EFFECTS OF AUGMENTED REALITY PRESENTATIONS ON CONSUMER'S VISUAL PERCEPTION OF FLOOR PLANS

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For the degree of  Master of Science

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EFFECTS OF AUGMENTED REALITY PRESENTATIONS ON CONSUMER'S VISUAL PERCEPTION OF FLOOR PLANS

A Thesis
Submitted to the Faculty
of
Purdue University
by
April L. Lutheran

In Partial Fulfillment of the
Requirements for the Degree
of
Master of Science

May 2012
Purdue University
West Lafayette, Indiana
To David Lancaster: Thank you for helping me determine what color my parachute was, I will be forever grateful for having known you.
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ABSTRACT

Lutheran, April L. M.S., Purdue University, May 2012. Effects of Augmented Reality presentations on consumer’s visual perception of floor plans. Major Professor: Patrick Connolly.

Home architects and designers use many types of presentation drawings to convey design ideas. Augmented reality is a relatively new technology that can be used to aid in design and marketing for residential builders. An augmented reality presentation provides a more complete idea of a design than other presentations such as 3D model renderings and hand drawn artist sketches. While designers are accustomed to visualizing 2D plans, this task is difficult for home buyers. This difficulty has been associated with lower spatial ability in people who are not accustomed to reviewing plans. Augmented reality can be used to make visualization easier and help developers save on marketing expenses. The use of augmented reality could lower sales and marketing expense by reducing the number of model homes built to help potential buyers visualize new concepts. While this technology has been studied by many industries, very little research has been done on how it could benefit residential builders. The research conducted in this study sets a baseline of consumers opinions on viewing and augmented reality presentation.
CHAPTER 1. INTRODUCTION

Even with today’s advanced technology, homes are currently only being marketed by two main types of media. The most basic is a paper, printed sales brochure. These brochures typically have information about the size, price, location, and rooms of a home. Another commonly used marketing venue is the internet. Along with text information, presentation quality drawings of the home are often included.

Driving the need for presentation drawings is the fact that many residential home buyers have problems imagining the final product. Traditionally, presentation drawings consist of 2D images either printed or displayed on a screen. The image cannot be viewed from any perspective other than what the creator chose. To compensate for this, companies build model homes. These homes allow the customer to see the home in its finished state.

One way to give customers a new tool to view a home would be using augmented reality. Augmented reality is a relatively new technology that is being used in many applications. The research conducted compared an augmented reality presentation against a traditional model home.

1.1 Statement of Problem

Many people cannot visualize a floor plan from standard sales brochures or construction documents. Residential builders therefore build model homes for buyers to tour. Model homes are a large marketing expense for the builder. Little research has been done on how using augmented reality could benefit a residential builder.
1.2 Research Question

What effect does an augmented reality presentation have on consumers’ visual perception of a floor plan?

1.3 Significance

For many consumers, home buying can be a daunting task. Many factors influence buyers’ decisions to purchase a specific home. One of these main factors is the physical layout of the home. Floor plans have multiple variables that make them distinct. The number of levels, split bedroom, open concept, and traditional are just a few of these variables. While some people have the ability to visualize the layout of a floor plan, others cannot.

In addition to sales brochures, to help buyers understand a floor plan, companies build model homes. Model homes are a worthwhile expense to home builders. They provide customers a chance to walk through a finished product. The problem is that if buyers cannot visualize a particular floor plan, they typically buy the same floor plan as a model home. If a buyer does not like the layout of a model home and cannot visualize from a floor plan, this creates an issue: the customer may not buy at all. As a result home builders build several model homes to help the buyer visualize different options. Multiple model homes can become a substantial expense to the builder. An augmented reality presentation would be significant to both consumers and the home builders.

1.4 Scope

The research in this study examined how an augmented reality presentation may or may not aid in visualization of the floor plan. Using an augmented reality presentation may help lower the number of model homes required by increasing visualization using digital technology.

