2h - Design Research Report

1) Title

Artistry

2) Team

Antonio Cao
Sarim Abbas
Kenyon Duncan
TanTan Wang

All team members contributed equally to the design research effort.

3) Problem & Solution

Problem

Much of an artist's journey is unreadable and therefore unrecognizable to a consumer or critic. How can we empower artists to represent the evolution of their work? In the status quo, many artists write in journals, take process photos, shoot montages, write essays etc. The purpose of these projects is either to provide the necessary context to consumers, or for artists to clarify their process to themselves. But these projects can take up a significant amount of mindshare and time or even morph into full works in their own right.
A related problem is of collaboration. No two artists are alike, and have different processes, inspirations and styles. How can we enable other artists to jump in and work together in the creation process?

Solution

Collaborative tools and environments for 2D digital artists already exist. We are instead targeting 3D artists (sculptors, architects, AR/VR creators, animators) and building a mobile application that provides 1) a section to collect ideas, 2) collaborative tools and 3) a community to engage and share with.

4) Research Goals, Stakeholders & Participants

Research goals

The research methods (below) helped us collect data that would help us understand:
- The process of creating and documenting an artwork
- How artists collect inspiration and ideas

- How artists gather feedback and respond to critique
- The frustrations and roadblocks artists face in their daily workflows

Research methods

Initially we had proposed 5 methods of inquiry: 1) Contextual Inquiry, 2) Fly-on-the-wall, 3) Interviews, 4) Diary study and 5) Survey. However, we did not proceed with 4) and 5) due to limited time and resources. In particular, we did not choose 4) Diary studies because we would have had to recruit artists to keep process documentation with the specific intention of contributing to our research - we could not just retroactively look at their prior work. We also did not choose 5) Survey, because while we could have reached many people, there would be limited means of follow-up.

So we chose methods 1-3, and our rationale is below.

Contextual Inquiry (CI)

Our group had contacts with a number of practicing audio and visual artists, and we spent time with them to better understand their creative processes. Before starting, we obtained consent from subjects and assured them of privacy. During the session, the CI method helped us observe artists in their natural environment and we let their work speak for itself. We followed the master-apprentice model and stepped through their process by having them walk us through a task. Two of us conducted these inquiries together - one was a note-taker and the other acted as the apprentice. We jotted down the salient aspects of the observed tasks, which included drawing, music production, and presentation.

Fly-on-the-wall (FotW)

We visited the open space inside the Yale School of Art, studios at the Center for Collaborative Arts and Media (CCAM), the Center of Engineering, Innovation, and Design (CEID), and art or music critique classes. During these visits, we observed the creators at work without informing them that they were being watched. We liked this method because it allowed us to collect lots of data at convenient times. At other times, we deliberately scheduled FotW sessions so that we could ask follow up questions in a more formal interview (below). In such cases, we obtained consent prior to the study, which lasted about an hour.

Interviews

We interviewed about 5 creators in various disciplines. Most of the interviewees were our friends, professors, and family members. Before the interviews, we created a list of cohesive questions. These questions included:

- How do you gather inspiration for your art?
- What are your pet peeves with the tools that you use?
- How do you explain your process to a client?
- Who makes the artistic decisions and why?

During the interview, we first obtained consent to record the subjects' responses. We then asked the questions and took notes via pen or audio memo. We also asked subjects to recall or simulate specific tasks like finding inspiration, building a portfolio or working on a client's project. The interview format helped us dissect tasks related to our research problem, and understand the subjects' intentions and expectations behind their behaviors.

