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SEARCHING FOR INSPIRATION: AN IN-DEPTH LOOK AT DESIGNERS EXAMPLE FINDING PRACTICES

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ABSTRACT

Designers frequently use examples during the design process as a way to provide a visual framework, allow for re-interpretation and allow for evaluation of design ideas. Although the use of examples is an important part of the design process, little is known about how designers retrieve these examples or the characteristics of the example set designers collect for a given project. Knowledge of this behavior is important, as research has shown that using examples too similar to the design problem or too familiar to the designer can cause design fixation and hinder creativity. Therefore, the current study was conducted to provide insights into these example retrieval processes by monitoring 18 professional designers during a 90-minute design task complemented by surveys and interviews for an in-depth understanding of user behavior. We relate our results to research on design fixation and provide implications for the development of example finding tools.

INTRODUCTION

Designers rarely start designing from scratch, but instead transform, combine or adapt elements of existing designs (examples) in order to generate new ideas [1, 2]. In this paper, we use the word example to mean any material, product, prototype or digital artifact that contributes directly or indirectly to a design. This could be a sketch, a photo, a webpage or any item that inspires creative thought [3].

Examples are seen as the cornerstone of the creative process and designers often search for these examples in the early phases of design in order to gain inspiration for new design ideas [4-6]. Because it is common for designers to be inspired by and reuse structures, aesthetics, and functions of existing designs in their own design ideas, the quality of their ideas hinges on the quality of the examples they select. For instance, if designers view high quality or highly innovative examples, the components they are inspired by or reuse will

likely be more high quality and innovative. On the contrary, if they select examples that are typical of the domain in which they are designing (not innovative), the ideas they develop will likely be less innovative. Therefore, the types of examples designers select for a given design task can have a large impact on the types of the ideas developed.

The selection of design examples is of vital importance in design given peripheral research in the area of design fixation which has shown that design examples can cause designers to prematurely commit to a limited set of ideas [7]. Design fixation has been exhaustively studied in both engineering (see for example [8-12]) and psychology (see for example [2, 13-20]). Although these studies provide a theoretical understanding of design fixation, the participants in these studies used experimenter provided examples during their design session and thus the studies only explored how well participants were able to leverage carefully selected example sets. While these studies provide a foundation for research in this space, it leaves the question if designers actually retrieve 'fixating' examples in practice and, if so, what methods or technologies can be developed to mitigate this fixation effect.

Thus, the current study was developed to understand how designers retrieve examples from the Web and if the examples collected are considered 'fixating'. In order to answer these questions, a 90-minute design session and a follow-up semi-structured interview with 18 professional designers (industrial, graphic and web) was conducted. The results from this study shed light on the strategies designers use to retrieve examples and the potential fixation effects that may arise.

RELATED WORK

While not studied in the context of design example retrieval, there has been substantial research in the areas of example selection, example repositories and Web search that provide a basis for this research. This section is meant to

summarize this research and provide the foundation for the proposed work.

Effects of Example Selection

Many studies have shown that examples serve an important role in designers' ideation practices [21-23]. For instance, they are used to create a visual framework, allow for re-interpretation and allow for evaluation of design ideas [3, 24]. In other words, there are many benefits to using examples during the design process and the collection of examples is very common in design practice [25]. However, the utility of these examples is greatly dependent on the types of examples designers retrieve for use.

Many research studies have explored how examples affect creativity. Jansson and Smith [7] were one of the first to study this effect by presenting half of their subjects with design examples (pictorial images) before ideation and half without. They found that designers in the exposure (example) condition conformed to the examples by keeping many of the same features in their design concepts. They concluded that even experienced designers can become fixated on examples similar to the artifact to be designed. Researchers have also explored the relationship between fixation and example familiarity. These studies concluded that fixation may only occur if designers are familiar with the examples they use [26, 27]. Finally, a more recent study looked at the relationship between expertise and fixation [13]. They found that expert designers are able to evoke more creative ideas when using sources less similar to the design task (inter-domain sources). Although novice designers did not appear to be influenced by the similarity of the example to the problem (intra- vs. inter-domain sources) they were heavily influenced by examples familiar to them, even if these examples were not directly associated with the design task [28, 29].

The evidence that fixation does occur is quite compelling. As a result, researchers generally acknowledge design fixation as a significant impediment on idea generation, thereby limiting the diversity and originality of creative outputs [23]. However, most of the research on fixation has only studied participants' ability to leverage examples carefully selected by the experimenters. No study to date has looked into the types of examples designers themselves collect for a particular task. Therefore, we are unaware if designers are collecting fixating examples in practice. If we can understand if or when designers collect fixating examples during a design task, and the search behaviors associated with this fixation, we may be able to develop tools to mitigate these effects. The purpose of this study was not to understand how designers' ideas are influenced by the examples they collect, but rather understand if and when designers collect the types of fixating examples found to influence ideation in previous studies.

