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DESIGN AND EVALUATION OF A FENG SHUI SUPPORTED AUGMENTED REALITY TOOL FOR FURNITURE PLACEMENT AT HOME

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SUMMARY

The purpose of this project is to design an AR-based tool to educate and guide people through furniture selection and placement in their homes by learning Feng Shui theory. This is a learning tool, and people will gain knowledge and might apply them in their future living space design. This tool would allow people to select and arrange furniture that brings a more balanced and comfortable living environment.

Several research methods have been employed to evaluate the AR design as follows: 1) literature review of related studies on AR technology and Feng Shui well-being 2) survey to gain insight into how people view their current home environment and interior design 3) prototyping of the AR tool that integrated 3D furniture models with interactive interface and 5) user study to evaluate the prototype with a total of 9 participants.

The study reveals the importance and potential of AR in guiding and helping people learn about furniture selection and placement properly in their living space. The limitations and possibility of further improvement of this study are also discussed in this paper.
CHAPTER 1. INTRODUCTION

1.1 Background

In the House of C. G. Jung: The History and Restoration of the Residence of Emma and Carl Gustav Jung-Rauschenbach, it is said by Carl Yung that “our home is our source of “comfort, belonging and other psychological riches” (O’Rourke, 2017). Home is not only the place we live, but there’s also a strong connection between the home environment and our psychological well-being. As for most of us, we spend almost one-third of our lives in the sleep environment, which ideally supports optimal health in all aspects of the human experience (O’Rourke, 2017). However, many people are unaware of how their internal home environment can significantly impact their health and well-being. When designing new solutions, it is said that home is the “representation of our values, emotions, memories, and social relations.” When designing our homes, we might need to take significant considerations about these elements since they support people’s well-being beyond a functional approach and determine the acceptance of new technological solutions (Pillan, 2017). Therefore, besides the aesthetic and functional factors we consider the most when designing our homes, considerations about human comfort and well-being are also important (Wang, 2018).

1.2 Furniture placement

There are many factors that need to be considered when thinking about interior design; choosing the right furniture is one of them. Furniture is an essential part of an apartment as it takes up about 40-50% of the floor space (Thøgersen, 2017). Each room design has different functions according to needs. And furniture plays a key role in how residents feel within an
apartment and meet their needs. Every piece of furniture should give the appearance of belonging so that without it, something seems out of place (Habel, 1980). Moreover, not only the function of how a furniture works could affect the resident, but the visual effect that furniture serves in a room is essential. The residents' living environment might be impacted if the interior design is poorly planned and thought out. The furniture, in this case, has a significant impact on the perception of space in a room (Thøgersen, 2017).

Studies have shown that furniture choice and arrangement can somewhat affect comfort level and emotions (Saruwono, 2012). Moreover, the awareness of applying well-being theory among interior designers has been increasing. The right combination of pieces of furniture gives rooms a balanced look and feel. However, choosing furniture in a good way is sometimes challenging as it is easy to get the favored style, but it is somewhat tricky to place it in the comfort position properly. As such, there is a need to explore a theory that helps people better select and place home furniture and transfer it into implementable solutions.

1.3 Feng Shui theory

One of the principles that provide guidelines with reference the historical building and environmental science is known as Feng Shui. The term Feng Shui began to appear frequently in popular interior design periodicals in the early 1990s (Kiehl, 2005). It is defined as ‘the art and science of designing harmonious environments based on the profound Chinese understanding of how people are connected to and affected by their close surroundings”. Feng Shui, literally translated as "wind and water,"; it is also the Chinese art of placement, balancing and enhancing the environment. (Ahmadnia, 2013). According to Feng Shui, there are three major aspects of the universe that need to be supported for a healthy environment: (O’Rourke, 2017)
1. Balance of yin and yang
2. Representations of the five elements (metal, wood, water, fire and earth)
3. Flow of Chi

There are many studies regarding the theory of Feng Shui, and even though people are living in a world today that is very different from that of ancient China, the Feng Shui principles are still commonly seen since it helps and guides people to make better use of their living space (Kiehl, 2005). According to Xu, Feng Shui may have supportive values for physical and mental well-being in a practical way rather than strictly superstition that it is connected to human well-being by its visual–psychological implications (Wang, 2018).

The philosophy of Feng Shui promotes the conditions that favor a living design tenet, implying room for growth, change, and flexibility within any environment (Lynch, 2003). These principles can be applied to any home arrangement, from any small space such as the top of a desk to a home furniture arrangement. For those who design their interior spaces, Feng Shui could provide suggestions or guidelines to address their home clutter, which can bring good mood or even optimize your health, and improve your life (Kiehl, 2005).

1.4 Augmented reality in home design

Augmented reality is one of the contemporary methods that help with home interior design. Its capability to track and visualize objects’ relations in space has led to diverse industry applications to support complex engineering tasks. “It can overlay spatially meaningful information on the 3D space, making it a promising option for supporting knowledge-intensive works” as it said (Deshpande, 2018). There are many advantages offered by AR for digital
architectural design and construction fields (Phan, 2010). Moreover, it is also considered a new design method in interior design that enhances users' perception and experience.

AR boosts the sense of reality by laying virtual items over the real world in real-time. It not only adds items to the real-world but also represents useful digital information in the real-world (Alkhamisi, 2013). Research has shown that AR has great potential to improve the experience of living at home. For example, an AR Microsoft Hololens can assist with interactive knowledge sharing with the caregivers to support people in need at home (Haidon, 2020). There are also studies about the use of AR in interior design. With the power of AR, it becomes easier for designers and architects to present and showcase their ideas to customers; it is also easy to quickly test new ideas or create a new model (Bhatt, 2021). Compared to the traditional way of planning and designing homes on a piece of paper, AR offers a more holistic 3-dimensional view for people to view and adjust at any time. Though some people might consider it takes some time to familiarize themselves with the AR tool/glasses, one primary use of AR in home design is through AR apps when people consider purchasing furniture for the home, which is convenient and valuable.

1.4.1 AR furniture apps

Currently, the AR apps for furniture selection and interior design are getting popular on the market since more customers consider a hands-on experience necessary for purchasing their homes. One report says that “over 71% of customers say their chances of purchasing increase when they can get an AR view of the products they intend to buy” (Bhatt, 2021). There are many AR furniture apps on the market; one of the most well-known is the IKEA Place app.

