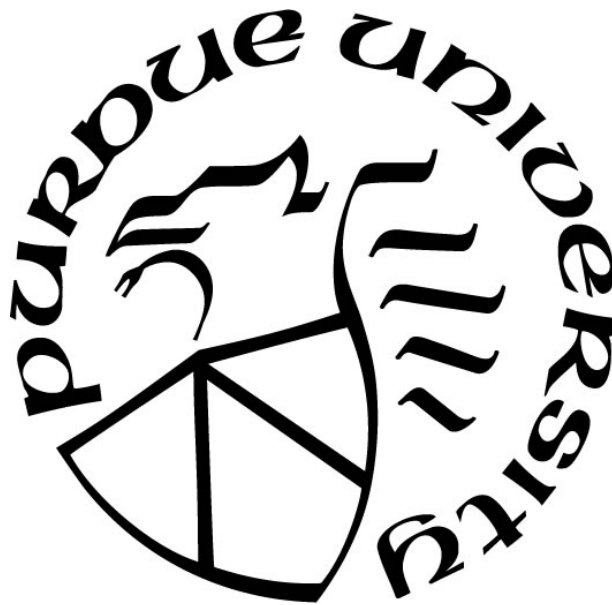# CLOSET GO: A DATA-DRIVEN DIGITAL CLOSET SYSTEM TO IMPROVE THE DRESSING EXPERIENCE

by

Weilun Huang

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THE PURDUE UNIVERSITY GRADUATE SCHOOL
STATEMENT OF COMMITTEE APPROVAL

Dr. Zhenyu Cheryl Qian, Chair

Department of Visual and Performing Arts

Steve Visser

Department of Visual and Performing Arts

Jung Joo Sohn

Department of Visual and Performing Arts

Approved by:

Dr. Arne Flaten

Dedicated to my future

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ABSTRACT

This thesis aims to introduce a system design that supports the user experience of outfit selection, storage, and matching. Clothes are indispensable items in daily human life. Purchasing one's wardrobe has become more affordable. This has allowed people to focus on purchasing more fashionable clothes. Garment shopping has even become a type of social and leisure activity. With the development of internet technology, shopping methods have changed dramatically. However, these seemingly convenient shopping methods also bring unavoidable problems, such as an inability to understand apparel companies' different size standards and the challenge of seeing the details of materials. On the other side, while overemphasizing the convenience of the shopping process, online companies have ignored people's clothes-wearing experience that is the most enjoyable and valuable for customers. This paper introduces an IoT (Internet of Things) design: "Closet Go" including a mobile application and a clip-able camera. "Closet Go" aims to improve customers' daily outfit selection experience by digitalizing their closets and conducting data analysis of customized dressing habits. In this thesis, I present the entire design process: user research, Ideation, UI/UX design, product development, and evaluation. In the research section, potential users were recruited for interviews to discover the current problems in acquiring, selecting, and matching outfits in daily life. The design process section introduces the design development progress and results via user flow, experience map, prototype, and user interface. Finally, the thesis concludes with a heuristics evaluation section that tests the design's usability and experience to refine the project.

CHAPTER 1. INTRODUCTION

1.1 Background

The clothes we wear are one of the most common things in our lives. After thousands of years of development in human history, the role and meaning of clothing have undergone tremendous change. However, no matter how it has changed, their significance has never been questioned. In the early days of human history, clothing protected us from the harsh environment. Later, it evolved into a symbol of aristocratic status, and today it has become an identification for everyone to show their personality. Also, with the reduction of manufacturing costs, everyone can afford beautiful clothes. The pursuit of clothing aesthetics has become a universal phenomenon, and the clothing industry is booming.

In today's digital world, the development of science and technology makes our lives more convenient, and people have more choices for purchasing clothes than ever. A smartphone makes it easy to search and purchase with the user's fingertips on the mobile application. There are various ways to buy clothes, from brick and mortar stores to totally digital marketers.
The trend of fashion styles is constantly changing. A piece of clothing worn by a famous movie star will arouse heated discussions in the streets tomorrow. It is a direct influence of the new media channels. Therefore, the method of how people know, browse, buy, and wear clothes has changed.

However, with this boom in the clothing industry, some problems have come to the forefront. Companies have been overly focused on the business aspects, so their applications make the payment procedure more convenient and faster during the shopping process to sell more items. Based on my research, companies have used research to understand customers' psychology and encourage them to purchase more items. These studies make purchasing processes efficient. However, I found current designs in the industry tend to overlook some of the customers' other needs after purchase.

Based on background research, this study focuses on customers' clothes wear experiences and unmet needs. I try to discover what users need regarding apparel use. Although most companies are interested in the purchasing process processes, this design focuses on the stage after people purchase their clothes. Actually, in the entire clothing-related experience, buying is just a tiny part of the process. Wearing clothes is the most valuable and enjoyable part for most customers. Therefore, this design addresses the neglected part and assists people by improving their wearing experience.

1.2 Design Process

This paper introduces the entire design process, including problem identification, research, and design development. In the first two chapters, I present the apparel area's background and context to lead readers to understand the current trend and current problems. The goal of the study is to improve customers' clothes-wearing experience. Chapter 3 introduces the methodologies used to complete this project, including research methodologies, design, and evaluation methods. In Chapter 4 and Chapter 5, I explain the research process and outcome. Those outcomes lead to the design direction in the following chapters. Chapter 6 is the most critical component in this paper, demonstrating Close Go's detailed design process. The design process began with problem and goal identification. And then, this chapter included Ideation, HTA chart, wireframe, and user interface to finish the application part design. This chapter also presents the physical product: a clip camera. Specifically, I explain the design iterations, including how the product and application design had been modified based on internal and external critiques. Chapter 7 introduces the heuristic evaluation and how it was used to find user experience problems and improve the design of the application.

CHAPTER 2. LITERATURE REVIEW

Design is an interdisciplinary process. Designers usually need to design for many disciplinary areas, like finance, sales, education, or healthcare. However, the designer may not have particular strengths in those areas. A literature review can offer forefront knowledge and enhance the speed of development. Hannah Snyder proposed that the literature review could be grouped into different types: systematic, semi-systematic, and integrative approaches (Snyder, 2019). All three types have different purposes and quality of execution. In this chapter, I mainly follow the integrative approach to present the current situation. At first, I analyzed the meaning of clothes and the changes with time. Besides, I presented two popular fashion trends and the reasons for popularity. In the second part, I analyzed shopping behavior from online shopping to multichannel shopping. Last, I researched the customer experience and introduced its meaning to clothes shopping.

2.1 Development of Clothing

2.1.1   Changes in the meaning and function of clothes

Clothing has been essential for much of human history. For example, according to the Bible, immediately after eating the forbidden fruit, Adam and Eve became aware they were naked. They sewed fig leaves together and made coverings for themselves. (Genesis 3:6-7) Although there are different theories on when clothes appeared precisely, it was inevitable that clothes occurred at the beginning of human civilization and played a significant role (Perrot, 1994). At that time, the primary function of clothes was protection. Clothes protected people from the grueling environment and ferocious beasts. However, with human society's development, the roles, styles, and techniques of making clothes changed dramatically. People no longer need to fight against animals and sleep outside. As people's lives have become more comfortable, the pursuit of aesthetics has become universal, resulting in diversity in style. Therefore, the focus has shifted from predominantly a functional perspective to predominantly an aesthetic perspective. Early clothing designers included different ideas and used different materials in clothes production to make clothes beautiful and novel. At this point, clothes began to transform into

fashion. Customers also began to purchase distinctive clothes to demonstrate their personalities. In some sense, clothes became a way to communicate and a business card to present identity (Barnard, 2002).

The occurrence of fashion gives clothes more meaning in society. Oxford English Dictionary defined "fashion" as "the mode of dress, etiquette, furniture, style of speech, etc., adopted in society for the time being… to be in the fashion: to adopt the accepted style" (Oxford University Press, 2000). In this definition, people consider fashion as an accepted style. There were some stages in history when people dressed in a similar style, and it became a fashion at that time. So, fashion is not a personal issue, and it is related to everyone in their society.

Studying clothes and fashion is not only just about aesthetics. Many scholars focus on clothes and fashion throughout history to find evidence of societal issues and hierarchy. Many scholars believe fashion to be the culture of the high-level class (Welters & Lillethun, 2018). They assert that only wealthy families can support the expense of fashion. Moreover, affluent women in the flourishing family are the primary audiences for fashion because they had more free time to focus on fashion trends.

2.1.2 The boom of the fashion industry

Since apparel manufacturing has become less expensive, companies have spent more money on design. They use creative strategies to attract customers and hire superstars to wear their clothes to create a trend. Therefore, the clothing industry turns into the fashion industry. Customers pay for clothes' style and design rather than the function. Currently, fashion is not only exclusive to the wealthy. Fashion has become a universal industry due to affordable access and popularity. In the past years, the fashion industry has developed prosperously (FashionUnited, 2021). Increasing sales in the fashion industry have attracted many businesses resulting in a rapid expansion of fashion apparel brands. Fashion has become a topic of everyday life and is not limited to the high-income group.

After the 20th century, digital media contributed to the fashion industry's boom. Today, A vlog and a picture can be propagated around the earth in just a few seconds. Customers can watch fashion news everywhere on their smartphones. The new way of sharing fashion ideas cuts down the cost of advertising and reaches more people. E-commerce has allowed people in rural areas to have the same opportunity to enjoy fashionable goods as people in big cities. Because of the internet, vlogs and posters demonstrate their unique advantages compared with fashion magazines. They give brand owners effective channels to communicate with ordinary customers and know their habits. At present, more brands would like to advertise on social media outlets (Scuotto, Del Giudice, Peruta, & Tarba, 2017). Those social media outlets can promote items to target users accurately by analyzing users' behavior.

2.1.3 Current fashion trends

The fashion in history was much different from current trends. Today's fashion has become more diversified. Today's fashion encourages people to be themselves and display their identification. People want to be unique and use their clothing to express their identity. To identify the problems with the current fashion market, I need to understand the current fashion trend and customers' preferences. This section introduces two popular trends to experience the customers' current situation. By learning customer preferences and analyzing their psychology, I can accurately discover users' real problems. Finally, those two fashion trends inspired the design of the "Closet Go."

2.1.4 Fashion style: fast fashion

As a result of fashion popularization, the fashion industry has more potential customers. Fast fashion is a business model that earns money by selling numerous items at low prices, which could attract more customers to buy. "Fast fashion describes the retail strategy of adapting merchandise assortments to current and emerging trends as quickly and effectively as possible." (Sull & Turconi, 2008). The popularity of fast fashion also benefits from the clothes industry's current situation; the current market has many potential customers. In the current climate, fashion changes fast. Every year and even every season, there will be new fashion styles. Instead of focusing on a few models and refining them, brands frequently design new styles. In place of

restocking sold-out styles, companies quickly move to the new season's design and manufactory. Compared with traditional brands that only have two seasons every year, fast fashion releases new items weekly. There are a few reasons that lead to the success of fast fashion.

1. Cheap cost of clothing manufacture. After the intention of sewing and advanced clothing technology, handmade clothes were fading out stage. The 1st reason reduces labor costs dramatically and production cycles. To increase the efficiency of manufacturing, fashion clothes manufacturers have often decreased the clothes quality. Because of the low price and poor quality, people do not keep their clothes for a long time; they would buy new clothes more frequently and throw out old clothes. Businesses found the opportunity there. They continually use low prices and the latest style to attract customers.

2. Benefits from the internet, information spreads broadly and efficiently. After traditional brands release items in a fashion show, fast fashion brands can easily imitate and produce them. Those clothes can then be sold at a lower price because the most expensive part of clothes is on design rather than manufactory these days (Rocamora, 2013). Clothes that were copies of expensive luxury items were then available to people of all incomes. As a designer, we can lament about stealing the designs by fast fashion companies, but it is a reality of the market today.

3. Talking about fast fashion, we cannot ignore quick-response(QR) (Bhardwaj & Fairhurst, 2010). The period between the clothes design to on sale reduces a lot. This phenomenon allows companies to rely on actual data analysis to decide how many clothes to produce rather than trend prediction (Rocamora, 2013). Compared with the high risk of predicting future trends, analyzing current data and responding as soon as possible helps fast fashion brands sell more clothes. That is how fast fashion companies take less risk and earn more profit.

2.1.5 Fashion style: vintage

Contrary to fast fashion, the vintage style does not target the majority of users in the market. Vintage clothes attract customers who like delicate quality and classic style, which goes to another extreme with fast fashion. It expresses a negative attitude and response toward fast fashion (Cassidy & Bennett, 2012). Those who are not interested in fast fashion can easily be

attracted by vintage fashion that emphasizes each piece's quality, history, and individuality. Vintage customers worship the texture and quality of clothes that have been worn for a long time. They enjoy the trail of time shown on the clothes.

At first, customers seek vintage clothes that have been worn for a long time in second-hand clothing stores. With the popularity of vintage, fashion designers have found opportunities and have begun to design vintage styles. They include the character of vintage clothes in their design and mimic old styles in new items. Brands craft those vintage-style clothes elaborately with high-quality fabrics to cater to vintage fans. Some of them are even made without machines to show the most delicate craftsmanship. Brands reproduce some classic vintage models that were initially released many years ago but still attract modern customers. Of course, the price of vintage fashion is much higher than fast fashion. However, more and more young people would like to pay for vintage styles that existed even earlier than their birth (Cassidy & Bennett, 2012). They adore the unique appearance and feel of the clothes after they had been worn many times.

Vintage can also express an attitude of sustainability. Based on research, some fast fashion clothes were discarded after only being worn near six times (Cassidy & Bennett, 2012). From Allwood's research (Allwood, Laursen, DeRodriguez, & Bocken, 2006), "In today's throwaway society, UK consumers alone generate 2.35 million tons of waste clothing in landfills every year." Vintage fashion extends the lifecycle of clothes and allows them to be worn longer.

Because of the popularity of the vintage style, people realize the resale value of their slightly used clothes. Rather than fast fashion clothes, some expensive clothes can be sold at a high price even after being worn for years. Based on ThredUP's 2019 Resale Report (*2020 Fashion Resale Market and Trend Report*, 2020), the resale growth was faster than the new apparel market from 2016 to 2019. The second-hand market was expected to double in the next five years. Except the vintage clothes are more special after being worn, the main reason for this rise would be customers' open attitude toward second-hand clothes. Research shows that 64 percent of women can accept used clothes, which increased from 45 percent in 2016 (Turner, 2020). The resale wave leads companies like Macy's and JCPenny to increase their proportion of secondhand

clothing. The wave also leads to an emergence of a series of online resale apps. In this culture, the customers will also consider the clothes' resale value when they are shopping.

2.2 Recent Shopping Trends

2.2.1 Online shopping

After 2020, E-commerce became even more a routine part of our lives than before. Online shopping has become part of our lives, no matter if people live in a metropolis like New York or a small town. Based on the study (*Online Shopping Statistics You Need to Know in 2020*, 2019), "Online shopping is growing so fast that the global online shopping market size is predicted to hit 4 trillion in 2020. Moreover, in the US alone, we are expecting to have 300 million online shoppers in 2023. That is 91% of the entire country's population!". We are experiencing a massive boom in online shopping. Undoubtedly, data growth benefits from the development of technology. Significantly, research has shown that the internet of things (IoT) and big data help the development of e-commerce (Fu, Manogaran, Wu, Cao, Jiang, & Yang, 2020). Those new technologies not only solved traditional commerce's problem but also brings customers a new shopping experience. However, no matter how fast the technology has developed, shopping's most essential elements do not change, such as shopping convenience, information seeking, immediate possession, social interaction, the retail shopping experience, and variety seeking (Rohm & Swaminathan, 2004). Brands and researchers conducted many studies in those categories and wanted to bring new changes. Some researchers try to study shopping problems from psychological perspectives. Hedonic and utilitarian dimensions were proven to affect the shopping decision (Childers, Carr, Peck, & Carson, 2001). The comfortable experience and beautiful environment make customers more likely to shop. The rapid expansion of digital games testifies to the hedonic impact of interactive technology. Including interactive elements in the process, the shopping experience will motivate customers and encourage them to make a purchase decision.

Unavoidably, online shopping also has weaknesses. Many people are concerned about privacy breaches, which could be the main hindrance to e-commerce. When people do online shopping, the stores know their addresses and phone number. There has been considerable research about

risk perception. However, people are still concerned about privacy breaches and fraud issues when shopping online. A study (Miyazaki & Fernandez, 2001) supports that the more advanced technology is and the more comfortable the customers' experience is, e-commerce is more challenging to prevent risks.

2.2.2   Multichannel shopping

Gradually, the popularity of online shopping impedes sales in physical stores. Some experiments (Schmid & Axhausen, 2019) about customers' choice between shopping online and shopping in-store shows that customers who have a positive attitude toward online shopping care more about the cost. Compared with electronic products, customers tend to buy groceries in-store. In general, the category of items affects the decision. In another study about the luxury shopping experience, researchers find that different factors affect customers' decisions on multiple channels (Liu, Burns, & Hou, 2013). Basil Schmid Kay and W. Axhause found that high education and high-income groups tend to have a more positive attitude to online shopping (Schmid & Axhausen, 2019). Another research study (Lissitsa & Kol, 2016) focusing on how age affects the choice of shopping channels shows us that the younger generation has more positive attitudes toward online shopping. In different categories, customers' decisions may vary. It is hard to make a universal conclusion about which shopping channel is better.

Over time, the competition between online shopping and physical shopping has become intense. Both compete on price, service, and quality of the products (Forman, Ghose, & Goldfarb, 2009). The offline transportation cost, online shopping disutility cost, and retailers' prices all affect the competition between online and in-store.