Stakeholders

We developed the following stakeholder diagram to analyze the various disciplines and institutions that relate to our research problem:
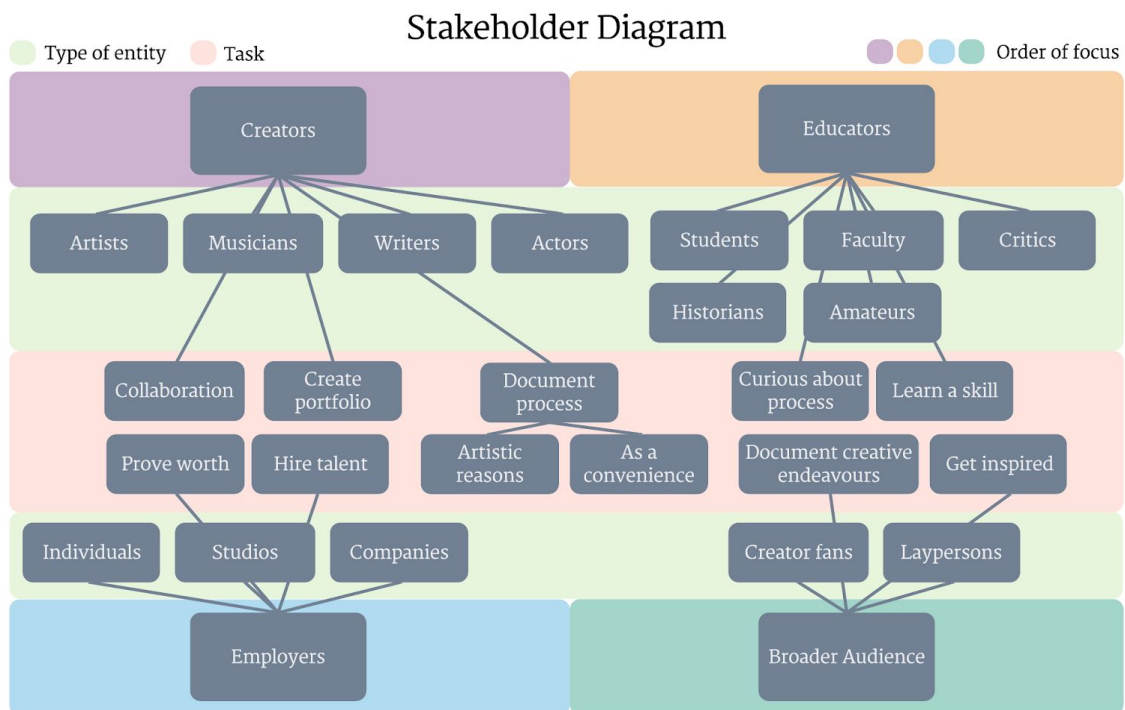

Fig 1: Diagram depicting the different stakeholders and their importance in the design of a potential product

Deconstructing the artistic process has foremost value for artists and creators. But we also felt that a potential solution could cater to the diverse needs of the following groups:
- Educators: e.g. university faculty, art historians and critics
- Employers: e.g. companies, design agencies, and studios looking to understand the qualifications and skills of potential hires
- General consumers: e.g. hobbyists, non-artists or laypersons who may want to gather inspiration or try out new, collaborative tools

Participants

After conducting research with the first couple of participants, we started to narrow our focus to visual artists (instead of other disciplines such as audio). We realized the difficulty of developing a one-size-fits-all solution in a limited timeframe. Our solution would not be able to cater to such diverse needs, nor could we hope to test out each feature with all disciplines in the prototype stage. Our selected research participants (below) reflect this decision.

Participant X

pe:
- Fly-on-the-wall (FotW)

Background:
- She is a undergraduate senior, double majoring in art and mechanical engineering. In an effort to gain experience for her portfolio and future employment, she takes on freelance work for clients.These clients include family members, student clubs, faculty, and even companies.

Environment:
- X works in a variety of locations based on needs. She often works at the School of Art, however, on occasion she also works in the CEID.
- The fly-on-the-wall interview was conducted in a computer lab on the second floor of the School of Art.

Unique observations:
- X likes to multi-task, and has a systematic way of organizing her workflow to juggle multiple projects.
  - She first ideates on a piece of paper, sketching out the general design.
  - She pulls up a note-taking app to jot down ideas, inspiration, font choices, color palettes and more. She later tells us that she likes having a place to "dump" her thoughts so that she can move onto another project.
  - The final designs start to take shape incrementally.
- X receives many requests for design work. However, she is not a domain expert on many of the areas she is expected to design for. For instance, one commission was for a poster for East Asia, another commission was a newsletter for a raffle event. Both of these tasks have specific aesthetics and design requirements to be followed, but the clients often provide little detail.
  - Therefore, X often does keyword searches on Google Images to find similar designs, conce**Ty**pts or motifs that she can incorporate into her work to make it more authentic.

Participant Y

Type:
- Scheduled interview

Background:
- Y is a graduate student at the School of Art. His main interest is in typography. He also works as a designer for a student-led startup.

