their job function as designing visualizations for others (e.g., UX designer, data analyst, BI developer). Only one of our participants identified as senior management, working as a manager of a team of data analysts. 86% of our professional participants reported between 3 years to over 5 years of visualization design experience. 80% of professional participants report using data visualizations either daily (n=7) or weekly (n=5). A total of 30 participants (17 males and 13 females) between the ages of 18 to 54 were interviewed. In-depth details of participants’ demographics can be found in our supplementary materials on OSF <sup>1</sup>.

### 3.2 Interviews

We conducted semi-structured interviews, which were held remotely and lasted between 43 to 83 minutes. All interview sessions were recorded and transcribed using Zoom. First, participants were briefed on the study protocol and given time to complete the consent form. Then, we asked open ended questions that encouraged participants to describe past experiences. For example, participants were asked “*Can you describe a situation where you found an example that sparked a new design idea for a visualization?*”. Participants were encouraged to share pictures of visualizations as they described their experiences. The interviews followed a loose script as follows:

1. **How do designers find examples?** To understand how designers found relevant examples, we explored what types of tasks lead to the search for visualization examples, and the resources (including recommendation engines) and strategies used to find them.
2. **How do designers identify relevant examples?** We asked questions to understand what makes an example useful, what features indicate a good example and what practices (if any) do designers engage in to curate and manage collections of examples.
3. **How do designers use examples?** To understand how ideas are transferred from examples to final designs, we investigated how designers use examples in their workflows, what tools designers used to implement their visualizations, and if participants were aware of design fixation and how do they overcome fixation.
4. **What challenges do designers face?** We investigated the challenges designers faced while seeking and using examples. We also sought to explore what designers thought an ideal search and retrieval process would be. To do so, we asked designers to

<sup>1</sup> [Click to visit our OSF repository](#)

reflect on their current processes of finding and using examples and describe what an ideal process would look like for them.

Our interview script is shared in our OSF Repository (see footnote 1).

### 3.3 Analysis

In line with existing qualitative analysis approaches [7], each response to an interview question was coded. We used an iterative open coding process where two coders independently coded every interview and then swapped codes with each other. Both coders worked together to correct mistakes in the transcripts generated by Zoom.

Then, each coder reviewed their partner's codes and updated any codes they agreed with but missed during their own coding. The coders met weekly to resolve disagreements in the codes. One coder consolidated the codes and organized them into clusters based on context. These clusters were subsequently analyzed, refined and consolidated (if needed) into a second layer of categories describing the high-level activities occurring within each cluster. The authors met to discuss these clusters and identify any emergent themes.

In the following sections we discuss these high-level themes across two main activities: the *Search* for examples (section 4) and *Utilization* of examples (section 5). In section 6, we discuss the cross cutting themes identified in our analysis: 1) the *criteria* to select examples, 2) example *curation* practices, 3) *design fixation*, and 4) participants' reflections. We use descriptive statistics in parentheses and quotes to support our claims. For the rest of the paper, we denote professional and student participants using the characters "P" and "S" respectively. Participants discussed multiple sentiments and also engaged in a variety of example usage activities; we report distributions on how many participants *explicitly* discuss each point we observed. The full list of extracted thematic codes and their corresponding distributions among our participant groups are available in the supplementary materials.

## 4 THE SEARCH FOR EXAMPLES

In this section, we discuss our observations on when and why visualization designers search for examples, the approaches taken to find relevant examples, and the challenges faced while searching for examples.

### 4.1 Why and When are Examples Needed?

We find that most designers look for examples when they want to *communicate* using visualizations. Examples are used to not only generate design ideas, but also to gain contextual information about data and the intended audience of the visualizations.

#### 4.1.1 Examples are Sought When Designing to Communicate

Whether the audience is clients, colleagues or the general public, visualizations provide an easy medium for designers to explain key ideas and concepts as opposed to displaying raw data [9, 49, 55]. Participants repeatedly discussed using visualizations to *tell a story* about the data and break down interesting insights into a form that can be easily understood by their audience (9 P, 13 S).

*So one of my biggest reasons, I would say, is when I'm trying to explain something to someone I use visualizations because it's easier to do it that way -S13*

While visualizations are a convenient medium for communication, participants struggle with finding an effective way to express ideas to an audience. Examples can provide *guidance* on what visualizations to create to achieve specific communication goals. Using examples, participants can acquire ideas and use them to inform their designs:

*These visualizations inform how decisions are made. I think when you need to convey your ideas to someone you start to look for examples and based on that example reference we iterate and it becomes our own visualization idea... -P14*

#### 4.1.2 Examples are Used to Generate Design Ideas

We observed that participants may search for examples at the start of the design process when brainstorming ideas or trying to find new representations of data. Examples may also be used in the later stages to refine their visualization designs. These sentiments were similarly echoed by engineering and graphic designers in prior work [24].

