

Charrette: Supporting In-Person Discussions around Iterations in User Interface Design

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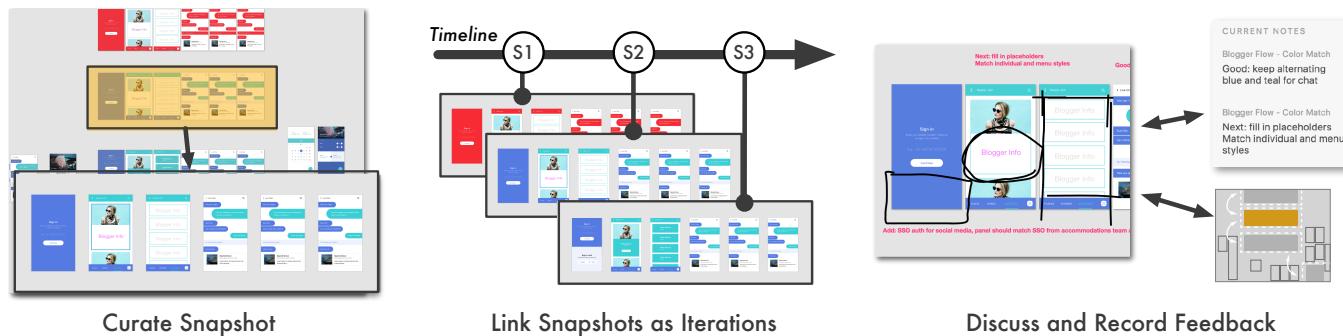


Figure 1. Charrette system features. Charrette allows designers to curate a subset of artboards from their canvas into a *snapshot*. Designers can link snapshots into interactive timelines to reflect iterative process. Designers can then record feedback during discussion through notes and annotations. These notes can be accessed from subsequent snapshots.

ABSTRACT

As a rule, user interface designers work iteratively. Over the course of a project, they repeatedly gather feedback, typically through in-person meetings, and update their designs accordingly. Through formative work, we find that design software tools do not support designers in managing meeting notes and previous design iterations as a cohesive whole. This causes designers to rely on ad-hoc practices for organizing work, which makes it hard for them to keep track of relevant feedback and explain their design decisions. To address this problem, we present Charrette, a system that allows designers to curate design iterations, attach meeting notes to the relevant content, and navigate sequences of design iterations with the associated notes to facilitate in-person discussions. In an exploratory user study, we evaluate how Charrette affects designers’ self-reported ease in handling feedback during face-to-face discussions, compared with using their own tools. We find that using Charrette correlates with increased confidence and recall in discussing previous design decisions.

Author Keywords

User interface design tools; design rationale; critique

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INTRODUCTION

Design iterations are a critical part of almost every real world design scenario. Designers often create one or more alternatives, present and discuss their work in face-to-face review meetings, and then iterate on the design until all parties are satisfied. Review discussions range from informal meetings to formal presentations, and they can involve clients, project leads, and fellow designers. This iterative cycle between creating designs and discussing them helps improve the quality of the design and how well it fits the stated goals [6, 10].

Unfortunately, designers find it hard to manage all the design iterations and feedback that arise throughout the process. Through formative work, we found that a key problem involves the lack of explicit support in current UI design tools for organizing design iterations. Most designers do their work on large zoomable canvases where they create and organize individual design drawings (also known as *artboards*). To iterate on a design, they copy and edit the relevant artboards and then arrange them spatially within the canvas. Designers adopt various layout schemes to distinguish current “best” designs from previous iterations and alternatives. Feedback from review discussions is usually recorded on paper or saved in separate files from the actual design.

This disjointed and ad-hoc organization of iterations and feedback makes it difficult for designers to explain their design decisions and process during review discussions. To clarify

a specific design choice, they often need to hunt around their canvas to find previous artboard iterations for comparison. In many cases, they may want to reference specific discussion topics related to these earlier iterations, which requires finding or remembering the relevant notes. These tasks become more difficult over the course of a project as the number of iterations and the amount of feedback grows.

In this work, we explore techniques to help designers present and discuss their work within an iterative design process. Based on formative interviews with designers, we identified common practices for managing iterations and feedback and then developed a tool, Charrette, that directly supports these practices. Charrette allows users to create *snapshots* from a subset of artboards within the canvas. Each snapshot serves as an atomic iteration and a copy for future reference. Within a snapshot, designers can annotate feedback and design decisions in *contextual notes* associated with that iteration. They can then link snapshots into *snapshot histories*, which they can easily access and traverse before or during design discussions. While individually these features are not novel, they come together to directly support designers in recording, tracking and recalling design discussions more effectively.

The contributions of this work include:

- Formative work that characterizes three iterative design practices for fostering face-to-face discussions around multiple design iterations
- A system designed for these practices that provides support for preparing and presenting design iterations during discussions over real world design documents
- An exploratory evaluation comparing professional designers' preference of the system against their own tools for preparing and discussing design iterations.

RELATED WORK

There is a large body of work on recording and managing feedback and design versions. However, helping designers manage multiple past iterations and design discussion through the entire lifecycle of a design project has yet to be explored.

Feedback Tools

Feedback is an important part of the design process. There are many existing commercial and research systems that offer ways to record feedback on text documents [33], information visualizations [13], and videos [25]. Additionally, in recent years, several efforts have explored how to obtain useful and timely feedback on designs via crowdsourcing [32, 2, 21]. Many of the basic techniques from this work, like text comments anchored to specific parts of the content and overlaid visual annotations, translate directly to our target domain of user interface designs and can be found in commercial design tools like Red Pen, InVision, and Adobe XD [26, 5, 3]. In the specific instance of control flow diagrams for interaction design, Hartmann et al.'s d.note system [12] supports augmented pen-based annotations that can modify the behavior of user interfaces. However, this work focuses on techniques for a *single* round of feedback. While we incorporate some common on-canvas annotation and commenting features into Charrette, our focus is on supporting the entire lifecycle of feedback

over the course of a project. In doing so, we contribute new techniques and interfaces for recording and revisiting feedback across multiple design iterations where both the designs and the feedback evolve.