Environment:
- The interview was held at his desk at the School of Art. Y's desk is part of a large studio space and on the second floor. He is surrounded by many artists that are printing, weaving, sawing, hammering away at their projects. There is camaraderie between them and they often call on each other for help.

Unique observations:
- Asked about collaboration with other artists in the space:
  - Y is on good terms with many of the other artists on the floor. However, setting up times and spaces for collaboration proves to be difficult.
  - Y shows me an interesting project: he developed an app to let artists trade resources with each other. For instance, Artist 1 could provide plaster to Artist 2 in exchange for a paintbrush. When asked why he did not publish the app, he seemed to reconsider but ultimately concluded the app was not feature-filled enough to promote active collaboration.
- Y starts the day with a cup of coffee and a vague sense of the design goals he needs to meet for the day. He wishes there was a way to keep himself more accountable, but it is difficult to judge progress on a work of art, since it is subjective and the work cannot be quantified into equal-sized chunks.

Participant Z

Type:
- Scheduled interview

Who:
- Participant Z is a junior at Yale majoring in Graphic Design and Computer Science.

Environment:
- Z was inside her home in California, and the interview was conducted over Facebook Messenger video.

Unique observations:
- Z complains about the Apple pencil because it was "too precise." Rationale: Z is probably referring to the Apple pencil's lack of fidelity and expressiveness. Even though the pencil attempts to imitate physical pencil's subtle stroke change, it still feels unnatural and unresponsive to use. Many designers agree that, so far, there is no tool that matches the power of classic pencil and paper.
- Z dislikes Dribbble because all of the designs there look too uniform. Rationale: most of the users on Dribbble are UI/UX designers at design agencies or technology companies, and their design can be quite uniform, especially when an artistic style (e.g. gradients or material design) becomes trendy. However, she says, in order to produce memorable designs, designers must have unique perspectives.

5) Research Results & Themes

Research results

Key findings:
- There is a discontent with the status quo, and tools that purport to solve a problem lack in one area or the other. For instance, Sketch and the Adobe Suite are presented as one-size-fits-all solutions for visual artists, however while they do help synchronize design teams and provide powerful editing tools, they are insufficient for collecting inspiration and presenting to/communicating with non-designers.
- Artists are a heterogeneous group with diverse workflows. We cannot cater to all of their needs, and have to restrict the scope of any potential solution. However there are some commonalities/shared annoyances between artists. The studied subjects agreed that there are few effective mechanisms to document their work. They emphasized that process documentation is a valuable artefact that would help justify their rationale to prospective clients and critics.
- Artists are as mobile as ever, but the desktop-based tools have not kept up. Inspiration strikes quickly and is fleeting, but there are rarely ways to capture it. Even if full-fledged versions of popular software were ported to mobile phones and tablets, they still rely on antiquated desktop metaphors that are ill-suited to the mobile environment.

Our research also helped us make sense of our problem space, and address a number of prerequisite questions for task analysis.

Who is going to use the design?
- We see our primary target audience being working artists. After all, they are the ones who are actually most missing a product like the one we foresee creating.

What tasks do they now perform?
- The main tasks our subjects performed are creating visual content such as posters, logos, typefaces, etc. During these processes, some common tasks include looking for ideas on the Internet, sketching, and researching about problems and communicating with clients.

What tasks are desired?
- Some tasks we found to be desired were easy shareability, faster ways to sketch and create mockups, and consolidating a common design language.

How are the tasks learned?
- Most tasks were learned through trial and error, for example when one of our subjects learned to use a new sketching program, they had to learn through their mistakes while using the app.

Where are the tasks performed?
- These artists work at virtually any place from their private rooms and studios to offices and even public spaces like coffee shops and public parks.

What other tools does the person have?
- The tools that these artists usually have are Adobe Creative Programs, and other software-based tools to supplement their physical artistic process.

How do people communicate with each other?
- People communicate through messaging and social media for collaboration, while professionals use websites like Behance and Dribbble to showcase their work.

How often are the tasks performed?
- Designers work on their tasks almost everyday for anywhere from 1 to 12 hours.

What are the time constraints on the tasks?
- Time constraints vary wildly depending on the project and artist. For example, client and professional work may have a quick timeline, while a fine artist may take many months to create a piece of art.

What happens when things go wrong?
- When things go wrong, such as when software malfunctions, artists typically use brute-force and time-consuming methods, such as hand-drawing or simply waiting.