The purpose of this study is to establish a baseline of consumers’ opinions of an augmented reality presentation. Potential customers were surveyed after viewing an AR
presentation to determine whether or not their understanding and opinions of floor plans changed.

1.5 Definitions

Augmented Reality (AR): AR is a mix of reality and virtual reality. AR systems are defined by having three characteristics: combines real and virtual reality, interactive in real time, and registered in 3-D (Azuma, 1997).

Building Information Modeling (BIM): “Represents the process of development and use of a computer generated model to simulate the planning, design, construction and operation of a facility” (Azhar, Hein, & Sketo, 2008, p 1).

Spatial Ability: Defined by Lohman (1979) as having three factors: visualization, spatial relations and spatial orientation. Spatial ability is a person’s mental capacity to visualize with or without visual stimuli.

1.6 Assumptions

The following assumptions were inherent in the pursuit of this research:

1. The residential builder has technology already in place to use augmented reality (i.e., AR software, laptop, digital camera, and projector).
2. The builder implementing the AR presentation will currently be using Revit.
3. The participants will have not viewed the home before.

1.7 Limitations

The following limitations were inherent in the pursuit of this research:

1. The research did not collect any demographic information about the subjects.
2. The research will look at using Revit, SketchUp, and AR media although other software options do exist.
1.8 Delimitations

The following delimitations were inherent in the pursuit of this research:

1. The research will be conducted in only one specific model home in one neighborhood in Wilmington, NC.
2. Augmented reality versus other forms of marketing.
3. The financial effects of implementing augmented reality software.

1.9 Summary

Consumers would benefit by better understanding the floor plan. A well informed decision may be made by increasing their ability to visualize the floor plan. Understanding the plan fully may also increase customer satisfaction.

In addition to increasing visualization, residential builders using AR presentations as a sales and marketing tool, could potentially lower the number of model homes built. Model homes or demo homes are typically completely furnished. Many companies employ sales agents to work in homes and show them to potential customers. Companies can build several model homes per community which is extremely costly since the builder has money tied up in the furnishing, agent on site, and lot costs among other expenses. Typically the model home is sold once the neighborhood is nearing completion. Model homes are sold for lower margins since many people have been in them and they are no longer considered brand new. The use of an AR presentation has the potential to lower some of these sales expenses by providing a more realistic final presentation.
CHAPTER 2. LITERATURE REVIEW

Home architects and designers use many types of presentation drawings for marketing design ideas. Augmented reality is a relatively new technology that can be used to aid in design and marketing for residential builders. An augmented reality presentation provides a more complete idea of a design than other presentations such as 3D model renderings and hand drawn artist sketches. While designers are accustomed to visualizing 2D plans, this task is difficult for home buyers. This difficulty has been associated with lower spatial ability in people who are not accustomed to reviewing plans. Augmented reality can be used to make visualization easier and help developers save on marketing expenses. The objective of this research was to determine if an augmented reality presentation can increase visualization for residential home buyers. While this technology has been studied by many industries, very little research has been done on how it could benefit residential buyers and builders.

There are three specific areas related to this issue. The first of these areas will be marketing. Marketing has undergone drastic changes because of new technology. Technology is rapidly changing the way consumers receive information about products. A new way this information is presented is with the use of augmented reality.

An overview of how floor plans are created and how presentation drawings are currently being done will also be discussed. Drafting techniques and programs used to create floor plans are becoming more intuitive. Building information modeling (BIM) allows for a floor plan to be created as a three-dimensional representation. Traditional computer-aided design (CAD) is typically only in 2D. How 3D models can help consumers better understand floor plans will also be discussed.

Finally, an overview of spatial ability will be presented. Studies have shown that spatial ability varies from person to person. A person’s spatial ability may affect how
well they can understand a floor plan. The main objective of an AR presentation would be to present information to reduce the amount of visualization.

2.1 Technology Background

Humans have been building structures and manufacturing parts for centuries. As construction and manufacturing evolved, so did the process of drafting and design. One of the earliest examples of a formal plan is the design for a fortress carved on a stone tablet dated around 4000 B.C. (Harris & Meyers, 2007). Since then, plans have been used to construct buildings, homes, or anything that is machined and/or manufactured. The research discussed in this paper will focus on residential construction.