IKEA introduced the ‘IKEA Place app’ that utilizes augmented reality technology, letting customers preview how furniture looks on their smartphones before buying. Users can insert and
move around virtual furniture in the space to see how it might fit in the environment (Siltanen, 2013). This interactive experience would help them visualize how furniture might look in their home to make purchase decisions. The home styler interior design app allows object resizing and displays in real-time the new furniture piece dimensions when we consider customizability (Sandu, 2018). With the help of these AR apps, the virtual furniture can be displayed and modified in real-time on the screen, allowing the user to view and have an interactive experience with the furniture in a real-world environment (Phan, 2010). However, based on the previous research, how people choose and place furniture significantly impacts home comfort and well-being. This AR experience did not quite tell or guide people how they choose before purchasing. Therefore, there is great potential in incorporating AR technology with Feng Shui theory to guide people when selecting furniture.

1.5 Objective and specific aims

We face many choices regarding our living space every day, from the size of the sofa to the position of the plants we choose for our living room. This makes room for many possible mistakes, from incorrectly measuring the space in the corner so that the furniture piece might not fit or how two new pieces of furniture would blend (Sandu, 2018). The process of determining design elements in the home requires knowledge. Therefore, we need to consider how we can leverage technology to design smart homes with practical well-being in mind?

This project aims to design and develop an AR tool to help people make better, more informed decisions in home interior design. Notably, this project aims to investigate how ancient Feng Shui principles can be applied to home interior furniture arrangement and decoration.
through the intervention of AR, which brings a more balanced and comfortable living environment.

In this study, well-being principles, primarily Feng Shui theory, will be investigated. It is crucial to understand the best way to arrange home furniture. Existing literature for Augmented Reality (AR) application use cases and well-being principles in home design will also be reviewed. Then it uses a survey design approach to understand how people view their current home environment/interior. Afterward, the final prototype was designed, developed, and iterated based on the above feedback and input. Finally, we conducted usability studies with 9 participants to evaluate and refine the AR tool for potential future work.
CHAPTER 2.  PRELIMINARY RESEARCH

2.1 Method

2.1.1 Survey

To gain insight into how people view their current home environment/interior design and if they are familiar with existing AR tools, a survey was created and distributed through Georgia Tech’s approved Qualtrics software to the public. Institutional Review Board (IRB) was approved for this survey, and people who are above 18 and live within the US are welcome to participate. The survey is mainly distributed through the social media platform and e-mail lists. The survey is designed to be straightforward to get as many responses as possible. There are a total of 19 questions in the survey; 16 of them are multiple choices with three open-ended questions (see appendix A). The first five are demographic questions (age, gender, ethnicity, employment status, and household income). Followed by questions asking about their satisfaction with current living space design and which design factors they considered the most when they think about interior design. Next, there are questions about AR technology and their familiarity with the use of AR in home design. Some of the survey questions are as follows:

1. In which type of housing do you currently live?
2. Which of the following best describes your current housing situation?
3. Are you satisfied with your current living interior space design?
4. Do you aware that design of interior space will affect physical and mental well-being?
2.2 Result

A total of 107 responses were collected in the survey, and 82 of them were valid responses. Incomplete responses are removed when analyzing the data. Some questions and respondents’ choices are shown in the tables below. As it shows, 62.2% of respondents rent their house, and the other 37.8% of them own their house. The awareness of the importance of space design and well-being, the majority of respondents (64.63%) are aware of it, 25.61% of them are somewhat aware, and the rest, 9.76% respondents do not aware of its importance. As for the factors considered in home design, there are many choices provided to the respondents; the top three are ‘Furniture placement/arrangement’ (15.95%), Color choice (15.70%), and Lighting (15.19%). This result helps us identify the primary design factor later.

Table 1 – Survey demographic questions

<table>
<thead>
<tr>
<th>Questions</th>
<th>Choices</th>
<th>Respondents Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>18 and under</td>
<td>2.22</td>
</tr>
<tr>
<td></td>
<td>19 to 25</td>
<td>48.89</td>
</tr>
<tr>
<td></td>
<td>25 to 39</td>
<td>38.89</td>
</tr>
<tr>
<td></td>
<td>40 to 64</td>
<td>10.00</td>
</tr>
<tr>
<td>Gender</td>
<td>Male</td>
<td>26.67</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>71.11</td>
</tr>
<tr>
<td></td>
<td>Not to answer</td>
<td>2.22</td>
</tr>
<tr>
<td>Ethnicity</td>
<td>Native American</td>
<td>1.11</td>
</tr>
<tr>
<td></td>
<td>African American</td>
<td>4.44</td>
</tr>
<tr>
<td></td>
<td>Asian</td>
<td>32.22</td>
</tr>
<tr>
<td></td>
<td>Caucasian</td>
<td>45.56</td>
</tr>
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</table>
Table 1 continued

<table>
<thead>
<tr>
<th>Employment Status</th>
<th>Hispanic/Latino</th>
<th>Other</th>
</tr>
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<tbody>
<tr>
<td>Employed full-time</td>
<td>32.22</td>
<td></td>
</tr>
<tr>
<td>Employed part-time</td>
<td>11.11</td>
<td></td>
</tr>
<tr>
<td>Student</td>
<td>50.00</td>
<td></td>
</tr>
<tr>
<td>Seeking opportunities</td>
<td>3.33</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>3.33</td>
<td></td>
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<table>
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<tr>
<th>Annual household income</th>
<th>Less than $25,000</th>
<th>$25,000 to $49,999</th>
<th>$50,000 to $74,999</th>
<th>$75,000 to $99,999</th>
<th>$100,000 to $149,999</th>
<th>$150,000 and more</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>37.78</td>
<td>21.11</td>
<td>15.56</td>
<td>8.89</td>
<td>14.44</td>
<td>2.22</td>
</tr>
</tbody>
</table>

Table 2 – Sample survey results

<table>
<thead>
<tr>
<th>Questions</th>
<th>Choices</th>
<th>Respondents Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Types of housing currently live</td>
<td>Apartment</td>
<td>46.34</td>
</tr>
<tr>
<td></td>
<td>House</td>
<td>41.46</td>
</tr>
<tr>
<td></td>
<td>Duplex</td>
<td>2.44</td>
</tr>
<tr>
<td></td>
<td>Condominium</td>
<td>4.88</td>
</tr>
<tr>
<td>Current housing situation</td>
<td>Home owner</td>
<td>37.80</td>
</tr>
<tr>
<td></td>
<td>Renter</td>
<td>62.20</td>
</tr>
<tr>
<td>Awareness of the importance of</td>
<td>Yes</td>
<td>64.63</td>
</tr>
</tbody>
</table>
Regarding whether people participate in their home design, most (85.36%) prefer to design by themselves or with family/friends. Only 10.98% of them will have professional interior designers participate in the design. That is interesting to know since it shows the need for a tool that helps people make design decisions without involving professionals. For people’s
familiarity with current AR apps in home design, 41.46% of the respondents do not know about them, and 37.80% of them know about them but have not tried them before. Only 20.73% of the respondents have tried the home AR apps. Some of them said in the short answer section that ‘it was too much work to set up the app’ or ‘it does not help a lot’, which reveals that there is a great opportunity in developing an AR tool used in home design.