Common themes, problems, practices

Ideation
Several designers that we interview wish that there was a more efficient way to explore the design space. Another designer suggests that we should create a tool to help designers iterate through different combinations of possible ideas.

Content creation
One interviewee complains that making mockups in Adobe Illustrator was very difficult. Almost all designers wish to automate the laborious aligning processes.

Presentation
The process of exporting and packaging a interviewee's design was so painful that, when she was required to show her progress, she would rather take a screenshot in the design software. In addition, almost all designers that we encounter experienced some pain or pressure when they are required to create a portfolio.

Collaboration

Working with other artists on projects can be difficult because of scheduling issues, lack of resources, lack of accountability, communication issues.

Sketching
For most serious creative activities, all designers that we interview start from sketching on a piece of paper. In fact, one designer mentions that her professor requires students to start a project from manipulating texts printed on physical papers. The professor emphasizes that such physical, tactile interactions with one's design is tremendously instructive.

Designer-developer handoff
For artists working in interdisciplinary teams or startup environments, communicating designs with developers can be difficult. The design tools do not have options to provide code snippets to the developers

6) Task Analysis

After conducting our research, we realized most of our data was biased in favor of visual artists. We thought it best to restrict our scope, and think about how a potential solution may best help visual artists carry out important tasks (below). We generalized the needs of artists into discrete personalities, which we incorporated into each task. The tasks are organized in descending priority, based on our current understanding of the problem and proposed solution.

Task 1: Logging artists' process

X is a struggling artist and student trying to juggle several expectations. His clients expect him to deliver reasonably quality (but not perfected) work on time, and iterate quickly. His professor/supervisor similarly wants him to be thorough but is a bit more relaxed with time-frame. But X sets the highest of expectations for himself. He feels stifled by the onslaught of deadlines and distractions. X wants to push his limits and produce works of high calibre. But he realizes that doing so makes him fall behind with other responsibilities. X desires a system that can help him log the efforts he has put into an art piece, and reduce distractions and cognitive load. This way he can devote more time into perfecting the finer details of a piece.

Difficulty: This task is medium difficulty and scope. Currently, users might log their process in text, voice memo or some other tools, so it is easy to become disorganized. And the product designer has to cater to many disciplines and content types. Some tool might be developed within a year, but more design cycles will be needed to adapt the tool to different use cases.

Task 2: Content creation when mobile

B is a professional appropriation artist based in Los Angeles that seeks to discover new meaning on previous works of art by using art and the world around her to create something entirely new. To gather new visual material, she takes daily trips around LA in order to capture the sights and sounds of the city and its many cultures. Often times, she takes everyday objects

on the street and likes to superimpose text and images to create quick graphical compositions to share with her social-media audiences. However, due to the availability of tools for portable devices like smartphones, she isn't able to find one solution where she can not only quickly access her discoveries and observations, but also to create quick compositions that are easily shareable. For her, depending on her desktop computer at home isn't an ideal situation, because so much of her process is done on her feet, far away from her home. Having something that will be available to her on the go would be immensely helpful.

Difficulty: The tasks that B are trying to accomplish are currently all doable on the go, however there has not been a technological implementation of a solution that tries incorporating all of this together. Attempting to make such a solution, without feature bloat and such, would be a sizeable task but technologically feasible.

Task 3: Sketching 3D models

A is an architect working at an architecture studio in NYC. A's daily work is mainly creating 3D models, rendering visualizations, and designing presentations for the studio. A loves sketching and always tries to keep a sketchbook with her to record her sparks of inspiration. In particular, A likes the expressiveness, sense of control, and immediate feedback available in the process of sketching. However, during her architecture design workflow, A has to use a mouse to draw splines, push vertices, and extrude surfaces of a 3D model projected onto a 2D screen. Even though A had several years of training in 3D modeling, the process still feels unnatural, unintuitive, and highly inefficient. For example, when she has to design a freeform shell for a project, A must painstakingly tweak a dozen splines simultaneously to make sure the curvature seems natural from all view angles. Therefore, A dreams that she can create 3D sketches with her hand and pencil in the near future.

Difficulty: even a trained architect would often find creating 3D sketches, especially those of freeform structures, a challenging task. On the other hand, implementing such technology is also very challenging, because it involves hand-pose estimation, localization of virtual objects, and hand-object occlusion.