**Finding common visualization designs.** Designers may seek out popular examples as inspiration for design ideas. This often occurs

during a brainstorming session with friends, teammates, or colleagues (3 P, 9 S). During these sessions, participants may iterate over examples and draw out ideas they would like to include in their designs (5 P, 2 S). These sessions may focus on understanding common visualizations for certain data types or topics (3 P, 7 S). For example:

*First I'll try to see what might be the best way of showing a data. And I may type my topic into Google just to see data visualizations examples for these topics. -S9*

**Finding new visualization ideas.** A few participants also distinguished between finding examples while brainstorming ideas and finding examples to avoid what they perceived as "boring" visualizations. In these cases the goal is to find *unconventional* ways of representing data (4 P, 5 S). A participant recounts searching for such examples while working on new projects:

*yeah I do that [search for examples] every now and then, when things are boring, to me, sometimes I just get bored and I want to try something new -P8*

**Making visualization designs fancier.** Some participants described searching for ways to improve design aesthetics after they already had some design priors in mind (4 P, 2 S). In this case the goal is to improve on current designs by making them "fancier". For example:

*I usually look for how to make it look fancier... I think of how can I do this kind of a bar chart and make it more beautiful. At that time I may find examples -P4*

### 4.1.3 Examples are Used to Understand What Users Want

Before beginning the ideation process, examples may be used to gain a high-level understanding of the needs of the target audience. Some professional participants described using examples to understand what their users want and how they will eventually use these visualizations (3 P). The contextual information derived from these activities influence the nature of visualizations that participants may search for and eventually implement. P8 describes working with clients to understand design requirements for visualizations. Once high-level goals are understood, P8 searches for examples, presents them to the clients for feedback, and uses that feedback to guide their designs. Similarly, P7 describes using examples provided by clients to guide their search:

*If they send me examples—when they have some good examples—I can go find more examples. I do send them something back to see [final designs] to make sure that it's clear... give me some feedback -P7*

One participant emphasized how important it is to understand who the target users of the visualizations are and how they intend to use the visualizations. This contextual information informs the design decisions for the dashboard they eventually create:

*I think the most important is to figure out who that user to be and then how they're going to use this dashboard. I think this leads to the main direction for me to design. -P11*

## 4.2 What Tools and Resources are Used to Find Examples?

Designers rely on various tools and resources to find visualization examples, such as search engines, portfolios, books, and news articles.

### 4.2.1 Common Sources of Examples

**Search engines and image sharing sites.** These two types of resources were mentioned the most during the interviews. Participants frequently utilized keywords to search for examples on Google and websites like Pinterest [2], Tableau public [5] and Behance [1] (11 P, 11 S). Participants may favor Google because of the *variety* of designs that can be found. On the other hand, designs from websites like Pinterest and Behance were perceived by some as having higher *quality*:

*...because Google, it has everything so whether it's good or bad it has everything, and Pinterest feels like someone already filtered those for you and if they are being collected by someone probably people think they're good, so it's one filter up -S9*

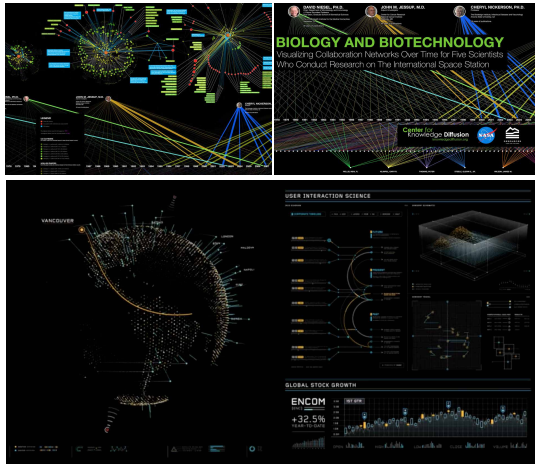


Figure 1. The top two images are visualizations created by P7, showing the authors and co-authors of published research funded by NASA and projects they have worked on. The image on the bottom is a snapshot of a futuristic design in a movie that inspired P7.

**Online communities.** Participants described browsing through examples on community sharing sites like Subreddits (e.g., r/dataisbeautiful [4]) where they can view and comment on visualizations. These types of resources were often discussed in the context of exploratory search and were frequently engaged in by professional visualization designers (7 P, 2 S). Participants generally found them to be great sources of information that require some filtering to sort through and find relevant examples.

**Published media.** Some participants rely on published media, such as news articles, blog posts, and movies, as resources to find examples. Participants described having specific news websites (e.g., New York Times, Washington Post) they frequent to find design examples (4 P, 5 S). Examples may also be sourced from books, research papers and occasionally training materials (6 P, 7 S). Books may be used when participants are looking for high quality examples. For instance:

*...but when we want more solid and accurate information, we kind of went into the library, I think we did go for hard-copy books...and look for visualizations which really connected to what we wanted to do. -P3*

Some professional participants also described using portfolios of experts and colleagues published online or on social media sites to find examples (7 P). In general, media resources provide participants with access to new visualization types and can help them gain inspiration, even from abstract concepts. For example, one participant describes getting inspired by a visualization example from a movie (see Figure 1):

*When I did this one, I was looking a lot at the futuristic user interfaces that you see in like science fiction movies. I think there was like a tron globe on this one and I liked how it connected with space. -P7*

**Software documentation.** Participants reported using documentation for visualization tools and libraries as a resource for examples (2 P, 5 S). Most visualization tool developers provide galleries of example designs. The main appeal for these resources is the availability of code or demo videos alongside visualizations, which serve as implementation tutorials and resources that can be modified or repurposed.

#### 4.2.2 Visualization Recommenders

Recommendation engines such as Tableau's Show Me [33] and Excel's Recommended Charts [38] are frequently used to find appropriate visual representations [33, 61, 62], and are employed by both professionals in their analytical work and in academia to teach students [59]. We asked participants about their experiences (if any) using visualization recommenders to come up with designs.