After a period of competition, companies begin to offer multichannel shopping to create pleasant experiences. Different customers have different preferences. Various shopping methods and environments satisfy various customer types (Lu & Rucker, 2006). Customers do not need to decide between online shopping and physical store shopping. They only need to experience a brand's service, either from an online store or a physical store. This experience will finally decide the purchase decision (Ahn, Ryu, & Han, 2004). As the study for "order online picks up in-store"

behavior (Chatterjee, 2010), the cross channel option has been required by more retailers. Each channel supports and complements each other in needed areas and creates an integrated and natural experience.

2.3 Customer Experience

2.3.1   Customer experience in traditional shopping

The definition of "customer experience" is considered as "the internal and subjective response customers have to any direct or indirect contact with a company" (Meyer & Schwager, 2007). It is how customers feel and react when they contact the company's product and service. Brands care about customers' experience and improve customers' satisfaction in various ways because customers' experience and satisfaction affect their repurchasing or appraisal directly. When people do not have online shopping, companies already started studying customer experience to improve their product and service (Khalifa & Liu, 2007). Without computers, companies used human mechanisms to comprehend customer feelings during the touchpoint, such as surveys, interviews, and telephone talking (Meyer & Schwager, 2007). At that time, those methods were helpful. Improving customer satisfaction is also an advertising method that tells customers the company cares about their experience. With the development of technology, companies collect more information about their customers. They can contact their customers efficiently and understand customers in different ways. Researchers do not need to go on the street and distribute surveys. They can distribute online surveys through emails to targeted users. Currently, researchers have more methods to understand people's experiences. They build empathy maps to understand how people are looking, feeling, and thinking. Moreover, with digital device help, researchers can repeatedly record and analyze data, making understanding customers' experience much more straightforward.

Understanding the customer's experience is not the primary purpose. It is the first step. After detecting the problems and identifying the joyful moment for customers, companies will improve the customer experience, fix the problem, and enhance the experience. Researchers divide customers' experience with design into two groups. One is that the organization did something wrong, or customers had a terrible shopping experience. Companies want to remedy the problem

and appease the customer. Another one is that companies did not make any mistakes. They find new opportunities or develop new functions, making the current experience better.

2.3.2   Development of technology affects the customer experience.

Before the development of the internet, physical stores were the only place to buy fashion items. Customers enjoy the process of shopping. They step into the store, touch items, try them, and make payments. With the development of technology, customers can buy everything online. However, the fashion industry cannot transform immediately like other industries, such as grocery and daily necessities (Week, 2012). The purchase of clothes needs more physical touch or interaction that directly affects the customer's purchase intention (Merle, Senecal, & St-Orange, 2012). To solve this problem, brands include AR technology in e-commerce. This function allows customers to try clothes virtually. Even though customers cannot touch the clothes, they can view clothes from different perspectives.

The whole online shopping environment is different from physical stores. There are no service providers who can accompany you immediately, and customers cannot touch or try clothes. In this situation, companies use various strategies in an online shopping environment. Augmented reality is used to try clothes virtually. This new function allows customers to interact with clothes, which decreases suspicion and enhances purchase intention. Online shopping assistants have also become more innovative. Customers can get help in multiple ways, like email, online chatting, or calling. Those changes make shopping enjoyable and encourage customers to shop online. Compared with physical shopping, there are some unique functions only provided by online shopping (Ahn et al., 2004). Customers can create their profiles with body data. Based on their information, the website may recommend suitable sizes for them.

As Sir Isaac Newton said, "If I have seen further, it is by standing upon the shoulders of giants." The direction of my study relies on the results of previous works. Those researchers give me a better understanding of the current apparel and apparel shopping industry. The users' behavior and psychology analyzed by previous research led me to design the detailed functions of the "Closet Go" system.

CHAPTER 3. METHODOLOGY

In this chapter, I will introduce the methodologies used in this study. The system design follows the double diamond design model and adjusts based on the UX design process discussed in the UX book (*The UX Book*, 2012). The dual-diamond design model is a widely employed method in the design industry. "Double diamond" was first proposed at the council in 2005 (Council, 2006) as a design process framework. We can find four phrases in the double diamond design model - discover, define, develop, and deliver. The double diamond is a universal design method that could be employed in most design projects. In the "Closet Go" design, I mainly focus on the user experience design for an application and a product. Based on this exact situation, I combined the double diamond model with the UX design lifecycle (from design to evaluation) mentioned in the UX book (*The UX Book*, 2012).
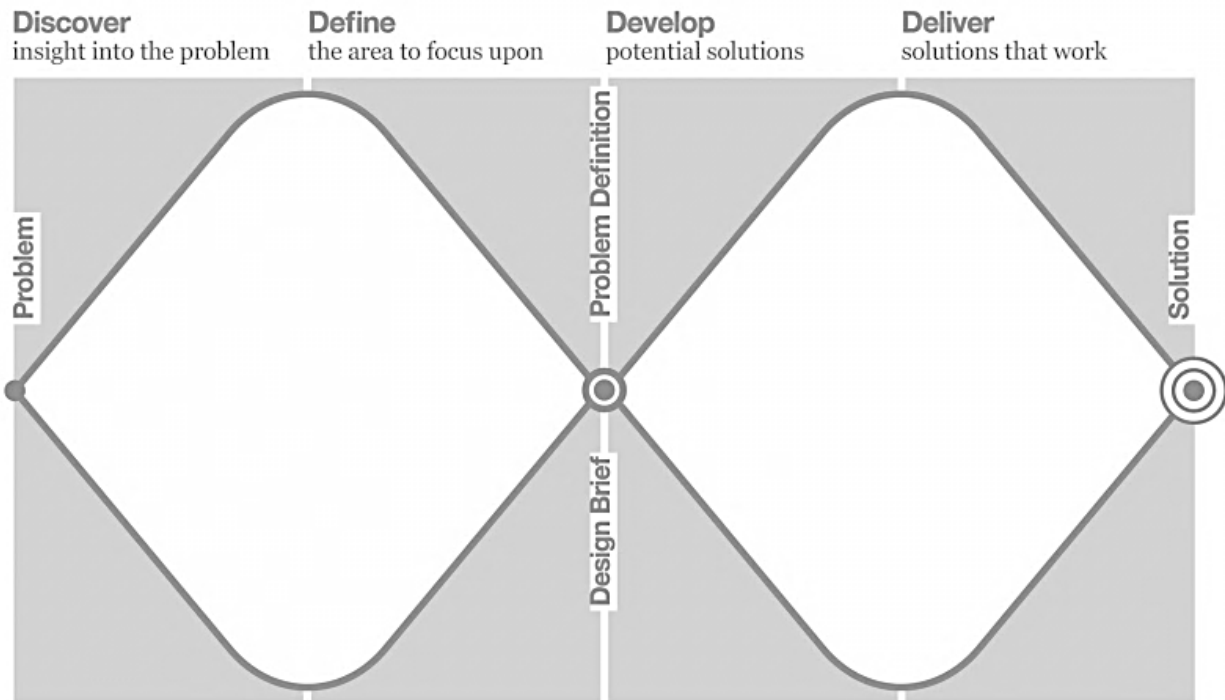
Figure 1. Double Diamond Design Process (Council, 2006)

All methodologies in this chapter can be divided into research methodology, design methodology, and evaluation methodology. I employed interviews and field studies to

understand target users. Moreover, a Competitive Analysis was used to understand the current market. After that, I applied the user experience journey map and created a persona to present and analyze data. I adopted HTA charting and card sorting methods to plan the system's structure and functions in the design process. Finally, I utilized heuristic evaluation to test the design.

3.1 Research Methodology in Discover Stage

Research is in the first quarter of the double diamond frame-discover. This section aims to collect information to discover problems and understand users. In collecting data, I employed interviews and field studies that allow me to reach users directly.

3.1.1 Semi-structured interview and field study

The interview is a valuable research method to collect qualitative data from users. The semi-structured interview is one of the most popular interview methods. This kind of interview is open and allows interviewees to go out of the researchers' control. Usually, researchers prefer to select the semi-structured interview rather than a standardized interview. The semi-structured interview is flexible and makes the experience more accessible to operate than a non-structured interview. (DiCicco-Bloom & Crabtree, 2006). A more open process can also encourage interviewees to express their thoughts, which is valuable in the interview study.

A certain level of the related pre-study is necessary for successful semi-structured interviews (Wengraf, 2001). To design the main structure, the interview designer should understand the interview topic and the interviewees. Furthermore, the interview should have a clear goal that helps the interviewers host the talk. Although semi-structured interviews will not restrict interviewees in a storyline, the interview still needs to be led by the interviewer and follow the goal. The interviews' data is valuable for future research. In the design process, data can help designers narrow down target users and clarify the design purpose. In the interview, all the sentences and actions should be recorded in detail to maximize data availability.

Field study is another research method that collects information from people's behavior. Different from the interview, the field study is observation-based and does not disturb the

observed people. The main goal of the field study is to understand people's natural reactions to a particular situation. By analyzing the information from the field study, researchers can identify problems people have. Usually, the researchers will conduct a small interview after observing people explain the reason behind their actions. Compared with the interview in a lab, the retrospective follow-up interview after the observation is shorter and more flexible. The main goal of this interview is to explain some of the observers' confusion during observation. The length and efficiency of the interview depend on the cooperation of the observed people. In the field study, sometimes researchers will let people know they are being observed and ask permission for later interviews. However, in this case, some researchers believe the study's outcome may be affected by the observation based on the "Hawthorne effect" (McCambridge, Witton, & Elbourne, 2014). In the "Hawthorne effect," researchers present an idea that the subject will change its actual behavior because of the observation. So sometimes, in a field study, researchers will not tell people they are under observation. After observation, researchers will contact the subjects and ask for their permission to keep and analyze the data.

3.1.2   Peer products analysis

Competitive analysis is an effective method to understand the current market. The primary goal is to analyze other products' strengths and weaknesses in the market. Therefore, designers can learn from the strengths and improve the weaknesses when they are designing a new product. In the competitive analysis, the first step is selecting competitive products. For example, I looked at products such as brand-specific websites, style book closet app, and augmented reality apps for this study. The most apparent competitive products are the products that have the same user group. For example, competitive products in this study could be other products in the clothing fashion industry. However, even in the same industry, products will focus on different phrases and different groups. For example, some products focus on expensive garments in the clothing industry, and others are focusing on less expensive clothes. Some colorful clothes are aimed at women. Some protective clothes are aimed at children. The more overlap two products' target users are, the more intense their competition is. Sometimes competitive products may come from different industries. For example, children's spare time is precious. They only have less than two hours of free time after finishing homework. During these two hours, children can choose to play

computer games, read books or play music. Those different activities are competitive for children's time, and even they represent various industries. Studying competitive products is essential because designers can learn from others. Future target users need to choose among those products, which decides the market occupation.

3.1.3   User experience journey map

The user journey map is a time-based chart used to describe the experience of a process. Unlike persona, the user study and competitive analysis investigate the products, and the method of user journey map focuses on the activities on the temporal dimension. The user journey map describes how the user interacts with a product, application, service, or other people in this period. Users' feelings, thoughts, and actions in each interaction point are usually described on the map.

Researchers build a user journey map based on the data from interviews and observation. Researchers include the most typical user's case or mix several interviewees' experiences to create a journey map.

The user journey map's primary goal is to help researchers locate the users' problems and find the cause of the issues. Also, during the design process, the designers can use the user journey map frequently. They bring the new design back to the journey map and evaluate if the design solved the problems.

3.2 Research Methodology in Define Stage

The Persona methodology is a widely accepted design approach used to depict users and help designers understand their target users. Cooper (Cooper & Saffo, 1999) initially presented the definition of personal as "A precise description of our user and what he wishes to accomplish." Later in 2002, Calde gives more explanation (Cooper & Saffo, 1999) and defines "Persona" as" User models. Personas are fictional detailed archetypical characters representing distinct groupings of behaviors, goals, and motivations observed and identified during the research phase." The popularity of personas benefits from another approach: "Goal-directed design" from

Cooper (Cooper & Saffo, 1999). "Goal-directed design" is a broader methodology in the interaction design area in Cooper's book. Cooper presented that an excellent design needs a clear goal. However, we cannot talk about purpose without people. That is why persona and objectives are essential in interaction design.

On the other hand, persona's practicability results in many professional designers using persona in their design project and share persona with the public. Designers always talk about design for users. However, who is our user? A persona answers this question. The persona offers a clear picture of expected users that allows designers to focus and easily communicate with the team.

To build a persona, people need to collect and analyze data from user studies. Although the persona is a fictional character, the persona method works only when this virtual character is built with actual data. Usually, designers use the information from user studies to create personas. User studies are all based on real people's cases so that those personas will be more reliable. However, with such broad usage of persona in the industry, designers' ideas and assumptions are being added into a persona (Chang, Lim, & Stoterman, 2008). It is hard to judge whether adding designers' ideas to personas makes the persona effective or not since designing is a relatively subjective process.

3.3 Design and Evaluation Method in the Develop Stage

3.3.1   HTA chart

Hierarchical task analysis (HTA) is usually employed as an ergonomics or a Human-Computer Interaction (HCI) method in academics (Stanton, 2006). Researchers use HTA as a graphic chart to represent the structure of tasks. The HTA chart represents the sequence of tasks, subtasks, and all the actions required to achieve the task. Generally, people use HTA to analyze a task and present the procedure to achieve the goal. So obviously, hierarchical task analysis is goal-oriented rather than action-oriented (Annett & Stanton, 2000). Researchers focus on a selected goal and analyze how to finish that goal with subtask.

HTA has been widely used in various industries, including interaction design. Users usually need to operate complicated interfaces and many different buttons in the interaction design or software design area. Finishing a complex task usually requires a lengthy procedure. HTA helps designers divide a big task into several small tasks. On the one hand, this analysis helps designers understand a page's structure and avoid uneven page capacity. One page contains many complicated tasks, and another page only includes a couple of simple tasks. This imbalance will make create wasted space and make the product hard to use. In practical production, designers use HTA before design as well as after design. Designers need to understand the design goals and achieve the goals before designing the user interface and components. So, designers use the HTA chart here to analyze the goal and find its subtask. After that, designers will move to the wireframe design and include those tasks into pages. The HTA also helps designers to evaluate the system. The system's structure will be different from the original idea in the designers' minds within the process. The HTA chart can help designers review the structure and goals to adjust page order and capacity. The chart makes the structure of systems' primary functions clearer and allows designers to review the design conveniently.

3.3.2 Card sorting

Card sorting is a widely used user-centered design method that encourages users to share their thoughts about information and build information architecture (Donna, 2004). Usually, researchers recruit potential users to group and sort several cards that are labeled information or functionality. Card sorting results can help designers better understand the users' thoughts and design a user-friendly product. There are two types of card sorting in the academic world: open card sorting and closed card sorting (Donna, 2004). Open card sorting allows more freedom and autonomy for participants. Participants do not have any rules on how to group the cards. They find their way to sort cards. In a closed card sorting, researchers have already established some information groups, and users only need to place cards into the correct groups.

User experience designers and researchers are in favor of card sorting because of its unique benefits. Card sorting is an easy organized method in the pre-design stage, which is not costly nor requires much time and gives designers a chance to understand the users' thoughts. However,

card sorting also has obvious weaknesses. It is only as good as the cards provided to the participants. If the designer omits or combined tasks, then the process will be flawed. Additionally, the result of this research may vary under different contexts. Most design is goal-oriented. With different goals, participants will groups cards differently. Also, card sorting is cognitive research. Therefore, various participants may give completely different answers, especially in open card sorting. Even though the analysis process is time-consuming and has inherent weaknesses, it is still helpful to the designer.

3.3.3   Heuristic evaluation

Heuristic evaluation is a famous usability research method for finding usability problems in an interaction design (Nielsen & Molich, 1990). In the evaluation, researchers will recruit several evaluators familiar with usability principles to judge the user interface design and explain the reasons. The evaluation will output a series of usability problems and help designers modify the design in future iterations. Compared with other usability methods, heuristic evaluation is low-cost, making it popular in the interaction design industry. Unlike other evaluation methods, usually, the evaluators in the heuristic evaluation are design experts because evaluators need to judge the user interface based on their own opinions. Evaluators should understand usability principles well for reliability. According to the balance between cost and effect, a heuristic evaluation with 5 to 10 evaluators will support a reliable result (Nielsen, 1995). As Nielsen presents, the number of evaluators affects the evaluation outcome. So choosing a reasonable number of participants is very important.

Admittedly, heuristic evaluation is convenient and efficient. However, it also has disadvantages. With heuristic evaluations, it can be hard to determine real users' problems without professional background knowledge because experts evaluate the design. Designers or experts cannot fully understand normal users' thoughts. Besides, evaluators sometimes identify a problem without a feasible solution. Sometimes designs cannot solve all the problems because of the current technology and other limitations.

All the methods discussed in this chapter helped my design become efficient and solve problems more effectively. These methodologies will be described in detail in Chapter 4, Chapter 5, and Chapter 6.

CHAPTER 4. USER RESEARCH

4.1 The Goal of The User Research

As the pre-study part of the design, user research's primary goal is to collect and analyze the target users' behaviors. The results of the research will offer essential support to future design processes. Before the research, potential users' picture is varied because customers in the fashion apparel area show great diversity. As mentioned before (Chapter 2), fashion is currently popular in American culture. The fashion chasers varied in education, income, gender, and social class. To design a user-friendly application, designers should know their target users. This user research is the first step to understanding people in this area. Later, after rounds of research, the target group of users could be condensed to a small and precise group of people, for whom the final design can focus.