Significant changes have occurred since the first plans were carved on stone tablets, and there remains opportunity for considerable exploration in enhancing the presentation of design concepts. Computer programs are constantly pushing the envelope by providing all inclusive services. The use of computer aided design (CAD) has drastically changed the drafting and design process. While there are many aspects to the design process, the final presentation drawing is often the most important. Presentation drawings are typically 2D images that are either printed or viewed on a screen and shown to prospective buyers as a concept of the final product. Presentation drawings have been done for years in many different forms which will be discussed further in the problem background. One of the newest ways to present information is with the use of virtual reality/augmented reality. Virtual reality completely immerses a person in an entirely virtual world. Augmented reality (AR) is a middle ground between reality and virtual reality, mixing both real life objects with virtual models (Azuma, 1997). Augmented reality is defined by Drascic and Milgram (1996) as in-between reality and augmented virtual on the reality to virtual continuum. They go on to say that “AR displays are those in which the image is of a primarily real environment, which is enhanced, or augmented, with computer-generated imagery” (Drascic & Milgram, 1996, p. 124). The displayed image is either viewed through a head mounted display or on a computer screen.

Augmented reality can be used with a variety of applications and equipment. The research in this paper will discuss using a laptop in conjunction with a digital camera and
a projector. AR can considerably enhance the viewer’s understanding of the design over a traditional 2D plan. While augmented reality is currently used for manufacturing, entertainment, and large scale commercial projects, it could also be beneficial on a smaller scale as a sales and marketing tool for residential builders.

2.2 Marketing

Marketing is defined by The American Marketing Association (AMA) as “an organizational function and a set of processes for creating, communicating, and delivering value to customers and for managing customer relationships in ways that benefit the organization and its stakeholders” (Gundlach & Wilkie, 2009, p. 259). The marketing discussed in this research will focus specifically on media for residential buyers. The most common media is through the use of sales brochures or presentation drawings.

There are many different types of presentation drawings that use either hand drawn techniques or computer generation plans. The most common form is to remove irrelevant information from the construction plan and use a basic 2D view of the plan as shown in figure 2.1.

![Figure 2.1 Tradition 2D presentations.](image)
This process is done with CAD software and takes the least amount of time. Some of the more popular hand drawn techniques are pen and ink, colored pencil, and watercolors. These techniques are time consuming and make it difficult for changes since they are completely done by hand. Hand drawn techniques are considered an art form, resulting in an additional cost of paying an artist. Due to these negative factors, residential builders predominantly use computer generated renderings for presentation drawings.

Computers can also be used to make presentation drawings by taking 3D models of a home and rendering either a photorealistic or non-photorealistic image. Photorealistic images look like an actual photo of the home. Non-photorealistic (NPR) images mimic the hand techniques mentioned earlier. Non-photorealistic rendering is believed to be an easier medium of imagery to view (Gooch, Long, Ji, Estey, & Gooch, 2010). Both Photorealistic and NPR require the construction of a 3D model as well as additional software to render the final image. Figure 2.2 shows an example of a NPR floor plan that is converted into a photorealistic 3D model. If the original plans were done in 2D CAD software then they would need to be modeled in 3D software. With the rise of building information technology more companies are switching to 3D software, making the further step to augmented reality a logical one.

![Figure 2.2 NPR to photorealistic 3D model.](Bill Clark Homes, 2012)
Building information modeling (BIM) develops a model of the home unlike 2D drafting that requires the drafter to draw elevations from scratch. Unlike 2D drafting software, BIM models contain objects “defined in terms of building elements and systems such as spaces, walls, beams and columns” (CRC Construction Innovation, 2007, p.3). Because a model is developed along with the working plan, most BIM software packages contain rendering software. How these software packages could use plug-ins or third party software to present residential drawings in augmented reality is a subject for further research.