A total of 11 participants report never using recommendation engines (5 P, 6 S). The remaining 19 reported using recommendation engines

frequently (7 P, 8 S) or at least once in the past (3 P, 1 S). On the one hand, some participants found recommendation engines to be helpful resources for providing new options and templates, which they could use to start their own designs (5 P, 7 S). These tools also eliminate the burden of implementing visualizations, making them easy to use and appealing to students (1 P, 6 S):

*It's easy to try out new visualizations that I, maybe wouldn't have tried before or like they're kind of too hard to do in a quick amount of time, so I think that the Tableau recommendations definitely do help me to look at new visualizations that are not total garbage -S8*

On the other hand, a few participants reportedly avoid using recommenders because they do not see value in the recommendations (3 P, 1 S). They tended to be professionals with considerable experience. For instance, P10 who has 3 - 4 years professional experience said:

*Recently it's it hasn't been as necessary as it used to be ... I used to use it a good bit back when I was still sort of grasping what you would need to maybe make an area chart... I've just become a little more skilled and knowing what I want once I understand the data. So I think I need less of that direction -P10*

Participants also noted specific challenges that may hinder the adoption of recommenders. Participants found that they may not understand why certain visualizations are recommended to them (1 P, 2 S). The variety of charts and styling options included in recommendation engines are limited and could restrict participants (1 P, 2 S). As a result, participants find themselves frequently making modifications to tweak recommended charts, which may discourage them from using these tools (2 P, 1 S). Finally, some participants find the available interactions (e.g., tooltips) in recommended charts to be too limited (2 S).

### 4.3 How do Designers Search for Examples?

Participants discussed different approaches they took to find examples. We characterize the different ways participants construct search queries to find relevant examples and discuss recurring themes here.

#### 4.3.1 Targeted vs Exploratory Search

Visualization designers may discover inspiring examples spontaneously or through deliberate retrieval efforts. Participants reported two main approaches to finding examples: *targeted* and *exploratory* search. Visualization designers may engage in a *targeted* search for examples where the goal is clearly defined (3 P, 4 S). In these situations, there is typically a design prior in mind and a search is initiated to find an example that matches this design prior (5 P, 7 S). For instance:

*...but then, if I know what my data looks like, for example, and I know how I need to visualize it, I will usually look for examples [implementation] in the particular tool I'm using to create the visualization. -S8*

On the other hand, *exploratory* search occurs when participants skim through examples with no goal in mind, hoping to randomly find an interesting visualization example (8 P, 2 S). In these cases, there is no established design prior and the search process is more open-ended (4 P, 3 S). We find that participants who engaged in this type of search were mostly professionals. Participants described engaging in exploratory search to keep abreast with what other people are creating:

*...to be honest I'll go out there and see what other people are doing and see how I can apply that to what we've got going on...If I'm bored I just type in some random stuff and I find something that looks interesting to me... -P8*

#### 4.3.2 Search is an Iterative Process

The search for relevant design examples is an iterative process. Participants report iterating over keywords to retrieve different sets of examples (4 P, 6 S). The search starts with general purpose keywords to find a diverse set of examples (1 P, 6 S) (e.g., *"map related data visualization"* -S9). As interesting examples are found and design concepts become concrete, the search shifts; keywords become more explicit to target specific examples. For instance, participants may refer to the type of chart they want to create (e.g., *"area chart"* -P5). Explicit keywords help to narrow down the scope of search results (2 P, 2 S).



Participants may also use visualization libraries or tools to fine-tune the search scope. Visualization tool names are used as keywords to narrow down the results or find implementations; excluding them as keywords increases the variety of retrieved examples (11 P, 12 S).

*Usually I'll try to find a couple of examples, three or five that I can compare and then I'll do individual searches on each one usually to get more specific. I know that I definitely don't want to look at these now or like these are definitely very interesting...I'll just kind of start adding words to my search to get more and more specific -S5*

#### 4.3.3 Search Query Construction

Whether engaging in targeted or exploratory search, we find that our participants emphasize different kinds of parameters, such as dataset characteristics, visualization design, and the visualization task that the examples are used for. We describe the key parameters here.

**Search based on dataset characteristics.** When asked to give examples of how they phrase their keywords during search, some participants often discussed their keywords in terms of the characteristics of the datasets they were working on (11 P, 6 S). There seems to be a preference among professionals to center their search strategies on dataset characteristics such as data type or domain:

*I work in sales marketing so I'll type in like "sales KPIs" or "targeting metrics" or "market share dashboard". So anything that I'm working on, and those are all like standard terms that you would use across any business. -P8*

**Search based on visualization design and elements.** Participants may tailor their keywords to finding a specific type of visualization (e.g., "pie chart" -P1) or visual element (e.g., "Matplotlib error bars" -S12) (3 P, 11 S). Participants may search through examples to find a target design or to identify a common strategy for creating a visualization, which they identify by examining and isolating common design concepts among the examples (5 P, 4 S). These types of keywords may also be used to find corresponding implementations (1 P, 6 S). For instance:

*let's say I want a visualization about a map, for example. I would actually search for "map" and google the D3 version [as keywords] and then it kind of pops out right away...and I get their sources [code]. -S7*

**Search based on a task or goal.** While less common, both professional and student participants may also use the intended visualization task (2 P) or their design goals to search for visualizations (2 P, 2 S). These strategies are exploratory in nature and would often involve general purpose keywords such as "connectivity city mapping"-P3.

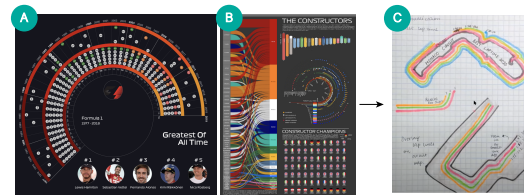
#### 4.4 What Challenges Arise When Searching for Examples?