Task 4: Ideation

Z is a graphic design student at Yale College, and she is currently designing visual identity for a perfume brand that she and her friend co-founded. Z often browses websites like Behance, Dribble, Pinterest, and design blogs on Medium, and she keeps a vast collection of designs and inspirations gathered from these online sources. Naturally, Z's brainstorm process starts from her collection of inspirations. In her visual identity project, from her collection, Z selects 5 images that contain diverse graphic patterns, color schemes, and content layouts. Then Z goes to Behance and pinterest, and selects 10 new designs in order to keep track of the current trend. For each of these 20 images, Z selects the most attractive colors and patterns, and shuffle them around to create fresh and interesting combinations. Since this shuffling process is time-consuming, Z wishes that some tool can help her iterate through these colors and patterns

automatically.

Difficulty: For designers, this ideation process takes a lot of time because it requires them to manually change content in a design. However, it is feasible to solve this problem with technology. There are already programs that can extract color schemes and patterns from a reference image, and it is not difficult to copy these components to a design and automatically shuffle them.

Task 5: Critique and Presentation

L is a sculptor and Master of Arts candidate working towards her final review and critique through the creation of original body of work. Most laypersons do not appreciate the enormous, multi-faceted effort that has gone into an art piece. Even other experts sometimes need to be made aware of the artist's process to justify the merit of a work. L wishes to both communicate the artifacts of his work (photos, sketches, tests, inspiration boards etc.) to critics and receive crucial feedback. Receiving candid, anonymized, specific feedback from sculptors using similar techniques would be very useful for L, in order to help her improve her work. The critique would be most useful for L if she could provide her colleagues with a window into the different processes of ideation for her project such that they could give feedback not just on the final sculptures, but also on the process L took to get to them.

Difficulty: The facets that L wants to incorporate into the task of critique and presentation require integration and organization of different media (photos, sketches, physical objects, etc.) into an understandable, presentable , and digestible format. The technologies already exist to place these different artifacts in conversation with each other, but providing means of compelling presentation (and anticipating audience understanding) would be quite challenging.

Task 6: Designer-developer handoff

 Y is an visual artist and designer working in an agile, fast-moving workplace. Weekly design sprints take place to ideate and improve the company's products. The engineers and designers often need to be on the same page. Not all designers know how to code and vice versa. Current communication with the engineers is inefficient and requires a lot of back-and-forth with design assets. In the status quo, designers like Y are trying to speed up their process by learning how to code. However, tutorials are confusing and software development is a fast-moving target. Y wants to get both parties on the same page and improve the "handoff" between designers and developers.

Difficulty: From the user's perspective, there is no clear path to turn design into code. Developing specialized, automated software to do this would be difficult because there is no obvious connection between pixels and language syntax. There are also obstacles to learning a new language/skillset to do this conversion by hand. The same goes for engineers learning a suite of design tools. Perhaps there are other ways to conveniently synchronize the two parties.

7) Proposed Design Sketches.

Scanned images of the three initial designs in the context of their tasks. The report should include one paragraph for each design that discusses how the design supports the tasks.

Design 1: Mobile App for a Community of Artists

The first design is a mobile app that aims to allow artists to share and collect feedback on their work. Viewers can "scrub" through multiple versions of the work and see how it developed over time (this feature can be implemented by making use of the history metadata embedded in each file or via a version control system). Viewers can also leave comment, engage in discussions with the author, and rate the work. Users can also collect inspiration into their personal libraries. This inspiration could be the colors, patterns and motifs present in artworks.

Task 1: Logging artists' process (Fig 1, 3)
- The app will allow artists to capture the following types of content:
    - Colors (hex code, RGB etc.)
    - Patterns (vector SVG tiles)
    - Photos & Videos
    - 3D assets
    - Webpages
    - Audio (voice memo or external)
- The many types of media can be posted publicly or privately to the artist's personal feed. The feed can therefore be used to collect inspiration or details of work and share with others

Task 3: Ideation (Fig 2)
- The "Extractor" function under each artwork listing will be able to use statistical tools like K-means, wave function collapse etc. to guess and generate the color palettes, patterns and motifs present within an artwork
- These can be remixed and permutated, and added to the artist's personal library