Managing Design Iterations

Many researchers have studied the benefits of creating and sharing design iterations [8, 6, 7, 9]. Of specific relevance is Kim et al.'s work that demonstrates the advantages of obtaining feedback on works-in-progress through a creative community platform [17]. Currently, there are two main ways that design tools support design iterations. One approach is to provide explicit design histories that offer visual, browsable sequences of edits. Such visual histories have been proposed for domains like graphic design [11, 28], image manipulation [4, 29], generative design [34], and software engineering [31]. However, these tools are designed to record a history of edits rather than manage specific, curated sets of design iterations and alternatives along with the associated feedback.

Another approach to managing design iterations is version control. Version control tools like Git are standard for writing code, and several commercial tools have introduced version control for graphical design tasks [1, 30]. At a high level, the problem of managing design iterations is similar to version control. A common goal is to help users explicitly keep track of related versions or iterations of in-progress work. However, most version control tools focus on tasks like how to merge edits (often from multiple collaborators) or revert to previous versions. While such situations do sometimes arise over the course of a design project, our formative work suggests that a more typical problem involves a designer trying to manage a very loosely structured collection of partial designs (i.e., individual artboards within a design file) that have evolved over multiple iterations. These iterations often contain many alternatives that evolve in parallel. To facilitate their design work and review meetings, designers often need to view and reference several iterations or alternatives of a given design from different points in the design history. These types of operations are extremely cumbersome in most version control tools, which expect users to maintain a single working version in the common case. In contrast, Charrette strives to make it fast and convenient to access multiple previous design iterations and feedback.

Synchronous Design Review

Finally, several works have investigated the design of creative tools for synchronous discussion. Many of these tools leverage augmented or connected display surfaces that work together to provide shared context [24] or support a combination of physical and digital interactions [15, 18]. Other work has examined the role that existing collaboration tools play in synchronous online collaboration [16] as well as in video conferencing [22]. While this previous research focuses on synchronous collaboration in the context of a single in-person or virtual meeting, our aim is to facilitate the progression of discussions that occur throughout the design process.

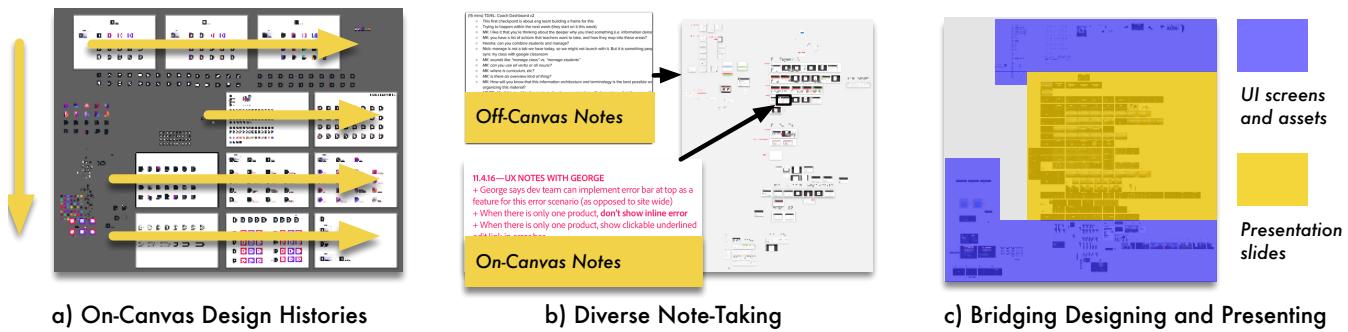


Figure 2. Three examples of design patterns from formative studies. a) On-canvas design history. A designer progresses from left to right, top to bottom by taking the top designs from one artboard to the next and iterating. b) Diverse note-taking. A designer records feedback from discussion in text boxes next to artboards, and also keeps notes separate from the canvas. c) Bridging designing and presenting. A designer compiles slides for presentations (yellow) next to the actual UI designs (blue).

FORMATIVE STUDIES

To better understand how designers manage feedback and design iterations over the course of a project, we conducted formative studies with design professionals at a large software company. All of the participants had extensive experience working within a design team. The bulk of our observations come from 2 semi-structured interviews with UI designers and 8 contextual inquiries where UI designers demonstrated their process using their preferred software tools. For additional context, we also interviewed two design managers and a user experience researcher who studied how designers use collaboration tools during feedback sessions. We focused our questions on how designers manage design iterations and alternatives, present works-in-progress to others, and record and organize the feedback that arises during discussions.

To analyze our data, we used an affinity diagram approach to organize our observations and the interview transcripts. We identified three common design practices (see Figure 2) for managing feedback and iterations, which we discuss below.

On-canvas design histories

All but one of the designers maintain an explicit history of their work by duplicating (rather than directly modifying) artboards at each design iteration. These histories help designers understand the progression of a design and to communicate design decisions to others. On the importance of preserving different iterations of work, one designer noted:

Designer EL When designers present at critiques, the successful ones will show all the steps they took, and will save every single version they worked on even if it was bad just so they can use it as part of explaining their process.

Designers typically save previous design iterations in the same design file (and often on the same canvas) as the current working version of the design. While there were no consistent patterns in how designers arranged artboards, much of spatial layout of the canvas seems to be driven by a desire to organize design iterations and alternatives. One designer mentioned:

Designer AH I have 'islands' of ideas in parallel, plus a 'graveyard' for obsolete iterations, plus a region to experiment with new designs.

Another designer laid out progressions of artboards in all different directions like the tentacles of an octopus, claiming

Designer DS I explore ideas all over the place and start heading a direction when I get a good feeling.

While these on-canvas histories make it easy to reference and re-use components from earlier designs, they also produce very complex design files; some of our participants showed us canvases with over one hundred artboards, with file sizes often exceeding 2 gigabytes (see Figure 3 as an example).