The challenges often discussed by participants were associated with the inability to find truly relevant examples. First, participants find it hard to identify the right keywords to use to search for examples (2 P, 5 S). As mentioned in subsection 4.3.2, participants often iterate over search keywords. This iteration occurs in part because participants may be unfamiliar with established terminology for their target visualizations. Hence, participants initially resort to trial and error to identify relevant keywords. For instance:

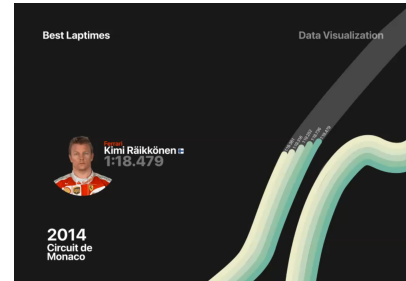
*With my first search trial, it may not work. But then I make some changes two or three times and then I get mostly what I want. So it's always difficult to look for the most optimal one, but you know it's pretty easy to get what you want after like two or three shots. -S8*

The search results may also be incompatible with participants' datasets (3 P, 2 S) or cluttered with examples that are not useful (2 P, 4 S). This requires additional effort from participants to identify and eliminate these irrelevant examples. One participant said:

*When trying to find examples of projection plot, it looks similar to scatter plot, so all the examples I was seeing it was like it just implementations of scatter plot they have like similar name and they look similar but they're actually different things. -S14*



(a) Design examples and sketches



(b) Final design

Figure 2. An example showing how ideas are translated from multiple examples into a single design. Visualization elements like circles with images of race car drivers are selected from example A and merged with paths from the Sankey chart in example B. The participant sketches their design idea in C and includes a note about radial bar charts as another source of inspiration. In the final design, we can identify relevant design elements from the two examples and initial sketch.

Even when the right keywords were identified and relevant visualizations were found, some participants reported having *insufficient experience or knowledge* to understand what makes a particular example good (2 P, 1 S) or how to use a good example when they find one (1 P, 1 S). P2 who uses blog posts to find examples said:

*You need to have the base knowledge to know what you're looking for and you need to have the base knowledge to understand the post you're reading, and really dig in to make sure that this example is completely irrelevant or not.*

A few participants describe not using examples often (3 P, 2 S). This may be as a result of their experience or lack of time.

*From time to time and try and get ideas but honestly I feel like my style is different ... maybe I'm too stuck in my ways and it really is a bandwidth issue too a lot of times I'll do it for like 15 minutes at a time, but I've got work to do. -P11*

## 5 USING EXAMPLES

Finding relevant examples is just one step in the visualization design process. The next step for visualization designers is to translate the idea(s) they derive from examples into their own design(s). In this section, we discuss strategies participants used to apply ideas inspired by examples, criteria for reuse, and challenges faced when using examples.

### 5.1 How do Designers Use Examples?

We observed that our participants were largely responsible for the design and implementation of their visualizations and described 3 strategies to using examples in visualization designs: (1) *select and merge* features from one or more examples, (2) *replicate* an example then *modify* it, and (3) *trial and error* with multiple examples.

#### 5.1.1 Select and Merge

Many participants report using more than one visualization examples to generate design ideas (11 P, 11 S). Using multiple examples allows participants to pick and merge different visual elements that inspire them (6 P, 8 S). For example, S2 describes using examples from a blog post, portfolio and radial bar chart to visualize the lap times of race car drivers, shown in Figure 2.

We can see the influence of the radial bar chart (A) and sankey diagram (B) in Fig. 2(a) on the representation of the lap times in Fig. 2(b), as well as the influence of example (A) on the annotated image of the driver with the fastest lap time in Fig. 2(b).

One participant described using the select and merge strategy to break down complex visualization ideas into individual components or visual elements. This allowed them to isolate elements in examples, and seek out implementations for these elements which they merge together in their design. A few participants describe combining multiple examples together to form multiple-view visualizations (3 P, 1 S).

### 5.1.2 Replicate and Modify

Examples are sometimes used as a baseline for visualization design. Some participants discuss making copies of interesting examples using their data (*replicate*) and altering the design (*modify*) to fit their design goals. The major reasons for modifying examples involved changing core features of the example (5 P, 7 S) such as adapting a visualization to match their data or introducing interactions to the visualization. P5 describes modifying examples to fit the scope of their dataset:

*...so the first modification is that ... I swapped the data content. The data content is different, so your data scope might be different. They [example] might be using very small dataset, for example, if you are using like bubble chart, your x axis or y axis can be super different; they can be very small, but yours might be pretty large -P5*

While replication is convenient, some examples do not meet the aesthetics standard a designer may want. Participants discuss making modifications to adjust visual styles and layouts in replicated examples (5 P, 3 S). These changes typically targeted components such as the font, orientation, and color schemes. For professionals, modifications may be aimed at matching designs to the stipulated company branding.