In addition to building an accurate user model, identifying problems that impact the everyday decisions about purchasing and wearing clothes is necessary for the research. Solving those problems is the goal of this design. During the interview, participants talked about their frustrating clothes shopping experiences, both virtual and in-store. I recorded the complete research process with the permission of the participants. After that, the raw data were reviewed and analyzed. I sorted the problems mentioned in the experiment by significance. The most severe problem stood out in this process. To keep the final product concise, the designer selected only limited functionality for the product, which means only a few issues could be solved. Choosing the most significant problem to solve from target users is also the goal at this step.

4.2 Participant Recruitment

To ensure the accuracy of the study, I added one requirement in the participant recruitment process. Only people who are qualified as target users will be included in the study. The research divides into two parts. The first interview is about the general shopping experience, and the questions are comprehensive. The participants in this part are targeted people who like fashionable clothes. This part aims to have a broad but shallow understanding of potential users and find interesting topics to focus on in the next part. The second interview is more targeted.

People in this group are filtrated again from the first study. They are my core target users who are young and like fashion shopping. The problems collected from them are more valuable to me. People in the second group will be involved in this design process continually based on their intention. In the later design evaluation part, they will be included again to help improve the design.

In the first interview, fifteen people joined whose ages are from 23 to 38. This age range is based on my anticipation of the target group: young people who have the financial ability to support clothes shopping. Nine males and six females participated in this interview, which helped me learn how gender affects shopping habits. Only participants who indicated that they are attracted to fashion apparel and buy clothes frequently were chosen for the second interview. Five of the participants were not selected because of the frequency of shopping.

4.3 Data Collection

Because of the pandemic in 2020, all the interviews were online. Participants used video calls to communicate with me. With the permission of participants, the interview was recorded and used for data analysis. A semi-structured interview was employed in this study. The structure of this interview was prepared in advance and divided into five sections. The typical time for an interview was around 30 minutes. However, four of them used significantly more than 30 minutes, and one of them only used 16 minutes.

During the interview, the first part was warm-up questions designed to make participants feel comfortable sharing their thoughts. Also, I asked some demographic questions to have a better understanding of the interviewees' backgrounds. I encouraged interviewees to share their clothes-related experiences in the past and their shopping habits in the second part. The questions in this section were open-ended. I only guided participants by encouraging them to talk about their related stories. Section three focused on customers' decisions between online shopping and in-store shopping. Do they have any personal preference for shopping channels, and why? Participants shared their online shopping and in-store shopping experiences. They talked about their attitude toward these two channels. In the fourth part, the questions are about their story

before shopping, such as shopping motivation. Those questions helped me understand the stimulations that lead people to decide to shop. Also, the inspirations for online and in-store shopping could be different. For example, people who care about fashion apparel may read fashion websites and magazines. The method of fashion news communication is also included in this part. Generally, the activities before shopping are all asked here.

In contrast to the before shopping experience, the fifth part is about the post-shopping experience. Post-shopping service is always a critical factor in the shopping experience. As mentioned in chapter 2, with the resurgence of vintage, the phenomenon of reselling has become more popular. Not all customers buy clothes to wear. Based on my observation, buying clothes as collections or reselling for money are also popular choices. While none of my interviews suggested this behavior, these uncommon customer behaviors and thoughts are worth studying.

4.4 Data Analysis

The primary data acquired from the interview is in the video record and notes. Because I was the only interviewer, the notes are somewhat limited. The very first step is to convert voice records to short-term notes. In this part, I cleaned the collected data, kept meaningful sentences, and categorized the qualitative data into the below chart.

I sorted all the insights and comments into appropriate areas, and there are three stages (pre-shopping, shopping, and post-shopping) in the chart (figure 2). Each step contains three colorful columns. The green column describes positive experiences, the yellow column is for neutral experiences, and the red is for negative experiences.

Stages	Pre-shopping			Shopping			Post-shopping		
Comments	Find favorite items. The items you have watched for a long time, finally going to release.	Read fashion magazines and news. Before going to the cinema, shop around in-store. A friend told you the news about the fashion item. Discuss with friends whether to buy an item.	Your favorite items are not sold in your town. You miss an item release and it's already out of stock. Nobody can go shopping with you. Your favorite brand doesn't have a store in your town.	Quick delivery from online shopping Identify the clothes from the new and buy it right away. The servicer helps you find the item you want in-store. Online purchase and offline pick up immediately. Enjoy the fancy technology including in the shopping process. Get service immediately when I need help. Purchased limited-edition items. Purchased desired items at a lower price.	The servicer helps you find the item you want in-store. The store always indicates what coupon you can use right now.	Get a wrong size from online shopping. Misunderstand the texture of the clothes. Wait a long time to get the clothes. The in-store has a long line to try clothes and purchase. Can't find the right size or rightsize is out of stock. Find something interesting online, but find it's already sold out in-store. Meet some problem, but can't find service to help me. Wait for a long line, but sold out right before you.	Enjoy the clothes and share with friends. Resell items and earn more money. The clothes I purchased match well with my other clothes. My friend compliments my new dress.	The store offers a lookbook to guild customers match their new clothes. Some stores still care about my wearing experience a long time after my purchase.	Always forget the clothes in cabinet Always forget the clothes in cabinet Wait a long time to get the refund. Too busy to return the clothes and it's expired. Bought new clothes but the weather is not suitable for wearing. Today's outfits are not suitable for today's weather. My friend said that new clothes don't look good.

Figure 2. Experience Analysis

4.5 Findings and Limitation

After analyzing the data from the previous interviews, I found the following problems mentioned by many participants.

Online:

- Buying the wrong size
- Clothes matching
- Arrange clothes
- Long delivery process
- Limited release items purchase

Offline:

- Finding items
- Long checkout wait times
- Clothes matching
- Waiting for purchase limited release items
- Bad service

These problems are the most common issues mentioned by the interviewees. After re-sorting and consideration, some of them became the goals of this design. The interview data also helped the designer clarify the target users and build a persona in chapter 6.

This study happened during the height of the COVID pandemic, which caused many limitations to the research. Face-to-face interviews had to be changed to an online video. Usually, researchers try to include eye interaction and small talk in the interview. Therefore, interviewers are in a different situation that is not always suitable for their idea expression. Also, because of the unavoidable internet connection problem, sometimes information was lost. Participants become less patient and less focused in this environment. Based on the study of micro-expression in interviews (Luciew, Mulkern, & Punako, 2011) from David Luciew, Janet Mulkern, and Ronald Punako, micro-expressions like movements of the face, hands, or body provide information to researchers (Finding the Truth: Interview and Interrogation Training

Simulations). In video conferences, only the face is shown on the screen. Significant information could be missed in this modality.

User research is the most critical phase to understand the target users. The understanding of users has the most impact on the success of the design. I spent notable effort on this phase in trying to discover users' needs. The findings in the user research gave my design a clear target (focus on the post-shopping wearing experience) that will be introduced in Chapter 6.

CHAPTER 5 MARKET ANALYSIS

This chapter introduces the current products and services related to fashion shopping in the market. The primary purpose is to understand the strengths and weaknesses of existing products in the market. Also, the goal is to learn from their strengths and improve on their weakness. This chapter is divided into existing products, existing services, and new technology in this area.

5.1. Current Products in Market

5.1.1   Official websites and apps
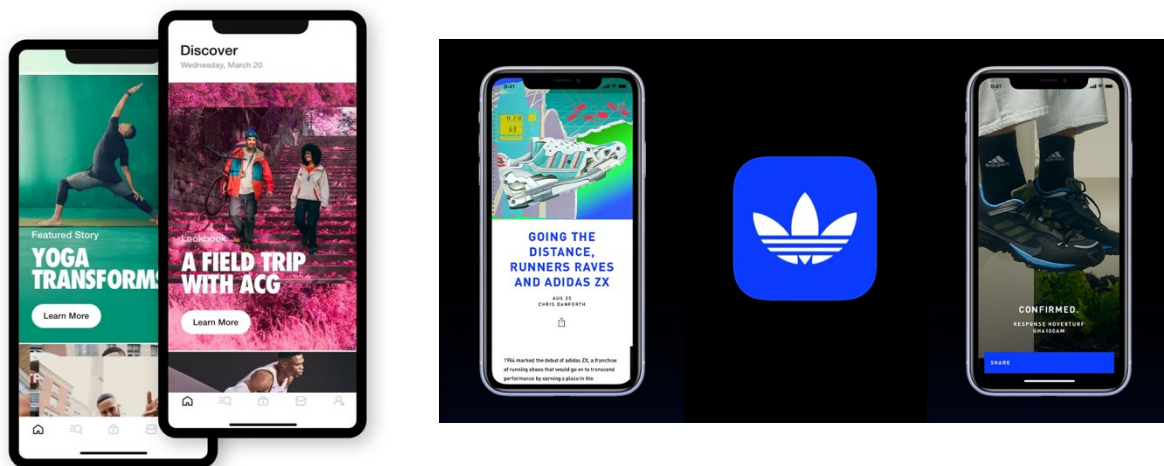
Figure 3. Official App from Nike(*Nike. Just Do It*, 2021) and Adidas(*Adidas® Official Website US | Sporting Goods*, 2021)

As mentioned in chapter 2, internet connectivity allows brands to build their online stores. Some brands like Nike, Adidas, and ZARA even have apps, which would enable their customers to go shopping anywhere. Applications and websites have almost become a necessary condition for brand development. The main reason is that the official website and apps are cheaper than advanced technology like AR, but websites and apps can bring considerable profits to the company. Since the website and app's technics have been developed for a long time, the

operation and maintenance methods are mature. Most brands' websites and apps are not very different, and some have even used the same framework. However, the changeless mode also has weaknesses. Customers complain that the brands have various size standards, and they cannot touch real clothes on websites or apps.

5.1.2　Fashion retail platform

Brand-based fashion shopping platforms aim to offer customers a retail platform for purchasing various brands' clothes in one place. Alternative platforms like Farfetch, END Clothes, and Urban Outfitters are not official brand websites or apps that only sell their clothes. Instead, they select clothes from different brands and sell them to customers. Most fashion shopping apps do not produce clothes. Most of the effort had been made on clothes selection and marketing. Those fashion shopping platforms are also different from Amazon and Alibaba. Who only offer a platform, and brand owners need to manage and maintain their stores and decide what to sell. However, fashion shopping platforms like Farfetch and END Clothes need to operate the whole platform and determine which brands and clothes to sell.

5.1.3　Fashion style apps

Unlike fashion shopping platforms, fashion style applications like "Stylebook" focus on helping users build outfits. Most fashion style products do not spend much effort on clothes selling. Their primary function is to help users make beautiful styles. I carefully studied Stylebook and consider it as the closest competitive product to my final design direction. My analysis of Stylebook is in chapter 5.3. Competitive product analysis.

5.1.4　Resell apps

Because of the desire for second-hand clothing items, some resell apps have become popular. This market could be divided into two groups (low-price resell and high price resell). As the name shows, the low-price resell indicates the reselling price is lower than the original price. Users will share their lightly worn apparel that is somewhat worn but still wearable. Clothes owners sell old clothes that they do not wear anymore and earn some money. High-price reselling means limited and valuable items resell at a price higher than the original price. Those

items are usually only released in a limited quantity, and only a small group of lucky customers can get access to buy them. Many other subordinate functions are designed to support the selling activity, like authentication in StockX and Goat. Those resell products have similar target users with official websites and apps. However, these are not competitive products because they focus on different needs.

5.2. New Technology Applied to Apparel Industry

The occurrence of new technology often leads to a revolution in the industry. Internet development has opened up new technology like AR (Augmented reality) and big data in the clothes industry.

5.2.1 AR (Augmented Reality)

As introduced in the previous chapter, not being able to try clothes is a big problem for online shopping. Thanks to the technology of AR, customers can try clothes virtually with a camera. Nike and Goat have already tried this technology in their app. These shoe selling applications provide an easy way to try new shoes. Compared with the AR feature for clothes, the AR proper function is easier to achieve with shoes because feet are easy to capture on camera.
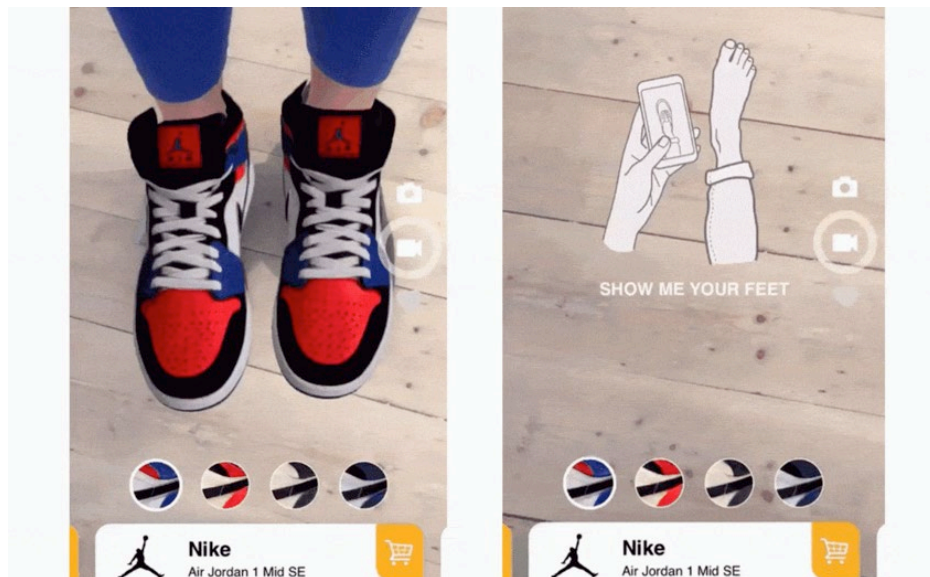
Figure 4. Nike's AR function(*Nike. Just Do It*, 2021)

5.2.2 Data-driven applications

We are living in an era of information explosion. Brands record customers' every action as data. With this data, brands can offer more targeted advertisements. As discussed in Chapter 2, fast fashion relies on big data to quickly respond to customers' new tastes and trends. Fast fashion brands will manufacture their clothes based on the data, which reduces the possibility of no one will buy their clothes.

5.2.3 Systematic fashion service

Despite having the benefit of the internet, this business empire's rise comes primarily from business strategy. These companies focus on service and have reformed the traditional shopping model by selling a clothes subscription box that offers their customer a box of new clothes monthly. Customers keep what they want and return the rest. Professional stylists pick those clothes for customers based on the data of their character and preference. This service benefits customers who are busy and want put-together outfits. However, this reduces the shopping experience for those customers. Therefore, the target users for clothes boxes often do not like clothes shopping or are too busy to spend time shopping. The best analogy is the difference between shopping at a full-service clothing store that offers knowledgeable and professional clerks vs. self-service shopping clothing stores where the customer selects their clothes, and then the clerk takes payment.

5.3 Competitive Product Analysis

According to my primary research and secondary research, I finally designed my app to help users select daily outfits and shop more reasonably. Therefore, the immediate need for customers after shopping is to style themselves with their clothes. My app will be one of the fashion style apps, as mentioned in chapter 5.1.3 Fashion style apps. Based on my research, I found Stylebook (*Stylebook Closet App*, n.d.) is a typical fashion style app with an original design concept. This design concept corresponds to the result of my research. I analyzed the Stylebook in detail, summarized the strength and weaknesses, then tried to address those problems with my design.

Stylebook has ten functions: look, closet, packing lists, calendar, style stats, shopping, size tracker, style expert, inspiration library, and Wifi share. Generally, I group Stylebook's function into four categories. The first one is a style helper that helps users build their outfits. Secondly, it allows users to record their own clothes' and what they wear every day. The third function is a shopping helper that helps customers with selecting sizes and a shop browser. The last one is a style adviser that teaches customers how to build a style.
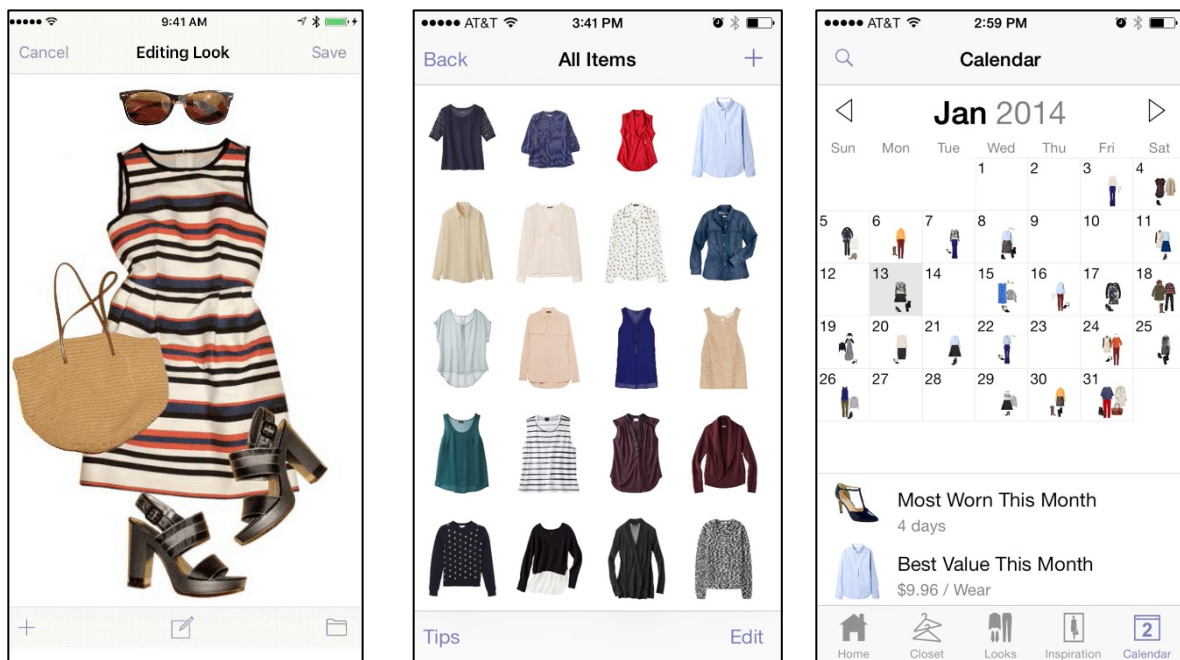
Figure 5 Stylebook's Styling Outfit Function

Building outfits with the clothes users currently have Stylebook's primary function, and it is also my primary design concept. To achieve this goal, I found there are many opportunities to improve from Stylebook. I analyzed Stylebook's styling process and found some weaknesses:

1. Stylebook focuses on the clothes themselves rather than users. Even with the same clothes, different people should show different results. The user's body characteristics and preferred style need to be considered.