Types of Example Repositories

There are many different repositories designers can use to retrieve examples including case-based libraries, books, magazines, and the Web and there are many benefits and

limitations to using these repositories [30]. For instance, case-based libraries provide designers with examples (in the form of 'cases') that are well documented and represented in as complete and discrete a form as possible [31-34]. Although there has been a long history of research on case-based design (CBD) including developing computational representations of cases and algorithms for efficient example retrieval (e.g. see [35, 36], this approach has just recently started to be applied to the creative design domains (see for example [37]).

One explanation for this non-adherence to case-based methods is designers are able to collect more examples in less time using other repositories such as the books, magazines and the Web [38]. While examples found using these other sources may not contain in-depth rationale like in CBD, the investment for locating multiple examples is disproportionately smaller. In addition, there is a higher cost associated with maintaining a case-based repository compared to using a global repository like the Web. Therefore, although designers can obtain more information about a particular example from a case-based library, they place greater value in the less detailed examples they receive from other repositories because they can see more of them in less time [3].

Designers have also stated that they prefer using the Web over books magazines and physical product libraries because it allows for more connections and more inspiration; they would have to search through an abundance of books and magazines to get a fraction of the information available to them on the Web. They also feel the other types of repositories are overly restrictive and reduce the variety of information available to them [3].

Relative to this corpus of studies on example repositories, our study differs in that we are investigating the benefits and limitations of using the Web to retrieve examples by conducting an empirical study. From this we can understand how to build computer-based tools to better support these practices.

The Web as an Example Retrieval Tool

There are several known issues associated with using the Web to find design examples. First, designers' have to know what they're looking for and be able to articulate that goal into a search query. However, since designers often search the web without a specific target in mind, putting their design goals into a search query is often a difficult task [39]. If designers are able to develop a search query, they are most interested in the search result not directly related to the inputted keywords as they hope the semi-related results will inspire them or help them develop a new design direction [3]. However, the goal of most search engines is to return highly specific and ordered results [1, 40, 41]. Therefore, designers are only privy to the artifacts directly related to their search terms, greatly reducing the chance of a serendipitous encounter [42].

Though not the specific focus, there has been research that could improve the Web for example finding. For instance, in the area of image search, Yee et al. [43] developed a category-based method that enables users to navigate along the

conceptual dimensions of an image set. Fogarty et al. [44] developed a new interface that allows users to perform image search through visual composition and search rules. Finally, new search engines are emerging that allow users to render images in order to illustrate main concepts and arrange the results in a 2D space.

These and other tools have the potential to aid designers in example finding, but until we have a better understanding of how designers search the Web for examples, and the types of examples their retrieving from these methods, it is unclear how, or to what extent, these tools will help designers find relevant examples. Our work contributes to filling this gap by provide a new understanding about what strategies designers employ on the Web, how successful they are in their quest, and what types of examples are retrieved using these methods.

METHODOLOGY

Our study was developed to answer the following questions:

1. When do designers search for and use examples during the design process? What process do designers' follow to search for examples on the Web? How, if at all, do the example retrieval processes differ by design domain?
2. What are the characteristics of the examples designers collect during the early phases of design (similarity to task or familiarity to designer)? Do these example characteristics differ across expertise or design domain?

Participants

In order to answer these questions, professional designers were recruited by emails and posters advertising the research study. These recruitment materials were specifically targeting local design professionals as well as students and faculty in the design college. Interested participants completed an online pre-screening survey prior to the study that included questions on design educational experience, a 5-point expertise Likert Scale and a question on the number of years of professional design experience. In total eighteen professional designers from the fields of graphic, industrial, and web design (6 from each domain) participated in the study. In each of the domains there were 3 self-classified expert designers with a minimum of 5 years of professional design experience (average 14.0, 14.3, 10.3 for graphic, industrial and web design, respectively) and 3 self-classified novice designers (average 3.2, 1.7, 2.7, for graphic, industrial and web design, respectively). These categories of designers were selected to represent three traditional, but vastly different, design domains in order to identify differences in the example finding processes across these domains. This is important because while many studies have looked at these domains individually (see for example [45-48]), few studies have directly compared example-usage practices across design domains.

For confidentiality purposes, throughout this paper, participants will be referred to by their domain area (GD, WD, ID), subject number (1-6) and expertise (E or N) throughout

this paper. Subjects were remunerated 30 dollars for participating.