2.3 Analysis

From the preliminary research as well as previous literature review, the design scope can be further identified and narrow down in the affinity diagram (Figure 1). In general, it shows that there’s still 1/3 of people who aren’t aware of the importance of well-being in home design. From the top three design factors considered in home design, we decided to pursue with the ‘Furniture placement/arrangement’ factor that takes the highest percentage. However,

![Affinity map of themes from survey](image-url)

Figure 1 – Affinity map of themes from survey
plant is also another factor where several people considered a lot as one stated in short answer:

“for eco and natural reasons, I think more about integrate plants in my home design to live in a heathier environment.” Some participants also mentioned in the short answer about the strategies they took to support well-being, such as ‘I might search online to find if it is suitable in my home’ or ‘take more considerations and ask for family’s opinion before purchasing furniture.’

There are also some opinions that respondents mentioned in the short answer section about furniture arrangement:

“I get stressed out if the arrangement is not in good position.”

“Without good functionality and arrangement, the space doesn’t feel calming.”

“Furniture choice and placement plays a major role in my home, but I don’t know how.”

Based on the feedback, there is a need to have such an AR tool that helps people to place and arrange furniture in their homes and raise awareness of well-being in home design. Since it shows that over 80% of respondents tend to participate in home design without the involvement of professionals, this tool would be used to show and teach them proper ways of placing furniture that they can use on their own. Furniture placement & arrangement would be the focus of this paper. Furthermore, because this is a learning tool, in-depth research about Feng Shui theory in furniture placement & furniture arrangement will be explained in the following section.
CHAPTER 3. DESIGN TO PROTOTYPE

3.1 Prototype tools and software

3.1.1 AR hardware and software

This study used Apple’s ARKit 5, Reality Composer, to develop the prototype. This software allows developers to create interactive augmented reality experiences with 3D. Users could view and place objects directly in the environment, moving or scaling the virtual object on their device. We implemented and ran the AR prototype on iPad and iPhone, which was also used later for usability tests. Both devices have the latest iOS, which is compatible with reality composer.

3.1.2 3D models and interface

This prototype contains a total of 12 3D furniture models; the models come from 1) USZD models in the built-in AR library and 2) downloaded/purchased from the Sketchfab website. Models were imported to the software for further design.

The user interface was fully developed in the Reality Composer; interface interaction was then added accordingly.

3.2 Design specification

This tool aims to guide and teach people the ideal placement and arrangement of furniture at home. It is an educational tool that helps people learn in the augmented environment. Several design requirements should be met:
• Choose the type of furniture from a menu list: users should be able to choose which type of furniture they would like to view and learn on the menu.

• Placing and manipulating models in an AR environment: users should be able to tap and place desired furniture/decorating elements through the AR tool and look in the real home environment. They can freely adjust the model’s scale and direction and check whether they fit.

• Display interface and interactions: the AR interface should contain each model's Feng Shui theory contents, including text or quotes to guide users when placing or arranging furniture. Other factors such as materials and design plan might also be included.

3.3 Design

3.3.1 In-depth research: Feng Shui concept

Before entering the design stage, in-depth research on Feng Shui concepts for identified furniture models was conducted to develop the prototype. From the research, one of the core principles is known as ‘Chi’, the flow of energy; it can be further divided into two elements (yin ‘shade’ and yang ‘light’) to create a balanced feeling (Mintorogo, 2000). Therefore, when considering the way of arranging furniture, the flow of the space and the sense of balance should be noted to deliver a life force energy.

Another key Feng Shui feature is known as the Bagua, which is usually used as starting point from which all design decisions are made. It includes directions such as North, South, East, and West. The study indicates Chinese have high regard for the South direction since consider it is considered the most auspicious. Therefore, people prefer to have the front door open to the South, allowing the optimal amount of good ‘chi’ to enter a building (Wolter, 1999). The Bagua
map, in this case, can help people better make decisions when placing furniture and help determine the best layout for all elements in home.

![Bagua map in Feng Shui](image)

Figure 2 – Bagua map in Feng Shui

### 3.3.1.1 Sofa

The sofa is the furniture usually in the living room, a place for the family to spend time together. When considering its placement, it is suggested in Feng Shui that the sofa is ideally placed with a wall behind it that is protected and supported (Painter, 2022). When seated, people should be able to see the door, like what is called the “command position” (Cheung, 2018). Although the trends lean toward letting furniture float in the middle of the living room, this is poor Feng Shui. Therefore, we should avoid putting a sofa in the middle of the room since there’s no sense of security (Andrew, 2019). Moreover, the sofa should never be placed in front of the window or door, which obstructs positive chi from entering the room (2022). If the house
has a ceiling beam, we should also avoid putting the sofa directly under the ceiling beam since it is considered as back luck/poor health in Feng Shui (Smart, 2022).

In addition, corners and hard angles are a significant deterrent to the restfulness of a space. The angles create what are called “poison arrows,” which point negative energy at a single point. To avoid this in feng shui living rooms, consider incorporating furniture with rounded edges (Smart, 2022). Moreover, there are different types of sofas, such as L-shape and high-back ones; usually, the L-shape sofa should be avoided as it creates the so-called ‘poison arrow’ in the living room, and it is not good in Feng Shui.

3.3.1.2 **Coffee table**

The coffee table is considered a vital part of the socializing aspect of a living room. It is the centerpiece of a living room. Families might gather around and have tea, coffee, and desserts or play games at coffee tables (Painter, 2022). Usually, it is grouped with the sofa and the side chair. It’s good in Feng Shui to arrange seats, and the coffee table faces the entryway of the room so that people don’t have to turn back when people coming into the room (Nicholson, 2021).

Overall, the coffee table has two significant shapes: oval/round and rectangular. According to Feng Shui principles, there are no strict rules on which types of people should choose to boost the flow of ‘chi.’ “A round or oval coffee table may eliminate concerns about poison arrows created by table corners; both shapes are inauspicious for a coffee table. It can generate a circular movement of ‘chi’ energy, weakening its auspicious benefits” (Painter, 2022). On the other hand, a square shape represents earth, which may be more appropriate and grounding in a bright room (Deizel). However, there might be concerns about the ‘poison arrow’ created by table corners.