Diverse note-taking

During or after design meetings, designers record notes and to-do lists that describe design decisions, discussions, and suggestions from peers or managers. While these notes are sometimes taken on-canvas next to designs, in most cases, designers either prefer not to pollute their design files with annotations or have a hard time finding space for notes in complex, densely-populated canvases. As a result, many designers take notes separately using common tools like (physical or digital) sticky notes and notepads. Such notes are used as a record of decisions and as a way to facilitate communication:

Designer LH When I'm presenting this and people give me feedback when I walk them through the design, I will use the Stickies app. Then after the meeting, I will make sure that things get fixed. If I send someone a web URL of the prototype, they would actually make comments on that prototype instead.

Still, some designers prefer to place notes next to their artboards, citing the value of notes *in situ* for sparking discussion:

Designer PM Normally when I'm discussing artboards, I take notes with people, and then write them on the artboard in pink. As for talking with different types of people, that changes the amount of notes I show to them. For example, with product managers I include lots of notes, with execs, no notes, with designers, we often just draw ideas out by making quick changes.

However, these designers also acknowledged that this practice was often difficult to maintain because notes in text boxes are not searchable, and could become out-of-date.

Bridging designing and presenting

Because design files often include many iterations and experimental work, they can look messy and confusing. As a



Figure 3. Diagram of three canvases from a Bohemian Sketch file from a designer in our formative study. Each of the three canvases contains a large amount of artboards, off-artboard design elements, and unofficial annotations in text boxes, which are color-coded as yellow, blue, and red, respectively. Elements are positioned according to the organizational preferences of the designer to facilitate spatial memory.

result, designers typically do not share these files directly for review and feedback. Instead, they often export separate slides or other visuals for design presentations. For more informal settings (e.g., one-on-one design reviews), designers sometimes do use their actual design files, but they often instruct the audience to only look at a particular portion of the canvas. In other cases, designers arrange the canvas specifically for the purpose of communicating their work. For example, one designer said she lays out her canvas with presentation slides on the left and her designs on the right:

Designer KB I like having my presentation in my actual [Adobe Experience Design] file. Having more tools around presenting would be nice ... If I had ability to share different parts of my file with different people, that would be great. For example, I wouldn't have to create a whole separate presentation for [the client], I could just click "only show them these pages."

Summary of pain points

These practices point to an important problem in current iterative design workflows. The fact that designers typically maintain design histories and working versions separately from their presentation assets and notes makes it hard for them to manage the progression of design iterations and related feedback as a project evolves. Notes are disconnected from the related artboards in the working design file, and new design iterations are likewise disconnected from the discussions that prompted the changes. As a result, designers struggle to keep track of relevant feedback and explain their design process in an effective way; without support from design software, they must rely on complex artboard organizations (see Figure 3) coupled with ad-hoc systems for organizing notes.

CHARRETTE SYSTEM FEATURES

To address this problem, we developed Charrette, an interactive system that helps designers manage feedback, organize design iterations, and communicate their work. Based on observations from our formative work, we identified three key system features that resolve some of the limitations of existing iterative workflows and, at the same time, align with current practice. We derived these features by moving from existing practice, to pain points, to features, as summarized below:

Bridging designing and presenting

- *Pain point:* needing to curate artboards from the canvas for presentation and discussion.

- *System feature: snapshots.*

Diverse note-taking

- *Pain point:* visual clutter and difficulty indexing.
- *System feature: contextual notes.*

On-canvas design histories

- *Pain point:* histories become difficult to manage.
- *System feature: snapshot history.*

Note that the individual features are not intended to be novel in and of themselves, but rather, they facilitate practices that lack support in existing design software. Our goal with Charrette was to design a system that supports common practices in a better, more holistic way than the current patchwork of tools that designers currently use. To help integrate Charrette with existing workflows, we aimed to design system features so that they seem familiar to designers.

Snapshots

Because designers have difficulty curating past iterations for discussion, we propose the notion of *snapshots*. Snapshots capture the state of a group of user-selected artboards at a given point in time. Designers create snapshots to identify specific design iterations or alternatives to discuss during an in-person design review or feedback session. When the meeting starts, the designer clicks on the snapshot to see a zoomed-in mini-canvas that only shows the selected artboards (see Figure 4a). By explicitly encoding a subset of the working design file as the focus for in-person feedback, snapshots provide a lightweight way for designers to create presentation assets without exporting separate slides or files. In addition, the isolated snapshot view allows designers to hide parts of their canvas that they do not want to share. When the designer zooms back out to see the entire design file canvas, Charrette shows a list of all existing snapshots in the right sidebar.

Contextual Notes

As noted previously, designers often record feedback separately from the relevant artboards. In contrast, Charrette allows designers to take notes directly on a snapshot canvas, either during or after design meetings. Each note is associated with one or more user-selected artboards and can include text, rectangular highlights, and freeform scribbles (see Figure 4b).

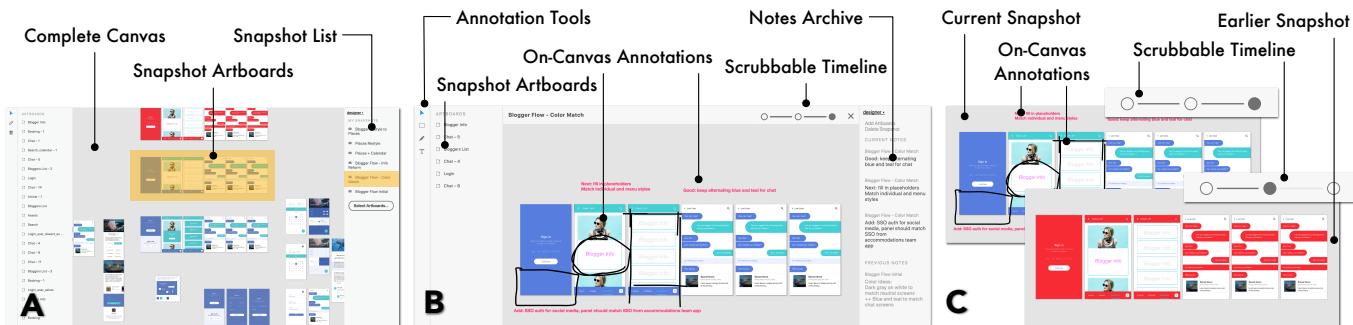


Figure 4. Charrette System Workflow. a) Full Canvas View. The designer selects subset of artboards on the canvas to create a snapshot. b) Snapshot View. Selecting a snapshot leads to a view where only the snapshot’s artboards are shown. The designer writes notes and leaves annotations on the snapshot’s canvas during discussion. c) Navigating Between Snapshots. The designer can link snapshots to earlier iterations to reflect a design’s evolution. Charrette allows navigating between linked snapshots through a scrubbable timeline.