Procedure

At the start of the study, the purpose and the procedures of the study were explained and any questions were answered. Next, participants were then provided with a design task (described in the following section), and given a demonstration of Google Notebook, which was used to collect relevant examples during the design task. Electronic notebook were used during the study because of their application in typical design practice for storing design information [49]. Once any questions were answered, participants were given 90 minutes to search for design ideas and ideate potential solutions to the design problem. Following the task, a semi-structured interview (described below) was conducted to gain feedback on the process used by the designer. Finally, a survey was conducted to identify participant's familiarity with each of the examples retrieved during the study.

Design Tasks

The tasks used in this study were developed by referencing design blogs and competition websites. The tasks went through a number of iterations and were reviewed in a pilot study in order to ensure they were representative of typical design work. These tasks were ill defined in order to create both a challenging problem and allow designers to freely explore the solution space. The tasks were as follows:

- *Develop a new product from recycled material (Industrial Design):* Users were asked to create a new consumer product made from discarded products such as tires, munitions, shipping containers, and cell-phones. Participants were allowed to choose the focus of their ideas.
- *Create a UNICEF campaign for campus (Graphic Design):* Users were asked to develop an ad campaign for UNICEF in the USA to be implemented on college campuses. The goal of the campaign was to encourage donations to UNICEF. Participants were allowed to choose the focus of their ideas.
- *Re-design NPR.org (Web Design):* Users were asked to develop a new homepage for the National Public Radio website (www.NPR.org). The purpose of the new home page was to encourage donations without making it the focal point of the page. Participants were able to choose the focus of their ideas.

Participants were instructed that the goal of the task was not to generate polished solutions, but to collect examples (from any Web source they desired) and to generate initial solutions. In other words they were asked to brainstorm ideas that could lead to new solutions and display the ideas in the forms of lists, sketches, notes, keywords, and other formats. Once they found an interesting or useful example, they were asked to store it in a digital notebook (Google notebook). To store an example, designers would either have to drag and drop the image/ link/ text / etc. to the notebook. The notebook could also be used to comment on the examples or write notes.

Task Representativeness

The design tasks used in this study as well as the ideation environment were developed in order to create an ‘ideal’ work setting. Idea generation and example finding are sporadic behaviors. Designers will sit down for long periods of time and search for design examples and interleave this behavior with other activities. This study aimed to recreate a typical ideation/example finding session.

According to the participants as well as the patterns of behavior recorded in this study, the designers followed the general process as they do in situ. GD2N stated, "It [my design process] was pretty much the same because we design in the same process for any project, no matter how big or how small." WD2E mimicked this statement, "It's pretty similar to the entire design process. You start off with this one notion, 'I like this. I'll stick here for a while.' So it's pretty similar." The main difference in the design process was that this example finding behavior is normally distributed across a longer period of time. However, designers stated they felt they generally followed the same overall design process regardless of the time limitations. Therefore, although this study was conducted in a 90-minute design session in a laboratory setting, the design tasks used and the design process followed by the designers were highly representative of their typical processes.

While the tasks were representative of typical design practices, the industrial design task can be perceived as more open-ended than the graphic and web design task due to the fact that it is not a re-design task. While these tasks will allow us to compare ‘typical’ design performance, future studies should explore the impact of close- versus open-ended design tasks across design domains.

Semi-Structured Interview

In order to gain a better understanding of the designer’s example retrieval process, a semi-structured interview was conducted following the design session that lasted between 30 minutes and 1 hour. The three categories of questions included: design concepts and idea formation, example finding behavior and solution and task representativeness. See Appendix for complete question list.

Post-Study Questionnaire

Finally, in order to gauge participant’s familiarity with the examples they retrieved during the study, a post-study familiarity survey was completed. This survey asked participants to rate their familiarity (0-100 sliding scale) with each of the examples they stored in their Google Notebook on four levels: the website in which the example was retrieved, the creator of the example, the information contained within the example and the design example overall. Before rating the examples, the designers were required to review all of their stored examples in order to minimize the biases of example order. The researchers provided the information for each example (website, creator, etc.) so the participant was only required to rate each example according to the information provided. Therefore, each example received 4 familiarity ratings.

Metrics

We also computed the following metrics for each subject to measure the types of examples collected based on their similarity to the task description. The calculation of this similarity metric (percentage of keywords from task description) is found below:

Example Similarity was compared based on the calculated measure *percentage of the keywords from task description*. This metric was computed by dividing the number of keywords from task description by the number of unique keywords (definitions below) from the task description (i.e. UNICEF, AIDS, HIV, etc.). The more similar the keywords, the more similar the search results will be to the design task.

Number of unique keywords was computed as the number of unique unrepeated keywords used during the design task for each designer. For example if a designer searched for HIV kids, then HIV children, then HIV facts for kids, a total of 4 keywords would be counted (HIV, kids, children, and facts). However, words that were direct synonyms were only counted once. In order to account for this, keywords were confirmed by checking for synonyms using Webster’s Dictionary. In this case, kids and children are direct synonyms. Therefore, the total number of *unique* keywords in this example is 3 (HIV, kids/children and facts).