2. For teaching styling skills, only offering style guide articles is not enough. Users need to practice and experiment more to effectively learn styling methods from the articles.

3. Stylebook does record some users wearing data. However, Stylebook does not take advantage of the data. There are many opportunities that should be employed to help users.

Generally, Stylebook accurately removes many of the pain points of users in styling outfits. I learned the shortcomings and advantages of the Stylebook to design my product's styling function. Also, I suggest employing more advanced technology to improve the design and include a shopping helper function to enhance the experience and help users more.

By analyzing peer products in the current market, I narrowed my target area and found the best competitive products. The strengths and weaknesses of these peer products inspiring and helping me design the final concept.

6. DESIGN PROCESS

This section introduces the design process and the outcome of this design. As mentioned in Chapter 3, I employed the double diamond design process. The entire design process can be divided into two diamonds. The first diamonds introduce the process of condensing a general topic to a specific design goal. The user research and market research are parts of the first diamonds. The second diamond describes the process of building a feasible design concept from the design goal. Finally, it is necessary to make a generative design. Within this generic design frame, user experience design theory and user-centered design principles help to build the design concept and refine it with potential users. Some design tools like card sorting, KANO frame, storyboarding, HTA chart, and wireframe were used to clarify my design concept. In the last part of this chapter, I present the outcome of this design: the "Closet Go" app and clip camera.

6.1 Problem Identification

After long-term research in Chapter 2 and Chapter 4, I analyzed data from potential users and other research papers. The goal of problem identification is to set a clear target for my design. Corresponding to the double diamond frame, problem identification is in the first phase of becoming more specific. The information obtained during the first expansion phase is overwhelming. A design cannot fix every problem and nor work for all customers. This phase helps the designer find a critical point for the design focus and solution.

Shopping is a lengthy process, from the emergence of shopping intention to the contact with the attire to purchase. In different stages of shopping, customers have various problems. The information collected during user research is categorized into a chart in Figure 6. It is easy to tell that most of the issues are in the shopping process. This result also echoes the market research — most products in the market focus on the shopping process. Most products target pre-shopping and shopping because brands want to attract customers to purchase their items. Of course, brands need to offer service to build friendly relationships with customers even before customers have a shopping intention. They provide help to customers in shopping and purchasing more conveniently. However, only a limited number of products focus on the post-shopping

experience, as seen in Figure 7. The reality is that post-shopping is even more important than the shopping experience for customers because, for customers, the goal of shopping is to wear the clothes. For this reason, I narrowed my topic down to the post-shopping experience.

Pre-shopping

Can't find the intended items

Find an item in the lookbook but forgot later

Receive tons of useless "on-sale" ads but miss the one really need

Can't find an official physical store in the city

Forgot release date

Search item in the new season.

Shopping

Find the cheapest prices from different stores.

Wait a long line to purchase and come into the fitting room.

Locate a specific item in-store.

Didn't wear suitable clothes to match the desired items.

Want to share the look of my clothes with my friends online

Spend a lot of time and energy to buy limited goods, but in the end, didn't get it.

Size is different in brands

Don't know if I have similar clothes or not.

Post-shopping

I don't know how to match the new item with the clothes I currently own.

It is difficult to find the clothes you want in various wardrobes and boxes

Old clothes disposal

Clothes Resell

The returning process is complex

Figure 6. Problem Identification

Pre-shopping　　　Shopping　　　Post-shopping

Official App
In-Store Table
Apparel Service
Concept Stores
Social Media
Resell App
My Thesis
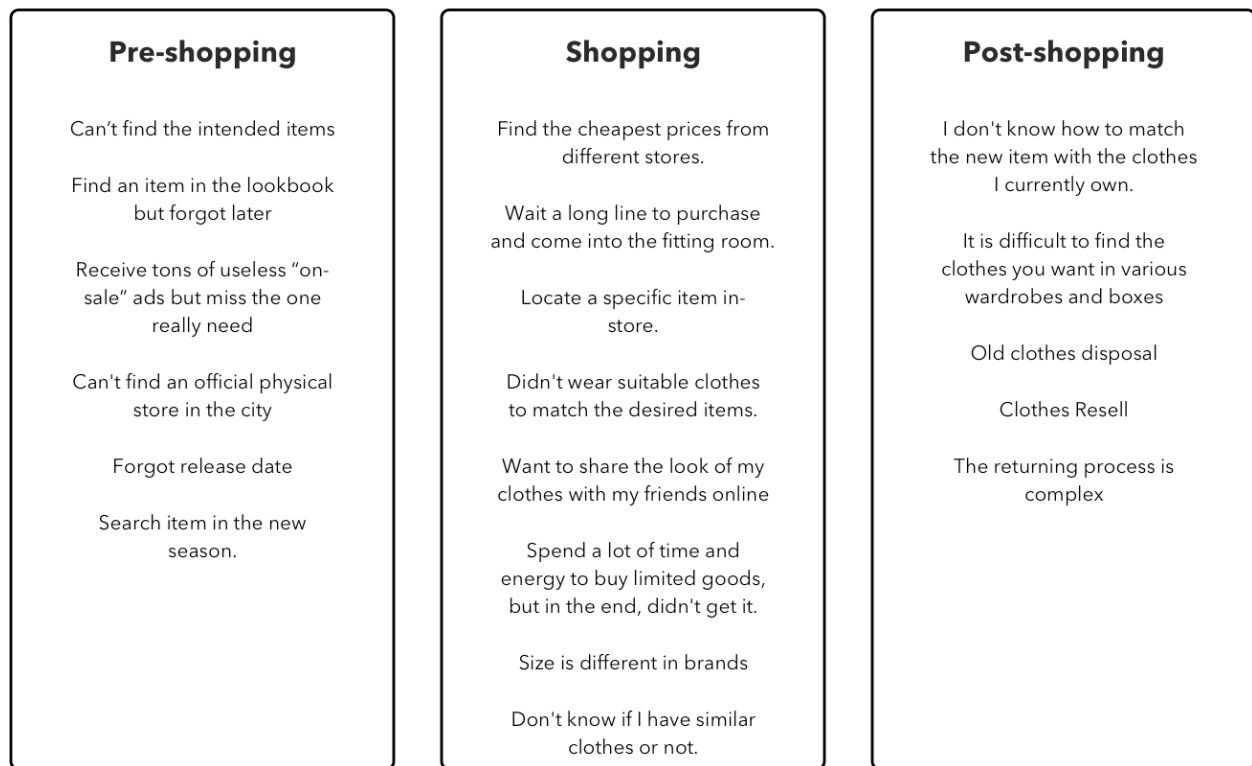
Figure 7. Problem Stages

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After reorganizing the collected data, I found the post-shopping problems are all concentrated in three parts: clothes matching, regret shopping, and closet management.

6.1.1 Clothes matching

Based on the interviews in Chapter 4, most fashion customers care about their outfits. They love fashion and pay for fashion. Of course, they want to have satisfactory outfits. However, the reality does not always make them satisfied. After you have purchased clothes in a store, information about how to match them is not available. It is like buying a machine without a manual. Some brands do offer some lookbooks. However, the lookbooks' clothes are all from a specific brand, and the customer does not possess most of them. It means if you want to have a good outfit like the models in the lookbooks, you need to purchase more from this brand. This problem did leads to some negative experiences. Sometimes customers purchased clothes but could not find suitable clothes in the wardrobe to match them. Therefore they have clothes in the closet that are not being worn because they have nothing to compare. It can be time-consuming to build suitable outfits. Instead of showing customers which items match well with other things they do not own, customers should know how to match clothes with ones they already own. Only in this way can customers build beautiful outfits with their items in the wardrobe. Gradually, they will have a unique fashion style and not just copy lookbook-matched outfits from one brand.

6.1.2 Regret shopping

Regret in shopping is a common feeling which has happened to almost every customer. Based on research, this feeling is caused for several reasons. Customers' emotions play a significant role in decision-making when shopping (Flavián-Blanco, Gurrea-Sarasa, & Orus-Sanclemente, 2011). Emotion is easily affected and can change in some environments, which may cause regret. Other than customers' reasons, the disconfirmation of information quality, shopping system quality, and the system quality may lead to regret (Liao, Liu, To, & Lin, 2011). This disconfirmation may come from the customer's misunderstanding or merchants deliberately being misleading. From exaggerated advertisements, customers may purchase items they do not need or already own. These studies, to some extent, prove the problems mentioned in the interview in Chapter 4. As mentioned in interviews, sometimes interviewees purchased clothes just because they are on sale

or those clothes have limited availability. If customers do not purchase right now, they may lose the opportunity to purchase. So, at this moment, customers are emotional and cannot make a rational decision. After a while, they will realize they do not need those items and may regret the purchase. Apart from this, some interviewees said they make poor decisions because of merchants' misleading information. The brands said their commodity is on sale. However, the price is no different from the regular price.

6.1.3   Closet management

The "management" here can be physically organizing clothes in your closet, or it can be abstract by understanding what you have in your closet and how to dispose of clothes. Our potential users who like fashion shopping have lots of clothes at home. Sometimes they found some expensive clothes that have not been worn for a long time and do not know how to deal with them. These clothes are still wearable, and the original price was expensive. Also, sometimes customers purchase the same type of clothes and forget they have similar garments at home.

Based on these three main problems, I planned to design a system that could help users manage their clothes wardrobe virtually. With this system, users can know how to match clothes in the wardrobe. With a digitalized closet, users can see the condition of clothes easily and make wise disposal choices. Also, I hope to encourage users to each other, no matter in clothes matching or shopping consultation. Customers should listen to other customers' voices rather than believe the brands' advertisements.

Initially, I plan to focus my design on the post-shopping stage. During the research, I found the clothes shopping and dressing are not totally separable. Irrational shopping decisions cause some post-shopping negative experiences. The entire shopping experience needs attention to improve this situation.

6.2 Ideation and Brainstorm

I move to the second expanding phase in the double diamond design frame to solve the problems identified. This phase includes brainstorming to come up with more possibilities. Brainstorming

helps designers come up with a variety of concepts that are used in the ideation phase. Those ideas are not all feasible, but those ideas expand design directions and help designers think profoundly from different perspectives. After detailed comparison and analysis and talking with potential users, one option became clear.

Facing massive design decisions, I decided to employ the card sort method to help with these decisions. Card sort is a famous UX design method to understand the importance of different functions to users. I invited five potential users from the first user research group to join a card sorting activity. Potential users sort brainstormed features from most to least helpful. After calculating the results, I divided design concepts into three levels. The first ones are the necessary functions that are mandatory for the application, i.e., those aiming to solve the most critical problems and those that users think are beneficial. The secondary functions are desired for the application, i.e., those functions that support the necessary functions and make necessary functions complete and adequate. The third functions are valuable functions. Those functions are helpful but not necessary.

If further divided, each of these according to their usage time with color-coding in the KANO frame as seen in Figure 8 further below. Red represents daily dressing-related functions, blue represents shopping-related functions, and yellow represents social-related functions. To keep the app clean and organized, I will not include all the functions from the desired functions and the helpful functions. I chose functions based on the KANO frame in Figure 8 and created the function list below:

- Clothes digitizing
- VR fitting room
- Clothes wear history
- Online items search
- Daily match suggestion
- Clothes update suggestions
- Chatting about one item
- Match picture sharing
- Shopping helper

: Daily wearing related function

: Shopping-related functions

: Social-related functions

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Necessary functions

Clothes information record

Record your clothes information every time you purchase clothes.

Record what clothes you wear every day

Communicate in social media with your personal figure.

VR fitting at home

Try new clothes with VR mirror.

Wearing history demonstrate

Demonstrate your dressing preference.

Demonstrate what you dressing activities within a period of time.

Give you a report of dressing activities after a period of time.

Search an item online

Know how other people think about it.

Know how other people who have purchased feel about it.

Know the detailed data about this item.

Check this item in other customers' pictures.

Daily wear suggestion

Give you suggestions based on the weather.

Give you suggestions based on your recent dressing activities.

Give you suggestions based on today's activity.

AR fitting in store

When you want to try on clothes in the store, let you match with different clothes. Even they are not here.

Desired functions

Old clothes disposal suggestion

Give you some reminders when some clothes that are not always worn.

Help you resell your old items.

Give you some match suggestion for some clothes that are not always worn.

Talking about a specific item

Communicate with users about a certain piece of clothing.

Dressing reminder

Double-check the clothes you have worn, and give some warnings if it's not suitable.

Repeatability check

When you search for some items, you can see if it fit with your current clothes or not.

Check if it is too similar to the clothes you already have.

Check if you have too many clothes in this category

Shopping reminder

remind you to go shopping when we found the clothes are not enough for the weather.

Helpful functions

Find a nearby store with stock

When you are interested in purchasing an item, help you find the closest store.

Check the stock in different stores.

Share your clothes in social media

Share the clothes you just bought.

Share outfits.

Share shopping experience and feeling.

Learning clothes match skills

Learn clothing matching skills from other users poster.

Post your matching picture and communicate with others.

Learn from the system smart suggestions.

Clothes wash reminder

Remind you to wash clothes when they have been worn enough times.

Shopping suggestion from other users

Encounter problems in shopping, ask other users for help.

Try clothes match in the app

Allows you to match clothes in the app with your clothes and the clothes you want to buy.

AR body measurement

Measure data on different parts of the body.

Personal virtual figure

Create a cartoon character based on your body.

The character help you try clothes and demonstrate clothes

Figure 8. KANO Frame

6.3 HTA Chart

Hierarchical task analysis (HTA) usually appears in user experience designs as a design method to understand an application's structure and track how users behave (Stanton, 2006). This method organizes the application's structure and distributes assignments to each page. After deciding the essential functions, I began building the app's main structure. The HTA chart is helpful because every application is made up of several small sections. For UX design, the sections should be rational and balanced. In "Closet Go," the most common scenario is that the users input their clothes, build outfits with those clothes, choose companies every morning, browse others' posts, and purchase items in others' posts. This scenario is also described in the following HTA chart in Figure 9 as the app's main storyline. After this, other HTA charts will describe users' procedures for finishing each assignment.
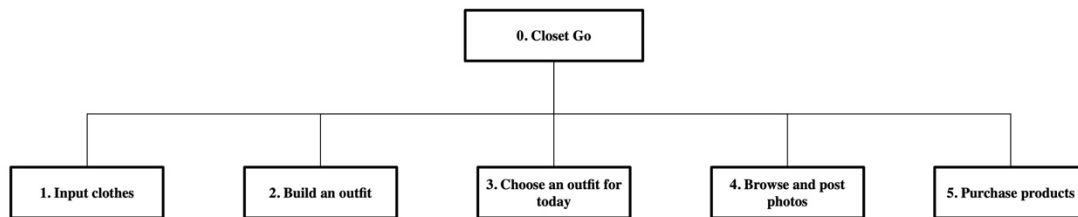