Placing notes on the canvas emphasizes the connection between the feedback and the corresponding artboards. It also allows designers to reference parts of the design visually (e.g., with a highlight or scribbled arrow), which can make written notes more concise (e.g., “make this (arrow) bigger than this (arrow)” vs. “make the blue icon at the top left of the screen bigger than the grey text label next to it.”). To make notes easier to browse, Charrette displays the text from each note in a vertical list in a sidebar to the right of the snapshot canvas. Selecting a note in the sidebar highlights it in the canvas by greying out all the unassociated artboards and other notes.

Snapshot History

To facilitate and formalize the construction of design histories, Charrette links related snapshots together into an interactive *timeline* to reference during discussion. More specifically, when designers produce new iterations of artboards from a previous snapshot and then create a new snapshot of their most recent work, Charrette links the new snapshot to the previous one. In the zoomed-in view of the new snapshot, Charrette shows a history widget that visualizes all the previous linked snapshots as a linear sequence of bubbles (see Figure 4c). Clicking on a bubble shows the corresponding snapshot along with any associated notes. This functionality facilitates in-person discussions in two important ways. It enables the designer to quickly refer back to previous iterations without searching through their entire design file canvas, which may include many alternative or experimental artboards that were not reviewed in previous meetings. Coupled with contextual notes, the snapshot history also helps designers explain their design decisions in the context of the recorded meeting notes, which are displayed with the relevant design iterations

SYSTEM IMPLEMENTATION

In developing Charrette, we wanted to support existing design workflows as much as possible. Thus, we implemented Charrette as a web application that works in parallel with a design application. Charrette parses design files and renders all artboards as images in the browser as they appear within the design software. In our implementation we worked with Adobe Experience Design (XD) but our approach extends to other design software.

Charrette system architecture. Charrette is implemented in Meteor.js [23], using Paper.js [20] as a front-end framework for

handling input events and rendering vector graphics. When the user saves a design file in Adobe XD, and that file is tracked, Charrette reads the manifest in the Adobe XD files and extracts the location and content of artboards on the canvas. It then renders the artboards on the canvas within the browser, from which the user can create snapshots.

Creating and annotating in snapshots. When the user produces a new iteration, an alternative, or any grouping of artboards or graphics that they would want to save as a group, they create a snapshot by selecting the artboards that they want to include in the snapshot and pressing “Create Snapshot.” Once the user creates a snapshot, it appears on the right-hand column of the canvas. Clicking on the snapshot opens the snapshot screen, as shown in Figure 4. Artboards within the snapshot are saved in a database so that the snapshot serves as an immutable copy if the constituent artboards were to change later on. The user can then add annotations on top of the artboards, which are also saved in a database and only appear on the artboards within the snapshot view. Thus, a snapshot serves as a representation of the state of an iteration, both in terms of its appearance and its associated discussion in the form of annotations. For cases where the designer needs to reference non-snapshot artboards during a discussion, users can augment the snapshot on-the-fly with additional artboards from the canvas.

Linking Snapshots. When creating a snapshot, the user can link the newly created snapshot with a snapshot created earlier, which represents a progression from one iteration to the next. By linking snapshots, each snapshot can have both a previous and a next snapshot associated with it. This allows Charrette to create interactive timelines of iterations. When the user is viewing a snapshot, Charrette displays a scrubbable timeline of previous and next snapshots to navigate successive iterations in the midst of discussion.

EVALUATION

We conducted an exploratory user evaluation to gather preliminary feedback on Charrette. Since the main contribution of our system is in helping designers present and discuss their work, we focused our study on these aspects of the design process, rather than on creating or editing the design content itself. In particular, our goal was to investigate how Charrette affects the way in which designers discuss previous design iterations in the context of review meetings.

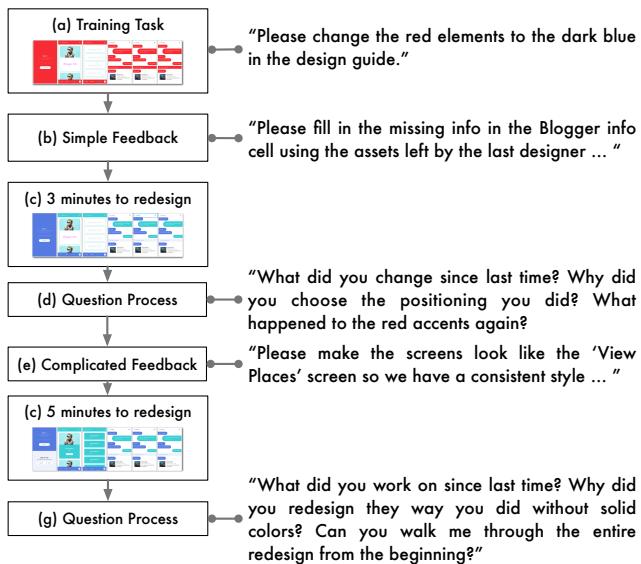


Figure 5. Creative scenario within study procedure. For each of two creative tasks, participants are assigned either to use Charrette or their own tools for recording feedback.

To this end, we conducted a comparative study in which participants worked through two design scenarios, each of which includes several iterations of discussion and design work, using Charrette and their own preferred tools. We observed how the designers behaved in both conditions and also obtained self-assessments on their sense of ease and confidence with the task.