Number of keywords from task description. Once the unique keywords were identified, they were compared to the task description and reused keywords were identified. For instance, if an industrial designer searched for ‘tires’, this would count as a keyword from the task description since the word ‘tires’ is in the description.

Example Familiarity was computed based on the participant’s self-reported familiarity during the post-study survey. Since each participant was asked to rate their familiarity with four sources (website, information, creator, and overall familiarity), there were four measures used for comparison.

Data Analysis

In order to answer our first research questions the ordinal data from the post-study survey was coded such that a response of ‘always’ corresponded to a 5, and ‘never’ corresponded to a 1 with the rest of the responses coded similarly. A Kruskal-Wallis test (non-parametric data) was used to compare across domain and expertise (i.e. do graphic designers utilize examples more in the early phases of design as compared to industrial and web designers).

In order to address the second research question, a (M)ANOVA was performed with the dependent variables obtained from (1) the post-study questionnaire for familiarity (website, creator, information and overall familiarity with each of the examples) and (2) the calculated similarity measure (percentage of keywords from task description). In both cases the Independent Variables were expertise (novice, expert) and design domain (graphic, industrial and web). All statistical tests were performed using SPSS 22 with a level of significance for all statistical tests of 0.05.



FIGURE 1: DESIGN CONCEPTS CREATED BY THE GRAPHIC DESIGNERS AND EXAMPLES COLLECTED TO INSPIRE THEIR DESIGNS (FROM RIGHT TO LEFT) GD4E, GD1N AND GD3E

RESULTS

Figure 1 shows some of the design concepts created by our participants during the study as well as the examples they collected to inspire these designs. In this section we will compare and contrast the process used to retrieve these examples as well as discuss the characteristics of the example set designers' retrieve

Example Retrieval

Our first research goal was to understand when designers use examples during the design process and how this was related to their ideation sessions, we used our screen and video capture data to log the start time and duration of each example retrieval and idea generation sessions; see Figure 2 for a representative sample. This data showed that the graphic designers' often retrieved examples when starting the design task but rarely returned to example retrieval after they started ideating. On the other hand, the industrial designers often began by searching the web to find background information and then interleaved ideation and example finding sessions. Finally, the web designers tended to start ideating solutions immediately and only looked to the web to find examples when they had specific solutions in mind.

In addition to understanding when examples are retrieved, we also wanted to understand what retrieval process designers employed. Similar to previous findings, our designers had difficulties articulating what they were looking for into a search query [39]. In order to combat this problem, the designers utilized several strategies which aided them in developing keywords for search including: relating the current task to relevant experiences, brainstorming keywords prior to search, browsing background information about the design task on the

web, and using an online thesaurus to look at both synonyms and antonyms. Designers not only performed keyword searches but also browsed through various websites in search of examples.

While there were overarching similarities across example finding strategies, there were also stark differences. The following sections outline the process used in each design domain to locate design examples and when this process was completed.

Graphic Design

The graphic designers in this study collected between 10 and 37 examples (mean 19) during their design session. The designers typically began their design process by understanding the UNICEF organization by searching the web for background information and examples of previous UNICEF campaigns. As GD2N stated they weren't looking at previous UNICEF campaigns to see what they should do, but rather to avoid replicating what had already been done. In other words, they were not using the existing UNICEF designs as inspiration, but as a means to gain a better understanding of the project space. Other designers specifically avoided other campaigns that UNICEF had done before or any related genres mainly to avoid clichés. GD5E stated, "If someone is too familiar with your design you're going to be ignored. So, I always try and figure out what's new or what's different, just to get someone's attention." In other words, they specifically avoided similar designs and instead started by searching for background information on UNICEF.

After finding background information the designers relied on image search to find additional examples. The keywords they used to perform the image searches were often ones they wrote down while reviewing background information on

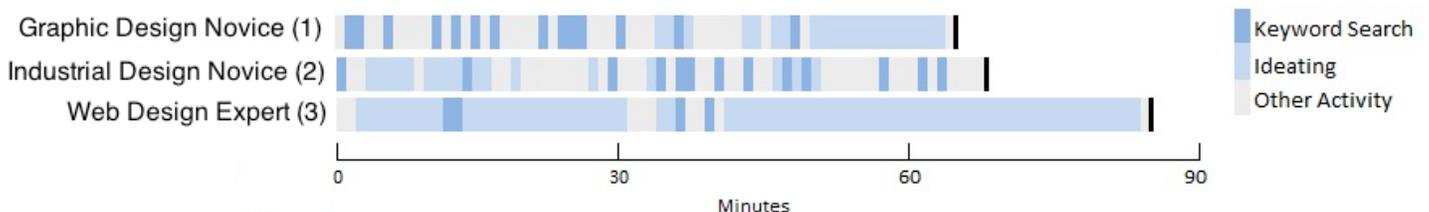


FIGURE 2: EXAMPLE RETRIEVAL AND IDEATION SESSIONS REPRESENTATIVE OF THE GRAPHIC, INDUSTRIAL AND WEB DESIGNERS IN OUR STUDY.