Figure 9. Main HTA Chart

In Figure 10, the main goal for task 1 is to input all user's clothes into the "Closet Go" app. First, to achieve this goal, users need to find the "input" button and click it. And then, users need to choose input options. In "Closet Go," there are five different methods to input clothes that users can choose based on their current situation. Various ways were designed for different needs and make the process of inputting convenient. As mentioned in 1.2.1~1.2.5, users can input clothes by scanning the barcode on new clothes, choosing an online confirmation email, using the camera to take a picture to innovative identity, creating a new item by themselves, or searching the clothes name online. After choosing each option, users can follow the instruction to finish the task.
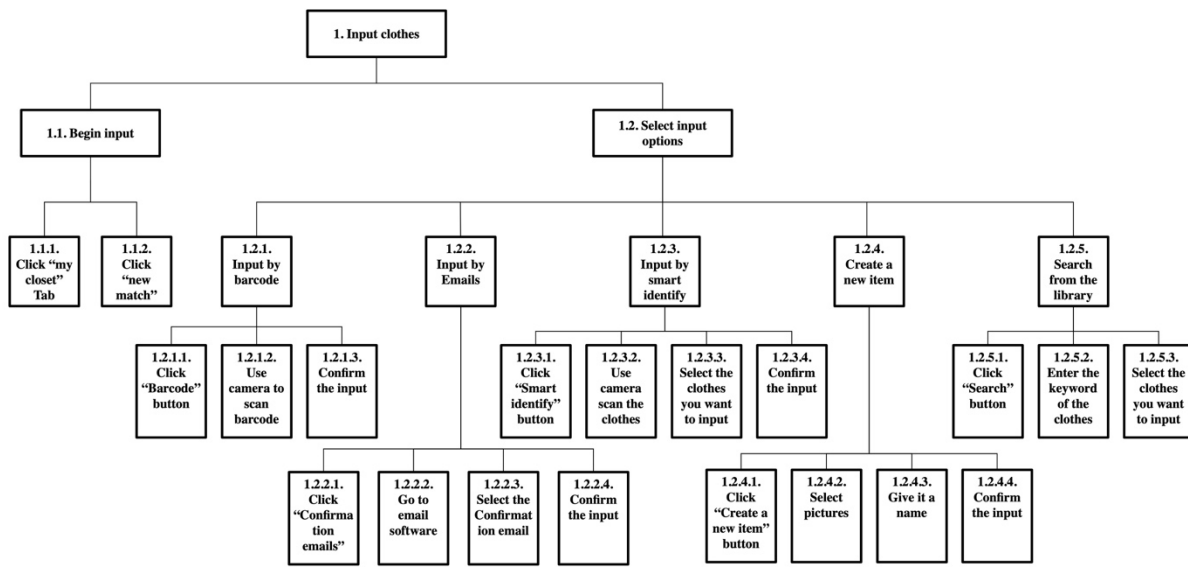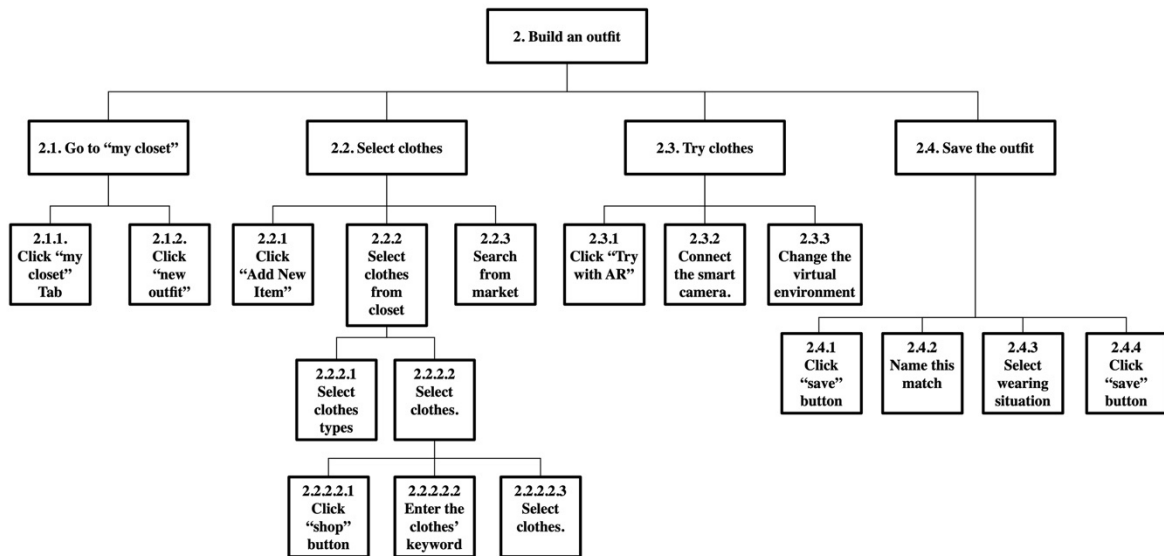
Figure 10. HTA Chart Task1: Input Clothes

1. Input clothes

- 1.1. Begin input
  - 1.1.1. Click "my closet" Tab
  - 1.1.2. Click "new match"
- 1.2. Select input options
  - 1.2.1. Input by barcode
    - 1.2.1.1. Click "Barcode" button
    - 1.2.1.2. Use camera to scan barcode
    - 1.2.1.3. Confirm the input
  - 1.2.2. Input by Emails
    - 1.2.2.1. Click "Confirmation emails"
    - 1.2.2.2. Go to email software
    - 1.2.2.3. Select the Confirmation email
    - 1.2.2.4. Confirm the input
  - 1.2.3. Input by smart identify
    - 1.2.3.1. Click "Smart identify" button
    - 1.2.3.2. Use camera scan the clothes
    - 1.2.3.3. Select the clothes you want to input
    - 1.2.3.4. Confirm the input
  - 1.2.4. Create a new item
    - 1.2.4.1. Click "Create a new item" button
    - 1.2.4.2. Select pictures
    - 1.2.4.3. Give it a name
    - 1.2.4.4. Confirm the input
  - 1.2.5. Search from the library
    - 1.2.5.1. Click "Search" button
    - 1.2.5.2. Enter the keyword of the clothes
    - 1.2.5.3. Select the clothes you want to input

Figure 11. HTA Chart Task2: Build an Outfit

2. Build an outfit

- 2.1. Go to "my closet"
  - 2.1.1. Click "my closet" Tab
  - 2.1.2. Click "new outfit"
- 2.2. Select clothes
  - 2.2.1 Click "Add New Item"
  - 2.2.2 Select clothes from closet
    - 2.2.2.1 Select clothes types
    - 2.2.2.2 Select clothes.
      - 2.2.2.2.1 Click "shop" button
      - 2.2.2.2.2 Enter the clothes' keyword
      - 2.2.2.2.3 Select clothes.
  - 2.2.3 Search from market
- 2.3. Try clothes
  - 2.3.1 Click "Try with AR"
  - 2.3.2 Connect the smart camera.
  - 2.3.3 Change the virtual environment
- 2.4. Save the outfit
  - 2.4.1 Click "save" button
  - 2.4.2 Name this match
  - 2.4.3 Select wearing situation
  - 2.4.4 Click "save" button

In task 2, users will build outfits with the clothes they have already input. To finish the task, users should go to the "My Closet" page, click the "new" button, select clothes, try this outfit and save it.

Task 3 in Figure 12 describes how users choose the day's outfit. The general sequence is to go to the home page, select outfits, and record what they wear. Users have three ways to select matches: choose directly from the pre-built clothes matches or build a new outfit based on what they wore yesterday. The last step is to record what they wear on the system because that data will help the system better understand the user and give them valuable suggestions.
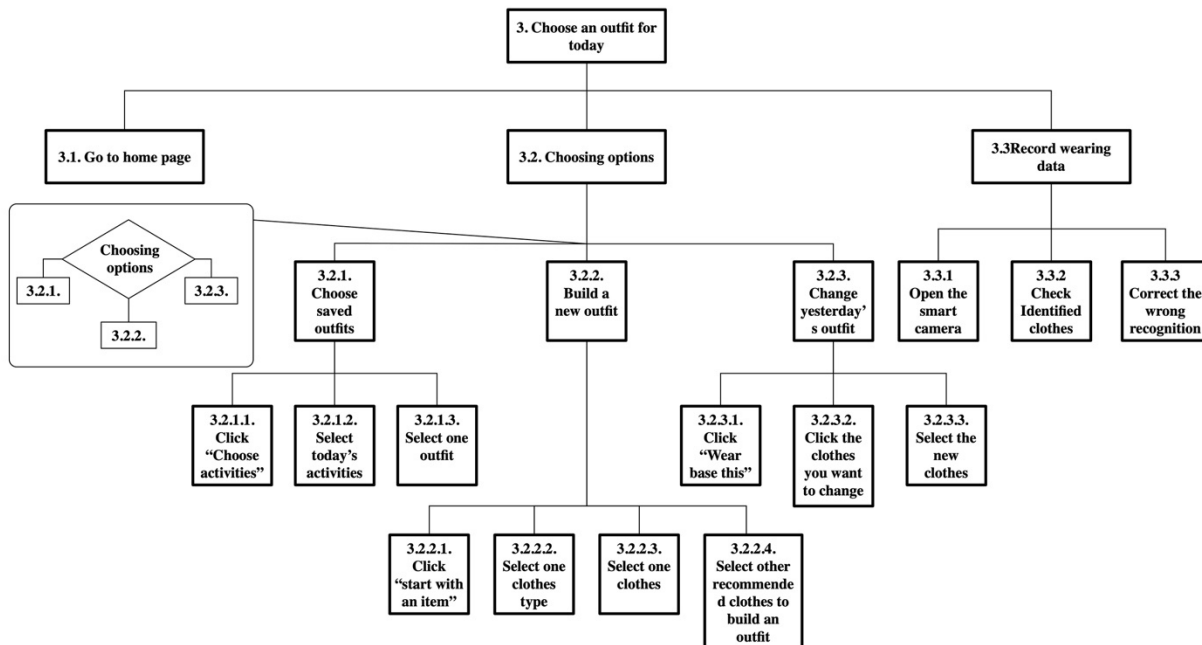

Figure 12. HTA Chart Task 3: Choose an Outfit Today

Task 4 and Task 5 are separate from tasks 1, 2, and 3. In task 4: "browse and post photos," users can post their fashion style pictures and browse other posts. If users are interested in the items showing in other posts, they will jump to task 5 to purchase them.
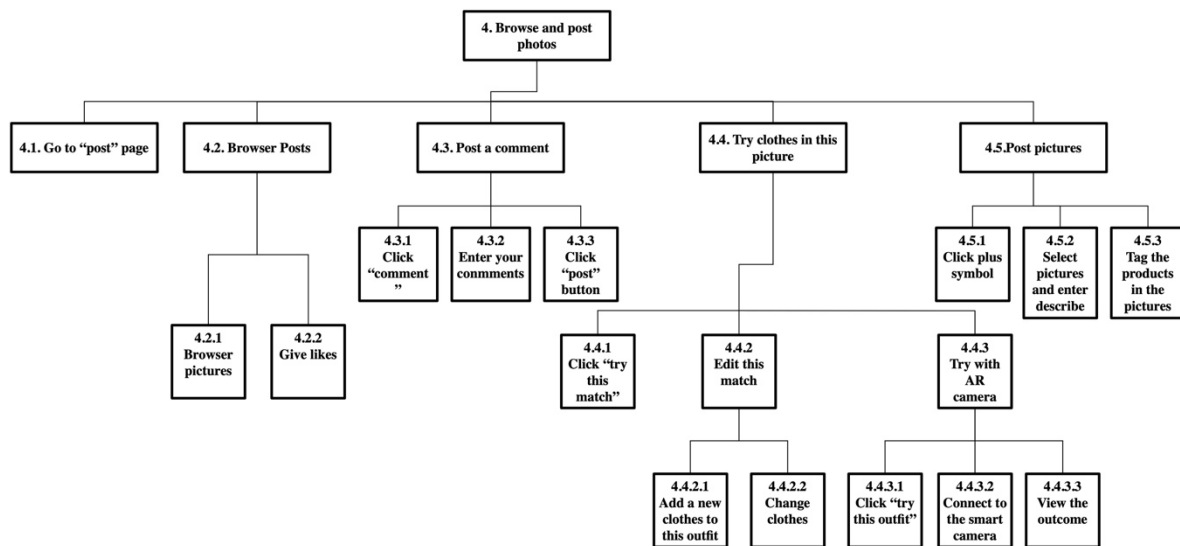
Figure 13. HTA Chart Task4: Browse and Post Photos
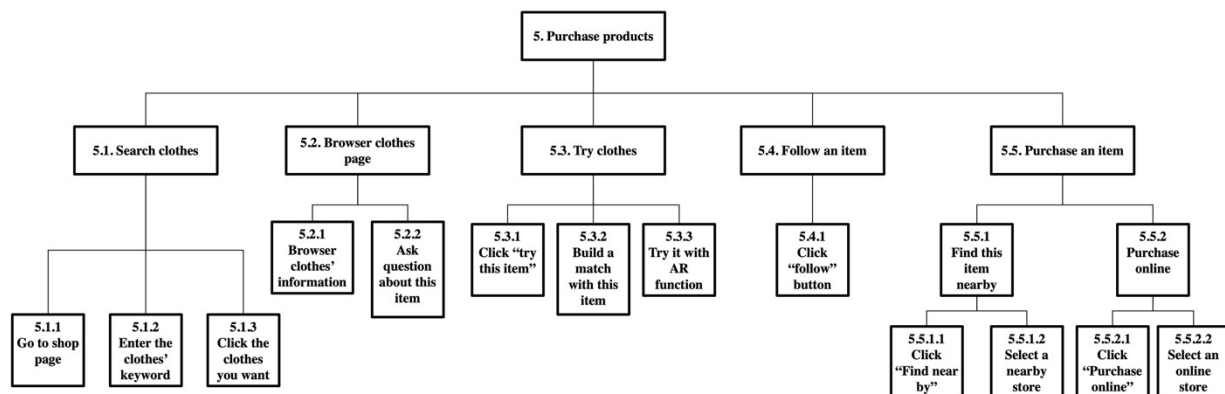
Figure 14. HTA Chart Task 5: Purchase

6.4 Wireframe

After organizing the HTA chart, I put those tasks into specific pages and began designing page components, designing low fidelity user interface: wireframe. The wireframe is a skeletal framework for UI. It depicts the main structure of the core elements and their attributes quickly and efficiently in a wireframe. I achieved all the HTA chart tasks with the element on the pages

during the wireframe design. Wireframes help to display creative design ideas to audiences. There is more than one method to achieve the task. Which one is the best? Designers can utilize wireframes to show ideas and test them with users. Usually, the wireframe is constructed on paper or computers. Drawing on paper can save time, but it is difficult to edit later. A digital wireframe is easy to edit, can be copied and reused later.

During wireframe design, the biggest challenge is designing the circuit and logic behind each page. From the HTA chart, I decided to include four bottom tabs to group pages: Choosing today's outfit page, social sharing page, shopping page, and my closet page. However, I found some subpages will appear in different tabs at the same time. This reuse means various tasks need to share some pages. It makes the circuit more complicated. Also, at this step, I should not only focus on the elements on pages. The relationships between the pages are essential. For each task, I designed the procedures from page to page. For instance, building clothes matches is the most complex task in "Closet Go." To join the clothes matching page, users need to find the right button. And then they need to add clothes one by one. Users should quickly locate the clothes they want to add from maybe hundreds of clothes for each adding. After selecting, the user then adds an environment picture to this match, tries it on, and saves it. All these actions need buttons to control them. Where to locate the button and what will happen after users click buttons are part of the wireframe design. All these processes should be carefully designed to let users operate efficiently.
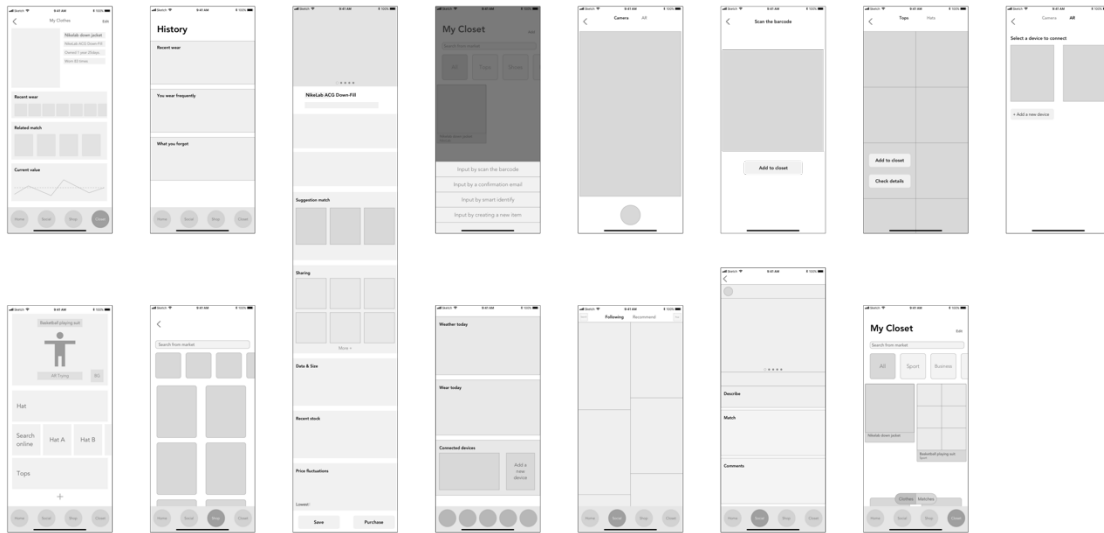
Figure 15. Wireframe

6.5 User Interface

Based on the wireframe, I kept modifying the structure and finally finished the high-fidelity user interface. The high-fidelity user interface is what users see on their phone screen, which is colorful and more detailed than wireframe. Designers need to determine the font type, size, and color usage in the interface.

In "Closet Go," I mainly used black, white, and gold. This limited color pallet was chosen because this is a fashion clothes-related application. There will be many colorful pictures in the application. The color choices will keep the user interface from interfering with the content of the pictures. The color choices also express a feeling of elegance.