Procedure

We conducted a 60-minute within-subjects laboratory study with 12 professional UI designers who work in design teams. We recruited the participants from an email list of professional designers in the greater Seattle area. One of the participants also participated in our formative studies. The study had two conditions: the Charrette condition (*Ch*), where designers used Adobe XD with Charrette; and the baseline condition (*Base*), where designers used standard Adobe XD along with their preferred method/tools for note-taking and presenting their designs in review meetings. We fixed the order of the two design scenarios and counterbalanced the order of the conditions. Within *Base*, 11 designers chose to record notes on pen and paper, and 1 preferred to take notes in a text file. Of the 11 designers who chose to record notes on pen and paper, 2 said they would have additionally used a project management tool (e.g. Asana) in their everyday work, and 1 said they would have printed her designs on paper and would have written notes on the printouts. We recorded the participants' screen and voice during the design scenarios, as well as kept any paper or digital notes that participants created during *Base*.

Each condition included a design scenario. The two scenarios followed the same structure but used different files. The main goal for each design scenario was to create plausible situations where participants had to explain design decisions and compare their work with previous iterations, two common occurrences in real design reviews. We created a simulated scenario where the experiment facilitator acted as a design manager

on a project and the participant acted as the designer on the project. The designer (i.e., participant) was asked to perform a sequence of design tasks. After each task, the participant had a review meeting with the design manager (i.e., experiment facilitator) to present and discuss their work. In these meetings, the design manager gave feedback and described the next set of design tasks. To make the review meetings as consistent as possible across participants, we authored a set of predetermined feedback and questions for the design manager that were generic enough to be appropriate regardless of the participant's individual design choices or responses. We also made the specific design tasks very simple to leave enough time for the review meetings.

We describe the steps in the scenarios, as shown in Figure 5.

Training task. Starting from a design file that we assembled containing roughly 20 artboards, we identified three specific artboards whose colors clash with the rest of the design. We asked participants to modify the colors based on a provided color swatch. Participants were free to ask questions about the task. If they were in the *Ch* condition, we also showed participants a 3-minute tutorial video for Charrette before the task was given and answered any questions about the system features during this time. After they completed the color modification task, we asked participants to prepare to present their work to their "manager" (i.e., the experiment facilitator).

Review Meeting 1. In this first review meeting, we asked participants to describe the change they made—in this case, just the color change—and did not provide any feedback on the change itself. We then asked them to fill in some incomplete artboards with assets from the design file. While the feedback and task instructions were relatively straightforward, we told participants that once the "meeting" was over, the facilitator could not repeat feedback or instructions, and so the key points from the meeting would need to be recorded.

Design Task 1. We gave participants three minutes to complete the design task. We then asked them again to prepare their work for a review meeting.

Review Meeting 2. We told participants to pretend as if a day had passed since the last meeting and then asked several questions about their process: what they had worked on since last time, why they chose the layout they did for the filled-in regions, as well as what happened to previous color choices that had been changed in the previous iteration. These questions prompted participants to justify their design decisions, which is common in designer practice [6, 10]. If participants attempted to reference earlier feedback from memory, we reiterated that the last meeting occurred a day ago and prompted them to explain their decisions using recorded notes and previous iterations of the designs. We then instructed participants to create an alternative for the screens they had designed either by matching the style of several other screens, or by handling a request from the client, depending on the scenario.

Design Task 2. We gave participants five minutes for this task and then asked them to prepare for a final review meeting.

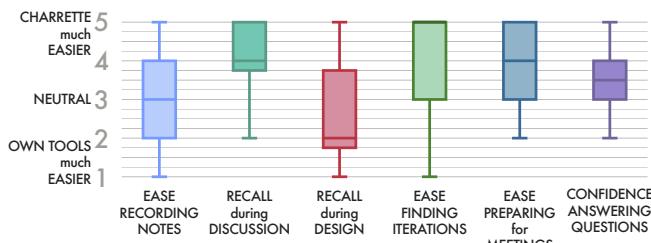


Figure 6. Box and whisker plot for Likert responses for 12 participants. A Likert response of 1 indicates that the participant found their own tools much easier to use, while a Likert response of 5 indicates that the participant found Charrette much easier to use.

Review Meeting 3. In this meeting, we asked participants to explain their work (again pretending that a day had passed), clarify a design decision from two iterations ago (Design Task 1), and walk the manager through their entire design process from the beginning of the scenario.

After each scenario, participants filled out a two-minute questionnaire about their experience completing the scenario under the relevant condition. The questionnaire asked participants how the tools they used (*Ch* vs *Base*) facilitated their tasks, and it what ways the tools were difficult to use during the scenario. After both scenarios, participants completed a five-minute exit survey with the following comparison questions, which they answered on a Likert scale from 1 (“Own tools much easier”) to 5 (“Charrette much easier”):

- **Record:** Which system made it easier to record notes?
- **Recall-Discussion:** Which system made it easier to find previous notes during design meetings?
- **Recall-Design:** Which system made it easier to find previous notes while editing the design?
- **Iteration:** Which system made it easier to find previous design iterations?
- **Prepare:** Which system made it easier to prepare for design meetings?
- **Confidence:** Which system made you feel more confident answering the team lead’s questions during design meetings?

Finally, we asked participants for verbal qualitative feedback on using Charrette versus their own tools.

RESULTS: OBSERVATIONS AND INSIGHTS

Overall, the Likert responses indicate that Charrette had a positive impact on most aspects of our design scenarios, with median scores above 3 (“Neutral”) for four of the six questions (see Figure 6). In particular, the responses suggest that Charrette was especially helpful in preparing for review meetings (**Prepare:** 4), finding previous notes (**Recall-Discussion:** 4), and finding design iterations (**Iterations:** 5) during discussions. These benefits seemed to help some participants feel more confident in presenting their work with Charrette (**Confidence:** 3.5). On the other hand, the feedback on how easy it was to record notes in the two conditions was mixed (**Record:** 3), and participants seemed to prefer their own tools for finding previous notes during the design tasks (**Recall-Design:** 2).

Here, we summarize some of the qualitative feedback and related observations from the study sessions.