UNICEF (i.e. love, care and donations). Many of the designers also used an online thesaurus to help identify additional keywords. GD5E provided rationale for this behavior, "I think the way designers work is that one word connects to another word which connects to another word. For me, the thesaurus serves that purpose. If I find a word that is a 'hit', or a new direction, I'll use it in a search... I also look for antonyms. Often the opposite of what I'm looking for gives a more visual concept and is the most direct."

The designers then used these keywords identified to search for relevant examples. GD2N stated, "Mainly I was doing word searches that related to what I was hoping to do. Those word searches, most of the time, got me somewhere useful." Specifically, GD2N mentioned looking at the Meth project because they felt this campaign did a good job with their 'branding', or people's ability to look at the poster and know what it represented. S/He wanted to create the same kind of atmosphere in this new UNICEF campaign.

GD3E, on the other hand, drew inspiration from the Red Campaign posters because it is a campaign still being used. Like GD5E they were looking for not only what they wanted to do, but also what they wanted to stay away from. They stated, "The red campaign affected (my ideas) a lot because I wanted to go the exact opposite route of that. I do not want to be remotely connected to it" (see figure 1c). This means some designers looked for images that were the opposite of what they are looking for to draw inspiration.

After the designers performed their example searches, they began brainstorming possible design solutions. They drew inspiration from past projects and examples they had retrieved. For instance, GD4E came up with the idea of doing a poster campaign about uneducated women; "Somehow in my search I typed in 'veiled women', I don't really know how I got to that point, but I got this image and it was powerful and she looked like she was a wreck and I came up with the idea that 'uneducated women come out as hurting women', reusing the images s/he found on Google (see Figure 1a). On the other hand, GD1N drew from their background in university athletic poster design. After s/he looked at the current UNICEF posters, GD1N felt they could use some of the ideas for the university, focusing on using basketball and football players in the poster because s/he felt most students look up to those players.

After the designers started ideating solutions they only returned to the web when they had a specific target in mind. GD2N stated their rationale for this behavior; "I usually am looking for specific images for a project after the brainstorm... I know what I'm looking for." GD1N also discussed their process, "I came up with the idea to do basketball players holding children's hands, but I thought that might be a bit cheesy. While I was searching for examples I came across this image (Figure 1b) which has nothing to do with my idea but I said 'OK, the UNICEF logo is round,' let's combine them." At this point they went back to the web to find a different UNICEF logo to fit into their concept. This also shows that although the designer was searching for a particular artifact, they were also open to serendipitous discovery during the process.

In sum, the graphic designers started the design process by searching for background information and examples of current campaigns. They then search for images of concepts they had developed and ideated potential solutions with the retrieved examples. They mainly look for examples in order to gain background information, find inspiration, and find examples for re-appropriation.

Web Design

The Web designers in our study collected between 4 and 19 (mean 9) examples during the design session. The web designers typically started the design process by visiting the current National Public Radio (NPR) website and identifying potential problems. Next, the designers immediately started ideating by replicating the existing design either on paper or using Adobe Photoshop and applying their knowledge to solve some of the problems they identified.

They then began looking for existing design solutions for the unsolved problems. WD6E commented on this strategy, "My first question is, 'what is wrong with the current site'. I start looking at what the problems are and then I brainstorm about what the known solutions are. One of my design philosophies is that there are designers out there that have already knocked the problem out. So, if you can build off of an existing standard, you'll save a lot more time" Therefore, in order to get an idea of how other websites combated the identified problems, designers searched for similar examples.

In this part of the design process, the web designers were focused primarily on the layout of the page and therefore were looking primarily for examples of different layout structures. WD3N said the web pages they use (their design examples) depend on their familiarity with the particular design field, in this instance non-profit news websites. S/he said, "If it's something I'm aware of I'll typically use the websites that I think are most common or most frequently used." WD4N commented that one limitation to only using these familiar or frequently used websites is that they are not as open to new perspectives. However, WD4N felt they had enough familiarity with NPR that they didn't need to search for more examples. The most frequently utilized sites for this task were CNN, PBS, and Yahoo. They used these sites to compare their features and organizational strategies to that of NPR. The rationale for choosing these websites was that they were "winning designs that had stood the test of time." WD5E also went to sites like CSSVault and CSSbeauty to look for other designs that people thought were 'pretty' or 'nice', noting what they like about each design and applying it to their concepts.

