Exploring Designers' Practice of Online Example Management for Supporting Mobile UI Design

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ABSTRACT

The use of digital examples plays a critical role in mobile UI design. Yet, it remains unclear how UX/UI designers manage (i.e., collect, archive, and utilize) examples to facilitate their design processes at different stages, and what possible challenges are imposed on the design of proper tools to support these practices. In this paper, we conduct a qualitative interview study with mobile UI/UX designers (12 experts and 12 novices), deriving the commonality in practices and analyzing possible differences across four design phases (Discover, Define, Develop, and Deliver) and expertise. In brief, we find that there is more diverse and frequent use of examples in the Discover and Develop phases, and that experts take more diverse advantage of the information from examples compared to novices. We further identify the challenges faced by designers when using existing example management services, and propose potential design implications for the development of more supportive design tools in the future.

CCS CONCEPTS

• **Human-centered computing** → **Human computer interaction (HCI)**; **Empirical studies in HCI**.

KEYWORDS

Example management; mobile UI design; design practice

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1 INTRODUCTION

Mobile devices, such as smartphones and tablets, have become a pervasive window for users to access information and services, e.g., over three billion of people around the world own a smartphone by September 2018 [1]. It is mobile user interface (UI) designers' goal to create good interactive experiences for mobile devices' features, content, functions, and apps installed. To succeed in this mission, mobile UI designers often turn to design examples for inspiration, reinterpretation, and evaluation of ideas [33], a common approach also taken by designers in other domains [30]. The typical mobile UI design examples include but not limited to graphic elements (e.g., logo, button, and UI animation), case studies (e.g., detailed design documents), and competitor apps. The visual illustration of these examples is shown in Figure 1. Despite that emerging online design repositories, e.g., Dribbble[1], Behance[2], and Pinterest[3], make it easier than before to search, catalogue, and share digital design materials [27], mobile UI designers still encounter many issues in their process of managing – collecting, archiving, and using – examples.

Prior research suggests that design fixation, *i.e.,* "a blind adherence to a set of ideas" [17], and difficulty in articulating query information are recurrent problems that web, graphic, and product designers run into when searching for examples from external sources [12]. Web designers also concern about their difficulty in identifying trustful resources of relevant design examples and about the inconsistent benefits of examples in different design phases [21]. While mobile UI designers are likely to experience similar hurdles identified in other domains during example management, those conclusions in other domains may not be directly applied to mobile UI design due to the notable difference between mobile devices and desktops including the lack of tactile feedback, ubiquity, limited screen size, etc [28]. Designers face additional, unique challenges introduced by peculiar characteristics of mobile UI design materials, such as form factors and interaction modalities [6].

[1]https://dribbble.com/
[2]https://www.behance.net/
[3]https://www.pinterest.com/

It is thus necessary to dig into the specific practices of mobile UI designers to uncover design opportunities for better technological support [3, 22]. In this paper, we seek to gain deeper insights into mobile UI designers' way of defining and applying examples as well as their experiences with existing online repositories. We are particularly interested in how their practices may differ across different levels of design expertise and across various design phases. Prior human-computer interaction (HCI) research indicates that proficiency in design affects how designers treat examples. For example, compared to novices, expert designers rely less on examples [25] and could evoke a larger number of creative ideas when presented with examples less similar to the intended design task [3]. However, little is known about the impact of other qualities that expertise entails, such as role in a project team, on mobile UI designers' example management practices, as well as about how such an impact spread across different design phases.

In short, we aim to explore how designers' practice of example management evolves throughout the mobile UI design process, and how design expertise plays a role within this context. To this end, we conduct a series of interviews with 24 designers including 12 experts and 12 novices. We compare their means to collect, archive, and employ examples in four design phases, *i.e.,* Discover, Define, Develop, and Deliver introduced in Double Diamond (DD) framework [5], to extract similarities and differences. Double Diamond framework was developed by Design Council, which has been commonly used in the design community. It is the design process model that was most frequently mentioned by our participants. Moreover, it has a clear, concise, and detailed definition of each of the four design phases [34]. We thus adopt DD framework in our paper as a guideline to systematically summarize the participants' behaviors. We also gather information about their ways of exploiting the existing online design repositories, the features they like, the issues they encountered, and methods for working around technological barriers, if possible. Our findings suggest that among all phases, managing examples takes place more often in Discover and Develop. Furthermore, compared to novices, experts discover more diverse usage of design examples.

The main contributions of this paper include:

- We provide a deep understanding of how designers manage (*i.e.,* collect, archive, and utilize) examples in their mobile UI design practice via a series of interviews with 24 designers.
- We compare the example management behaviors of the experts and novices across distinct design phases to uncover the similarities and differences.
- We identify places where current online design material services fail to meet the need of mobile UI designers, and suggest opportunities for developing future design support tools.

2 RELATED WORK

2.1 Example in Design

Examples involved in creative design process are the materials that designers constantly refer to. It is a typical type of design collections [23], which may come in various forms, including graphic elements, sketchy prototype, interaction logic, physical models, *etc.* [12]. They provide templates of design solutions, organized ideas, and sources of inspiration for various perspectives [8].

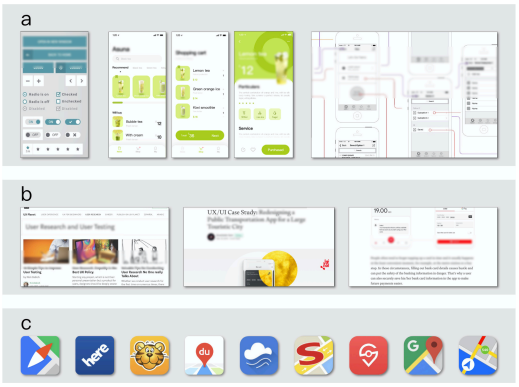

Figure 1: Illustrations of the three types of examples: a) UI page, b) case study, and c) competitor

Prior studies have extensively investigated the effects of design examples. On one hand, as a vital part of design activities, using examples brings essential benefits to the design process [36]. Examples facilitate the creation of a visual framework, the reinterpretation and evaluation of design ideas [2, 31]. In particular, the designers tend to generate more diverse and creative ideas if they have more adequate proper examples [30]. Meanwhile, designers can benefit from examples by comparing and evaluating different design features. On the other hand, examples can cause impediments in terms of design outcome. Negative effects of exposure to low-quality examples have been observed, even for experienced designers. More specifically, semantically far inspirational examples can be harmful in creativity during productive ideation [4]. Further, designers can be fixated while facing examples similar to their own artifact to be designed [17]. This is so-called design fixation, in which case, the diversity and originality of the design outputs are limited by particular examples [26].