Navigating design iterations

In the baseline condition, participants mostly organized their iterations within their design file and presented directly from the canvas. To find previous iterations, designers scrolled around the canvas and often zoomed into specific artboards to verify which version they were looking at. Only two participants exported separate presentation assets in the baseline condition (as a PDF and screenshot images), and these designers searched for previous iterations by flipping through multiple PDF pages or screenshot files. In contrast, with Charrette, designers had a much easier time finding design iterations (**Iterations:** 5) by scrubbing the Timeline, which was heavily used in this condition.

By making it easier to access previous work, Charrette also resulted in more thorough design presentations. Three participants explained their entire process (without prompting) in review meetings with Charrette but did not do so in the baseline condition. When we asked one of these designers to explain her behavior, she responded:

Participant 10 If it's been a while since the people in the room have met, I always start from the earliest iteration so we can talk about our design process so far and everyone can know what we've already worked on.

Another participant noted that this ability to step through design iterations made her feel more confident during the review meetings:

Participant 5 As far as what Charrette does, even though I had issues with the usability, I really did feel more confident presenting with it. Having the timeline felt very professional, otherwise I just would have had folders everywhere, which isn't something you want to show your boss.

Recording and using notes

All but one participants took notes in both study conditions. In the baseline, eleven participants used pen and paper or text files, and only one added notes directly to the canvas. Of the eleven participants who used pen and paper, two said they would normally use a project management tool in addition to paper, and one person annotated printouts of past iterations. With Charrette, participants mainly used the text-box tool when creating notes, and one additionally used the pencil tool. On top of these differences in note-taking behavior, we observed a clear difference in how participants used notes during the review meetings. With Charrette, designers used contextual notes as aids during all discussions, often referring to the text in conjunction with the adjacent design content. In many cases, participants explicitly used the notes as evidence when explaining their design decisions:

Participant 3 I did realize that having all the notes and iterations linked was really helpful. That way, when I was discussing with the manager, I didn't have to convince myself that what I'm saying is correct.

On the other hand, in the baseline condition designers tended to use notes more as personal reminders of the specific design

tasks they had to perform. Since the notes were typically recorded separately from their design iterations, they often did not refer to them during the review meetings:

Participant 11 For notes, I normally fold my paper into four columns with the client name at the top. Rough notes go on the left—where all hell could break loose—as well as questions and thoughts on the right, and important points to the column left of that ... And that's my paper, it's living document just for me.

Charrette facilitated recall during discussion only

There is an interesting discrepancy in how easy it was for participants to find previous notes with Charrette during review meetings (**Recall-Discussion:** 4) versus finding previous notes during design tasks (**Recall-Design:** 2). We speculate that the difference is due to our implementation of Charrette as a web app that is separate from Adobe XD. During design tasks, this separation required designers to switch contexts from XD to Charrette in order to access their notes. Seven participants stated that switching between the two applications hindered their workflow. This feedback suggests that Charrette's features should ideally be integrated directly into the design tool itself.

When asked which tool (Charrette or their own current tool set) they would prefer to use *for a real world design task spanning weeks or months with many design iterations*, all but one participant said they would prefer Charrette, provided any usability issues related to annotations and switching between XD and the browser were addressed.

LIMITATIONS

Usability issues

Our study highlighted a few usability issues with Charrette. As noted earlier, the fact that Charrette was not embedded within XD caused some friction in designer workflows. In addition, all participants expressed some dissatisfaction with our text-box implementation for writing notes on a snapshot. Some designers also made specific suggestions for how to improve the appearance and behavior of our overlaid visual annotations. We plan to incorporate this feedback.

Evaluating Charrette only during discussion

Our exploratory study evaluated the use of Charrette mainly during design meetings from the point of view of the designer. To control the design discussions as much as possible and to expedite the study sessions, we kept the actual design tasks to a minimum. As a result, we did not gather much insights into how Charrette could benefit a more realistic, open-ended design task. We would like to do so in the future.

DISCUSSION AND FUTURE WORK

Curating and sharing one's design process

During the design scenarios, participants did not write down every piece of feedback given by the design manager; instead, they were strategic about what they would and would not record. Participants explained that if they were able to leave annotations in a more organized way than Charrette currently allows, then they would want to share their annotations and iterations with their teammates as a form of “evidence.”

Specifically, five participants explicitly mentioned that they wanted to share their snapshot histories with their collaborators. This contrasts with our formative work which suggested that designers had developed diverse note-taking practices as a means of individual reflection, often hiding notes for one's own use. This suggests that communication of design process is more complicated than we originally envisioned, with tensions between public and private notes within the iterative process.

This sentiment is echoed in one particularly interesting account from a participant after explaining her design process for an entire scenario:

Participant 11 Sometimes annotating at all doesn't communicate the complexity of the situation ... If it gets to that level of complexity [with competing feedback from clients], I won't even record anything because discussion moves too fast. In that case, if I really care, I'll make something unofficial and tell my boss the reasons why I think it's the best decision, and she can choose to convince the client or not. I try to be very convincing. I don't have time to annotate with that kind of language.

Previous work studying collaboration in engineering and architecture has explored how designers in those professions selectively show and exclude information as a means of controlling discussion (e.g. [19] and [14]). In particular, Retelny and Hinds [27] detailed how architects select which information to present and exclude within their drawings to preserve their own design intent. These works show that designers use presentable artifacts as a means to an end, ranging from complete transparency and evidence to selective, strategic curation. Because Charrette allowed designers to organize their iterations and feedback within one interface, designers began to think about what feedback they would and would not want to share with others on their team. In the future, we would like to investigate how Charrette might facilitate sharing design process asynchronously, as opposed to just sharing in-person. Such work could explore multiple layers of privacy within annotations or functionality for sharing different levels of detail in snapshots with different stakeholders.

Supporting critique beyond UI design

Our work focuses on UI design because it is a well-known domain where discussions and feedback typically play a prominent role. Also, studying a specific domain allows us to evaluate our system in a concrete, real-world context. That said, we believe many aspects of Charrette would readily apply to other types of design. For example, many graphic design workflows (e.g., icons, logos, etc.) involve the creation of many alternatives that are gradually refined and filtered through discussion. Most of Charrette's features would directly support this process. More generally, feedback and design iterations are pervasive across almost all design disciplines. As a result, we believe our general approach of supporting design discussions through linked iterations and notes can potentially generalize to other domains, although the specific implementation and design of Charrette's features may require domain-specific refinements. While we can speculate about which findings might generalize to other domains, these hypotheses would need to be validated with actual experiments. As it stands, the main

value of our study is in validating and providing more detailed feedback on our approach in the context of UI design. However, Charrette's design provides a basis for experimenting in other design domains.