3.3.1.3 **Wall art**
Wall decoration, including artwork, photos, or sculptural pieces, is one of the most common ways to decorate the wall. It is about inspiration and creative energy, making it a powerful tool to shift and enhance the energy in our home (Cho, 2021). Feng Shui design favors artworks that are centered around positive energy. Selecting artwork is a personal practice, and everyone’s energy and taste are unique. In Feng Shui theory, the north wall in the living room embodies success and career, so hanging art with water elements like an ocean, waterfall, or lake would be the best. The west wall in feng shui represents creativity; for this reason, we can hang abstract paintings on the wall. The east corresponds with health and family in feng shui. Therefore, vitality pictures encourage positive energy, such as family photos are best on the east side. The south wall symbolizes fame, rank, and reputation, so images of nature are recommended; at the same time, try to avoid water elements in the south wall to avoid bringing on negative energy (Tarrant).

The location of artworks and items depends on which room they are in; for the living room specifically, hanging artworks on the wall right behind the sofa wall would be a good choice. In addition, hanging up artworks in the living room is essential in Feng Shui. One of the most common mistakes when hanging artwork is to hang art too low. Hanging the art too low will lower ‘chi’ flow and lead to depression. That is, hang the art at the appropriate height for the space and the size of the piece (Nguyen, 2020).

3.3.1.4 Dining table

Besides the living room, the dining room is also a primary space for the family to gather and share conversations or food. It plays an integral part in our physical wellness. On the other hand, the dining table is the focal point of the dining room and should occupy the center position
Applying Feng Shui theory in dining table arrangements can soften the dining room's energy to create a more harmonious gathering spot for family and friends.

The shape is one of the tools that Feng Shui practitioners use to shift the energy in a space. There are two types of shapes: rectangular ones and round ones. In Feng Shui, round ones are always preferred since it creates a smooth, gentle flow of ‘chi’ around the room. It also provides equality in that everyone seated around the table is no more or less than everyone else seated around that same table (Smart, 2017). However, rectangular dining tables are also standard these days. In order to lessen the disturbance of energy flow by sharp edges, we can balance it with rounded shapes such as rugs in the rest of the room. (Lagodinsky, 2014). Regarding dining table placement, it is best in Feng Shui to place the table at the center of the dining room and with its back facing the walls instead of a door or window. As it might cause people to feel insecure.

3.3.1.5 Bed

The bedroom is the most private area for the individual who resides there, which should reflect the individual's goals, desires, and personality. The bed placement is the most important in this case; choosing the right Feng Shui bed position will ensure people sleep peacefully in the bed (Painter, 2022). As it is one of the home's most essential rooms, following Feng Shui principles can mean the difference between a restful night and a fitful sleep. In Feng Shui, 'chi' should be able to flow unobstructed from the door through the room, so it is crucial that the bed does not block the path of ch'i through a doorway.

There are lots of Feng Shui rules for bed placement. First, like the placement of the sofa, the bed should also be supported by a solid wall which means people are supported from the
back (Cho, 2021). Since the door and window are the mouths of Qi energy, they may potentially direct unfavorable ‘chi’ or Yang energy generated outside the bedroom. Therefore, the bed should not be placed in line with the door, which can make people restless and vulnerable to the surprise of unexpected visitors (Wang, 2018). In addition, we should avoid doors opening directly onto any part of the bed and avoid having our feet point straight out the door. This placement is often referred to as the “coffin position.” The best place for a bed is to be placed diagonal to the door, allowing the occupant to view all that enters the room. (Wolter, 1999).

3.3.1.6 Green plants

Plants are one of the essential things in home design to create a positive flow of energy based on Feng Shui theory. They act as natural air filters, provide good ‘chi’ and increase the life energy in the home. Having green plants at home will bring calming and relaxing effect on the environment. Also, they strengthen the ‘wood’ energy in Feng Shui and bring robust growth to the space (Cho, 2022). However, where to position plants needs careful consideration, and it’s important to consider the different areas of the Bagua map and how they correspond to your space (Gaumond). Since all plants belong to the ‘wood’ element in Feng Shui, it’s necessary for us to balance the elements when putting plants inside the home.

The Bagua shows that the east and southeast area are good places to place plants since both areas belong to the element of wood. Indoor house plants will have the ability to enhance the wood energy of that area. The South area is also a good place since it belongs to the element of fire. Adding plants here can enhance fire energy because fire feeds on wood (Cheung, 2016). In addition, there are a few places where we can put indoor plants based on the Feng Shui theory—for example, the entry hall and living room. As mentioned earlier, the living room is
where family members gather; adding green plants can attract energy and help create a lively and welcoming space for living.

Moreover, small plants can be placed in the home office, which helps concentration and improves learning. There are also some places that are recommended not to place the plant in, such as the bedroom, since the plant's energy contradicts the energy needed to get a good night's sleep (2021). Overall, placing indoor plants properly can bring health and Feng Shui benefits to the home.

3.3.2 Prototype design

After the in-depth research on Feng Shui theory with a specific furniture, we began to create the preliminary AR prototype using Apple's ARKit5 and the Reality Composer. We imported furniture models to the software and began to add interface flow to the prototype.

3.3.2.1 Categorize models

The models used in this prototype are categorized into ‘functional’ and ‘decorative’ parts. The place where the furniture is usually placed is also being noted. In this study, we focused on the main furniture in both the living room, bedroom, and dining room. All models are USDZ files that are compatible with reality composer. Below is the table of all the models:

Table 3 – List of furniture model with their type, shape and image that were presented in the AR tool.

<table>
<thead>
<tr>
<th>Category</th>
<th>Place</th>
<th>Type</th>
<th>Shape</th>
<th>Image</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

20
<table>
<thead>
<tr>
<th>Functional</th>
<th>Living room</th>
<th>Sofa</th>
<th>Straight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional</td>
<td>Living room</td>
<td>Sofa</td>
<td>L-shape (sectional)</td>
</tr>
<tr>
<td>Functional</td>
<td>Living room</td>
<td>Sofa</td>
<td>High-back</td>
</tr>
<tr>
<td>Functional</td>
<td>Living room</td>
<td>Coffee table</td>
<td>Rectangular</td>
</tr>
<tr>
<td>Functional</td>
<td>Living room</td>
<td>Coffee table</td>
<td>Round</td>
</tr>
<tr>
<td>Functional</td>
<td>Dining room</td>
<td>Dining table</td>
<td>Rectangular</td>
</tr>
<tr>
<td>Functional</td>
<td>Dining room</td>
<td>Dining table</td>
<td>Round/Oval</td>
</tr>
<tr>
<td>-------------</td>
<td>-------------</td>
<td>--------------</td>
<td>------------</td>
</tr>
<tr>
<td>Functional</td>
<td>Bedroom</td>
<td>Bed</td>
<td>Regular</td>
</tr>
<tr>
<td>Decorative</td>
<td>Living room</td>
<td>Green plants</td>
<td>General</td>
</tr>
<tr>
<td>Decorative</td>
<td>Living room</td>
<td>Green plants</td>
<td>Tall</td>
</tr>
<tr>
<td>Decorative</td>
<td>Living room</td>
<td>Green plants</td>
<td>Small</td>
</tr>
<tr>
<td>Decorative</td>
<td>Living room</td>
<td>Wall art</td>
<td>Regular</td>
</tr>
</tbody>
</table>
3.3.2.2 **Interface design**

The next step would be adding UI to the furniture models. This tool is designed to educate and guide people on the way to choose and place home furniture according to Feng Shui theory. We began to add notes and buttons around the furniture model and created a UI flows storyboard shown in Figure 3.