Only one designer, WD1E, started looking for these 'known solutions' by searching for similar websites using terms such as non-profit sites, best non-profits in the world, and what makes a good non-profit site. WD1E said, "I wanted to know what it is about a non-profit site that makes it successful. I didn't know what it was about non-profit sites because I have never done one before." However, because the search results 'weren't what they expected' they went back to the sites they normally use for inspiration (in this case CNN and Yahoo).

In sum, the web designers started by applying their own design knowledge to the design task and then either searched for examples or utilized websites they deem 'best in the field' as design inspiration. Finally, they only returned to the examples they already retrieved, and had kept open in tabs, once they had started ideating to compare different design features. The examples they retrieved in the early phases of design tended to deal primarily with the layout of the site and things they could reuse in their new design ideas.

Industrial Design

The industrial designers in this study collected between 12 and 20 (mean 17) examples during the design session. They typically began the task by searching for relevant background information on recycled products to draw inspiration. ID5E said, "I went to LOHAS.com to get information on market shares. They gave me a good idea of the areas that have bigger markets. That is where I got the idea of working on product packaging". Similarly, ID4N first searched for images and recycling statistics on tires and then, "tried to use the existing knowledge to relate it to things that the tires could be used for." Another starting strategy designers had was to connect the design task to things they had recently seen. For instance, ID1E started by retrieving an article s/he a colleague earlier in the day about RV recycling. ID4N recalled a recent television show that used black piping to heat water so they started researching how they could use this in their design. They used this memory to give them a starting point for their research.

Once the designers had a firm understanding of the problem space, they began visiting familiar websites and weblogs to aid in ideation. ID6E stated, "Forums are good once you have knowledge because they give you more context. If you go to something that is only text based or only image based, it's hard to find something insightful." ID2N actually started searching Google before visiting the blogs without much avail. "I started with Google images and typed in water bottle but I got back 400 results. I'm not going to sift through that. Plus I started seeing stuff that wasn't really relevant so I started to think of things I had done in the past and design blogs I had visited, so I went there." After designers reviewed the designs on these websites and ideated a potential solution, they then performed searches examples similar to their solutions.

For instance, ID3N started his/her design process at instructables.com and treehugger.com because s/he was familiar with those websites. While browsing the website s/he found many examples of products reusing plastic bottles which led him/her to look into glass bottles because s/he thought it was a more versatile material. His/ Her first idea was to create a cap kit or pour spout for different bottle sizes so that people could reuse bottles by filling them with soap and using them as a soap dispenser. S/he then looked for examples similar to this design concept to help her understand if, and to what extent, this idea exists. While looking at these examples s/he thought, "This would look nice in a garden because they're natural

colors." So s/he started looking for examples of bottle fencing, something s/he could design and customers could buy in a store where there would be a little stake in the ground and the top of the bottle would be partially buried, see Figure 3.

ID1E had a similar strategy. S/he first started by trying to search for recycled RV's to get more background information on what has already been done. However, s/he accidentally mistyped it and searched for 'recycles RV'. Although this wasn't what s/he was looking for s/he called it a 'happy mistake' because it took him/her in a new design direction; creating a line of RV accessories made from recycled RV parts. At this point s/he went to a familiar website, campingworld.com, and searched through the accessories on the website. S/he felt it was important to see the visuals because, "A word is going to take me down a narrower hallway where a picture gives me a hallway where if I push against it, it might open up another door." This shows that although the background information is definitely important, the industrial designers also needed visuals to help them ideate solutions.

In general, the industrial designers tended to search for relevant background information, exhaust internal ideation resources and then intersperse ideation and example finding sessions. During the first ideation session they tend to identify relevant keywords for future research paths. They utilize examples retrieved in the early phase of design to gain background information on the problem and find examples that can be re-appropriated in a new design. In addition, they use examples to help them make new connections between concepts. For instance, ID03N stated, "examples help me think. If I see something it might remind me of something I already know. It helps me make new connections."

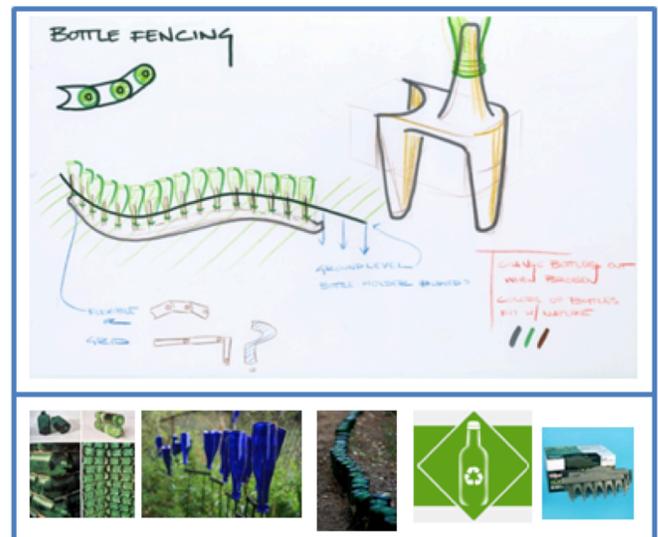


FIGURE 3- TOP: DESIGN CONCEPT CREATED BY ID3N, BOTTOM: EXAMPLES RETRIEVED FOR INSPIRATION.