Framing for longitudinal study

While our lab study provided insight into designers' initial experience with Charrette, it did not explore how software support for keeping track of iterations and discussions would affect designers' process over a period of weeks or months. To address this gap, we would like to deploy Charrette in a longitudinal study that examines the effect of creating and linking snapshots as the size and complexity of the canvas increases. We anticipate that some of the benefits of Charrette observed in the lab study, for example, increased ease finding previous iterations, would be more pronounced with designers working in their everyday setting. Towards this goal, we believe that our lab study identifies useful methodologies and metrics that could inform the design of a longitudinal experiment. For example, our study suggests that it may be useful to measure how well designers recall previous discussions both during the design phase and during review meetings. In addition, given the heavy use of the snapshot timeline, instrumenting this component would likely reveal an interesting range of navigation behaviors. Finally, our study only examined how designers managed and integrated feedback they were given, but did not look at how design managers give examine several iterations for giving feedback. We would like to investigate the impact of Charrette on design managers and potentially explore new features that specifically support their needs.

CONCLUSION

In this paper, we examined the difficulties designers face in presenting their design process during in-person discussions. Effectively presenting process requires both handling diverse feedback as well as we alternatives and history. Through formative work, we identified three archetypical practices in design work. We then implemented Charrette, which provides software support for each of these practices. We evaluated Charrette in a short-term exploratory comparative study with 12 professional designers to gauge how software tools to support these practices affected designers' ease in discussing their process. From this evaluation, we show that, although they faced usability issues, designers readily leveraged explicit support for design history to ground discussion with previous work and feedback.

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REFERENCES

1. Abstract App. (accessed 2017-09-16). *Secure version control and design workflow management*. <https://www.goabstract.com/>
2. Michael S. Bernstein, Joel Brandt, Robert C. Miller, and David R. Karger. 2011. Crowds in Two Seconds: Enabling Realtime Crowd-powered Interfaces. In *Proceedings of the 24th Annual ACM Symposium on User Interface Software and Technology (UIST '11)*. ACM, New York, NY, USA, 33–42. DOI: <http://dx.doi.org/10.1145/2047196.2047201>
3. Adobe Experience Design CC (Beta). (accessed 2017-09-16). *Adobe Experience Design desktop software*. <https://www.adobe.com/products/experience-design.html>
4. Hsiang-Ting Chen, Li-Yi Wei, Björn Hartmann, and Maneesh Agrawala. 2016. Data-driven Adaptive History for Image Editing. In *Proceedings of the 20th ACM SIGGRAPH Symposium on Interactive 3D Graphics and Games (I3D '16)*. ACM, New York, NY, USA, 103–111. DOI: <http://dx.doi.org/10.1145/2856400.2856417>
5. InVision: Digital Product Design Workflow & Collaboration. (accessed 2017-09-14). *InVision*. <https://www.invisionapp.com/>
6. Nigel Cross. 2016. *Design thinking: understanding how designers think and work* (reprint 2016 ed.). Bloomsbury Academic, London Oxford New York New Delhi Sydney. OCLC: 992436223.
7. Steven P. Dow, Alana Glassco, Jonathan Kass, Melissa Schwarz, Daniel L. Schwartz, and Scott R. Klemmer. 2010. Parallel Prototyping Leads to Better Design Results, More Divergence, and Increased Self-efficacy. *ACM Trans. Comput.-Hum. Interact.* 17, 4 (Dec. 2010), 18:1–18:24. DOI: <http://dx.doi.org/10.1145/1879831.1879836>
8. Eureka Foong, Steven P. Dow, Brian P. Bailey, and Elizabeth M. Gerber. 2017. Online Feedback Exchange: A Framework for Understanding the Socio-Psychological Factors. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17)*. ACM, New York, NY, USA, 4454–4467. DOI: <http://dx.doi.org/10.1145/3025453.3025791>
9. Elizabeth Gerber and Maureen Carroll. 2012. The psychological experience of prototyping. *Design Studies* 33, 1 (Jan. 2012), 64–84. DOI: <http://dx.doi.org/10.1016/j.destud.2011.06.005>
10. Tom Greever. *Articulating Design Decisions: Communicate with Stakeholders, Keep Your Sanity, and Deliver the Best User Experience*.
11. Tovi Grossman, Justin Matejka, and George Fitzmaurice. 2010. Chronicle: Capture, Exploration, and Playback of Document Workflow Histories. In *Proceedings of the 23Nd Annual ACM Symposium on User Interface Software and Technology (UIST '10)*. ACM, New York, NY, USA, 143–152. DOI: <http://dx.doi.org/10.1145/1866029.1866054>
12. Björn Hartmann, Sean Follmer, Antonio Ricciardi, Timothy Cardenas, and Scott R. Klemmer. 2010. D.Note: Revising User Interfaces Through Change Tracking, Annotations, and Alternatives. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '10)*. ACM, New York, NY, USA, 493–502. DOI: <http://dx.doi.org/10.1145/1753326.1753400>