Driving the need for presentation drawings is the fact that many residential home buyers have problems imagining the final product. Traditionally, presentation drawings consist of 2D images either printed or displayed on a screen. The image cannot be viewed from any perspective other than what the creator chose. Augmented reality would allow the buyer to view a 3D plan that can be rotated to any angle.

A study conducted by Trainor, Rapp, Beitelispacher, and Schillewaret (2011) examines how information technology can be used to increase the effects of marketing. They hypothesized that e-marketing is positively related to customer relationship performance, and organization performance. They define e-marketing as “a broad set of interaction-enabling technologies” (p. 162). There results showed that companies that use information technology better communicate information to the customers. Using augmented reality may be a way to better communicate floor plan information.

2.3 Spatial Ability

Spatial ability has been defined and redefined by many professionals in different fields. Lohman (1979) defines spatial ability “as the ability to generate, retain, and manipulate abstract visual images” (p.188). While there is no agreement on one final all-encompassing definition, experts do agree on the basic concepts that comprise spatial ability. The most often repeated components of spatial ability include mental visualization, rotation, and orientation. All three of these aspects, along with other spatial ability skills, are important in understanding architectural plans but visualization is the most.
Spatial ability is important in drafting/design and architecture because of the graphical information that plans provide. According to Akin, Dave, and Pithavadian (1987):

Architecture is a particularly relevant domain to investigate the comprehension of graphic information for many reasons: (a) graphics are the primary medium of communication used; (b) the domain has both a conventionalized language and symbol system which facilitates coding the think aloud protocols that are generated in response to the architectural plans, and (c) generating verbal descriptions about buildings is an integral part of the domain i.e., in discussing plans with colleagues and clients (p. 1).

Architecture or construction plans often require background knowledge of what the symbols and specific lines represent. Typical floor plans are drawn as if the top part of the building was cut off at the four-foot mark. This leaves information technically above the discard line unavailable to viewers. An example of this would be kitchen wall cabinets. Kitchen wall cabinets are represented on plans as a dashed line. Other information such as ceiling breaks, optional items, or future fixtures are often shown with dashed lines, as well. Typically a cathedral or vaulted ceiling is shown with a dashed/dot line, or center line. Lines are also plotted at different weights to show depth. Figure 2.3 shows several standard linetypes found in construction plans.

![Figure 2.3 Typical linetypes](image-url)
People frequently find it difficult to visualize information represented by these lines. Akin, Dave, and Pithavadian (1987) say that people who have experience reading plans often have higher spatial abilities because they constantly practice these skills. Another article by Salthouse, Babcock, Skovronek, Mitchell, and Palmon (1990) discusses how spatial visualization ability decreases in retired architects. This decrease is because they are no longer using visualization skills as frequently.

Another aspect of spatial ability is the comprehension of graphics versus. text. Graphics by nature present all information instantly where text is read linearly (Akin, Dave, & Pithavadian, 1987). Graphic information on a plan can be misleading depending on the viewer. If a plan calls out a dining room but the buyer wishes to use the space as a living room, the buyer may have a difficult time visualizing the room being used as anything other than a dining room. The textual information instantly provokes mental visualizations of objects associated with that text.

Augmented reality can be used with architectural plans to reduce the amount of mental visualization and rotation needed to view plans. A 3D model of a floor plan more accurately depicts tight spaces like hallways and closets and can be rotated, allowing the viewer to see from multiple angles. Even though the use of AR can have multiple benefits there remain issues that need to be addressed to make it as effective as possible. For example, augmented reality would allow the viewer to visualize a 3D model of the plan, but with a camera and screen display, the viewer ultimately sees a 2D image. Also, if a model is rotated and the plan floor is not kept along the ground axis, the viewer could be confused.