Colors

SHAPE UI ELEMENTS

| #DF9957 | #000000 | #F6F6F6 |

Primary Color

FONTS

| #202842 | #000000 | #AEAEAE | #FFFFFF |
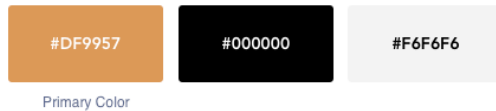
Fonts

Avenir | 24px - regular/bold

Avenir | 18px - regular/semibold/bold

Avenir | 14px - regular/semibold

Avenir | 12px - regular

Avenir | 10px All Caps - semibold

Buttons

Purchase online — 40
180

Try on AR — 40
180

Ask a question — 40
160

Wear base this — 30
110
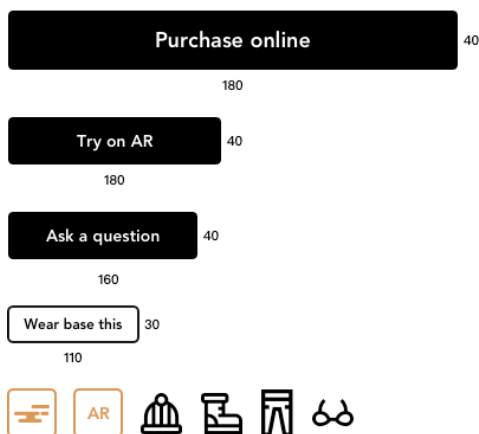
Figure 16. UI Guideline

Among the four bottom bars, "my closet" is not the most used. However, it is the fundamental function. In my closet tab, users can input their clothes and build their clothes matches. That tab shows the number of times the clothes were worn and the users' recent dressing history. My closet tab stores all user's clothes, like a physical closet at home. Users can swipe left or right to switch among matches, favorites, history, and clothes tab. On the matches page, the system displays saved clothes matches and grouped them based on different activities such as "Sports," "Business," "Commute," and "Rainy." Users can also search a match's name directly to locate it. To create a new clothes match, users can hit the button beside the search bar and go to the "new match" page. When users hit a match's picture, it will lead users to the match detail page to edit this match.
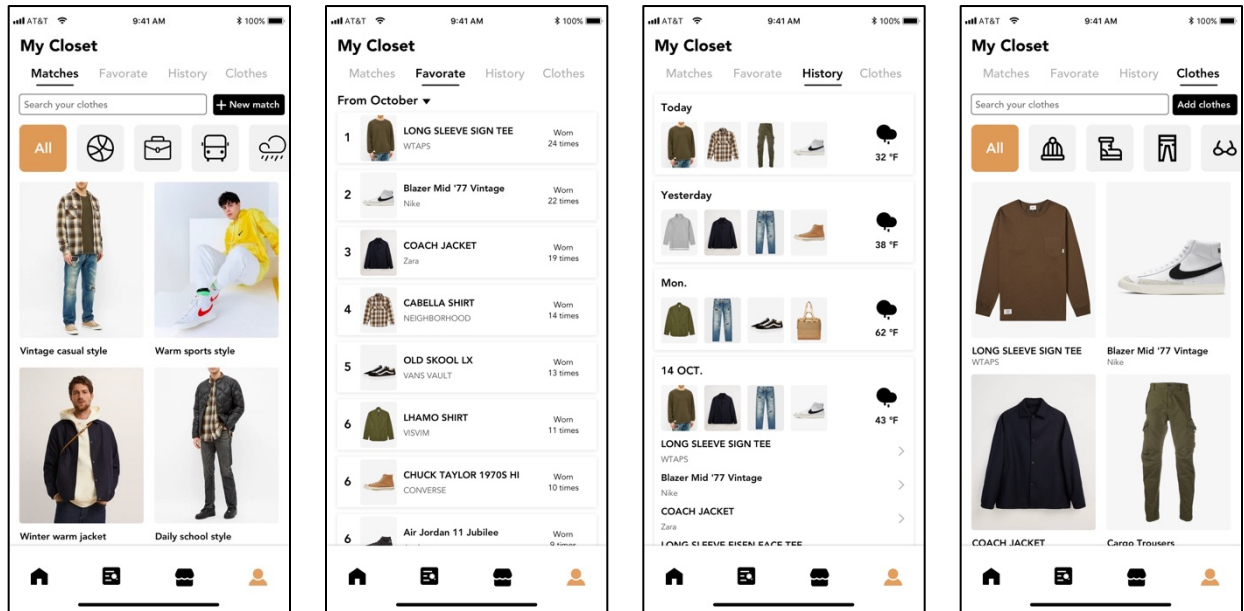
Figure 17. My Closet UI

When users go to the favorites page, there are lists of wear from most to least. Users can also search based on different standards such as a date, this month, this season, or this year. On the "history page," users can view clothes they recently wore and the weather of the day. When the user clicks one row, it will expand to show the details of all the clothes worn on that date. On the "clothes" page, the layout is similar to the "match" page, but all the items here are single clothes. They are also grouped into different categories. Users can click the "add clothes" button to add new clothes in "Closet Go."

One of the primary functions of the app is to help users build an outfit. Users can begin to build a match for various occasions. The most general one is on the "my closet" page. The "matches" tab in the "my closet" pages shows the clothes matches that users have created. Users can also create a new match by clicking the "new matches" button. In the create new matches function, users can build a match by adding clothes they have to it. In the preview window, users can preview the result of this outfit. Also, users can see what they look like in the outfit with the AR function even without physically wearing them. They can create different outfits for different environments. This app allows users to give the preview window a virtual environment to check the outfit carefully. When users add a new item to a match, the system will recommend a suitable

one. This recommendation is based on big data and machine learning. Because of big data, the system knows how most people will match this item. The system knows about the user's preference and taste because of machine learning, which helps the app recommend preferred options.
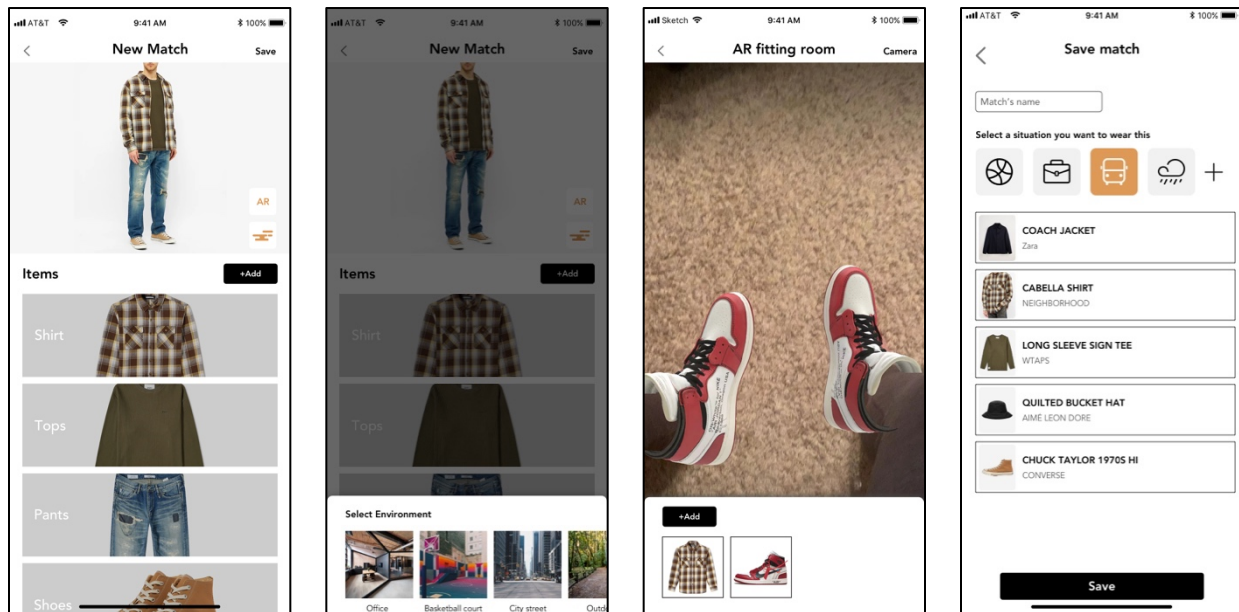

Figure 18. New Match UI

After users finish this match, they can click the "save" button to save it. On the "save match" page, users can view all the clothes included in this match. Users can give this match a name to make it easily searched and then choose the situation for this outfit. Later, users can find this outfit when they want to do a specific activity.

The second occasion is when users want to mimic a match presented in others' poster sharing. The purpose of a designer is to create clothes matches and help the user build better matching skills. When users browse other good outfit ideas, they can follow this pattern and create a similar outfit with their own clothes. In this situation, the user interface layout is similar to building an outfit on the "my closet" page.
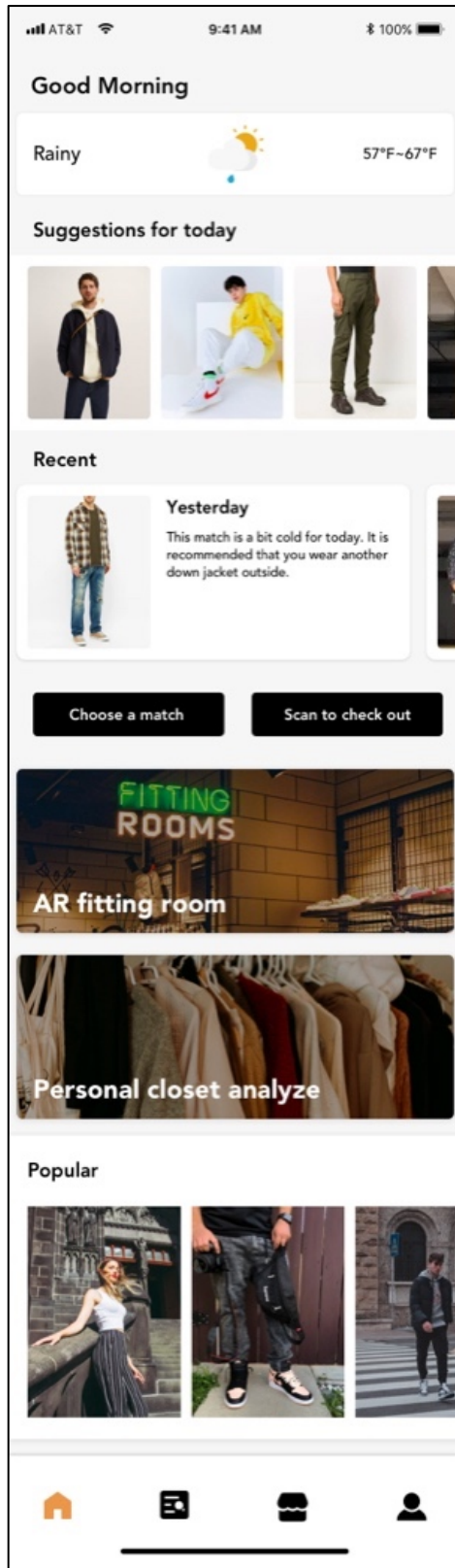
Figure 19. New Match UI

The home page is the most important in "Closet Go," and users will choose the day's outfit here. The top area displays the day's weather to help users select their outfits. The system also gives suggestions based on the weather. On the second part, users can check their recently worn matches. Every day's clothes matches are included in a card and associated with today's wearing suggestions. Swiping the cards, users can access the most recent seven days of clothes matches. Users can choose to keep wearing this match or build today's match based on this match. If users are still not satisfied with current options, they can click the "Choose a match" button to choose a match from the outfit library. By clicking the "Scan to check out button," the "Closet Go" app will connect with a smart clip camera, as explained in Chapter 6.6. The Clip camera is for users who have selected their clothes for the day. By using the camera to record their outfit, the system will be able to offer more recommendations.

After users finish their outfit selection, the content before the "AR fitting room" will disappear. The "AR fitting room" will be the first content on this page. By clicking the "AR fitting room" card, users will go to the AR fitting room to fit clothes virtually. By clicking the " Personal closet analyze" card, users can access a detailed analysis of their closet: how many items in each category, items worn most often, and items not worn for a long time.
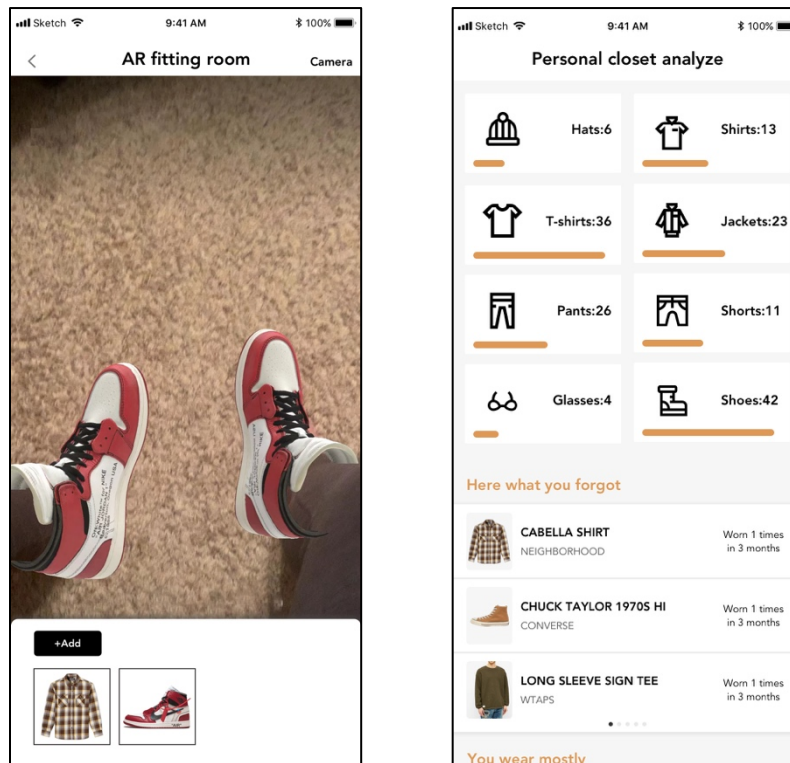
Figure 20. AR Fitting Room and Closet AUI

The second bottom tab is the social platform in "Closet Go." "Closet Go" allows users to share and communicate with other users. They cannot talk directly, but they can chat under a poster or an item page. The poster page can be linked with Instagram. I chose Instagram rather than Facebook and WhatsApp because, in the market research, I found many people sharing their outfits on Instagram. Those people can be "Closet Go" 's target users. When users post a picture in "Closet Go," they can sync this picture to their Instagram account. Users can also keep their relationships with friends on Instagram. On each picture, people will list what they wear in the picture. Other users can then easily chat about this item and mimic their outfits. Users can follow each other's patterns and create their own outfits.

Users can share their outfit style pictures by clicking the plus icon on the right top corner. Under the "following" tab, users can see photos posted by the followed users. The pictures under the "recommend" tab are selected by popularity. Users can also click the magnifier at the top left corner to search photos posted by an author or include a specific item.
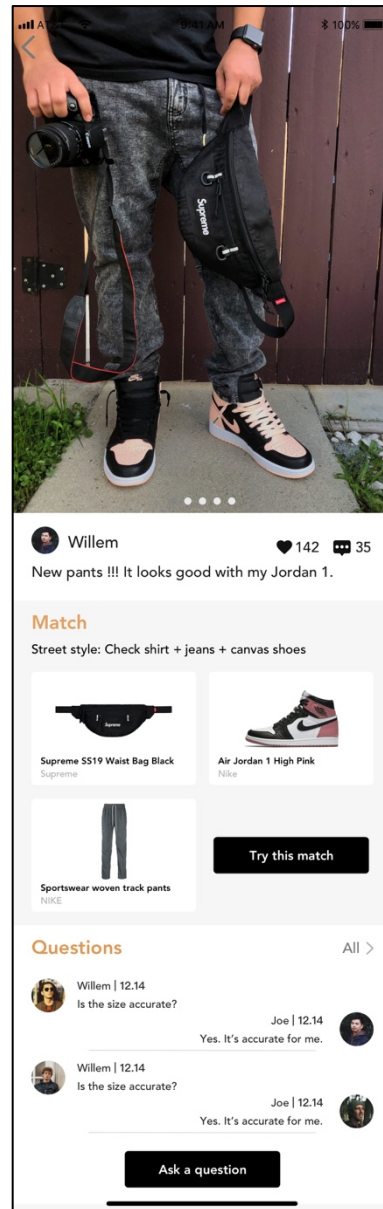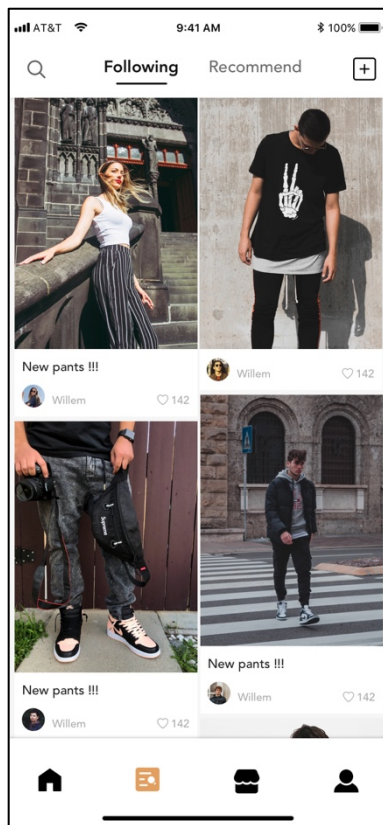
Figure 21. Pictures Sharing Page UI and Pictures Detail Page UI