Task 5: Content creation while mobile or travelling (Fig 3)
- The mobile app allows artists to collect inspiration around them using their phone camera and microphone. Their personal library can be synced to desktop design tools like Sketch
- The app also allows some limited editing functionality such as text overlay, shapes, paint brushes etc. to allow for quick compositions

Task 6: Critique and Presentation (Fig 2)
- The timeline lets viewers have an insight into the artist's process, and the work evolves

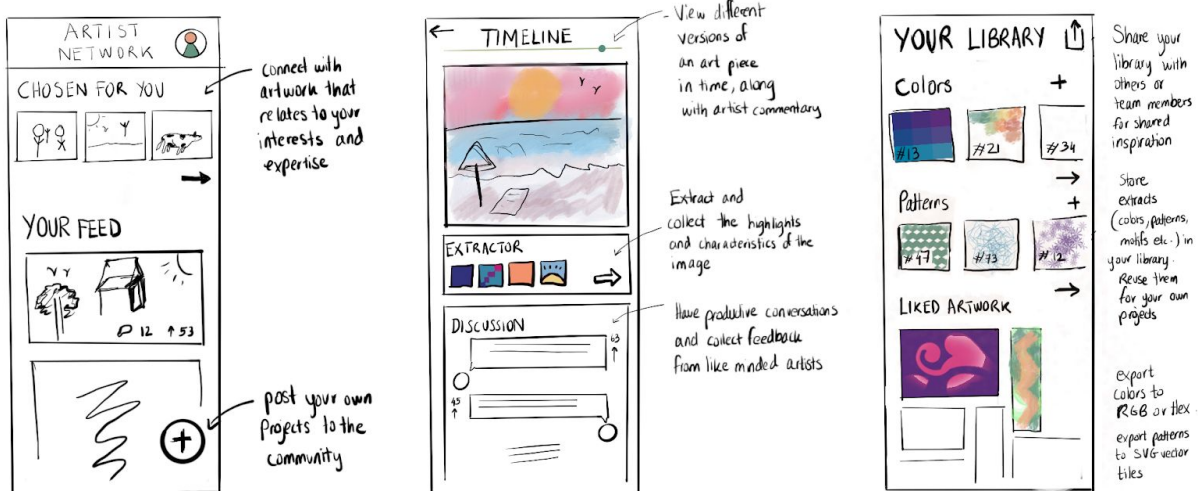- The threaded discussion section lets creators respond to critics and explain their reasoning

Fig 1, 2, 3

Design 2: VR Sketching System

The second project is a VR-based 3D sketching system that allows the user to create 3D sketches with a digital pencil and hand motion. The system estimates the user's hands based on multi-view camera images captured from the VR Google's front cameras, fit a 3D hand model onto the user's hand, and then segment the hand to create virtual occlusion onto the 3D object. Multiple users can access the 3D model, and leave comments to the author. The author can access a library of 3D assets that serve as references and inspirations.

Task 1: Logging artist's process
- System captures the changes done to the 3D model (use Zbrush's timeline as an example).
- System allows the user to automatically a screen capture of the 3D model in exploded view.
- System allows the user to save color schemes, brushes, and 3D assets into an organized, sharable format.

Task 3: Ideation
- The "Reference" section allows the user to browse and deploy sample 3D models as references.
- System can automatically iterate through different colors and materials and apply them onto the 3D model to help the user brainstorm.

Task 4: Sketching 3D models
- System estimates hand-pose based on images from multi-view camera in front of the VR-google.

- System fits a virtual hand model onto the user's view port based on the estimated hand-pose.
- System segments the hand to create real-time occlusion on virtual objects.
- System connects with digital pencil to allow accurate modification of virtual meshes.