2.4 Summary

There is significant research on augmented reality, but very little information about how it can be used to improve marketing of residential design. Current research involves using augmented reality on many other applications rather than for residential building. This research could show how augmented reality can aid residential building and develop another practical uses of the technology. Implementing augmented reality presentations provides the potential for significant increase of visualization of floor plans.
In addition, there are possible savings in marketing and sales costs for residential builders.
CHAPTER 3. METHOD

A 3D representation of the model home from the Brunswick Forest neighborhood in Wilmington, North Carolina, was developed using Revit. The 3D representation was designed to match the model home as closely as possible. That representation was then exported into SketchUp to be used with an augmented reality plugin. Potential customers who visited the model home at Brunswick Forest viewed an AR presentation, after agreeing to participate in the study. After seeing the presentation the potential customers toured the model home in typical fashion. An online questionnaire was used to determine the effect of the AR presentation on potential customers’ opinions. This chapter outlines the manner in which the research was conducted.

3.1 Hypothesis

The research conducted addresses three separate hypotheses:

H01: An AR presentation does not change a person’s understanding of a floor plan.

H11: There is an increase in a person’s understanding of a floor plan after viewing an AR presentation

H02: A person with little plan familiarity does not feel the AR presentation increases their ability to understand the home in order to make a good buying decision.

H12: A person with little plan familiarity feels the AR presentation increases their ability to understand the home in order to make a good buying decision.

H03: A person with little plan familiarity does not feel that the AR presentation is an effective way to view a home if no model was available.

H13: A person with little plan familiarity feels that the AR presentation is an effective way to view a home if no model was available.
3.2 Population

The population consisted of new construction home buyers in Wilmington, North Carolina. The voluntary sample of 15-20 home buyers were interested specifically in the Brunswick Forest neighborhood, which was chosen because a model home was already established. The homes are in a higher price range and vary greatly in style. Building multiple model homes would be extremely expensive in this neighborhood for the residential builder.

3.3 AR Presentation Design

The 3D model was created by importing the floor plan from AutoCAD into Revit. Using existing 2D plans the time to trace the walls and window locations into Revit was relatively short. To provide the sales agent access to the model Google SketchUp was installed on their laptop. Revit has a built in export function that works directly with Google SketchUp; however, all texture information is lost while exporting the model. Extra trim details and textures were applied to the SketchUp representation. Textures were matched as closely as possible to the existing model home. AR Media has a commercially available plug-in that works with Google SketchUp. AR Media also has a plugin for 3ds Max that would have preserved the texture information from Revit, but since 3ds Max is more complicated and not free, Google SketchUp was used instead.

An augmented reality presentation is significantly different than a traditional sales brochure since it gives viewers multiple vantage points. AR works by using a printed marker. The marker used for this research is shown in figure 3.1. This marker is typically black and white, printed on white paper. The key to the marker is the distinct border. The marker can be made in any pattern and each marker is unique to one model.
AR software, such as the AR Media plugin, works with a web camera connected to the computer. When the camera detects the marker, the software retrieves the model associated with that marker and imposes the model over the marker. Figure 3.2 shows an example of a model in SketchUp on the left, with the same model imposed on a marker on the right. The image on the right is what the viewer would see on the computer screen.

Potential customers visiting the model home at Brunswick Forest were asked if they would be willing to participate in a graduate thesis study. If they agreed, the sales agent showed them the floor plan in AR format. The sales agent showed the home from...
various angles and zoomed into features such as cabinet details and bathrooms. The customers were allowed to hold the marker themselves and manipulate the angle from which they viewed the representation. There was no time constraint on how long the customers viewed the AR representation of the floor plan.

When finished viewing the AR presentation the customers toured the model home. After touring the model home they were instructed to click on a link that directed them to a survey to answer questions regarding their opinion of the AR presentation. The main objective of the survey was to establish whether or not customer’s visual perception of the home improved after viewing the AR presentation.

3.5 Permissions

Permissions to conduct this research at the model home at Brunswick Forest were given from the area manager of Bill Clark Homes (see Appendix A). Further permissions were granted from the Human Subjects approval through Purdue University (see Appendix B).