Figure 3 – UI flow storyboard

<table>
<thead>
<tr>
<th>Sofa</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Sofa Image" /></td>
</tr>
<tr>
<td><img src="image2" alt="Sofa Image" /></td>
</tr>
<tr>
<td><img src="image3" alt="Sofa Image" /></td>
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<tr>
<td><img src="image4" alt="Sofa Image" /></td>
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<tr>
<td><img src="image5" alt="Sofa Image" /></td>
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<table>
<thead>
<tr>
<th>Coffee table</th>
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<tbody>
<tr>
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<td><img src="image19" alt="Coffee Table Image" /></td>
</tr>
<tr>
<td><img src="image20" alt="Coffee Table Image" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bed</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image21" alt="Bed Image" /></td>
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<tr>
<td><img src="image22" alt="Bed Image" /></td>
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<tr>
<td><img src="image23" alt="Bed Image" /></td>
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<tr>
<td><img src="image28" alt="Bed Image" /></td>
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<tr>
<td><img src="image29" alt="Bed Image" /></td>
</tr>
<tr>
<td><img src="image30" alt="Bed Image" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wall art</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image31" alt="Wall Art Image" /></td>
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<td><img src="image32" alt="Wall Art Image" /></td>
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<tr>
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<tr>
<td><img src="image39" alt="Wall Art Image" /></td>
</tr>
<tr>
<td><img src="image40" alt="Wall Art Image" /></td>
</tr>
</tbody>
</table>
For each furniture piece, there would be a general introduction on top of the model to give a basic intro. On the right side is a button list to choose different types. Using ‘Sofa’ for example, it has three different types: straight, L-shape, and high-back. Users can tap on the button to switch between each type in augmented mode. Since this tool focuses on educating the user on how to place the furniture, there would be an interface page that introduces the critical theory regarding the placement of this specific furniture. Users can click on the ‘explanation’ button to view the detailed Feng Shui reason/theory behind such recommendations. We also iterate the user interface to add the ‘hide all’ button. For those who only want to view the model, this function would allow them to view it without any notes (Figure 4). We also created a menu

Figure 4 – Sofa model with interface sample
page for users to choose and navigate between each type of furniture. Users would be able to return to the menu at any time (Figure 5). Some of the major guidelines of furniture placement in this tool including:

- How to best place Sofa according to Feng Shui theory?
- What’s the best dining table material?
- How to choose/hang wall art according to Feng Shui?
• Where NOT to place indoor plants?

Figure 5 – Menu page UI

Regarding the AR experience, this tool allows users to freely scale or rotate the model in the AR environment. When users place the furniture, they can walk closer to the physical environment to watch the model closer in the AR mode, as shown in (Figure 6). The position and size of the model won’t change as the user walk closer and view it from different angles.
After all key features had been defined and integrated into the tool, we iterated on the current design by adding recommended ‘furniture combination.’ Since it shows from the research that there are some ideal arrangements of furniture according to Feng Shui theory. Therefore, we added the option for the user to choose to view the combination in this AR tool in order to have a better understanding of the theory (Figure 7).

Figure 7 - Furniture combination example prototype
From the psychological viewpoints, sleeping in this position offers positive intuition of being supported and secured from aggressors, people may experience better acoustic quality and better visual command of the space.
CHAPTER 4. USABILITY STUDY

4.1 Methodology design

This AR tool aims to educate and teach people the ideal placement and arrangement of furniture at home. It is a tool for people to gain knowledge about Feng Shui theory. This usability study aims to know whether people can gain adequate knowledge through this AR prototype.

4.1.1 Participants

A total of 9 participants were invited (F=6, M=3), they were recruited via email list (Table 4). Each participant’s occupation and experience with AR tool in home design were recorded. The participants are at least 18 years old without any prior knowledge or experience with home design required. Each participant was invited to the design studio to test the prototype.

Table 4 – List of participants labeled from P1-P9, their current occupation and experience with AR tool in home design.

<table>
<thead>
<tr>
<th>Participants</th>
<th>Occupation</th>
<th>Experience with AR tool in home design</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>Graduate design student</td>
<td>None</td>
</tr>
<tr>
<td>P2</td>
<td>Graduate design student</td>
<td>Heard of it</td>
</tr>
<tr>
<td>P3</td>
<td>Graduate non-design student</td>
<td>None</td>
</tr>
<tr>
<td>P4</td>
<td>Graduate non-design student</td>
<td>None</td>
</tr>
<tr>
<td>P5</td>
<td>Undergrad design student</td>
<td>None</td>
</tr>
<tr>
<td>P6</td>
<td>Undergrad design student</td>
<td>Heard of it</td>
</tr>
<tr>
<td>P7</td>
<td>Graduate design student</td>
<td>Used it</td>
</tr>
</tbody>
</table>
4.1.2 Procedure

At first, we briefly introduced the purpose of this AR tool and informed them that this is a learning tool that might take some time for them to learn. We also showed them how they could interact with the model in the AR tool by using two fingers to zoom in/out or rotate the AR model. Then, we asked them to go through two screens introducing Feng Shui theory on a laptop to have a more profound understanding of the theory they were about to learn. Afterward, they were asked to try the AR prototype, followed by an interview session and a user survey.

4.1.2.1 Task and think aloud

We asked the participant to start the AR tool on iPhone and began exploring the features. We encouraged the participants to think aloud while using the prototype and speak out any thoughts or concerns. For example, if they stuck with placing furniture in the desired spot, we could guide them. The aim is to let them learn as much as possible from this tool. Therefore, we asked them to read every quote on each piece of furniture. We also asked the participants to imagine the studio area as their own living space; they are trying to choose and arrange furniture for their homes using this tool. Participants can freely walk around the space in the studio to explore the prototype (Figure 8). We were able to see the whole process of how they clicked and interacted within the AR tool.

Table 4 continued

<table>
<thead>
<tr>
<th></th>
<th>Full-time employed</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>P8</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>P9</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>
4.1.2.2 Data collection.