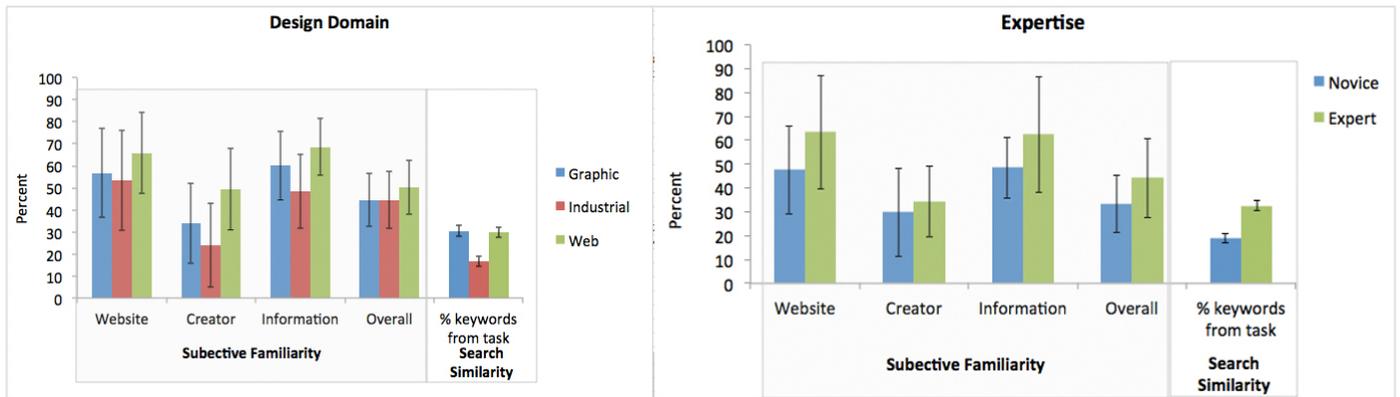


FIGURE 4: AVERAGE FAMILIARITY/ SIMILARITY BY DESIGN DOMAIN.

Our second research objective was to understand the differences in the characteristics of the example set designers collected during the design session. Previous research has shown that designers can become fixated on designs based on their expertise, familiarity with the examples, and the similarity of the example to the design task. Our study aimed to quantify these results by dissecting designers' search queries and self-reported design example familiarity. In sum, we found that the graphic and web designers view more familiar examples than the industrial designers and the expert designers viewed more familiar and similar examples than the novices, see 45. As a reminder, we used the keywords measures from the task description to compare how similar the design examples were to the design task. Participants also reported their familiarity with each of their stored examples on four dimensions.

Creative design domains: Our first goal was to understand if there were any differences in the examples used between the three design domains. The results show that the industrial and graphic designers were less familiar with the creator (photographers, designers, organizations) of their retrieved examples ($p < 0.01$). The industrial designers were also less familiar with the information contained within the examples (i.e. Meth Advertisement Campaigns, news websites, recycled products blogs, $p < 0.001$) and the examples overall ($p < 0.001$). This means that the graphic and web designers utilized examples they were more familiar with, see Figure 4.

This could be attributed to the industrial designers utilizing design blogs, which post design examples from a multitude of sources. Therefore, the industrial designers were more familiar with the website, but since the information is constantly updated, they were unfamiliar with the information contained within the site. There were no significant factors for similarity.

Expertise: Our second goal was to understand if there was a difference in the characteristics of collected examples between expert and novice designers. Our results show that expert designers were more familiar with the examples they collected (based on overall familiarity $p=0.02$), and the information contained within the examples ($p=0.00$). In addition, experts utilized a higher percentage of keywords from the task description, meaning they searched for examples similar to the task ($p=0.03$).

These differences could be attributed to experts being more successful than novices when searching for design examples, specifically because they are more able to articulate their search

terms [50]. Additionally, many of the expert designers related the task to previous projects in which they had topic familiarity which has also been linked to an increase in search performance [51]. Thus, the chance of expert designers encountering less familiar or less similar search results could be greatly reduced due to their search patterns and the highly filtered and ordered search results.