3.6 Data Source

The sole data source was the online survey. According to Evans and Lindsay (2005), a Likert scale is a common means of measuring participant degree of opinion. A standard five point scale was used for the majority of the survey questions (see appendix C).

A survey is an appropriate instrument of measurement when trying to learn about people’s attitudes, opinions or beliefs (Creswell, 2003). For this research, a cross-sectional design survey was used. According to Creswell, a cross-sectional survey design is when “the researcher collects data at one point in time” (pg 398). Chief advantages to this type of design are that the survey provides information in a short time frame and measures current attitudes.

Three industry experts reviewed the survey for relevance prior to it being used. Expert one is an area manager for a national top 100 residential builder in North Carolina.
with over 30 years of experience in new home construction and all aspects of the selling process.

   Expert number two is the sales manager for the Wilmington division of a national top 100 residential builder in North Carolina. Expert number two is responsible for establishing all of the sales and marketing policies for the division.

   The third expert is a professional homebuilder with a General Contractor License and a background in architecture, neighborhood planning and large-scale homebuilding operations. Along with five years of experience designing commercial and residential architecture this expert has spent a decade building homes and managing contractors with an Atlanta based builder.

### 3.7  **Summary**

   This chapter outlined the methods in which the research was conducted for this study. The hypothesis, population, AR presentation design and experiment design were outlined first. Then the permissions required and the data source used were explained. In the next chapter the results of the survey will be given.
CHAPTER 4. RESULTS

This chapter details the results of the data collected by the online survey. Descriptive statistical analysis will be shown for each of the survey questions. Also $t$-test results will be given for question four against questions three, eight, and nine addressing the three hypotheses. The data has been checked for the assumptions of running a $t$-test of independence, normality and continuous. While the questions are assigned a number for discussion purposes, the questions were randomized in the actual survey.

4.1 Demographics

The survey was taken by twenty three participants. While no official demographics were recorded for this study, the sales agent who administered the survey was asked to give an estimate of the demographics. He said participants were typically in the age range of 55-65. Realtors did not take the survey, but several were shown the presentation. According to the sales agent “it is very popular with the agents that I have shown. Most of them are late 20's to early 40's” (B. Norris, personal communication, February 20, 2012).

4.2 Descriptive Statistical Analysis

The descriptive statistical information given for each question consists of the minimum, maximum, mean, and standard deviation. Because question one was asking willingness to participate in the study, the analysis will begin with question 2.
4.2.1 Question 2

The participants were asked “Do you feel that the AR presentation helped you better visualize yourself in the rooms?” with the available response of Yes or No. All of the participants answered Yes to this question.

4.2.2 Question 3

The participants were asked “How does this experience compare to walking through and actual home as it pertains to your ability to understand the home in order to make a good buying decision?” The available responses were a five point Likert scale from Not at all Similar to Very Similar. Of the 18 participants, zero responded Not at all Similar, two responded Barely Similar, one responded No Difference, 18 responded Fairly Similar, and two responded Very Similar. The mean response was 3.87 with a standard deviation of .69. There was a significant similarity of the AR experience to walking through and actual home, \( t(22) = 3.87, p < .001 \). Figure 4.1 and table 4.1 show the descriptive statistical analysis for this question.

![Figure 4.1 Bar graph results for question 3.](image)
Table 4.1 *Question 3 descriptive statistics results.*

<table>
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<td>Mean, $\mu$</td>
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<td>$t$-value</td>
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</tr>
<tr>
<td>$p$-value</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

4.2.3 Question 4

The participants were asked “Would you say your familiarity with reviewing plans is above or below average?” The available responses were Below Average, Average, or Above Average. Of the 23 participants, ten responded Below Average, ten responded Average, and three responded Above Average. The mean response was 1.70 with a standard deviation of .70. Figure 4.2 and table 4.2 show the descriptive statistical analysis for this question.