After the think-aloud session, we interviewed the participants for feedback and data collection. The interview consisted of two parts: questions assessing the usefulness of this tool as well as their learning experience. It was then followed by a SUS survey to evaluate the usability of this tool. There was also an optional follow-up assignment at the end.

We opened the interview by asking about their overall experience with this AR tool. We encouraged them to talk about any specific features they like or do not like about this tool. Then, they were guided to comment on how this tool might help with their furniture selection &arrangement and how it enhanced their knowledge of Feng Shui theory. In addition,
participants were asked whether they might consider using this tool for the long term and recommended it to family members. Their recommendations about improving current features were also asked and recorded. These interview results were transcribed and categorized using an affinity map for further analysis to identify common themes.

The second part of the interview focused more on their learning experience. At first, participants were asked to draw out their current room layout and the changes they would like to make based on the theory they had just learned. We asked them to use simple lines to represent the current and new layout. Next, we provided them with a piece of paper with two-room layouts and asked them to identify any improper arrangements according to the theory they had learned (Figure 9). They were encouraged to check theories back in the tool for reference. In addition, we asked them to explain why certain design decisions are favored in Feng Shui theory, and they are also encouraged to check in the tool. Afterward, they were asked to fill out a SUS survey to evaluate the usability of the tool.

The optional follow-up assignment aims to determine how users might use this tool in their living space. Those who were willing to take the test received and installed the prototype on their own device. They were asked to use this tool in their own living space and played around with the furniture model to see how the theory might help with their current furniture selection and arrangement.
4.2 Results

4.2.1 Findings from the interview

The affinity map categorized and analyzed the interview responses (Figure 9). Most participants were generally satisfied with the AR tool's learning experience. They like how they can visualize furniture in their living environment and how it looks and should be placed. Many of them also expressed positive opinions about the text explanation behind each statement; P1 said that "the explanation about Feng Shui theory makes much sense as before, I might wonder why to choose this, why to choose that, but now I know from the theory." Most participants also mentioned that this tool enhanced their knowledge of Feng Shui theory and their awareness of the importance of furniture placement. Since most of them have not heard about Feng Shui theory before, P2, P5 and P6 said that:
“This tool helps me to know where my furniture to get the energy to have a better environment and also helps me to get an image to know the best way to organize my furniture.” [P2]

“I never really know and think how to place furniture, since I usually buy first and then place it, but this helps me think more about the placement.” [P5]

“What I learned help me to find a balance in trying to achieve a better environment in my apartment” [P6]

Figure 10 – Affinity map of themes from user study session

Regarding the design, most participants expressed positive opinions about showing Feng Shui theory along with the furniture model that they can learn and think simultaneously while playing around with the furniture model. They also appreciated the option of viewing different styles of the same furniture with one click, which is convenient. Moreover, most participants like
the ability to freely move, scale, and position furniture models in the AR environment; P9 stated that "the way which I can freely move, and scale furniture model is beneficial in terms of how easily to view the placement." Many participants mentioned that they favored the 'furniture combination' models since they helped them get a clearer understanding of the arrangement. As P6 stated, "the sofa, chair, coffee table combination was a good example of showing the proper way to arrange my living room, wish it can have more like this in the tool."

There is also lots of useful feedback from the second-half interview. Since they were asked to draw the current room layout and changes they wanted to make, many found this a helpful exercise since many of them thought their existing room had some improper arrangement after learning from this tool. Some participants (P1, P4, and P8) talked as they sketched:

“My bed was placed at the corner of my bedroom, but based on the Feng Shui theory, I think I would move the bed to the right a bit and allow space for the nightstand. I would move the tall plants to the living room as well.” [P1]

“The sofa in my living room was placed under the window since I love to see the view outside but now, I think I would move it to the side, against the wall, in the command position. I might also add a few plants to increase my house energy.” [P4]

“Most of the tables in my home have sharp edges and now I know those are bad in Feng Shui. I would like to consider using more rounded tables in my living room and dining room.” [P8]
Their drawing showed that the theory they learned from this tool helped them make a more proper arrangement at home. In the next part, where they were asked to make changes to the given layout, although the changes they made are visually different, all the drawings show improvements to the existing furniture arrangement according to Feng Shui theory (Figure 11). Since P8 stated that he had participated with his own design before, he stated, “I began to have more sense of the furniture placement after I learned from the tool, and I can easily say which arrangement needs to take more consideration than before.” In the end, when they were asked among the theories, they had just learned which of them most benefit them as a user. 6 out of the 9 participants stated ‘bed’ as the top furniture they knew the most. As most of them said that almost half of the time was spent in the bedroom, so they thought the way to place the bed and accessories around it were the most important. However, P7 stated that theories about ‘plants’ and ‘wall art’ benefit him the most, as he said, “I have over ten plants in my apartment; these are small pieces which I move often, so I consider more about their placement at home.”

![Sample drawings show furniture arrangement changes of given layout](image)

Figure 11 – Sample drawings show furniture arrangement changes of given layout
4.2.2 Findings from the take-home assignment

Three out of 9 participants (P2, P4, and P5) took the take-home assignment where they installed the prototype on their own device and used it when they were back home. All participants shared positive feedback about the experience of using the prototype in a real home environment. As P5 said, “using this tool in a real home is different from what I feel during the study session; I am able to check and see how the furniture looks at my home.” Another participant [P4] stated, "I am now able to see how plants look in my living room and where I should place them. It is fun!” P2 also stated that “One of the major differences from what I felt in the user testing session is that I pay more attention to the ‘south/north’ direction settings at my home. I considered my housing situation at the same time when I tried to learn from this tool.” It turns out that using this tool in a home environment provides a more realistic experience for the participants compared to the studio settings.

Moreover, a few participants also re-stated the need for the measurement shown within the tool. P4 mentioned that “I really the way that I can adjust the size and direction of each piece of furniture, yet I do want to know the real size of the straight sofa, for example, to know whether its placement will fit in my living room. Adding the dimensions would be much easier for me to compare.” Participants also gave feedback about the ‘lighting issue’ as P5 stated, “the lighting in my house somewhat affect my arrangement choice, like where to put the plant, if this tool takes lighting into consideration, I think it will provide more precise suggestions.” Overall, the feedback from the take-home assignment helps me further identify usability issues for future improvement.

4.2.3 Findings from the survey
Participants’ answers to each question in the SUS rating sheet are normalized and converted to become the final SUS rating shown in Table 5. The SUS score is 83.61 based on the calculation which falls in the excellent range of user experience referring to SUS grade ranking. However, there are still space for improvement according to their feedback in the study session.