*...And I think that goes back to there's not a lot of business examples out there, so you kind of have to "steal" from other contacts and a lot of it isn't that translatable that you can just grab it and go. I think most of the time it would require applying our branding guidelines to something. So that's color palette, fonts that kind of stuff. -P6*

### 5.1.3 Trial and Error

While most visualization designers distill ideas from one or more examples, a few would resort to a brute force approach towards using examples. Six participants report trying to implement multiple visualization examples and ideas until they find an acceptable design. Participants resorted to this strategy when they were in situations where they did not know what to create or were stuck in making design decisions (2 P, 1 S). Participants may also use a trial and error approach when working with tools that provide quick access to different visualization designs (e.g., visualization recommenders) (3 S):

*What I used to do in tableau is just hit every every button... if I really don't know what to do, I can change the map layers, I can include this check the boxes if I want streets on here or landscapes, like all those different things make it pretty easy to customize -S6*

For some designers, trial and error is not limited to recent searches for examples. They may also iterate over design ideas from visualizations remembered from previous design sessions. P9 describes:

*To me it's almost like testing a hypothesis, when I come to a dataset I've got some preconceived notion of what I want to tell people... At this point in my career, I will have observed so many different visualizations styles that I have a decent idea of what I want to try first. And then I will try to objectively judge how well I've succeeded there and then I'll start tweaking it and occasionally scrap the whole thing and start over, so it's kind of like trial and error -P9*

## 5.2 Reusing the Same Example

Participants report reusing the same example for multiple visualization designs (10 P, 11 S) when they are engaged in repetitive tasks such as representing different dimensions from the same dataset, or when engaged in creating visualizations that were "standard" for their field. A few participants reuse examples by applying the same design concept to represent different data points. For instance, P3 who is an architect



Figure 3. An example of reusing a single example to generate multiple data representations. Here, P3 reuses a base map layout (A) to visualize data on building structures in a specific geographic location (B).

describes using a single map layout example to visualize data on multiple aspects of building structure as seen in Figure 3. Some participants may be inclined to reuse an example because it has been successful at communicating information to their audience in the past (2 P, 3 S).

*These are things people have already seen in my own field so it's sort of a common language type of thing. So it's best to just go with the same thing. -S8*

Participants may also reuse an example if they have easy access to the code (2 P, 2 S). For example, S10 recalled reusing the concept of a 3D scatter plot from a word cluster to visualize human skeletons in 3D by visualizing each joint with a point as in a scatter plot. They were even able to reuse the same code. We also find that participants often engage in reuse when the underlying visualization task is similar. For some participants, this may be a result of the type of data they work with. For instance, P5 who is a risk management associate, tends to reuse the same examples and designs because their job is mostly concerned with identifying trends in data.

## 5.3 Tools Designers Use

Most participants discussed using visual analysis tools like Tableau to create visualizations. Other tools mentioned include direct manipulation and sketching tools (e.g., Adobe Illustrator, and visualization libraries such as D3.js in JavaScript or Matplotlib in Python). A few participants mentioned using specialized tools to create custom visualizations. For example, S5 uses ArcGIS to develop story maps. The supplementary materials<sup>2</sup> contain a detailed breakdown of the distribution of tools used by the participants.

Participants generally felt supported by visualization tools (10 P, 8 S) as they help expand their visualization design skills, provide guidance on how to create visualizations, and allow users to customize their visualization designs. Participants reiterate that each tool plays a specific role in the design process. For instance, Tableau reduces effort for conventional designs and allows quick exploration of visual designs. On the other hand, tools like D3 are more useful when there is a specific design in mind. Participants may also sketch out design ideas on paper or using tools like MS Paint before implementing their designs (6 P, 8 S).

## 5.4 Challenges Faced While Using Examples

So far we have discussed how participants re-purpose ideas from examples and the tools used to implement their designs. However, the process is not always easy. We summarize the main challenges that designers face when using visualization examples.

Several participants (mostly professionals) complained about how much time they had to spend modifying examples to implement their design ideas (7 P, 3 S). These complaints focused on the significant time needed to tweak replicated examples. A participant comments:

*I think the big challenge is that it's not fun right, it's fun to have a good quality output and it's fun to have the moment where you understand that your visualization is going to work for what you intended to work for. But it's the formatting, the layering,*

<sup>2</sup>Click to visit our [OSF repository](#).

*the time spent on all the little things that maybe you're the only person who's ever going to notice. You know that can be a bit of a slog. -P9*

Another challenge is related to operationalizing desired changes using specific tools. For example, participants may have difficulties translating desired changes to specific components that need to be modified in the target example (4 P, 3 S). Some participants complained about not knowing how to use tool interfaces, or they had troubles understanding the documentation and tutorials (5 P, 1 S). Tools often require too much manipulation to implement changes (2 P, 4 S), and the designers may have to use multiple tools that may not be compatible (1 P, 4 S). Additionally, programming based tools often required significant effort (3 P, 6 S) and version changes may make examples created with previous versions no longer functional (2 S). One participant said:

*Now, regarding the fine tuning that's the trickiest part because that's what requires knowing where exactly to change to make it suitable...For that, I just go to the documentation to see if I can find what I'm looking for. Sometimes it doesn't work, because it is not easy to read. So I just end up spending some of my time on stack overflow or general forums on how to get certain things done. -S13*

A few participants acknowledged the role that their experiences played in responding to challenges faced while implementing design ideas (5 P, 3 S). Participants thought that understanding what and how to make modifications became easier as their experience and understanding of the design process and tools increased. A few participants describe the process as learning on the job. One participant (P5) in particular reflected on the nature of strategies they employed to create visualizations. For this participant, as a novice, it was easier to just replicate examples; as they became more mature in the field, they found themselves graduating from copying ideas to devising their own ways to improve designs as they came across examples.

## 6 CROSS CUTTING THEMES AND ACTIVITIES

Our analysis revealed three themes that cut across the two main design activities (search and utilize): (1) criteria for determining if an example is useful, (2) practices and perspectives for curating examples, and (3) factors inducing design fixations and overcoming fixation.

### 6.1 Selecting Examples

Here, we discuss factors influencing how professionals search for and select visualizations and key criteria for selecting useful examples.