DISCUSSION

Although the use of examples is common in many design disciplines, little research has been conducted on how designers use the Web to retrieve examples. In addition, although empirical evidence has reported designers become fixated on examples similar to the design problem or familiar to the designer, there has been little evidence on whether or not designers actually collect these types of examples in practice. This study offers many insights into these processes.

No one size fits all solution

One of the most important implications derived from this study is that there is no 'one size fits all' solution to aiding designers in example finding on the Web. Our results show differences in the characteristics of examples designers choose as well as their strategies for retrieving these examples across design domains and levels of expertise. Therefore, the type of constraining environment (too many similar or familiar examples) varies based on these dimensions. In addition, the purpose for retrieving these examples varies during the design process. For instance, the industrial designers used examples in the early phases of design to gain background information whereas the web designers were looking for known solutions to existing problems. In turn, it is difficult to construct a global interface that retrieves a suitable set of examples for all designers because the same set of examples does not have the same degree of appropriateness for all design situations. This means that researchers should focus on both how to develop engines help designers retrieve set of examples, and also help designers identify when they are collecting fixating examples.

Although there is no one solution, one possible aid for example finding could be to create a visual display that shows how constraining a set of examples are. For instance, this could be accomplished by creating a window in the web browser that shows the last few examples collected, the similarity of those examples to one another and the familiarity of the examples to

the designer. These measures could be calculated using the provenance data of the examples and the browsing history of the designer. This type of system would benefit designers by creating a cognitive awareness of the types of examples they are collecting. Future work should explore these factors as well as consider the fixation that occurs from the design process followed.

Allow for serendipitous discovery through example re-composition

One of the main uses of examples is to take existing designs and compare the features between the products in order to identify interesting components [29]. However, our results showed that designers in different domains have different strategies for comparing examples. One of the main problems with current methods for comparing and analyzing features of existing designs is that they examples are often stored in a linear structure or designers are required to flip between Web pages. Neither of these strategies truly allows designers to make interesting comparisons between examples. If better comparative techniques were developed, designers would be more open to serendipitous discovery during this comparative process.

For instance, GD1N had this type of experience when they were searching for examples of basketball players holding children's hands. They said, "I came across this image (Figure 1b) which has nothing to do with it (my idea) but I said 'OK, the UNICEF logo is round,' let's combine them." Recognizing the similarities in size and shape of these objects allowed GD1N to make the association between the basketball shape and the UNICEF logo shape.

One way to aid in these discoveries is to show examples at different levels of abstractions. For instance we could apply segmentation techniques for extracting basic shapes and objects from the stored examples and make them available as elements in existing content creation tools, like layers in Adobe Photoshop. Designers could then arrange the layers to quickly synthesize new design ideas or form new connections between the elements.

It is worth noting that the industrial design task could be considered more 'open-ended' than the graphic and web design tasks. These tasks were selected to represent typical tasks of each domain. However, the openness of the industrial design problem may have altered the comparisons between example finding practices. Future studies should explore more close- or open-ended tasks in order to ensure generalizability of these findings.

CONCLUSION

Using examples to inspire creativity is a highly valued and prevalent method in the creative design industry. However, it remains unclear how designers search for and utilize examples to stimulate creative outputs and how technology could best facilitate this behavior. Our work has made several contributions addressing this problem by performing a

laboratory study with representative and challenging design tasks in three domains.

First, we observed notable differences of search strategies and example utilization across design domains. The variety of resources designers seek and dimensions of examples they use are highly dependent on the design domains. Second, we found that the design domain and expertise influence the examples designers utilize during the design process. We found that expert designers rely on their own knowledge and only seek highly familiar or similar examples, losing the potential benefits from exploiting a more diverse set of examples. The graphic and web designers also collected examples that shared more characteristics with types of examples that have been shown to cause fixation than the industrial designers. This leads to interesting research questions on how we can better support these design domains that have received relatively little attention in terms of design fixation in research literature. Finally, we provide practical design implications for tools aiming at facilitating example-finding activities.

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APPENDIX (INTERVIEW QUESTION LIST)

1. Please briefly describe your design process for this task from when you were given the task until when you stopped the study?
2. Please briefly describe your favorite design concepts generated for this task.
3. Which examples helped you develop this design concept, if any?
4. Was there any type of example that was particularly beneficial for this task? Why?
5. What types of example were the least helpful, if any? Why?
6. For what purposes did you utilize examples?
7. How and why did these examples affect your design activity?
8. Can you briefly describe your strategy for finding examples?
9. What were the strengths and weaknesses of these methods?
10. Were there any websites that were particularly beneficial for this task? Why?
11. What type of information did you collect from these websites?
12. What were some of the difficulties you encountered when searching for examples?
13. What other sources of examples or other information would have been useful for this task?
14. What was the most difficult aspect of this task, please elaborate?
15. How do you think your process of finding examples could have been improved, if at all?