2.2 Practice of Example management

Existing HCI research has found that design example usage varies in different stages of design [12]. For instance, in the idea generation stage, example usage helps to deepen the understanding of the current market, promoting reinterpretation on existing designs and originality of the proposed design, while in the evaluation stage, example usage serves as a method to measure the originality and validity of the design solutions [12]. Behavioral differences have also been observed between design experts and novices. As experts have accumulated more design ideas and experience than novices do in general, they rely less on design example [25]. Although with this fact, it turns out that design fixation happens more severely to experts [35]. These existing studies, however, merely focus on one factor, either design process or design expertise, without taking both of them into one picture for discussion. Consequently, they generate limited insight into how to support the novice and expert in actual design practice. Moreover, while such findings have identified the patterns from a general design perspective, they might not be generalized to a specific domain, mobile UI design, given the distinct practice across domains [12]. The unique design features of

mobile devices, such as their ubiquitous nature, small size factors, and interaction modalities, as well as the existing standardized design guidelines, significantly distinguishes mobile UI design from other design fields [6]. To shed light on how computer technologies might better assist mobile UI designers, we look into the practice of online example management with existing services. Our work differs from existing research in coupling the consideration of design process and design expertise within the context of mobile UI design.

2.3 Tools and Platforms for Example management

Multiple ways to find examples have been identified during design procedures, such as referring to physical materials and online resources, meeting people, and so on. Among them, online management platform is recognized as a crucial and prevalent channel for designers to gather information and inspirational materials, especially with the recent advance of online design repositories [21, 25]. But limited attention has been paid to how those online platforms support example management and thereby foster creative designs. The most relevant work is done by Koch *et al.*[21], in which they confirmed online platforms as a prevalent source of design ideas through a survey study. By looking at what online materials designers refer to, the authors showed that designers have concerns about trust and relatedness about online examples. Nevertheless, they did not touch how these online platforms support example management and what challenges designers may face in this process.

There has been research on developing tools for designers to support example management, which can be summarized into two categories. One is to facilitate designers to attain examples in an efficient and natural manner. For example, Yee *et al.* introduced a category-based interface that enables navigation along the conceptual dimensions [39]. Kang *et al.* designed *Paragon* which helps to browse examples efficiently by leveraging metadata [20]. A more recent technology so-called *Swire* takes designer-created sketch as input and returns relevant UI examples, providing natural and novel interaction for example query [16]. The other branch of studies encourages both exploration and exploitation of design examples, in order to avoid the pitfalls of design fixation. A typical work is by Koch *et al.* who developed a machine learning supported tool for interactive ideation assistance, allowing the adaption of exploration and exploitation strategies [22]. Our study is orthogonal to these work by providing the detailed implications into designers' needs for mobile UI design.

3 METHODOLOGY

The ultimate goal of the paper is to explore designers' practice of online example management and establish a comprehensive and systematic understanding of it. To this end, we conduct semi-structured interviews to address the following research questions: (1) What types of online examples do designers refer to during mobile UI design process? How do they collect, archive, and utilize those materials in practice? (2) How, if at all, does the example management practice differ by design phases and design expertise? (3) What are the challenges and opportunities of current example curation platforms for mobile UI design in the process of example management?

3.1 Interview Procedure

We recruited interview participants through word-of-mouth and advertisement on various social media, e.g., Facebook, Twitter, and WeChat. Among the applicants, we selected 12 expert designers (*E1-E12*, who have at least two-year working experience in the industry) and 12 novices (*N1-N12*, who are university design students without working experience) (including 14 females and 10 males, Age_{mean} = 26.7). Among the experts, seven work for a company, three work for multiple clients at an agency, and the other two work for a university. The participants were all required to have mobile UI/UX design experience. We conducted semi-structured interview, either face-to-face or online, with 24 participants. After getting their consent, we began each interview session by inquiring about the participants' recent or ongoing mobile UI design projects, which serves as a warm-up and offers context for further conversations about their example management behavior. Discussions about the interviewees' current design practice started with one specific mobile UI project, gathering data about in what design phase(s) they would use digital examples, and what types of examples they apply as the design process unfolds. We then asked participants to describe how and why they typically collect, archive, and utilize examples. They first derived a general pattern from their own memories and then referenced their recent design works as concrete instances to walk us through specific actions involved in their actual design process. Subsequently, for each management-related action identified in the conversations, we asked about their goal and how they achieved that. More specifically, we are interested in knowing what tools they have been using, what their expectation are and what barriers they have encountered with existing services. Further, we posed questions about how the examples they fetch affected their design outcomes. We asked for additional example management actions until the participants cannot recall any more cases. Finally, we closed the interviews with sharing of overall impression about current search tools. Each interview lasted around 90 minutes.

3.2 Thematic Data Analysis

To conduct thematic analysis on the interview data, three of the authors first familiarized themselves by going through video recordings and transcripts from all sessions to become fully immersed in the data. Then, the three authors extensively and carefully performed open coding on those data over several rounds. During this process, the team met regularly to compare and discuss each other's codes, consolidating different codes into potential overarching themes related to reoccurring patterns of example management behavior, including example collection, archiving, and utilization. Through several rounds of reading, comparing, and refining the emerging themes, the team generated several sub themes and came up with an embryonic form of the code book. More specifically, we allowed for new codes to emerge if they do not fit clearly into extracted codes and for the codes to evolve if the definitions are too narrow or too broad. From there, we defined the themes that we identified and organized them into a coherent set that fit together

to capture the experiences of the participants. When we reported quotes from participants, we referred to the transcripts and translated them into English if the interview session was initially carried out in other languages.