*Figure 4.2 Bar graph results for question 4.*
Table 4.2 *Question 4 descriptive statistics results.*

<table>
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<td>Mean, µ</td>
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</table>

4.2.4 Question 5

The participants were asked “Do you agree or disagree that the AR presentation aids in demonstrating the craftsmanship of the builder?” The available responses were a five point Likert scale from Strongly Disagree to Strongly Agree. Of the 23 participants, zero responded Strongly Disagree, five responded Disagree, 12 responded Neither Agree nor Disagree, five responded Agree, and one responded Strongly Agree. The mean response was 3.09 with a standard deviation of .79. There was no significant that the AR presentation aided in demonstrating the craftsmanship of the builder, $t(22) = 0.53, p = .604$. Figure 4.3 and table 4.3 show the descriptive statistical analysis for this question.

*Figure 4.3* Bar graph results for question 5.
Table 4.3 *Question 5 descriptive statistics results.*

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<td>3.09</td>
</tr>
<tr>
<td>Standard Deviation, $\sigma$</td>
<td>.79</td>
</tr>
<tr>
<td>$t$-value</td>
<td>.53</td>
</tr>
<tr>
<td>$p$-value</td>
<td>.604</td>
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</tbody>
</table>

4.2.5 Question 6

The participants were asked “Would you be interested in using this type of technology from your home computer?” The available responses were a five point Likert scale from Definitely will not to Definitely will. Of the 23 participants, two responded Definitely will not, 11 responded Probably will not, seven responded Don’t know, two responded Probably will, and one responded Definitely will. The mean response was 2.52 with a standard deviation of .95. There was significance that participants would not be interested in using this technology from home, $t(22) = -2.42, p = .024$. Figure 4.4 and table 4.4 show the descriptive statistical analysis for this question.

*Figure 4.4 Bar graph results for question 6.*
Table 4.4 *Question 6 descriptive statistics results.*

<p>| | |</p>
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<td>Standard Deviation, $\sigma$</td>
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<tr>
<td>$t$-value</td>
<td>-2.42</td>
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<tr>
<td>$p$-value</td>
<td>.024</td>
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</table>

4.2.6 Question 7

The participants were asked “Do you feel that viewing an AR presentation helps you better visualize kitchen layouts, bathrooms, or other tight spaces?” The available responses were a five point Likert scale from Strongly Disagree to Strongly Agree. Of the 23 participants, zero responded Strongly Disagree or Disagree, four responded Neither Agree nor Disagree, 18 responded Agree, and one responded Strongly Agree. The mean response was 3.87 with a standard deviation of .46. There was significance that the AR presentation helped participants better view tight spaces, $t(22) = 9.11, p < .001$. Figure 4.5 and table 4.5 show the descriptive statistical analysis for this question.

*Figure 4.5 Bar graph results for question 7.*
Table 4.5 *Question 7 descriptive statistics results.*

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<td>t-value</td>
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<tr>
<td>p-value</td>
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</tbody>
</table>

4.2.7 Question 8

The participants were asked “Would an AR presentation be an effective or ineffective way to view a home if no model was available?” The available responses were a five point Likert scale from Very Ineffective to Very Effective. Of the 23 participants, zero responded Very Ineffective, Ineffective, or Neither Effective nor Ineffective, 20 responded Effective, and three responded Very Effective. The mean response was 4.13 with a standard deviation of .34. There was a significance that the AR presentation would be an effective way to view homes if no model was available, $t(22) = 15.74, p < .001$. Figure 4.6 and table 4.6 shows the descriptive statistical analysis for this question.

![Bar graph results for question 8.](image-url)
Table 4.6 *Question 8 descriptive statistics results.*

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<td>15.74</td>
</tr>
<tr>
<td>( p )-value</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

4.2.8 Question 9

The participants were asked “Did the AR presentation increase or decrease your overall understanding of the floor plan?” The available responses were a five point Likert scale from Decreased to Increased. Of the 23 participants, zero responded Decreased or Somewhat Decreased, three responded No Change, 13 responded Somewhat Increased, and seven responded Increased. The mean response was 4.17 with a standard deviation of .65. There was significance that the AR presentation increased the overall understanding of the floor plan, \( t(22) = 8.66, p < .001 \). Figure 4.7 and table 4.7 show the descriptive statistical analysis for this question.