#### 6.1.1 The Role of the Target Audience in Search and Selection

Most of our professional participants described their job roles as primarily involving creating visualizations for "clients". These clients were typically colleagues, management, or business stakeholders who were often described as being less visualization savvy. We observed that professional designers often discussed how much the backgrounds, needs, and interests of their target audience influenced the types of visualizations they searched for and selected.

For example, participants have to consider how clients would perceive the visualizations (2 P) and the context in which the visualization will be used (3 P) when making design decisions. Some professional designers restricted themselves to using common visualizations such as bar charts in order to accommodate the needs of their clients, even if they would prefer to try out more sophisticated designs (4 P):

*...So while I have created a chord diagram for fun, in the professional world I would never share that to anyone to transmit a message. I would share it only to make them impressed with how well I can visualize ... if I were to put it [chord diagram] in front of someone, I'm going to have to spend a long time explaining to that person what the chord diagram is and they're going to have to spend a long time studying it ... and there is almost always a simpler way to represent what's going on. -P9*

Participants would also stick to using charts that their clients are already familiar with to avoid presenting charts they may not understand (5 P).

Accommodating participants' requests for specific designs can be particularly taxing for designers as they have to prioritize these requests

even if they may not necessarily think they are good designs. Participant P9 recalls clients requesting designs that were not always feasible or appropriate and, in some cases, having to "...talk people out of bad designs". Ultimately, these considerations may leave participants feeling limited on the amount of control they have over design choices. While some participants consider this limitation as part of the job, others find ways to introduce interesting designs into their visualizations.

*...although most of our clients like things simple, like a bar chart for example, or tables...you have to find a way of being creative with the things they give you. So instead of showing just a bar chart of this year's sales, you can show last year sales overlaid behind it, instead of just a pie chart use a donut chart with KPIs in the middle. -P11*

#### 6.1.2 Criteria for Selecting Inspiring Examples

During our interviews we sought to understand what signals participants used to determine how useful a design example was. We identified six criteria that participants use to select useful design examples. While we discuss these criteria individually, participants often considered multiple criteria simultaneously when evaluating the usefulness of an example. The weights placed on each criteria were subjective.

**The effectiveness of a visualization.** Most participants (11 P, 7 S) agreed that the most useful examples are effective at communicating the right information to their audience i.e., the example is easy to understand. Participants often stressed the importance of making sure that visualizations were easy to interpret and presented the message as simply as possible. These participants were often less concerned with how well the design adhered to visualization rules like the appropriateness of data encodings. On the contrary, data encodings were generally an *implicit* consideration for useful examples and only mattered if the rules of thumb for data encodings were violated.

*When I started doing data visualization, there was a lot of emphasis on Edward Tufte versus Nigel Holmes rules [where Tufte placed emphasis on visual processing while Holmes was more concerned with making visualizations memorable]...So I'm no longer interested in "this is the Platonic ideal of visualization" and more interested in what are people going to see, or respond positively to... -P6*

**The aesthetics of a visualization.** Several participants mentioned visual elements such as visual appeal and color schemes as criteria for determining if an example was useful (14 P, 6 S). Surprisingly, participants often held aesthetics in the same regard as the effectiveness of an example, mentioning the two criteria together. The aesthetics criterion may include layout and fonts used in a visualization, how appealing a visualization looks, or the use of annotations or colors to provide contextual information. For instance,

*100% the color scheme is the first thing that comes to my mind, if they have like the nicest colors on there, like different shades of purple is something that I really gravitate towards for some reason, as soon as I like that [example], it's like a fish bait, then [the second point] it's can I quickly understand it? -P11*

Three participants discuss having to find some balance between the aesthetics and effectiveness of visualizations (1 P, 2 S). They admit that the most aesthetically pleasing examples may not be the most effective at communication, indicating some trade-offs between the two criteria.

*I also try to balance it out like it's not all visual aesthetic and the data doesn't correspond to the scale and stuff. So I'm trying to like balance at all -S2*

**The similarity between design priors and examples.** Some participants evaluate how similar an example is to the design idea they have in mind as a criterion for selection. In these cases, participants select an example only if it matches their idea or improves on their original design (3 P, 4 S). Occasionally, visualizations that provide improvements are described as unique since they are not visualizations that participants have encountered before (4 P, 4 S). One participant said:

*For me it would be how unique the design is. I try to compare it with my previous work. At times I compare it [example] with what I really wanted at that moment. Most time I focus on how it improves from what I want -P1*

**The ease of integration with data and tools.** We find that some participants were concerned with how compatible examples were with the dataset they intend to visualize and how much effort would be required to implement the example. These participants were more likely to select examples that had similar data structures (1 P, 6 S) and were easy to implement (1 P, 5 S). One participant comments:

*So communicating the data is more important than being able to create it easily, but there is a threshold. If it's too difficult, then I'll start thinking is there some other way I can spend my time... -S1*

**The use of interactions and animation in examples** A few participants discussed using the presence of interactions and animations as criteria for selecting an example (3 P, 4 S). Participant P10 notes that interactions can be combined with complex charts to help users understand examples and tell a moving story. Another participant said:

*I will say, the one thing I love seeing is like somebody using like actions, in a creative way ... I just like people who get creative with it [dashboard] in a way that's still really easy to use...because they're [clients] always going to ask another question and then another question, so you want to make sure you have the ability to get to all four or five level questions within your one dashboard either by drill downs or by filtering or by whatever...a simple overview is never enough. -P8*

**How examples support inclusiveness** Three participants discussed criteria for example selection that focus on evaluating how the design choices in the example support people who may be colorblind or have ADHD (Attention Deficit Hyperactivity Disorder). Participant P8 reports that since they have ADHD, they tend to disregard examples with designs that have too much going as these examples “wreck my brain” and make it hard to concentrate on the key ideas within the examples. Two participants (P5 and S9) consider how the colors used in visualization may be perceived by users who are colorblind.