In the following sections, we first describe the themes about collecting, archiving, and utilizing examples. Next, we report how example management behaviors differ between expertise and across design phases. Lastly, we identify the challenges encountered by designers with existing example-related online platforms for mobile UI design, and further provide implications on the improvement of example management services.

4 COLLECTING EXAMPLES

An important topic emerged from the interview responses is about example collection, including what examples do designers commonly use for mobile UI design and how do they retrieve such examples from a large repository of online design material. We identify three major types of design examples and three kinds of search behaviors.

4.1 Example Identification

While standalone UI pages, as mentioned in [11], are the kind of design examples brought up the most by all our interviewees, UX/UI case studies (75 %) and competitor apps on the market (60 %) are two other categories frequently exploited to inspire and/or inform design. Figure 1 showcases these three design types according to our interviewees. We find that designers tend to leverage them for different purposes and thus often focus on different aspects of information.

4.1.1 UI Page for Inspiring Graphic Design. A standalone UI page is a static or dynamic snapshot of a mobile app interface. It can exhibit different levels of prototype resolution, which refers to the degree of sophistication [15], ranging from wireframes to realistic screenshots [11] (Figure 1.a). Designers mainly inspect UI pages for gaining insights into mobile app graphic design (*E6,12 and N6,7,11,12*). Some of them focused on the overall graphic design, such as "the page layout" (*E1,3,7 and N1,3,9,10,11*), "the graphic style" (*E3,4,5 and N4*), and "design trend" (*E2,5*). In particular, E5 and N10 examined wireframes that illustrate realization of features through organization of functions and UI pages. N4, instead, scrutinized the visual aspects, "In the visual presentation design, I would imitate the graphic styles and colors of examples. That's why I expect their color schemes can match the key visual style of my own project". Others (*E3,4,5,11 and N2,3,8,12*) highlighted the importance of identifying specific static UI components for reference, including but not limited to icons, buttons, and menus. *E3* "would inadvertently mimic the interactive button, the shadow and the style of the icon". *N8* added, "When I am not sure which certain icons might be better, I always find the examples with those icons to see how they appear in the actual design". A few respondents were also interested in UI animations, the dynamic changes within each UI page or those between pages (*E4,5,11 and N2,12*). Since static pages cannot capture this vital dynamic UI feature, they have to obtain dynamic snapshots of UI pages saved in animated images (Gifs), videos, or interactive prototypes. Such UI examples, however, are rather scarce compared to still images (*E7,9 and N9*).

Though UI pages are prevalent examples employed in mobile UI design process, they have several inherent limitations. First, interaction logic and flow are not explicitly demonstrated. Hence, some designers try to reverse-engineer the logic from a sequence of pages. Further with the limited contextual information depicted by UI pages, it is hard to make sense of and articulate the design ideas. As E4 described,"When I communicate with developers, using static documents or scattered pages to illustrate the prototype and convey the concept is normally time consuming."To tackle these challenges, designers would leverage another typical type of examples, case study, which " delivers more details and context" (*N7*).

4.1.2 Case Study for Learning Design Rationale. A UX/UI case study is a detailed documentation of a successful design project, sharing the design experience and outlining the issues essential to consider on projects of different kinds and aims [18]. It usually conveys the information about background, functionality, and user research [18] (Figure 1.b). Functionality presented in a case study enables designers to have a design experience with its complete interaction logic, as pointed out by the majority of the interviewees. According to *N9*, " When designing art museum apps, I will use functions and interaction logics of all the museum's apps as references to construct my own."

In addition, 11 of our designers found the adequate contextual and analytical information provided in case studies particularly insightful for special purpose-driven design."The case studies explain reasons and intentions behind each design decision. They largely enhance my understanding of the examples and avoid superficial reference to them." *E6* further demonstrated how he employed case studies, "When I design a weather data visualization app, I read a lot of case studies of existing data visualization demo and then apply the same rationales to backing up my own UI choices." Moreover, five designers indicated the use of case studies to keep up with the most recent design trends and to study how they arise and evolve. *E5* for instance said that she would "research on case studies or industry reports to learn the most fashionable design." Despite their practicality, UX/UI case studies are not widely available on the Internet. Perhaps that is why many designers thus turn to existing applications as an alternative for design reference. *E8* mentioned "In the initial stage of app design, I often research competing products and try not to miss each update version of them. "

4.1.3 Competitor for Benchmarking. A competitor app is an existing mobile application available in Appstore that shares similar, if not the same, target users, business goals, and/or functions to the on-hand projects [13]. Designers often leverage two pieces of information of an online app: designers examine the meta data of the existing apps in appstore, such as "the feature list, the interface pages, the product description, and user comments" (*N1*), and a taste of actual user experience obtained by downloading competitor apps and interacting with them. Through assessment of competitor apps, designers could "become more familiar with what is already available on the market" (*N2*), which serves as a guidance to their own projects (*E11,12 and N2,7,10*). First, in app design, it is critical to adopt well-accepted design patterns to ensure consistent user experience [10]. As *E3* mentioned, "In one of my previous projects, I was unclear about how to design the log-in page for a particular type of app. So I looked for the log-in page of the competitor apps

and learned from their element composition and layout." Second, learning competitors helps foreshadow the effect and acceptance of certain design feature in reality (*E3,5*), *e.g.,* "how notification features are realized through specific salient colors and dynamic page transitions." (*E3*) Third, designers make constant comparison with competitors to prevent their designs "looking similar to what already exists on the market" (*N6*). However, they need to avoid fixating on the existing solutions and patterns of competitors [26]. While all types of examples have their own advantages and disadvantages, we noticed that the frequency of their usage may vary between experts and novices.

4.2 Practices in Conducting, Assessing, and Terminating Online Example Search

We also looked into how designers look for online examples during mobile UI design and and under what condition they will terminate the retrieval process.