Task 6: Critique and Presentation

- System allows multiple users to tag comments onto specific regions on a 3D model.
- Timeline allows users to view the entire creation process.
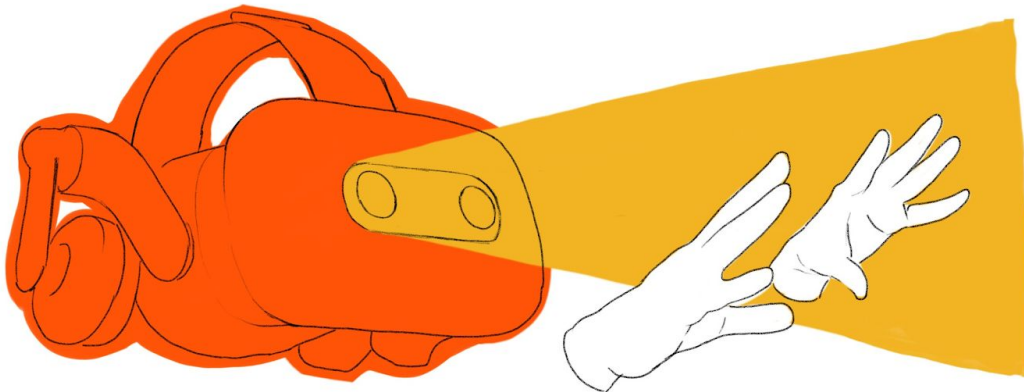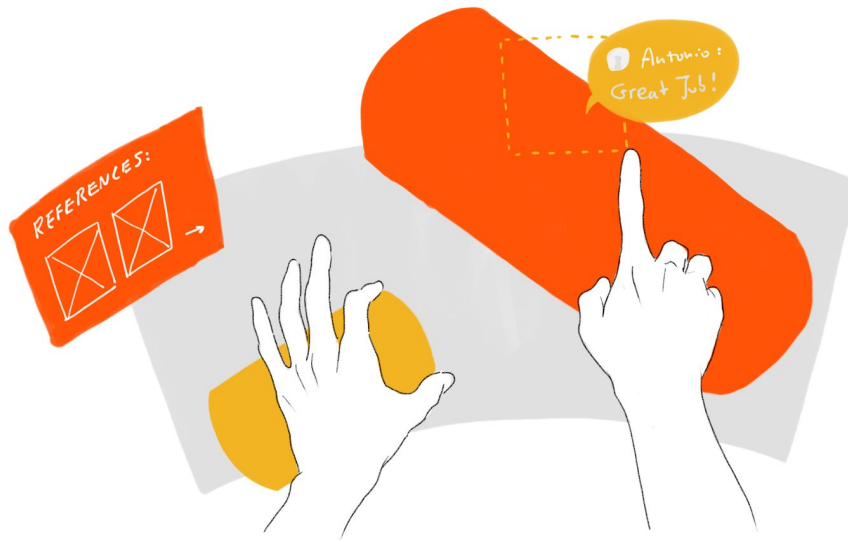
Design 3: Smart Studio Space

This third design builds upon previous ideas of a "smart studio," where the actual interface would merge with the physical space that the artist normally works in. In this case, the central

hub would be a computer system with an additional camera and projection system and sensors to track positioning of hands and a stylus. While the computer portion is a normal computer, the additional hardware allows for people who own the system to share their physical desktops with each other as well.

Task 1: Logging artist's process
- The system records every single visual change on the artist's tabletop, and through the computer the artist is able to scroll through past iterations, like a "time machine" of sorts. The artist is also able to manually capture desktop "screenshots" at any given time.

Task 2: Design-Developer Handoff
- For the designer, being able to submit creations from your physical space virtually to a developer with the capabilities of viewing your physical space in real-time would solve a major problem. The ability to track hand movements and a stylus would allow, for example, the developer to mark up sketches on an actual table, while the designer would see those marks and notes being made in real-time as well.

Task 3: Ideation
- The artist can interact on the computer monitor for online materials and browsing through snapshots, and compare digital images and materials directly next to physical objects and canvases through the projector and camera system.

Task 6: Critique and Presentation
- System allows for remote and instantaneous critiques, where critics from different locations can directly point and gesture at parts of the canvas for the artist to see in their studio
- Artists can also do presentations of the work remotely, where they can receive both feedback from a remote audience, who are also able to view previous ideations of the work through previously captured desktop "screenshots"

8) Chosen Design & Tasks.

Design Rationale

We chose Design 1 — a mobile app for a community of artists — because we felt it catered to the core needs of our target users. For earlier assignments, we had proposed problem areas faced by all artists (musicians, sculptors, painters, engineers etc.). Later, we narrowed down our research focus to visual artists. We have now narrowed down our focus further to artists that might require 3D modeling or drawing tools (e.g. sculptors, architects, animators) and who want to interact with a community of like-minded peers. We are colloquially referring to such artists as "3D artists". We felt that Design 1 was the best candidate to further refine and develop to best serve the needs of these types of artists.