13. Jeffrey Heer, Fernanda B. Viégas, and Martin Wattenberg. 2007. Voyagers and Voyeurs: Supporting Asynchronous Collaborative Information Visualization. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '07)*. ACM, New York, NY, USA, 1029–1038. DOI: <http://dx.doi.org/10.1145/1240624.1240781>
14. Kathryn Henderson. 1991. Flexible Sketches and Inflexible Data Bases: Visual Communication, Conscription Devices, and Boundary Objects in Design Engineering. *Science, Technology, & Human Values* 16, 4 (Oct. 1991), 448–473. DOI: <http://dx.doi.org/10.1177/016224399101600402>
15. Hiroshi Ishii and Minoru Kobayashi. 1992. ClearBoard: A Seamless Medium for Shared Drawing and Conversation with Eye Contact. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '92)*. ACM, New York, NY, USA, 525–532. DOI: <http://dx.doi.org/10.1145/142750.142977>
16. Young-Wook Jung, Youn-kyung Lim, and Myung-suk Kim. 2017. Possibilities and Limitations of Online Document Tools for Design Collaboration: The Case of Google Docs. In *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing (CSCW '17)*. ACM, New York, NY, USA, 1096–1108. DOI: <http://dx.doi.org/10.1145/2998181.2998297>
17. Joy Kim, Maneesh Agrawala, and Michael S. Bernstein. 2017. Mosaic: Designing Online Creative Communities for Sharing Works-in-Progress. In *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing (CSCW '17)*. ACM, New York, NY, USA, 246–258. DOI: <http://dx.doi.org/10.1145/2998181.2998195>
18. Scott R. Klemmer, Michael Thomsen, Ethan Phelps-Goodman, Robert Lee, and James A. Landay. 2002. Where Do Web Sites Come from?: Capturing and Interacting with Design History. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '02)*. ACM, New York, NY, USA, 1–8. DOI: <http://dx.doi.org/10.1145/503376.503378>
19. Charlotte P. Lee. 2007. Boundary Negotiating Artifacts: Unbinding the Routine of Boundary Objects and Embracing Chaos in Collaborative Work. *Computer Supported Cooperative Work (CSCW)* 16, 3 (June 2007), 307–339. DOI: <http://dx.doi.org/10.1007/s10606-007-9044-5>
20. J. Lehni and J. Puckey. 2011. Paper.js. (2011).
21. Kurt Luther, Amy Pavel, Wei Wu, Jari-lee Tolentino, Maneesh Agrawala, Björn Hartmann, and Steven P. Dow. 2014. CrowdCrit: Crowdsourcing and Aggregating Visual Design Critique. In *Proceedings of the Companion Publication of the 17th ACM Conference on Computer Supported Cooperative Work & Social Computing (CSCW Companion '14)*. ACM, New York, NY, USA, 21–24. DOI: <http://dx.doi.org/10.1145/2556420.2556788>
22. Jennifer Marlow, Scott Carter, Nathaniel Good, and Jung-Wei Chen. 2016. Beyond Talking Heads: Multimedia Artifact Creation, Use, and Sharing in Distributed Meetings. In *Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing (CSCW '16)*. ACM, New York, NY, USA, 1703–1715. DOI: <http://dx.doi.org/10.1145/2818048.2819958>
23. Meteor.js. (accessed 2017-09-16). *Platform for building web and mobile apps in pure JavaScript*. <https://www.meteor.com/>
24. Lora Oehlberg, Kyu Simm, Jasmine Jones, Alice Agogino, and Björn Hartmann. 2012. Showing is Sharing: Building Shared Understanding in Human-centered Design Teams with Dazzle. In *Proceedings of the Designing Interactive Systems Conference (DIS '12)*. ACM, New York, NY, USA, 669–678. DOI: <http://dx.doi.org/10.1145/2317956.2318057>
25. Amy Pavel, Dan B. Goldman, Björn Hartmann, and Maneesh Agrawala. 2016. VidCrit: Video-based Asynchronous Video Review. In *Proceedings of the 29th Annual Symposium on User Interface Software and Technology (UIST '16)*. ACM, New York, NY, USA, 517–528. DOI: <http://dx.doi.org/10.1145/2984511.2984552>
26. Red Pen. (accessed 2017-09-15). *Web application to solicit design feedback*. <https://redpen.io/>
27. Daniela Retelny and Pamela Hinds. 2016. Embedding Intentions in Drawings: How Architects Craft and Curate Drawings to Achieve Their Goals. In *Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing (CSCW '16)*. ACM, New York, NY, USA, 1310–1322. DOI: <http://dx.doi.org/10.1145/2818048.2819932>
28. Frederick Aliaga Craig Scull Steve Johnson Fredo Durand Sara L. Su, Sylvain Paris. 2009. *Interactive Visual Histories for Vector Graphics*. Technical Report. MIT.
29. Michael Terry and Elizabeth D. Mynatt. 2002. Recognizing Creative Needs in User Interface Design. In *Proceedings of the 4th Conference on Creativity & Cognition (C&C '02)*. ACM, New York, NY, USA, 38–44. DOI: <http://dx.doi.org/10.1145/581710.581718>
30. Folio Simple visual version control tool for Mac based on Git. (accessed 2017-09-16). *Version control for design documents*. <http://folioformac.com>
31. Moritz Wittenhagen, Christian Cherek, and Jan Borchers. 2016. Chronicler: Interactive Exploration of Source Code History. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16)*. ACM, New York, NY, USA, 3522–3532. DOI: <http://dx.doi.org/10.1145/2858036.2858442>

32. Anbang Xu, Shih-Wen Huang, and Brian Bailey. 2014. Voyant: Generating Structured Feedback on Visual Designs Using a Crowd of Non-experts. In *Proceedings of the 17th ACM Conference on Computer Supported Cooperative Work & Social Computing (CSCW '14)*. ACM, New York, NY, USA, 1433–1444. DOI: <http://dx.doi.org/10.1145/2531602.2531604>
33. Dongwook Yoon, Nicholas Chen, François Guimbretière, and Abigail Sellen. 2014. RichReview: Blending Ink, Speech, and Gesture to Support Collaborative Document Review. In *Proceedings of the 27th Annual ACM Symposium on User Interface Software and Technology (UIST '14)*. ACM, New York, NY, USA, 481–490. DOI: <http://dx.doi.org/10.1145/2642918.2647390>
34. Loutfouz Zaman, Wolfgang Stuerzlinger, Christian Neugebauer, Rob Woodbury, Maher Elkhaldi, Naghmi Shireen, and Michael Terry. 2015. GEM-NI: A System for Creating and Managing Alternatives In Generative Design. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15)*. ACM, New York, NY, USA, 1201–1210. DOI: <http://dx.doi.org/10.1145/2702123.2702398>