4.2.1 Behaviors and Strategies of Example Search. From the interview feedback, we identified different behaviors our participants adopt to get examples. Existing studies have classified the exploration of information into a browsing activity (i.e., serendipitous discovery) and a searching activity (i.e., look for answers to specific questions). Similar to the previous research [12, 14], we found that the identified retrieval behaviors can be characterized by these definitions and thereby summarize them as browsing and searching behaviors. Browsing behavior occurs when designers retrieve examples without particular targets. Designers make browsing retrieval to gain background knowledge of relevant theme especially in early stage of their projects. As *E9* described, "We collect existing apps on the market to analyze industry trends, such as the layouts, color schemes, interaction, and etc." Unlike browsing, searching behavior manifests the retrieval process where designers have a clear expectation on the example-targeting search. Therefore, it is normally done by the support of search engines. As *N9* highlighted, "For the design content I am familiar with, I always have something over my head to look for. So I just search for the results which exactly match the picture in my mind." We also found that most of the participants would switch between the two types of behaviors. For instance, when designers conduct exploratory search and encounter something of interests, they will switch to focused search to dig into that particular type of examples. As *E2* mentioned, "When I look for arbitrary examples about Map applications on Pinterest, I happened to see an awesome post. Then I just focus on the recommended similar designs".

Within each behavior, designers use different strategies which aid them in getting online examples with existing online services. One of the most common methods to retrieve online examples is by searching with keywords (*E1,2,3,4*). E1 gave an example that "[i] directly search the keyword 'map' for navigation Apps when i need inspiration from their flow and features" while *E2* just searched the name of competitor app recommended by the colleges. They also search with keywords that describe the expected graphic style, *e.g.,* "Scandinavian style" when a minimalist scheme was in need by *N7*. In addition, some participants used keywords referring specific components (*E1, 3, 4*), *e.g., E1* searched 'button status' to find out "how buttons are designed for different status", and E4 collected an icon for password input via searching 'password' in Google or Dribbble. Apart from searching by words, it is also prevalent to search by images for examples. As *E3* stated, "I search on Google Image or Pinterest with a satisfying image on hand to obtain similar ones. This also happens when I look for high resolution version of a low resolution image". When presented with a large example pool, designers can utilize restriction functions, normally provided by the platform, such as tag or filter, to narrow down to more accurate results.

For instance, in Pinterest the 'mobile UI' filter button restricts the search results into the domain of mobile UI, which provides "more relevant examples to the App I design" (*E1*). *E2* and *N5* had similar statements during the interviews. In some cases, the filters and categories can even waive the search keyword when the filter itself has strictly restrict the results, such as "exploring UI pages in certain colors" (*E4*). Other filters provide the criteria capturing social management information, *e.g.,* user ratings, amount of followers, and amount of likes, that *E5* considered useful.

4.2.2 Termination of Search. Example search can be a labor-intensive activity. Sometimes people may find many hits and feel that they could not exhaust all the candidates. Other times, they may end up with nothing after rounds and rounds of queries. Hence, to control the time and effort cost in example searching, designers often preset an expectation on the spent time and number of good results, to help determine when to call a halt..

According to the interview results, we found that designers' effort required for a retrieval activity is closely related to the time cost. The retrieval time varies from hours (*E1,3,5,9,11,12 and N1,3,4,5,6,7,11,12*) to days (*E2*). As participants reported, it is highly dependent on the overall schedule of the project. With an approaching deadline, the designers would intentionally control the time cost. As *E2* stated, "I don't go beyond half an hour in case being stuck. Once time is up, I will just stop and start to decide on strategies for the next step." In addition, some designers evaluate the timing by the amount of visited examples, *e.g., E4* usually browses "five to six screens of result pages, at most ten ", before switching the platform or stopping example retrieval, while the others stop the retrieval when the results become repetitive, which in their opinion indicates "the exhaustion of novel results." (*E3*) Another reason that leads to the end of a retrieval is the frustrating search trials. Participants might give up the search after they exhaust the strategies they know but fail to get what want.

5 ARCHIVING EXAMPLES

After collecting useful examples, designers commonly archive them for further utilization. In this section, we summarize their archiving methods based on whether they are integrating examples for direct or future usage.

5.1 Integration for Situated Inspiration and Direct Usage

In the archiving process, 14 designers intended to visually integrate the collected materials into one file, usually in the form of mood boards or design documents. A mood board is a type of collage consisting of multiple examples (e.g., images and text) of a certain topic [9].

Designers including *E3* and *E4* make a mood board in the archiving process as it "abstractly depicts the ideal design output, to provide guidance and inspiration for further desig" (*E4*). Design documents, such as Photoshop and Sketch files, are also widely used by our interviewees. They copied, downloaded or took screenshots of the retrieved examples to their own design documents to simultaneously reference them (*E1,3,5,12 and N5,10*). In particular, they often merged the "directly editable examples into the UI design documents, to visually evaluate them before storag" (*E3*) and "build an mood board of the fashionable UI designs" (*N10*). Such documents include "an entire set of UI kits"(*E3*),"a UI page template document" (*N1*), etc.

5.2 Classification for Future Usage

Apart from integration, designers also perform classification of example documents, into different categories. This process can be carried out online, using archived features of the example management platforms, e.g., "Board" in Pinterest (*E1,5,6,8 and N3,4,6,7*), "Bucket" and "Like" in Dribbble (*E3,4*), or using the "Bookmark" of browsers (*E1 and N1,3,4*). "I add plenty of examples to bookmarks before organizing and utilizing them."(*E3*) In particular, N8 mentioned that using bookmarks can "boost my work efficiency". It can also be launched offline for various reasons like "worrying about failed access to online platforms" (*E5*) or "lack of archived features on the sites" (*E1*). "I often download pictures in my favorite styles, create a folder of collection, and use it when necessary in future." (*N2*) Specifically for competitor Apps, seven of our interviewees installed these Apps on their mobile devices, interacting with and analyzing them many times (*E1,3,5,11 and N2,3,11*). I downloaded 'Google Map' and 'Baidu Map' during the project of a navigation App. I analyzed and referred to their wireframe with UI pages, whenever needed" (*E1*). Additionally, some designers (*N2,5,11 and E7,12*) used tools like "Wiznote" and "Eagle" that can classify both online and offline documents, so that "the examples are saved locally for utilization while still being accessible any time and anywhere" (*N5*). *E12* mentioned that she classified examples in "Eagle", which "allowed sharing with teammates through its cloud service."