The third tab at the bottom is the shopping assistant. "Closet Go" does not sell items. However, it helps users shop at low prices to purchase much-needed items. The first area on the shopping page is a search bar that allows users to find an item directly. Below are the items that users are following. The lowest area is a long picture list that suggests popular items to users. By clicking an item picture, users will enter the item detail page. On this page, users can see more photos, price history, official match demonstration, size guide, people's communication about it, and other users' posts, including this item. This information helps users make wise shopping

decisions. At this point, "Closet Go" can help users find a nearby physical store with the item, find an online store with the lowest price, or save the item in the following list to notify users when the price drops.
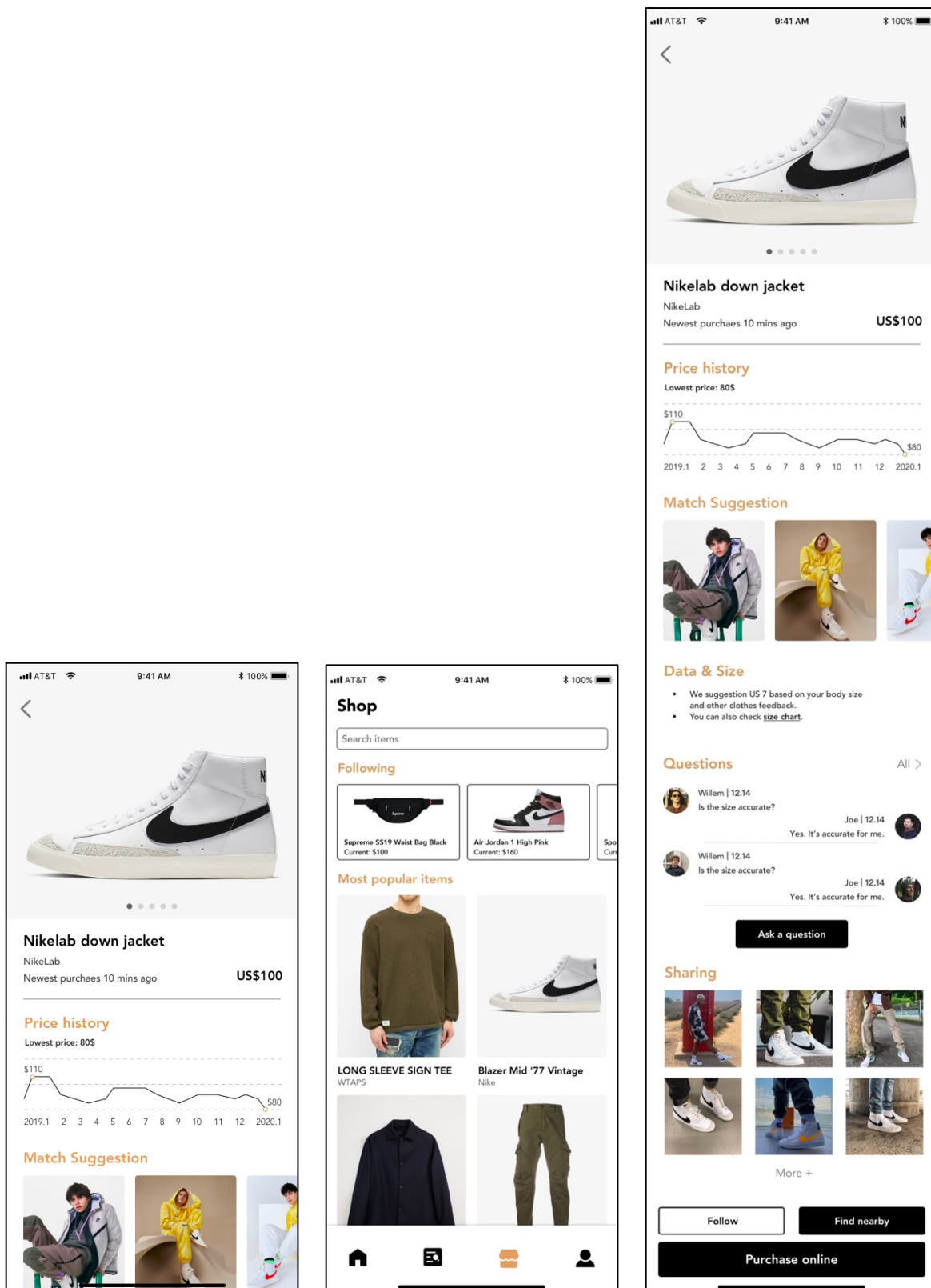
Figure 22. Shopping Page UI

6.6 Physical Product Design

During the design process, I found two negative experiences that are difficult to solve with any new app function. The first one is with using the AR fitting room function because the phone camera is too close to the body because of the limitation of the arm's length. However, the AR fitting room function requires users to shoot their whole body to show users with clothes virtually. At first, I tried having users put their phones on a farther table. The camera can take the entire body, but users cannot see the screen Instantly and modify it based on the screen's pictures. The second negative experience is that every morning when users have selected their outfits for the day, they still need to let the system know what they are wearing. This data is valuable because the system needs to record dressing activities and analyze users' behavior. However, after communicating with potential users, they complained that the process is complex and time-consuming. They were not motivated to finish this task. In this case, I need to design a new approach that takes less time and can record what the user is wearing in the system.

Based on these two situations, I planned to design a physical product that could support the "Closet Go" application and provide users a better experience. The critical function of this product is to have a camera that can shoot your whole body. This camera will smartly identify what users wear every morning, so users do not need to select what they are wearing on the app.

6.6.1   First stage: Interactive mirror

After a series of brainstorming sessions, my first idea was an interactive mirror. The mirror is necessary, especially for potential users who care about their outfits and spend a long time checking in front of the mirror before leaving the house. This mirror has a tiny camera that can achieve the app's requirement of shooting the integral body. Moreover, part of the mirror is made of an interactive screen that is touchable and able to show pictures. With this mirror, users do not even need to use the smartphone anymore. The mirror can be connected to the app, which means all users' pre-saved clothes matches are accessible from the mirror. Every morning users can select today's match in front of the mirror. Users can use the "Closet Go" app to edit and update new clothes matches in their free time. The main strength of the mirror idea is that users don't

need their smartphones every morning. Morning time is frantic for everyone, so selecting clothes on the smart mirror can save more time.

My initial consideration was to make mirrors with interactive screens (see Figure 23). When the mirror screen is off, it serves as a regular mirror. However, considering the manufactory expense, I only built a small part of it as a screen.
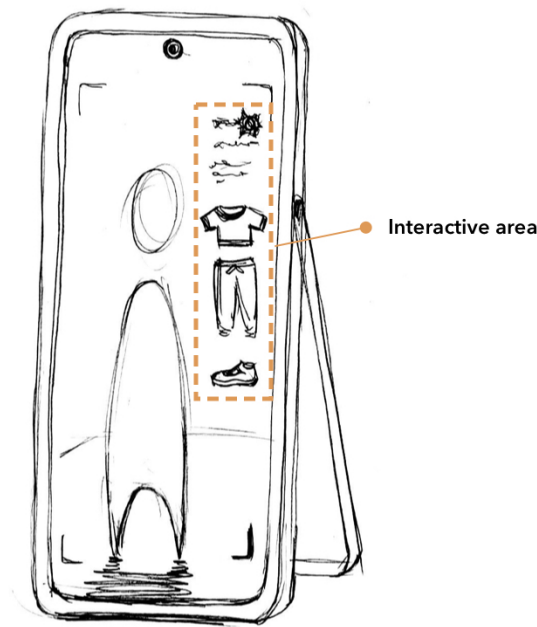

Figure 23. Diagrammatic Sketch for Interactive Mirror

After the first concept, I talked with my potential users and found different families have different situations. Some of them already have a standing dress mirror and do not want to spend more money on a new one. Some of them have a dressing mirror fixed on the closet door or have a bathroom mirror, so they do not need a new standing mirror. After some research, I considered that instead of designing a mirror, maybe I can design a mirror attachment. Because my potential users already have a mirror at home, whether a standing mirror, door mirror, or bathroom mirror, I can design a touchable screen for attaching to their existing mirror. Based on various family conditions, people can connect the screen to various locations to fit their everyday life (see Figure 24).
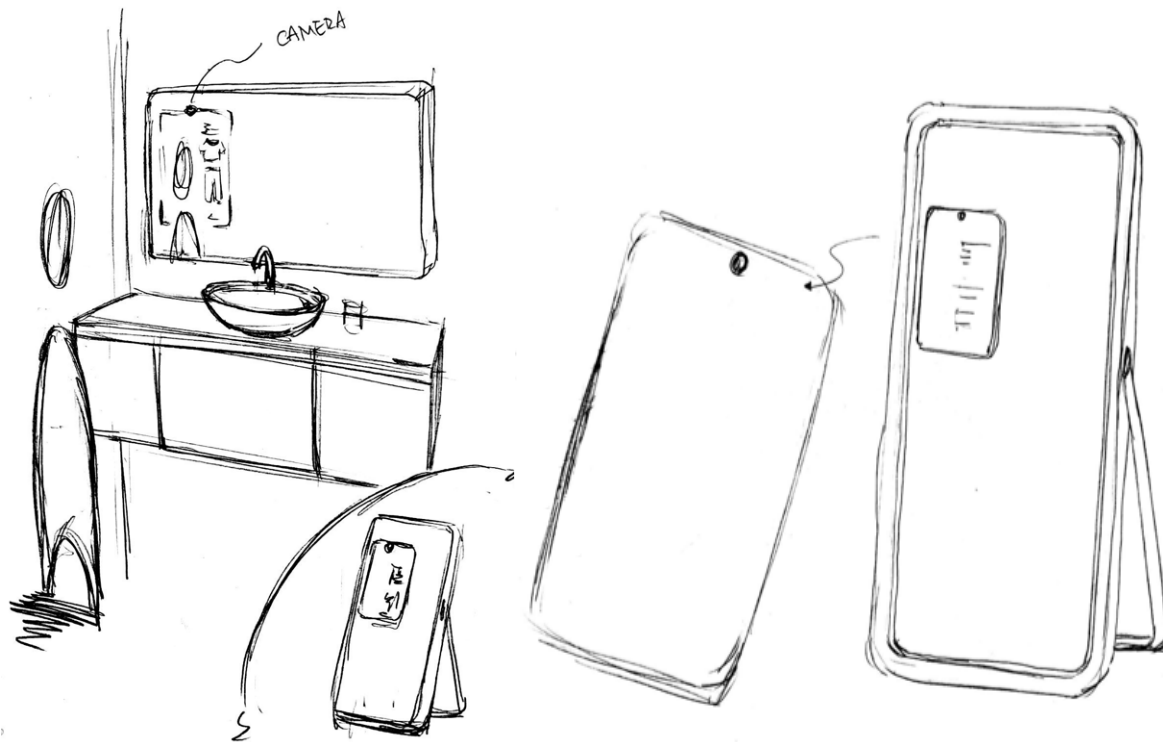
Figure 24. Diagrammatic Sketch for the Attached Screen on a Mirror

In the design process, the main concern is still the cost. The expense of manufacture will be more than hundreds of dollars because of the camera and interactive screen. I am not sure if my users would spend the money on an application-associated product. I tried to cut down costs by replacing the interactive screen that is the most expensive part. I included the gesture interaction method. Since the product already has a camera. It can capture users' gestures. Then, the touchable screen can be replaced by a standard screen.

The other problem I want to solve concerns user privacy. According to the scenario, users will stand in front of the mirror to select today's outfit. If users put the screen on the bedroom's mirror, privacy needs to be taken into account. Users will worry about their bodies being exposed to a camera that is connected to the internet. Other research revealed that people do not trust cameras. They think that the camera steals their privacy, even when the indicator light shows the camera is closed. Hence, I designed a rotatable camera for this screen that can be physically closed by hand. When users want to open the camera, they can rotate the camera to shoot their body by hand. After using, users can rotate the camera to the ceiling. So even the

camera is open, it can capture nothing. This rotatable form can make the camera fit different height people, also. (see Figure 25).
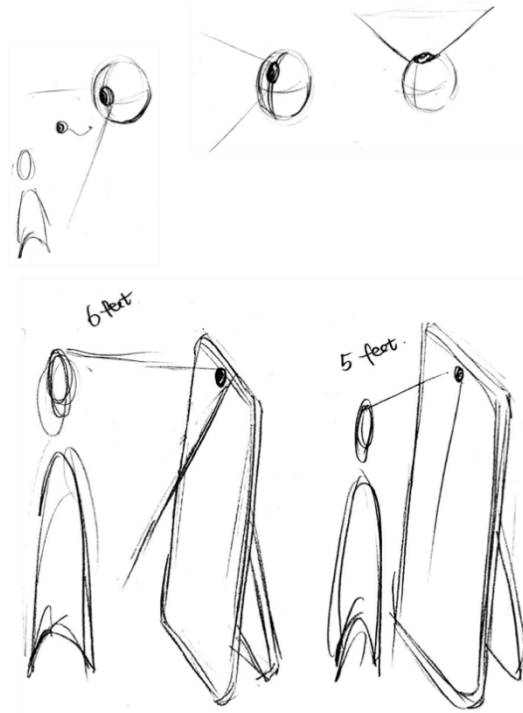

Figure 25. Diagrammatic Sketch for Rotatable Camera

6.6.2   Second stage: a movable camera

After reporting the screens with a rotatable camera idea to the committee and potential users, they still think the product's price is higher than their expectations. I decided only to keep the essential function which is the camera, and remove the screen. The screen on the smartphone can replace the parts of the original screen. Users can operate the system on the smartphone and use the camera to shoot their bodies. Then I moved to the second stage: camera design. The key feature of the camera is that it can be attached to another object and shoot the whole body. It can also be physically closed. After a few iterations, I designed a laptop-shaped rotatable camera that can close by rotating the cover. It has two layers; the top one includes the lens, and the bottom layer has a Bluetooth button and indicator lights. This camera can be placed on any flat surface or attached to a mirror.

Figure 26. Renderings for the First Prototype of Rotatable Camera

6.6.3 Third stage: a clip camera

After evaluating the rotatable camera, I found two problems. The first one is that the shape is not beautiful. It looks heavy and dull. The second problem is that it cannot be charged anymore when it is attached to the mirror. I started the second round of ideation to find a new way to connect it using a clip. The clip camera can be clipped to any thin surface, such as a desktop, laptop, or mirror. To protect privacy, I used a slide cover on the lens. Users can push the lid to open the camera or pull to close it. The indicator light on the cover will also indicate the status of the camera. The button on the side of the clip can connect with the app with Bluetooth. It can be charged through a Type-C port at the rear side (see Figure 27). The camera's body is made of plastic, and the rear handle area is made of rubber to increase friction.

Figure 27. Rendering of the Clip Camera

6.6.4 Limitations and refinements

After present this clip camera design with my committee and potential users, we all agree this product achieves the preset goal. Users can easily record their outfits into "Closet Go" and use the VR fitting room conveniently with this product. However, after a critical evaluation, we found some limitations that can be improved.

The first one is the location of the indicator light. The function of the light is to indicate the camera's working status. Right now, it locates on the slide. When users push the slide, the light's color will change to indicate different working status. However, with users' finger is cover the light, they can't see the chance of indicator. My potential solution could be moving the indicator

close to the Bluetooth button. Whether users press the slider or click the button, the indicator light will not be affected by human hands. The second problem is about the lens. The lens contains most of the electronic components. Based on the shape of the camera, the top area is thicker. It is more reasonable to place the lens on a thicker upper part.

Design is a process of continuous refinement and improvement. Based on the limitation, I improved the design that displays in figure 28. The new version changed the location of the lens and the indicator light.

Figure 28. Rendering of the Clip Camera Refinement

6.7. Design Iteration

The total life cycle of my thesis design has three rounds of design and two rounds of evaluation. In the first design round, the design only has a general form and plan. Then the first round of evaluation came. Three professional design professors on my committee joined the evaluation and reviewed my design concept. After the first evaluation, my design concept changed slightly, especially the physical product change from a smart mirror to an attached camera mentioned in chapter 6.6.2. I found that a smart interactive mirror is expensive and requires complicated operations. Finally, I decided to keep the mirror's essential function which is smart identification, and eliminate the less critical function of the interactive screen on the mirror. Users can use their mobile phones to complete these operations. In the end, all the necessary functions are contained in one camera.

The second round of evaluation is a formal heuristic evaluation that presents in Chapter 7. The final refining after the heuristic evaluation is the third round of design. At that time, the product's structure did not change. I focused on the details like the style of the user interface and the interaction of each button. After that, the whole design process was finished, and the final design was complete.

6.8 Data-Driven Design and Augmented Reality

6.8.1 Employ data analysis technologies to drive the design

Machine Learning is no longer a strange technic to the public. It focuses on building a system that can improve itself through more experience (Jordan & Mitchell, 2015). An efficient machine learning model needs an accurate model and massive data to improve the machine (Al-Jarrah, Yoo, Muhaidat, Karagiannidis, & Taha, 2015). It is also why machine learning always uses big data.

In fact, current media and researchers have realized the significance of big data usage. Many applications employ big data and machine learning technology in their system. These technologies also benefit "Closet Go" design. "Closet Go" is a data-driven product that offers services based on the data we have. In order to help customers make better clothes matches, the system first needs to know the current fashion trends. Even though fashion changes rapidly, the system can improve itself and give users new suggestions. With more than one fashion style, different users can get various suggestions. The data collected by "Closet Go" at this time will make our application smarter and evolvable.

Based on research, Gerard George, Martine R. Haas, and Alex Pentland think data collection and analysis are the essential processes in big data application (George, Haas, & Pentland, 2014). In "Closet Go," the system records every click, selection, and browse on the app. In detail, the user's every day's outfit choice, all likes given to a picture, and each clothes match are valuable data to us. By analyzing this data, our system will be smart and know more about the user.

The system assigns all clothes and outfits different tags that represent the clothes' style. Our recommendation will rely on which type this user likes—knowing which styles the user likes will be analyzed by the user's big data. The more actions a user has in our system, the more accurate "Closet Go" will understand this user.

"Closet Go" will not only focus on one person's data. It will collect data from all users and analyze the data between them. After accurately understanding one user, the system can abstract out a model. This model has some specific characteristics, behavior, and preferences. If we find some other users who also have those characteristics, we can assume they have the same behavior and preferences. Those data and models help us predict users' behavior and offer helpful suggestions.