*So I feel like sometimes some of the examples are not very like color blind friendly...So sometimes I may look for something that's like you know not completely based on the color like sometimes if they have like patterns, but you know, sometimes, if we add more patterns, it will make the graphic looks very busy for normal people -S9*

## 6.2 Curating Examples

We explored designers' example curation practices to assess how curated examples may be used in the design ideation process. Similar to past research, we also find that some participants regularly save examples for future use while others do not curate examples [24]. We discuss the emergent patterns for example curation below.

### 6.2.1 Curated Examples are Rarely Revisited

Several participants regularly save useful visualization examples found during search. These collections take many forms such as digital file folders (4 P, 3 S), web browser bookmarks (4 P, 3 S), links in text files (3 P, 2 S) or liked examples on social platforms (e.g., Pinterest) (1 P, 2 S). Due to the volume of curated examples, these participants labelled collections either by visualization type (e.g., bar charts) or the topic of the project they were working on. This labelling strategy helped participants organize their collections to simplify example retrieval.

We observe that only 3 participants reported routinely reviewing these collections to either organize or retrieve examples after they save them. Most participants who curated examples said that they never returned to these collections after creating them (3 P, 1 S), or returned to them only if they remember something exists (3 P).

*If I see something I will usually like bookmark it, whether it's in my browser or my reading list or if I'm on Reddit. The problem is I don't ever go back to my bookmarks. -S8*

Participants struggled with managing their collections. These challenges can be attributed to collections being messy, requiring designers to manually search through them. For example P15 recalls clicking through a list of saved web addresses to find an example they had found

before. One participant noted that due to the volatility of web pages on the internet, some bookmarked pages may not be accessible when they return to them. Finally, managing saved examples is a time consuming task that may dissuade designers from saving them in the first place.

### 6.2.2 Interesting Examples Will Be Remembered

Roughly half of our participants said they do not curate examples (6 P, 10 S). Some participants found curation unnecessary because they could easily remember where they came across compelling examples (4 P, 3 S), or they prefer to implement these examples immediately. We find that participants who expressed this sentiment had a median of 3 to 4 years of visualization experience. Some participants often rely on examples they have seen in the past to generate new visualization ideas (3 P, 2 S). One participant said:

*No, I'm either making a visualization for a purpose or not. I mean certainly I might store away in my head the fact that some kind of visualization exists but I won't save it -S12*

## 6.3 Design Fixation and Its Effects on Example Use

We sought to understand if designers were aware of design fixation and how they avoid getting fixated on design ideas while searching for and using examples. Inline with the protocol used in past work on design fixation [18,43], we first asked participants if they were familiar with design fixation and then explained the concept using Jansson and Smiths' experiments [29] as an example of design fixation and its effects. We present our observations on factors that can induce design fixation and strategies that participants use to overcome this fixation.

### 6.3.1 Factors that Induce Fixation

Participants often noticed fixation when they relied too much on past work, made assumptions about what visualizations were industry standards, or were overly focused on examples found during search.

Participants recall fixating on designs they had previously created which were well received by clients. Participants often assumed that these designs were safe and would often continue to use them for different projects over an extended period of time (3 P, 4 S). Participants may also fixate on ideas they perceive as standard visualizations that are accepted by their industry or community (3 P, 7 S).

*...only because I see certain visualizations being used in a certain way and people responding to those visualizations, so I get attached to those designs alone and it does have a big impact on me, maybe not consciously -S13*

This perception may also be induced by the types of examples that participants find while searching for examples. Some participants may commit to designs that repeatedly appear in search results, as they assume that such examples must be the standard or the best way to represent the information they want (2 P, 4 S). For a few participants, fixation could be caused by requirements from superiors which may make it difficult to balance new design ideas with job expectations (2 P) and cause them to commit to inappropriate ideas (2 S).

### 6.3.2 Examples and Feedback Can Help Avoid Fixation

Participants often tried to avoid fixation by changing their search terms to use simpler words, or adding new words such as “fancy” to change the types of examples they are seeing (4 P, 4 S). Others may consider completely changing the tool they use to search for examples. For instance, S2 mentioned switching from Behance to Google when they would find themselves seeing the same types of design examples.

Participants may connect with colleagues, teammates and clients to talk through ideas they are fixated on, in order to get a different perspective that may guide them to alternative designs (3 P, 7 S). Feedback may be obtained from evaluations of implemented designs or through conversations with people (5 P, 10 S). For example:

*...I just think out loud to my co-authors “hey how about this” and just kind of describe my ideas. And I will look at their expression or excitement, and that gives me good feedback. Even if they don't tell me which one is a good direction to go in -S13*



## 6.4 Reflections on Desired Tools

We asked participants to reflect on their current process of finding and applying examples and to describe ideas for ideal tools and resources they would like to use instead. We summarize their ideas below.

**Increased search modalities.** Participants frequently described a desire for tools that support more search modalities (1 P, 5 S). These ranged from booklets of examples and corresponding implementations, to tools that could allow search in design centered domains, to find examples outside of data visualization. Three participants (S1, P9 and P3) also mentioned tools that support search for examples based on uploaded datasets. P9 described tools that can transform the underlying dataset into a format that is compatible with target examples. Designers also want to specify search criteria through examples (1 P, 4 S), design specifications (1 P, 2 S) or natural language descriptions (3 S).