6 UTILIZING EXAMPLES

The interview results suggest that examples can serve different purposes in the mobile UI design process, which we summarized into two main categories, *i.e.,* construction of feasible design space and facilitation of specific design generation.

6.1 Constructing design space

Design space refers to the assembly of design points, among which designers conduct systematic analysis and prune unwanted points based on relative parameters of interest [19]. Designers often switch between diversifying design ideas and specifying design choices constantly to refine their design space [3]. Within this practice, examples serve as a critical source for designers to collect background information to understand user needs, seek inspiration to diversify design ideas, and validate design choices to narrow down the design space.

6.1.1 Collecting background information. A starting point to define the design space is to collect adequate background information. In this process, designers conduct research on stakeholders and the market to fully understand the needs and background of the project.

Designers understand stakeholders' preference by studying relevant examples, often the stakeholders' previous products. As *E1* said, "I would check the stakeholder's previous products in a chronological order to learn the characteristics and iteration of their products." Through examples, designers also understand stakeholders' expectation on the product, *e.g.,* "Exploration of examples allows me to discover the direction in which stakeholders expect the design to be developed."(*N4*) Designers further utilize examples to understand stakeholders' preference in the product, *e.g.,* "I often use examples to confirm stakeholders' preferred visual design styles and branding strategy with them."(*N2*) In addition, most participants agreed that gaining background knowledge by examples is important for establishing a comprehensive understanding of the market. As *E3* stated, "Competitor examples deepen my understanding of actual user need and demanded functions. They also provide marketing strategies for reference, such as how to bring users and how to keep them." Furthermore, by widely studying examples, designers gain a more precise understanding of the user needs and tastes. As *N7* commented, "I like to check the comments left by real users in app stores because they can reveal what aspects of an app design users like and dislike." *E1* added, "I spend plenty of time on analyzing the examples with higher ratings or more downloads because they are more likely to achieve better user experience."

6.1.2 Seeking inspiration. Designers seek inspiration in examples when they do not know where to start and need to become familiar with the target users or application domain. In particular, four participant commented that referring to examples can speed up their design creation, *e.g.,* , *E8* mentioned that "when I am stuck at some point, going over the examples that are similar to my target design gives me concrete hints to move forward." Meanwhile, some designers mentioned that through examples, they can explore more diverse and new design solutions (*E4,5 and N2,4,7,8*). *N8* commented that "Examples often bring me new ideas that I cannot come up with. For example, I recently came across an amazing log-in page design which was hard for me to imagine without such a hint." Examples can also keep them in pace with the design trends (*E4,5 and N4*), which is critical to professional design practices.

As *E5* stated, "I always browse Dribbble to learn what is the current UI design trend. By going through abundant updated material, I establish an impression of the fashionable designs, which invisibly keeps my designs trendy". Many designers consider such exploration as a common routine to expand their design vocabulary (*E11,12 and N2,4,7,8,11*). *E2* added that "There was a time when the isometric graphic styles was on trend. I longed for improvement on my visual design skills, so I learned this new drawing styles by collecting and mimicking relative examples".

6.1.3 Validating design choices. After designers accumulate a certain number of plausible design ideas, examples further assist designers in validating available design options and thereby narrowing down to specific rational design plans. Such validation happens in two identical situations, adding absent important choices into, or removing unfeasible ones from, the design pool.

First, some designers leverage examples to avoid missing essential features. When designers witness adequate successful examples

on certain features, which has not been considered yet, they are likely to add such features to the design pool. For instance, *E1* tried to collect an enormous amount of examples at the early design stage to ensure "getting exposed to as many awesome ideas as possible". Second, the design space consisting of all possible ideas is arguably large – too large to explore efficiently. It is thus necessary to rapidly narrow down the design space to eventually converge to an optimal solution by pinpointing the feasible alternatives among available candidates under given goals. All participants reported that they often compare different UI features appeared in examples of a certain function and learn from the design rationale behind more suitable designs. Third, examples can also help designers avoid common design pitfalls. Since it is difficult to anticipate some mistakes from an rudimentary idea, designers examine relevant examples to validate the design choices. If an example shows serious predictable mistakes of an idea, designers are likely to eliminate it from the design pool. As E1 stated, "By carefully studying the design of competitors, I realize that there will later be severe conflicts in the combination of these two features, so I remove one of them from the design pool or define a hierarchy between them in advance."

6.2 Facilitating design generation

After designers develop a clear design plan, they further utilize examples for efficient generation of design outcomes.

6.2.1 Speed up design generation. When there are no specific design guidelines to follow, designers utilize examples also to abstract common design patterns among similar products. With this strategy, they save the time and effort of creating all features from zero, *e.g., E3* said that "While designing a sports App, I wish to generate UI styles that are sporty, dynamic and fancy. However, there are no guidelines for such characteristics. Therefore, I learned from successful examples to gradually abstract how to design an ideal sports App UI with proper use of vibrant colors and gradients." *E1* also mentioned that "To quickly find out common interaction solutions and localization design strategies of navigation App design, I downloaded more than ten competitor Apps to find their common UI features and themes. So I could quickly draft design solutions of the key features and save plenty of time for further design in detail."

6.2.2 Communicating generated designs . Designers also utilize examples to build common ground in design communication. Examples are utilized as a "boundary object", which is a tangible concept that grounds the conversation between the designers and other collaborating parties [24]. Designs are commonly illustrated with originated design documents and verbal or textual descriptions. However, originated documents are usually time-consuming, therefore not suitable for all details of design, while verbal and textual descriptions are convenient but not comprehensive enough. Therefore, examples serve as effective and efficient complementary materials since they are well visualized, some of which are even interactive, and consume much less time and effort in comparison to originated design illustration.