Design 1 is also more flexible and accessible than the other designs. Smartphones are more ubiquitous and cheaper than VR/AR hardware or purpose-built projection-based interfaces, a crucial factor for working artists. App experiences are easier to develop prototypes for. People tend to be knowledgeable about app experiences and so we can present them with mockups and get feedback quickly. Anchoring the 3D experience on a phone provides portability and ease of use.

Tasks

Task 1: Logging artists' process

One of our initial team goals was to empower artists to better organize and record their own works, and while doing so, inculcate a respect for their process in others (laypersons or critics). We still feel this is one of the most important tasks, since artists put a lot of time and effort into learning tools and creating masterpieces, but usually only the end result is visible. This can sometimes lead others (especially non-artists) to make simplifying or trivializing generalizations.

Task 2: Content creation while mobile

While lots of powerful tools exist for traditional desktop environments, the tools available on mobile hardware leave a lot to be desired. But we don't just want to port something like Photoshop on the iPad. Instead, we feel that there is a synergy between mobile hardware and 3D design, which benefits from immersion and change in perspective.

The other tasks were about 2) Designer-developer handoff, 3) Ideation and 6) Critique and Presentation. We feel that by enabling Task 1, we are already incorporating some elements of Task 6 via our feeds feature. Although Task 2 and 3 are interesting, they are less weighty problems for social and collaborative good.

9) Written Scenarios.

Scenario 1: Logging artist's process (Figure 1)

Bob is an artist who is creating illustrations for a website. Bob has spent 2 months on this work, going through a dozen iterations, and he uses our app to show the artistic creation process to his clients, in order to help them visualize how the idea takes shape.

1. At the beginning of this creative process, Bob creates a new project in the app and adds the initial sketches of his ideas.
2. Whenever he finishes a part of the artwork or starts a new idea, Bob whips out his phone, takes a snapshot of the work, and records it in the app.
3. Two months later, when Bob's client asks him for a progress update, Bob uses the app to generate a sequence of images with a slide bar that scrolls through the whole creation process.
4. When the client asks Bob about how he comes up with the design for the sky in the artwork, Bob zooms in on the sky and uses the slide bar to show his client how the sky takes shape.
5. At the end, Bob exports this project from the app to his portfolio. The app automatically generates a sequence of snapshots that display the artistic creation process in a nice, clean layout.

Scenario 2: Mobile 3D content creation (Figure 2)

Jack and Tina are industrial designers collaborating on an automobile design project. They use our app to create a shared virtual workspace, and sketch 3D objects using their mobile devices.

1. Jack opens the app on his phone, attach it to a Google cardboard VR headset, and straps the headset onto his head. The app automatically starts to wait for bluetooth signals of nearby virtual workspace.
2. Tina opens the app on her iPad, and also opens the app on her laptop. Then Tina creates a new virtual workspace, imports a few reference 3D models and images from the laptop's hard drive, and hit the "Play" button to launch the virtual workspace.
3. The app on Tina's laptop searches for nearby devices using bluetooth connection, and sends requests to her iPad and Jack's phone. After Jack and Tina accepts the request on their mobile devices, the app then uses the laptop as an anchor to localize Jack's phone and Tina's ipad. Therefore, the laptop not only serves as a robust mobile hub for bluetooth connection, but also provides a common frame of reference for the 3D workspace.
4. Jack and Tina can walk around in the room and sketch out their ideas. In particular, the hand-gesture recognition feature in Jack's phone allows him to draw splines and meshes with his hands. The AR functionality in Tina's iPad allows her to create 3D lines by tapping and moving the iPad around.

5. During the creative process, Jack and Tina can view, modify, and add references that floats nearby them. Using the AI assistants on their mobile devices, the app allows Jack and Tina to search new references by saying the keywords.
6. When they want to rotate the entire virtual workspace, Jack and Tina can simply rotate the physical laptop that defines the coordinate system of the workspace.
7. Jack and Tina finishes their 3D car sketches, and exports the 3D sketch to their shared Google drive directory.

10) Storyboards of the Design.

Figure 1. Logging artist's process.

Figure 2. Mobile 3D content creation.

Figure 2: Collaborative artists begin new project together

Figure 3: Artists create and interact with each other using the 3D workspace

Figure 4: Artists can use device of choice to interact with their shared design project