**Automation to aid, not replace design decisions.** Regarding tools that recommend charts to meet the specified design criteria, four participants (2 P, 2 S) expressed concerns about balancing how much control they would have over the design decisions with the level of automation in these tools. For these participants, automation should only be used to augment their skills by providing designs they would not have found themselves and the ability to rapidly evaluate multiple designs. The final say on what design is used should be left to the designer.

*I need to think about the audience and the context of the data as well, so that part I think I'll do it [make decisions] myself -S13*

## 7 IMPLICATIONS FOR FUTURE RESEARCH

Our findings highlight interesting patterns of example search and usage that are unique to visualization design as well as patterns that echo observations in other design domains [24, 39]. Unlike designers who specialize in preparing and handing off visual concepts to developers [56], our participants are responsible for designing *and* implementing their visualizations. As a result, data is an important consideration for these designers throughout the design process. Visualization designers have to take into account the constraints imposed by data, the needs of their target audience, and the effectiveness of designs as they search for and use examples. This challenge is also magnified by external factors such as job expectations that can influence their design choices.

We find that experience plays a huge factor in how designers search for and use examples. Professional designers heavily rely on their experience to determine what visualizations they need to create and are more interested in seeing variety in visualization design. As a result, professionals mostly engage in exploratory search and are more likely to focus on examples that are both effective at communicating insights and aesthetically pleasing. On the other hand, students are limited by their knowledge of visualizations and programming languages. Consequently, students are more concerned with the ease of integrating examples into their current workflows, and often opt to replicate and modify examples or iterate over different designs before settling on an optimal design. Our participants acknowledge that these challenges diminish as experience increases. We reflect on the practices and challenges faced by designers and discuss research opportunities for example retrieval and visualization authoring.

**Enhance visualization retrieval: more criteria, modalities and diversity.** Our results reveal three main criteria used by designers to search for examples: 1) dataset characteristics, 2) visualization features and styles, and 3) visualization tasks. However, existing visualization retrieval systems only support search using specifications of visualization features and styles [28, 48]. To support the needs of designers, visualization retrieval systems and example gallery designers need to support more searching criteria based on data semantics and tasks. Additionally, these tools need to go beyond using specifications as search parameters to accommodate more modalities, such as natural language descriptions and visual examples. Such tools will enable visualization designers expand their example search space.

Our results also suggest that a tool that supports the serendipitous discovery of new and interesting visualizations may be preferred by experienced users. However, current retrieval tools are optimized to find results that match search queries, potentially missing less relevant

yet useful examples. This presents an opportunity for the visualization community to explore how to support serendipity in exploratory search for examples. Specifically, research has to identify how to balance variety in search results with the quality and relevance of visualization examples [39].

**Understand and support example-based design ideation.** Examples are useful for conceptualizing design ideas for visualizations. However, there is a risk that designers could focus on examples that lead to ineffective designs. Design fixation does not necessarily happen because of inherently bad designs, it may result from multiple factors such as a mismatch between examples and tasks, or inappropriate perceptions of the examples. For instance, student designers might fixate on a specific design if they thought it was favored by their community or someone with greater authority (e.g., a professor). These observations entail the need to understand, measure, and model the effects of examples on ideation outcomes. The results will be useful for mitigating fixation and steering ideation practices towards better designs.

**Balance multiple design objectives and factors.** Research has explored automated generation (e.g. diatoms [15]) and recommendations of baseline designs to build on. However, analysts and designers desire effective *and* captivating visualizations [14, 65]. Thus, these tools must balance the effectiveness and aesthetics of visualizations, and provide transparency into why the designs are generated or recommended. These tools can also be extended to support direct editing and parallel prototyping, so that users can effortlessly explore and compare multiple design alternatives [20]. Furthermore, research should explore how and to what extent the socio-cultural factors identified in our work (e.g., expectations of clients and superiors) influence design choices, and deliver better tools to facilitate design feedback and iteration.

**Author visualizations with examples as inputs.** Existing visualization authoring tools do not adequately support any of the example reuse strategies that we have observed (select and merge, replicate and modify, trial and error). In particular, it is not possible to transfer features between multiple visualization designs, nor are there easy ways to import an example and modify it directly. Some visualization authoring tools offer support for replicating and modifying example templates for visualization designs [19, 23, 37]. However these systems are limited in the type and format of examples they can support. How to easily turn any example into a usable template is a promising research direction. Future authoring tools need to support seamless transfer of design elements from an existing example to new visualizations. One possible approach is to extract visual properties such as color, axis design, and glyphs from examples and apply these properties to specified attributes. To support such features, systems first need to understand how to automatically isolate and infer the role, organization and constraints of different visual elements from an exemplar image.

### 7.1 Limitations

Our work is intended to provide the much needed context on how visualization designers use examples as sources of inspiration. Like many other interview studies, our participants may not reflect the overall population of visualization designers. Specifically, our participants were recruited from institutions of higher learning and visualization tool communities, consequently the experience of our participants is slightly more advanced and analytical in nature, which may not reflect the experience of casual and non-technical visualization designers.

## 8 CONCLUSION

In this paper, we interviewed thirty student and professional visualization designers to understand how they find and use examples to generate and implement visualizations. We observed two main approaches to the search for examples and three strategies that designers use to translate ideas from examples to their visualization designs. We also discuss cross cutting themes related to the selection and curation of examples as well as the challenges designers face in finding and using relevant examples. Our findings highlight a lack of support in current visualization tools for common example search and implementation strategies used by designers. We hope our findings inspire research towards supporting the retrieval and application of relevant visualization design examples.

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