Designers use examples for communication to other designers in the team. In collaboration scenarios, designers utilize examples to update the design progress and reach consensus among teammates to improve design efficiency, *e.g., E7's* colleagues "frequently use examples to illustrate which feature he/she is working on so that everyone can keep at the same pace." With examples, designers can avoid 'lost in translation' especially when the designs are complex or dynamic as designers care about many details of specific design features and developers do not necessarily speak the design language. While delivering the high-resolution prototype to engineers for implementation, several participants used interactive examples to demonstrate dynamic UI features and interaction flow (*E1,4,7,12 and N4*). *E4* pointed out that " Compared to other UI elements, animations are more ubiquitously standardized and not as specified among different cases. Therefore, I used a lot of animated examples to show engineers how they are expected to integrate the UI design into an actual app." *E1* also mentioned that "Sometimes the resolution of prototypes is not high enough, so I would use examples to illustrate the designed interaction to engineers." Another usage of examples appears in communication with stakeholders, who expect to see the potential outcome and understand the design rationale behind though the design process. Once designers scope down their design options, some participants would take examples as a tool to communicate the design concepts with their stakeholders. *N4*stressed that "I used examples in discussion with stakeholders to prove the feasibility of my designs."

7 DIFFERENCE BETWEEN EXPERTISE AND ACROSS DESIGN PHASES

Based on the interview feedback, we were aware of the different behaviors between experts and novices as well as the difference across design phases.

7.1 Difference between Experts and Novices

7.1.1 Different Dependence on Examples. Expert designers we interviewed often expressed that they are rather familiar with existing graphic design conventions (*E6,7,8,10*) or have formed their own style (*E1,6,7,10,11*). Few novice designers mentioned such patterns. In other words, the experts rely much less on examples than the novices when it comes to designing common UI components. For instance, E1,7 only searched UI examples while facing particular design challenges, rather than generic issues, as there are both personal and enterprise UI design library for them to utilize. *E1* stated that "I search for examples mostly when I am facing specific design problems like a same button in many different status, which is not common in pratice". *E11* mentioned that "Compared to instant example retrieval during the design process, I would rather learn from examples in my spare time to integrate them into my own design vocabulary. So I can avoid the interruption to the design process by example retrieval". In contrast, several novice designers frequently collect UI examples to gain design inspiration (*N6,8,9*). According to N6, "the color theme, page layout, and the functionality of a UI example can inspire me a lot and help me come up with concrete ideas for my design."

7.1.2 Different Levels of Example Exploitation. We discovered that our expert designers tend to take more diverse advantage of the information from examples compared to novices, perhaps due to the more critical roles that experts play in a project. For instance, *E2,3* were often in charge of a complete mobile app design project and

thus need to examine the local marketing strategy of competitors to ensure a long-term prosperity of a product. As *E3*stated, "It is important to check competitors' marketing strategy, because I have to consider how to bring users to my App and how to keep them." *E3* also studies the target users, problem solutions, and how features are realized. *E5*, who is responsible for an entire feature, downloads competitors and analyzes their users' feedback to discover design potentials in her own project. She stated that, "I dig out potential directions for optimization of my products by carefully reading users' comments." On the contrary, none of novice interviewees brought up such needs.

7.1.3 Different Consistency between Intentions and Behaviors. In the Develop phase, experts intentionally focus more on target examples and avoid distraction by exploratory contents, yet such situation has not been mentioned by novice designers. As *E3* stated, "With a specific design task such as a UI page, I would force myself to focus on the target examples in result pages, and try not to exploit results that are not relevant enough, even though they could be visually attractive."

7.2 Difference across Different Design Phases

To attain a deeper understanding of example-related behaviors, we compare how they vary across design phases, *i.e.,* Discover, Define, Develop, and Deliver. From Table 1, the most example-related behaviors happen in Discover (42%) and Develop (40%) phases, as these two phases require more divergence than convergence of design treatments and background knowledge. Then comes Deliver (14%) and Define (4%), of which retrieval behaviors are more convergent. But in Define, both behaviors take place, though with a lower frequency.

We specifically look into collection behaviors across different phases as it appears more often (49%) than utilization (36%) and archiving (15%). In the Discover and Develop phases, designers tend to collect and store broader types of examples than other phases. For example, they would "download many competitor Apps to learn the common design solutions and compare their flows" (*E1*) and "make mood boards to collect and summarize examples at the same time to explore proper identities" (*E4*) for their own design. *E4* further illustrates how he makes a mood board for a fitness equipment App design in this phase, "I make a collage with images of athletes, dynamic movements, and futuristic UI pages, to depict a modern, energetic and high-tech image of my product". In the Define phase, designers collect examples mainly for reference to produce graphs such as "Personas" (*E3*) and "User Journey Maps" (*E5*). The common practice is example classification, either through adding valid posts to bookmarks, downloading them to local devices or copying them to the graphic design documents.

In addition, designers conduct more searching than browsing behaviors in Develop and Deliver phases, when they already have a focused and converged idea. Such pattern is also reflected in retrieval time, shorter than that of the Discover and Define phases. As stated by *N1*, "In the early exploration stage, it costs more time to collect relevant materials while in the later Develop and Deliver stage I seldom browse for more examples".

	Challenge	D	B	A	P	G
Collect	cannot search by image	○	○			
	cannot search by author	○		○	○	
	unclear organization of search results	○			○	
	inaccurate search results	○	○		○	
	inefficiency to find competitors	○	○	○	○	○
	lack of example categorization	○	○		○	
	too many advertisements				○	
Archive	extensive effort in labeling examples	○	○	○	○	○
	cannot bookmark examples	○	○	○		
	limited support to group examples	○	○	○		
Utilize	lack of copyrignt					○
	outdated examples	○	○		○	○
	lack of interactive examples	○			○	○
	lack of UX-oriented examples	○	○		○	○
	low-quality examples	○			○	○

*D: Dribbble | B: Behance | A: App Store | P: Pinterest | G: Google

Figure 2: The summary of the typical challenges encountered by the designers with the existing tools.

8 CHALLENGES AND OPPORTUNITIES

8.1 What are the barriers encountered in existing tools?

The unsatisfied experience reported by the participants are mostly associated to the negative experience with the low-quality examples and the limited support they received. We summarized typical challenges the designers encountered in five most mentioned tools (Figure 2).