6.8.2   Adapt augmented reality to amplify the user experience

Augmented Reality is another critical feature in "Closet Go." During the research phase, I found that the main weakness of online shopping is that customers cannot touch and try commodities. This phenomenon may affect the customer's decision-making. Several stores have applied AR (Augmented Reality) to display the commodities from different perspectives, as Nike mentioned in Chapter 5. AR is defined as "the superposition of virtual objects (computer-generated images, texts, sounds, etc.) on the real environment of the user" (Faust, Roepke, Catecati, Araujo, Ferreira, &Albertazzi, 2012). However, the benefit of AR is not limited to that. A colorful way to display the products allows users to examine the commodity in more detail. When the user can see clothes on themselves virtually, it is better than seeing them on a hanger. AR technology overcomes the shortcomings of online shopping.

In "Closet Go," AR is used mainly in the process of outfit building. To create a satisfying clothes match, users need to try on many clothes. Putting on and taking off is time-consuming and inconvenient. But with AR, users do not need to wear clothes. They can easily select the clothes, and those clothes will appear on their body on the screen. Even for those clothes not owned, users can try them with AR and then decide to purchase them or not.

The design process lasts a few months and finally forms the system, including the "Closet Go" app and flippable camera presented in this chapter. The design should be repeatedly modified to find problems and improve the user experience. Chapter 7 introduced the heuristic evaluation that helped me find terrible experiences in the current design.

7. HEURISTIC EVALUATION

As mentioned in Chapter 6: Design iteration, the whole design process has two rounds of evaluation. The first round is after the design concept presentation. The professors on my committee helped me evaluate the design concept and direction. After modifying my design based on feedback, I finished the design and built an interactive prototype and a mockup for the physical product. Then, I conducted the second round of evaluations. The second round of evaluation is more formal and professional, used to evaluate the usability problem based on the prototype and mockups. Considering the experiment's efficiency and the pandemic's restrictions, I adopted the heuristic evaluation that is an effective evaluation method to identify usability problems for interactive designs. During the evaluation, five experts went through the design and identified usability problems based on heuristics. Then, the designer could discover the usability problems and their severity.

7.1 Eleven Usability Heuristics

Deciding the heuristics is a crucial step in heuristic evaluation. A reasonable heuristic can let evaluators follow the metric to test the design effectively. Also, it leads evaluators to focus on the designer's area of interest. Since this design mainly focuses on interface design, I chose my heuristics based on Jakob Nielsen's ten general principles for interaction design (Nielsen, 1995) and Shneiderman's eight Golden Rules better interface (Shneiderman, 1998). After modification based on the specific situation, I finally decided on the ten usability heuristics listed below.

1. (Feedback) Visibility of system status. The system should always keep users informed about what is going on through appropriate feedback within a reasonable time.
2. (Consistency) Consistency and standards. Users should not have to wonder whether different words, situations, or actions mean the same thing. Standards and conventions in product design should be followed.
3. (Understandability) Speak the user's language. The system should use vocabulary and phrases that users can understand without causing misunderstandings

4. (Metaphor) Match between system and the real world. The image of the system perceived by users should match the model the users have about the system.

5. (Navigation) Users should always in control of the system and know the exits of every page.

6. (Anticipation). Users should be able to predict what will happen after their actions.

7. (Undo) Permit reversal of actions. The system should always offer users obvious ways to reverse their actions or recover from errors.

8. (Memory) Recognition rather than recall. Minimize the user's memory load. Make objects, actions, and options visible. The user should not have to remember information.

9. (Shortcut) Flexibility and efficiency of use. The system should provide more flexibility and high-efficiency ways to accomplish tasks.

10. (Minimalist) Aesthetic and minimalist design. The visual layout should respect the principles of contrast, repetition, alignment, and proximity.

11. (Visibility) The user interface should have comfortable colors and suitable font sizes.

Table 1. Heuristic Evaluation Form

	Metrics	Explanations
A. Affordance	(Feedback)Visibility of system status	The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.
	(Consistency)Consistency and standards	Standards and conventions in product design should be followed.
	(Understandability)Speak user's language	The system should use language and phrases that users can understand without causing misunderstandings.
	(Metaphor)Match between system and the real world	Match between system and the real world. The image of the system perceived by users should match the model the users have about the system.
B. Functionality	(Navigation)	Users should always in control of the system and clearly know the exits of every page.
	(Anticipation)	Users should be able to predict what will happen after their actions.
C. Usability	(Undo) Permit reversal of actions	The system should always offer users obvious ways to reverse their actions or recover from errors.
	(Memory)Recognition rather than recall	Recognition rather than recall. Minimize the user's memory load. Make objects, actions, and options visible. The user should not have to remember information.
	(Shortcut) Flexibility and efficiency of use	The system should provide more flexibility and high-efficiency ways to accomplish tasks.
D. Aesthetics	(Minimalist)Aesthetic and minimalist design	Visual layout should respect the principles of contrast, repetition, alignment, and proximity.
	(Visibility)	The user interface should have comfortable color and a suitable font size.

7.2 Evaluation Process

As mentioned in Chapter 3.3, how many evaluators are in the test affects the result. I recruited three professional designers who are master students and university instructors to join the

evaluation. None of them have seen the design before the evaluation. I conducted two evaluations in the lab and one evaluation online.

Table 2. Heuristic Evaluation Participants Record

Evaluator	Professional Filed	Duration of Evaluation	Evaluation Date
E1	Second-year graduate student major in interaction design	60 Mins	4/4/2021
E2	Third-year graduate student major in industrial design	30 Mins	4/4/2021
E2	Third-year graduate student major in interaction design	40 Mins	4/5/2021

The evaluation has three parts. At first, the research introduces the general information and the meaning of each heuristic. I then introduced the design in detail to help the evaluator better understand the application. In the second part, evaluators need to experience the app and the physical product. The app's interactive prototype and a physical mockup were used in the evaluation. Because the interactive prototype is not full-functional, the evaluators have several tasks to finish in the app. During the last part, evaluators need to do severity ratings on the evaluation form and explain the reasons.

The severity rating scale is a method to describe the importance of each usability problem. Evaluators need to rate from 0 to 4.

> 0 - no problem;
>
> 1 - cosmetic problem;
>
> 2 - minor usability problem;
>
> 3 - major usability problem and important to fix;
>
> 4 - usability catastrophe and imperative to fix.

After evaluators finish the rating, the categories with higher grades mean a severe usability problem and may need an emergency repair. The severity rating outcome could help the designer decide the sequence of redesign for each part of the design. In industry, it also helps the company to distribute resources to different teams to redesign.

7.3 Evaluation Outcomes

Table 3. Severity Rating for Heuristic Evaluation Results

Metrics	Evaluator 1	Evaluator 2	Evaluator 3	Total Severity Ratings	Mean Severity Ratings
(Feedback)Visibility of system status	0	0	0	0.00	0.00
(Consistency)Consistency and standards	2	2	2	6.00	2.00
(Understandability)Speak user's language	2	2	3	7.00	2.33
(Metaphor)Match between system and the real world	1	1	2	4.00	1.33
(Navigation)	1	0	3	4.00	1.33
(Anticipation)	2	2	1	5.00	1.67
(Undo) Permit reversal of actions.	0	0	0	0.00	0.00
(Memory)Recognition rather than recall	1	0	0	1.00	0.33
(Shortcut) Flexibility and efficiency of use.	2	1	3	6.00	2.00
(Minimalist)Aesthetic and minimalist design	1	0	1	2.00	0.67
(Visibility)	0	1	4	5.00	1.67

In the evaluation result, the most severe problems are from the Shortcut(2), Consistency(2), and Understandability (2.33) metrics. All of their mean severity ratings are higher than 2. Metaphor (1.33), Navigation (1.33), Anticipation (1.67), and Visibility (1.67) are from 1~2, which means they are second severe issues. Feedback(0.00), Undo(0.00), Memory(0.33), and Minimalist(0.67) are lower than 1.

According to the feedback from the evaluation and their severity rating, I listed the most critical 11 problems below:

1. The placement of pictures and texts is not consistent. (Consistency)
2. The environment icon is confusing. (Metaphor)
3. The second-bottom tap icon is not very clear. (Metaphor)
4. The amount of clothing or shoes is not clearly presented. Users might get confused about the display bar below the item. (Anticipation)
5. A match should have at least two clothes. (Anticipation)
6. Need an "add clothes" button on the home page. (Shortcut)
7. On some pages, the list is a bit overwhelming. (Minimalist)
8. Some fonts are much too small. (Visibility)

Table 4. Findings for Heuristic Evaluation

Metrics	Findings
(Feedback)Visibility of system status	
(Consistency)Consistency and standards	•Greeting text will change after choosing today's match. •The placement of pictures and texts does not keep consistent. •Items boxes are not quite consistent, some boxes might have more detailed information and prices than the others
Speak user's language	•"here what you forgot" is unclear. •"add success" is hard to understand. •"Check out" and "match" are hard to understand without context. •When add clothes, the selection of "confirmation emails" is very confusing.
(Metaphor)Match between system and the real world	•Environment icon is confusing. •Second bottom tap icon is not very clear. •The amount of clothing or shoes are not clearly presented. User might get confused about the display bar below the item.
(Navigation)	•When adding identified items, should allow users not adding every scanned item (skip or next). •Under my closet tab, move clothes bar next to matches bar. •On home page, smart scan button located under yesterday match is very confusing.
(Anticipation)	
(Undo) Permit reversal of actions.	
(Memory)Recognition rather than recall	
(Short cut) Flexibility and efficiency of use.	•Need an "add clothes" button on the home page. • Liking people's outfit feature quickly. •There is no quick exit when inputting clothes.
(Minimalist)Aesthetic and minimalist design	•Some pages the list is a bit overwhelming. •some pages looks crowed (searching/ add).
(Visibility)	•The choice of the gold color can be a bit random. •Some fonts are way to small.

7.4 Design Refinements

From the evaluation's findings, I want to solve some serious problems: The layout of the home page, the bottom bar sequence, the missing size help, and usage of icons. As shown in figure 29, after the redesign, I changed the icon of the weather forecast. Multi-color icons are more attractive and more suitable for color pictures on the screen. The title color d from gold to black to make the page cleaner and more organized. The order of submodules also changed. I moved "suggestions for today" closer to the weather forecast because the suggestions generally are based on the weather. They are more related. The number of "recent matches" has increased. It used to show only yesterday's choices. However, people will not only wear yesterday's clothes, but all recent clothes may be worn. Therefore, I designed the slide card function to allow users to slide to check recent week's outfits. Then, I reorganized the layout of the buttons. I removed the "keep wearing it" button. Users can click one of the slide cards to achieve this function. Moreover, I renamed the "smart scan" button as "scan to check out," which is initially obscure and hard to comprehend. The "start with an item" button and "Choose activities" buttons were merged into a new button named "choose a match."

As for the "my closet" page, it was designed as a personal page. However, participants in the evaluation complained that it was more related to the user's clothes rather than the user. I designed an identification card on the top area that displays user information and other achievements they made in "Closet Go." By clicking the identification card, users can edit their personal information in the app.
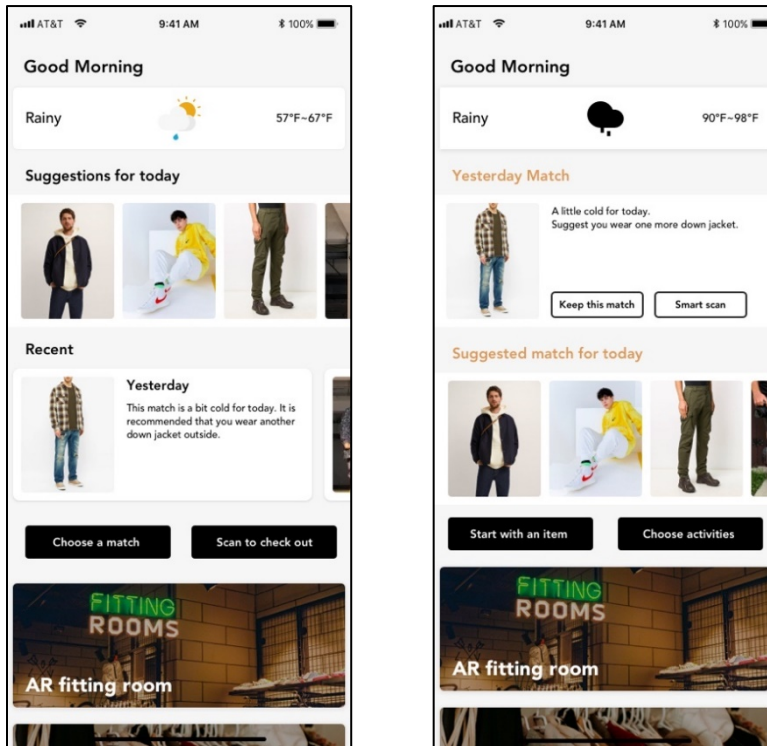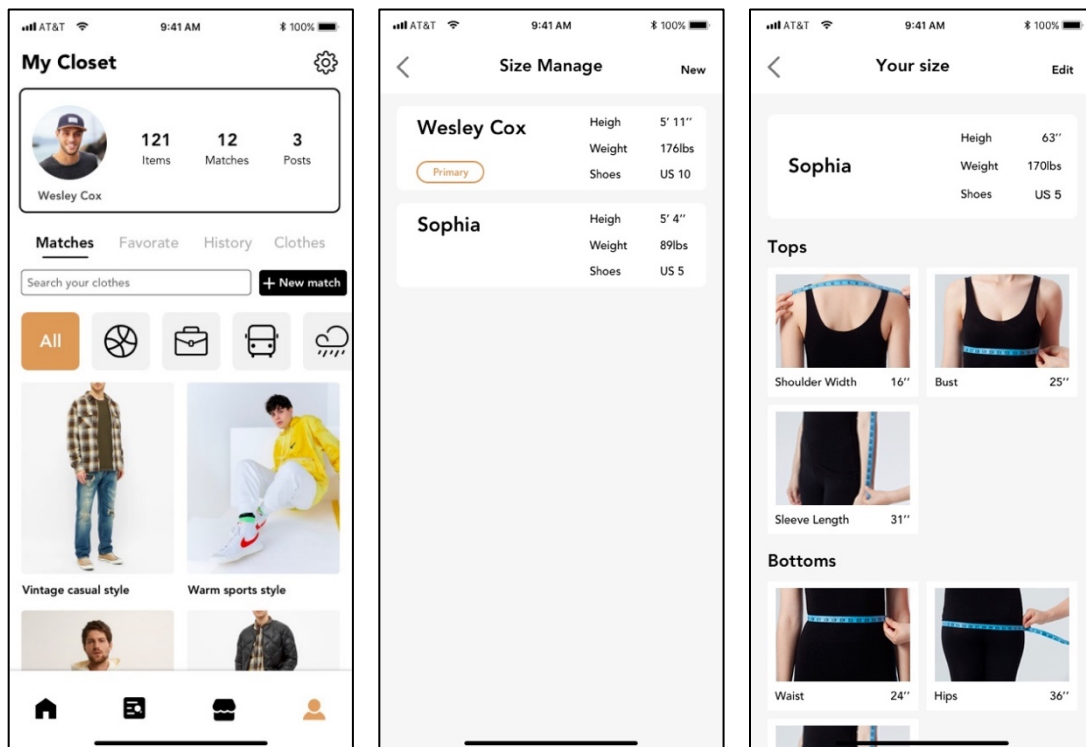
Figure 29. Redesign for Home Page

Figure 30. Redesign for Personal Page and Size Guide

At the first round of idea evaluation, the most desired feature noted from the committee is the size help. According to the research of different brands size charts, I noticed different brands' sizes are various, which means a user has to buy shoes with different sizes at different brands. This experience is not desirable. They need a helper to tell them the correct size when they are shopping, especially for online shopping. Therefore, I designed a size suggestion function in "Closet Go." The first-time users download the app, they can enter their body size into the system. After that, every time users purchase new clothes. They will ask to give feedback on the size. With more feedback in the system, the more accurately we can understand the user's body size and give the correct size suggestion.

8. CONCLUSION

This study focused on the dressing experience of the after-shopping stage and proposed a new possibility of solving clothes matching and shopping wisely. This research is valuable for companies that have invested much energy into the shopping process research. Brands have overlooked this area that looks the least profitable but can affect customers' lifestyles.

The original idea of this design comes from my and my friends' personal experience. However, with deeper research, the personal problem evolved into an industry weakness. While the development of technology has brought us a more convenient life and much industry innovation, it has also resulted in the industry ignoring customers' most basic needs. For clothes customers, their most basic needs from ancient times to the present time have not changed - it is dressing. Current trends overemphasize profit and technology in the clothes industry and ignore people's needs. The development of technology is endless. After ten years, maybe the recent popular topics are already out of style. People begin to pursue new technologies again. However, no matter how this world changes, human being's basic needs never change. As a designer, we need to focus on humanity itself and analyze human's experience and needs. Therefore, technology is only the tool we can use to improve people's experience and solve people's needs.

This IoT Design includes two parts: the application design and the clip camera design. However, the most valuable area is the experience design beyond these two products. How the design solves the current problems and changes users' dress lives. This paper presents the entire design process, from the problem identification to the evaluation. This process also demonstrates the fundamental part of experience design. The goal of experience design is to solve the problem or negative experience. The prerequisite for solving the problem is to find the problem, which explains the first step in experience design: problem identification. After finding the problem, we need to find the reason that leads to the problem, which is research. When we find the cause, the next step is to create possible solutions, usually called ideation in design. Sometimes we need to test the feasibility of the resolution, so we have evaluations. It is easy to see that all the design

process is about solving the problem. This paper presents a detailed example of experience design theory.

Admittedly, there are many problems with the app and product identified from the evaluation. I only refined part of them. By explaining my idea to different people repeatedly, I find more possibilities of improving the design. Instead of claiming an ending for this design, I realize a new door has opened. I will continue to explore the potentials, improve the design, and keep new ideas emerging to enrich the user experience.

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