<table>
<thead>
<tr>
<th>Survey Questions</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>Average</th>
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</thead>
<tbody>
<tr>
<td>I think I would use this tool</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>5</td>
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<td>5</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>4.78</td>
</tr>
<tr>
<td>I thought the system is not complex to use</td>
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<td>4</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>4</td>
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<td>4</td>
<td>4</td>
<td>5</td>
<td>4</td>
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<tr>
<td>I was able to learn quickly from this tool</td>
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<td>5</td>
<td>4</td>
<td>4</td>
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<td>4</td>
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<td>4</td>
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</tr>
<tr>
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<td>4</td>
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<td>4</td>
<td>4.33</td>
</tr>
<tr>
<td>I thought the design of the tool is consistent</td>
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<td>5</td>
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<td>4.67</td>
</tr>
<tr>
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<td>5</td>
<td>4</td>
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<td>4.33</td>
</tr>
<tr>
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</tr>
<tr>
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<td>5</td>
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<td>4</td>
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<td>4.78</td>
</tr>
<tr>
<td>I do not need to learn a lot of things before I could go with this tool</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>4.78</td>
</tr>
</tbody>
</table>

Table 5 – Usability survey result

4.2.4 Limitations and discussion

1) The current tool does not provide dimensions and measurement of the furniture model

A few participants mentioned that they would like to see the dimensions of the furniture model while viewing it in AR mode. Since this tool allows users to scale each model's size freely, the size can be different from the view of different participants, which might confuse them. For instance, P1 stated: “I like the way it can be scaled; however, when I consider the way of placement, I would like to see its actual size relative to other furniture in my home.” P2 recommended, “if the furniture measurements can just pop up when we scale to the right size, that would be much more convenient.”

2) The current tool does not support customization of the furniture placement
Based on the research, the furniture placement and arrangement guidelines are not always the same according to Feng Shui theory. There are many factors which can affect that, such as house direction/location. A few participants hoped that the guidelines they learned would vary based on their housing condition and their preference. For instance, P3 stated that “it would be amazing if the tool can analyze my room and provide customization according to the Feng Shui theory. In this way, my home arrangement would be more balanced.” Adding customization with the model would be beneficial as P9 said that "customization of the furniture selection would be better since I can learn more about the Feng Shui theory in different circumstances.”

3) The current tool does not provide importance level of each theory

Since all the theories listed in this tool were shown in the text box around the furniture model, some participants thought there was a lack of the importance level of the theory they learned. P2 stated that “all theories seem to be useful, but there are just so many of them, and I’m not sure which one or two are the most important that I should definitely know.” Prioritizing or indicating the top theories would be more beneficial as “I would take more considerations about the ones highlighted when placing my furniture” [P3]. P8 also mentioned that “highlight keywords or make special marks might be helpful after glancing over this text.” Overall, this tool needs to provide more precise instructions and highlight the important part for users to quickly learn and understand.
CHAPTER 5. CONCLUSION AND FUTURE WORKS

5.1 Discussion and Conclusion

In this thesis study, we researched, developed, and evaluated an AR-based tool for people who want to make furniture selections and arrangements for their living space. This application educates and guides people to learn about Feng Shui theory while allowing them to view models in the AR environment. The findings from the user study revealed that this tool helps people know where their furniture gets the energy to have a more balanced environment, as well as get an image to know the best way to organize their furniture.

Previous studies have shown that AR is a profound visualization method that enhances users’ perception of home design. When users operate the AR tool, they have the chance to visualize and test how furniture looks in their living space before purchasing them. The tool shows “how the furniture fits in the physical space” (Sandu, 2018). Currently, as participants stated, the ability to visualize the furniture fit at home is essential; however, being guided along the selection of furniture is more beneficial. With this AR learning tool, all the participants expressed that they could not only freely superimpose 3D furniture models onto their living environment in real-time to view how furniture looks but also were taught how furniture should be positioned. This aligned with the research, which indicates the importance of furniture arrangement that “interior arrangement should be supportive to a comfortable conversation and visually balanced composition; it is also essential for human comfort and well-being” (Wang, 2018). Overall, all participants mentioned that the AR tool makes them more confident in choosing and organizing their furniture without the invention of design professionals.
The Feng Shui theory included in the tool, known as the practice that suggests a way for people and nature to live harmoniously, provides guidelines for living space design (Kiehl, 2005). Incorporating such guidelines along with the furniture model is helpful as participants stated that they were being educated on the theory, which shows the best way to organize and arrange their home furniture. Integrating ancient well-being theory with modern technology is innovative and beneficial as the literature research revealed that the furniture arrangement could somewhat affect comfort level and emotions. This tool is crucial to show and guide the proper way that they might choose and place furniture at home.

5.2 Limitations of the study

1) User group show less concerns and awareness regarding home design

The majority of our users in the study are students who do not own their houses; therefore, this particular user group is less concerned and does not raise enough awareness about the importance of home design since they do not need to. The main problems discussed in this thesis are targeted at those who need to take serious concern about interior design since it is their own house that they would occupy for years. However, the user group in this study showed insights about their understanding of themselves or their family’s home design experience, which are helpful. However, future research can include people who own their houses in the study to know how they can learn and benefit from this AR tool.

2) User study did not take place in the real home environment

In addition, our user study was conducted in person at the design studio, a public space that students can quickly get access to. This was convenient for our users; however, it weakened the
testing effect since this tool is designed to be used at home. All participants needed to pretend that they were inside a living environment to try and learn from this tool. This was not the ideal environment for them to place the furniture model since the studio layout is very different from our home layout. In further studies, we can consider inviting users to an empty apartment so that users can have a more realistic experience while using this AR tool.

5.3 Future Iteration

For future iterations of this AR tool, we considered showing measurements and dimensions of the furniture model as some participants suggested that this would help determine the model's actual size. It could also allow users to better place furniture inside the home with dimensions kept in mind. Another improvement that many participants request is adding a customization feature. For example, we allowed users to choose a design style on the menu page. Afterward, different furniture model styles would appear based on their choice, and users would be able to learn theory accordingly. In addition, we might add a tutorial at the beginning to demonstrate how to use this tool to be clearer to all users. Overall, these iterations will make the AR tool even more comprehensive to bring a better user experience.
APPENDIX A. SURVEY QUESTIONS

You are being asked to be a volunteer in a research study. The purpose of this study is to understand how people view well-being of their home environment. The survey will take approximately 5 minutes to complete.

You must be over 18 and live within the US in order to take the survey. You will not benefit or be compensated for joining this study. We will comply with any applicable laws and regulations regarding confidentiality. To make sure that this research is being carried out in the proper way, the Georgia Institute of Technology IRB may review study records. The Office of Human Research Protections may also look at study records.