8.1.1 Exposure to Low-Quality Examples. A common problem our interviewee encountered is frequent exposure to low-quality examples in online repositories. Due to the limited quality control in most existing online platforms, a large number of poor examples may appear in queried results, leading to inefficient retrieval experience. As *E2* described, "When I was searching with 'machine learning icon' on Google, the results were very dull and ugly. It was a pretty tiresome experience to keep facing those weird designs." That is why some participants (*N4,5*) favored Dribbble in which all materials are shared by design professionals and thus have relatively higher quality. To understand their preference on examples, we asked about how they evaluate the examples attained from an online service. Our participants provided different criteria, including visual appeal, feasibility, and richness. Designers would comprehensively consider these criteria while evaluating the examples. They are particularly cautious with the examples with high aesthetic quality but low feasibility. "Many beautiful examples on Dribbble are too fragmentary. Usually I just take a glance at their overall graphic style and wouldn't spend much time on them. Because they cannot fit into real applications"(*N4*). Moreover, some interviewees valued the rich contexts and styles of examples (*N7 and E8*). But the mechanism of some online platforms like Pinterest tends to present similar design examples with common content or visual styles, which led to a limitation of diversity.

8.1.2 Ineffective Tools for Example Management. Designers also suffer from ineffectiveness of existing platforms for example collection, archive, and utilization. From the interviews, we identified three main obstacles that hinder designers from getting satisfactory examples efficiently, including insufficient navigation support

		DISCOVER	E	N		DEFINE	E	N		DEVELOP	E	N		DELIVER	E	N
Collect Examples	What	UI page	12	12	What	UI/UX case study	1	0	What	UI page	9	9	What	UI page	1	0
		UI/UX case study	9	6		competitor	1	1		UI/UX case study	9	7		competitor	2	0
		competitor	10	8						competitor	4	2				
	Behavior	browsing search	12	11	Behavior	focused search	1	0	Behavior	focused search	11	12	Behavior	focused search	11	0
		focused search	12	11						browsing search	2	2				
		switch between behaviors	3	1						switch between behaviors	10	11				
	How	search with keyword	10	9	How	search with keyword	3	1	How	search with keyword	11	12	How	search with keyword	10	4
		search with image	1	0		search with image	2	0		search with image	3	1		search with image	3	1
		search by category	1	0						search by category	9	5		search by category	4	1
		search by filter	1	0						search by filter	3	1		search by filter	4	1
		search by suggestion	3	1						search by suggestion	0	2				
		search by author	2	1						search by author	2	3				
		search for page layout	1	2						search for page layout	4	1				
		search for color scheme	1	0						search for color scheme	3	2				
		search for interaction	2	1												
		collect existing Apps	6	5												
Archive Examples		integrate into mood boards	4	2		add valid posts to bookmarks	3	0		group competitor Apps	3	2		group competitor Apps	1	2
		download the retrieved examples	6	6		download to local devices	1	0		create mood boards	3	2				
		create folders as design libraries	4	2		copy to design documents	1	0		copy to design documents	4	4				
		classify examples online	3	2						create folders as design libraries	4	3				
										classify examples online	6	6				
Utilize Examples		gain background knowledge	8	4		expand design vocabulary	4	0		take creative sources for inspiration	6	4		illustrate prototypes	9	8
		understand target users' need	11	7		keep designs in trend	2	0		speed up design creation	2	2		deliver prototypes to engineers	7	4
		understand clients' need	4	5						communicate with teammates	5	4				
		find out common functions	3	8						follow existing guidelines	3	1				
		take creative sources for inspiration	11	10						avoid common design pitfalls	2	1				
		assist designers in validating options	1	3						communicate with clients/colleagues	5	5				
		communicate with colleagues	6	4						demonstrate dynamic UI features	7	6				

Table 1: Summary of codes extracted from our interviews with 24 designers regarding the behaviors around example management.

provided by existing repositories, ineffectiveness of the search engines, as well as a lack of archive and utilization feature in online repositories.

Half of the participants criticized that the limited navigation support from existing services makes retrieval process inconvenient and time-consuming, especially given the overwhelming available examples. In particular, the lack of detailed categorization poses challenges for designers to dig into a particular type of examples. *N10* complained that "there is no category feature in Dribbble or Pinterest to avoid irrelevant examples. When I search 'Mobile UI for game applications', instead of mobile UI examples, many game posters and websites show up in the result." For other platforms such as Mobbin and Pttrns, which classify examples in a certain manner and benefit users in example exploration, cannot address designers' different needs for navigation. "I like the category provided in Pttrns because it helps me compare the patterns across different types of UI. But it only differentiates examples based on their function and doesn't support other criteria, such as graphic styles or target users."(*E3*) The problem of insufficient navigation becomes more severe in the cases that users have difficulty in coming up with keywords for a query. Similar to a prior study [12], we found that many designers feel hard to articulate keywords accurately describing the examples they are looking for. In such cases, they are in stronger need of navigation support to help them narrow down search space.

The performance of the search engine in existing example management platforms, was challenged by five of the interviewees. Compared to professional search service like Google, those platforms have less capacity of providing accurate search results, *e.g.,* " Dribbble's search service can somehow handle a broad keyword but performs badly when given a long and concrete one. On the contrary, Google gives much closer examples to expectation"(*N2*). N1 even "searched for contents of Dribbble by Google" instead of using the integrated search engine. In addition, some designers expected those platforms to have Google's image search function. "There are a couple of times I would like to use image search to find the examples that look similar to my design, but Dribbble and Behance don't have such a function so I have to switch to Google."(*N8*)

Another hurdle pointed out by our participants is the lack of effective features supporting example archive and utilization. In particular, how to help users to organize their collected examples for later usage is under explored by the existing services(*E1,2,and N2,5,7*). "I had to download or copy and paste the examples as local documents after getting examples online. Manually classifying and labeling them was very troublesome. Such process could lead to difficulty in later example query(*E1*)." "It was hard to find previous examples since we archived them by name or date, because usually we could only remember approximately how they look"(*N3*). Therefore, some designers expected a feature of the platforms "to automatically label the examples for convenient and accurate return visits"(*N12*). Moreover, our participants were unsatisfied with the tedious process searching the same item among diverse existing online platforms(*N1,2,6 and E2*). For instance, "because the online platforms have distinct sources, I had to search with the same keyword on different platforms and chose the best result. The switching was quite time-consuming and inefficient" (*N1*). So *E2* expected that "A new platform would be awesome if it collects the content of all different sources".