If you have any questions about the study, you may contact the Primary Investigator, Dr. Allstonby, by email at lea.allstonby@design.gatech.edu. If you have any questions about your rights as a research subject, you may contact Ms. Melanie Clark, Georgia Institute of Technology at (404) 894-6942. Your participation in this study is voluntary.

You do not have to be in this study if you don’t want to be. You have the right to change your mind and leave the study at any time without giving any reason and without penalty. You do not waive any of your legal rights by agreeing to be in the study. Your completion of this survey provides your consent to participation. Thank you for participating!

1. What’s your age?

   - 18 and under
   - 19 to 25
   - 25 to 39
   - 40 to 64
   - 65 and above

2. What gender do you identify with?

   - Male
   - Female
   - Prefer not to answer
   - Other

3. Please specify your ethnicity

   - Native American
   - African American/African/Black/Caribbean
   - Asian
   - Caucasian
   - Hispanic/Latino
   - Prefer not to answer
   - Other
4. What's your current employment status?

- Employed full-time
- Employed part-time
- Student
- Seeking opportunities
- Retired
- Other

5. What's your annual household income?

- Less than $25,000
- $25,000 to $49,999
- $50,000 to $74,999
- $75,000 to $99,999
- $100,000 to $149,999
- $150,000 or more

6. In which type of housing do you currently live?

- Apartment
- House
- Duplex
- Condominium
- Other

7. Which of the following best describes your current housing situation?

- Homeowner
- Renter

8. Who do you currently live with?

- Alone
- With friends
- With family
- Other
9. Are you satisfied with your current living interior space design?

- Very satisfied
- Somewhat satisfied
- Not satisfied
- Other

10. Do you aware that design of interior space will affect physical and mental well-being?

- Yes
- Somewhat aware
- Not so much

11. The interior design of your property can significantly stimulate and affect your feelings and well-being as we are visually exposed and influenced by our surroundings, which of the following factors do you consider when you think about interior design? (Please select all that applies, if not listed below, please specify)

- Organization & Storage
- Furniture match
- Home layout
- Color choice
- Function & perception of space
- Texture, elements and material
- Green Plants
- Lighting
- Other

12. For the choice(s) you select above, could you briefly share why you consider those factors to be important when design your home?

13. Do you participate in your own home/apartment interior design? Or do you have someone else who provides design guidance?

- Yes, all by myself
- Friends or family members
- Interior designers or agencies
- Other
14. What are specific strategies that you might use to make sure your home/space support wellbeing?

15. Where do you pick your furniture?
- Furniture store
- Online
- Both
- Other

16. Do you know there is an Augmented reality app on market that allows you to visualize furniture in your actual space that can assist with furniture picking?
- Yes, I have tried it before
- Yes, but I haven't tried it
- No

17. If answer is ‘yes’, could you please share your experience with AR apps (please specify which apps you have used)
APPENDIX B. USABILITY STUDY INTERVIEW

You have now completed the questionnaire. I’d now like to ask a few questions to gain further feedback. The first 6 questions are about assessing the usefulness of this tool.

1. Please describe your overall experience when using this prototype?
   Answer:

2. In your opinion, how does the tool benefit in guiding you through furniture selection and arrangement?
   Answer:

3. Do you think this tool enhance your knowledge and awareness about Feng Shui theory? How?
   Answer:

4. Would you introduce this tool to your friends or family members? Why or why not?
   Answer:

5. Is this the tool you would consider using for the long-term?
   Answer:

6. Please recall the principles you just learned; do you have any recommendations to make the tool better?
   Answer:

Next, I will ask 4 questions about your learning experience

7. Think about your current home layout, how might you apply the Feng Shui theory you just learned to your current design, what changes you might do? Please draw the current layout and changes you would make based on the Feng Shui theory.

8. Here’s a simple living room and bedroom layout. Please identify any improper arrangement based on the Feng Shui theory you just learned. You can draw any changes you would make here.

Answer:

9. Here are several Feng Shui favored furniture selection/arrangement statement, could you tell why these arrangements are favored in Feng Shui theory? You can check in the tool to find out.
   a. Bed shouldn’t be placed in line with the door.
   b. Avoid place sofa directly under the ceiling beam.
c. Wood dining table is favored in Feng Shui

10. There are many Feng Shui theories taught in this tool, which of them most benefit you considering your current home environment?

Answer:

This concludes the last part of today’s testing. Thank you again for participating!

In the meantime, I’m wondering if you like to do the follow-up remote test, I will e-mail you the prototype video which you can watch it at home and then there will be some quick questions to answer. The goal for this is to let you learn and apply the theory in your real home environment.

Questions:
  1. Could you describe how you apply the theories in this tool in your own home environment? You might take photo of it or draw it out.
  2. Please identify which theory(s) you applied and how they help with the design?
  3. How did this tool help you make better furniture selection or arrangement decision?

That’s the end of today’s testing! Thank you again for participating! You did a great job and we learned a lot from your experience! Do you have any questions for me that you would like to ask now?
**APPENDIX C. USABILITY STUDY SURVEY**

You are being asked to be a volunteer in a usability testing study. The purpose of this study is to explore and document the usability and usefulness of the AR based prototype that is designed to guide people through furniture selection and arrangement to achieve wellbeing in the home environment. The survey will take approximately 2 minutes to complete. You will be compensated $25 for joining this study through a e-gift card. However, you will not be pro-rated compensation for early withdrawal. The funds are reimbursed by Georgia Institute of Technology. We will comply with any applicable laws and regulations regarding confidentiality. To make sure that this research is being carried out in the proper way, the Georgia Institute of Technology IRB may review study records. The Office of Human Research Protections may also look at study records. If you have any questions about the study, you may contact Leila Aflatoony at telephone (404) 988-1474. If you have any questions about your rights as a research subject, you may contact Ms. Melanie Clark, Georgia Institute of Technology at (404) 894-6942. Thank you for participating in this study.

<table>
<thead>
<tr>
<th>I think I would use this tool</th>
<th>Strongly disagree-1</th>
<th>Disagree-2</th>
<th>Neutral-3</th>
<th>Agree-4</th>
<th>Strongly agree-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>I thought the system is not complex to use</td>
<td>○</td>
<td>○</td>
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<tr>
<td>I found this tool is easy to use</td>
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<td>I was able to learn quickly from this tool</td>
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<tr>
<td>I would imagine most people learn to use this tool quickly</td>
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<tr>
<td>I'm satisfied with the function of this tool</td>
<td>○</td>
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<tr>
<td>I felt confident using this tool</td>
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<td>I do not need to learn a lot of things before I could going with this tool</td>
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Habel, Katherine L. "Furniture arrangements." (1980).