9 DISCUSSION

9.1 Example management in Mobile UI Design and Other Design Domains – Link and Difference

Herring *et al.* identified the benefits of examples in the design domains of Web, product, and graphic design [12]. Our results suggest that mobile UI designers utilize example in a similar manner. For instance, like designers in other domains, they also exploit examples to internalize stakeholder's needs in the Discover and Define phases (i.e., preparation stage in [12]), and to validate the demand and originality of their own UI products in the design stage. One difference we identify is that mobile UI designers seem to employ a broader form of examples. For instance, they prefer to use mood boards rather than individual visual examples in Discover stage.

As for the design expertise, similar to the findings of previous works on graphic designers [25], our expert interviewees in mobile UI design are more proficient at example management than novices. In fact, they seem to perform less example search on demand compared to those with lower design expertise. For one thing, according to our interview feedback, managing examples have become a routine practice of many mobile UI design experts. They have formed the habit of gathering good examples whenever they encounter one. When a new project comes, they have had a high-quality collection of examples to begin with. For another, it is likely that experts have converted the examples they experienced before to internal knowledge to a good extent. They may call upon such knowledge instead of looking for new examples in face of a design request [25]. Additionally, different from the works in other design domains, we found that the expert UI designers also take more types of roles in design process and thus make use of examples in a more diverse ways than novices. For examples, expert designers (*E2,3*) who are in charge of a mobile app design project will look for the marketing strategies of competitors and will utilize the examples to illustrate their design thoughts to the engineers. On the contrary, our novice mobile UI designers are usually responsible for parts of the projects such as visual design, and they search for those fractional examples without considering much the budgets and project feasibility.

9.2 Design Implication

We derive the following implications for the future development of more supportive example management tools.

9.2.1 Compile metrics to filter out low-quality examples. Our study shows that designers have negative experience with exposure to low-quality examples in online design material repositories. Even though platforms such as Pinterest and Behance use social voting (e.g., 'like') to help designers assert the quality of examples, users often find this information insufficient for decision-making. "A bunch of returned examples share similar number of likes and it is hard to pick the good ones from them" (*N4*). One feasible way for example repositories to ensure example quality effectively and efficiently is to derive computational metrics to perform automatic assessment. Our mobile UI designers point out different criteria to evaluate an example, such as "visual appeal", "richness", and "feasibility". The platforms could first invite their designer members to provide comprehensive metrics for the examples and then build up structured scales to assess the quality of each UI example. Apart from the criteria mentioned above, other automatic quality metrics of UI could also be incorporated, such as visual complexity [29] and mobile UI personality [37], depending on the need of individual designers.

9.2.2 Facilitate keywords formulation for search navigation. Search engines, particularly those employed by mobile UI example repositories, usually assume that designers already have some targets in mind when they use their services. However, our mobile UI designers often have no clear thought of what they want and thus have difficulties in articulating search keywords. Under such conditions, the example-sharing platforms could proactively provide a set of keywords to help users to narrow down the search space step by step. For example, the platforms could use the commonly used keywords to form several example galleries to help users get a sense of the kinds of available design materials. Once the users show interests in one specific example (e.g., click on it or have longer dwell time), the search engine could suggest a set of semantic keywords that could describe its characteristics from different aspects [38] to assist users in consolidating their thoughts and formulating search queries. Even when the mobile UI designers have a target in mind, they sometimes are "unable to explain their thoughts in a design language" (*N8*). In this case, the example search engine could incorporate the general search services like Google, which can try to make sense of not so precise ideas expressed in everyday terms. It could further incorporate domain-specific crowdsourcing service [32], through which the users can learn how to express their intents to search engines based on other designers' suggestions.

9.3 Develop effective features for better example management

As aforementioned, most of the online platforms fail to support designers to archive their collected examples. Designers have to spend extensive manual efforts such as formatting, categorizing, and labeling examples after they download them. It would become especially time-consuming when designers face a large amount of collected examples. The development of automatic example analysis features (*e.g.,* semantic and style classification, brand recognition, automatic hierarchical management, *etc.*) might benefit designers for improving efficiency.

Moreover, the disparity between experts' and novices' knowledge of and experience with examples imposes a need for the platforms to tailor its example management methods based on user expertise. For example, if a designer claims to be new to mobile design area, the platforms can return more diverse types of examples, e.g., UI page, case study document and competitor apps, to get them inspired. In contrast, for experienced designers, the platforms could display more examples of competitor apps and specific features of a mobile UI.

9.4 Limitation and Future Work

Our study has several limitations. This work focuses mainly on offering a qualitative understanding of designers' behaviour around online example management with insights derived from a relatively small sample size. To investigate the statistic detail of the

derived findings, we will need to conduct further quantitative studies with a larger number of designers in the future. We organise our findings on example management behaviors according to the Double Diamond (DD) model mentioned by our participants. However, there are over one hundred design process models other than the DD model, ranging from short mnemonic devices to elaborate schemes [7]. Although it is neither necessary nor realistic to exhaust all the design process models, we could possibly expand our research to a few more design models to develop a more comprehensive conclusion on example management behaviors, such as the "ISO 13407 Human-centered design processes for interactive systems". While we have derived several implications, we did not test them by implementing an example management tool. We might design a tool based on the implications for verifying their effectiveness in actual design scenarios.

10 CONCLUSION

In this study, we present a comprehensive understanding of designers' behaviors around online example management for mobile UI design. In particular, we dig into the practice about how designers collect, archive, and utilize examples by a series of interviews with 12 novices and 12 experts. We compare how their behaviors vary between expertise and across different phases. We find that there is a more diverse and frequent use of examples in Discover and Develop phases. Moreover, compared to novices, experts use design examples for a more diverse purpose. We further identify the challenges encountered by designers with existing example management services, and propose potential design implications for the future design of more supportive example management tools.

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