*Figure 4.7 Bar graph results for question 9.*
Table 4.7 *Question 9 descriptive statistics results.*

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<tr>
<td>Mean, ( \mu )</td>
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</tr>
<tr>
<td>Standard Deviation, ( \sigma )</td>
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<tr>
<td>( p )-value</td>
<td>&lt;.001</td>
</tr>
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</table>

4.3 **Hypotheses t-Test Results**

This section will discuss the inferential statistical analysis of three separate hypotheses. The main hypothesis of this research was to determine if the AR presentation increased a person’s overall understanding of the floor plan. A t-test was calculated looking at a person’s familiarity of plans (question 4) against if they thought the AR presentation increased their understanding (question 9). The second hypothesis examined if a person’s familiarity with reviewing plans was below average (question 4) did they feel the AR presentation was similar to walking through an actual home as it pertains to their ability to make a good buying decision. The third hypothesis was if a person’s familiarity with reviewing plans was below average (question 4) did they feel that the AR presentation was an effective way to view a home if no model was available. For all three hypotheses \( \mu_0 = 3 \). Because the questions are on a five point Likert scale, a mean of three would suggest no change or no difference in questions three, eight, and nine.

4.3.1 **Hypothesis 1 Results**

A t-test was performed by calculating the mean responses for Below Average, Average, and Above Average response for question 4 as they pertain to an increase in overall understanding of the floor plan in question 9. Figure 4.8 shows the mean response with the standard error.

The mean Below Average response was 4.4 with a standard deviation of .516, \( t = 8.57 \), and critical value < 1.833. Participants with a Below Average response on
question three had a statistically significant increase of their overall understanding of the floor plan. The mean Average response was 4.1 with a standard deviation of .737, \( t = 4.719 \) and critical value <1.833. Participants with an Average response on question three had a statistically significant increase of their overall understanding of the floor plan. The mean Above Average response was 3.66 with a standard deviation of .577, \( t = 1.98 \), and critical value <2.92. Participants with an Above Average response on question three did not have a statistically significant increase of their overall understanding of the floor plan (see Table 4.8).

![Subjects familiarity and their overall understanding of floor plans](image)

*Figure 4.8* Mean responses of plan familiarity with standard error.
Table 4.8 *Hypothesis 1 results.*

<table>
<thead>
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<tbody>
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<td>&lt;1.833</td>
<td>&lt;2.92</td>
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4.3.2 *Hypothesis 2 Results*

A $t$-test was calculated by taking the mean responses for Below Average, for question 4 as they pertain to the similarity of viewing the AR presentation compared to walking a model home to understand the home in making a good buying decision in question 3. Figure 4.9 shows the mean response with the standard error. The mean Below Average response was 3.7 with a standard deviation of .674, and $t$ =3.284, and critical value <1.833. Participants with a Below Average response on question three had a statistically significant similarity of viewing the AR presentation compared to walking a model home to understand the home in making a good buying decision (see Table 4.9).

Table 4.9 *Hypothesis 2 results.*

<table>
<thead>
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<tbody>
<tr>
<td>Participants, N</td>
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<td>Standard Deviation, $\sigma$</td>
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<td>$t$-value</td>
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<tr>
<td>Critical Value</td>
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</tr>
</tbody>
</table>

4.3.3 *Hypothesis 3 Results*

A $t$-test was calculated by taking the mean responses for Below Average, for question 4 as they pertain to the effectiveness of viewing an AR presentation if no model
home were available (question 8). Figure 4.9 shows the mean response with the standard error. The mean Below Average response was 4.0 with a standard deviation of zero. Because a standard deviation of zero cannot be used to conduct a t-test since it would cause a zero in the denominator, a standard deviation of .001 was alternately used. The results were $t=7.98$ and critical value $<1.833$. Participants with a Below Average response on question three had a statistically significant effectiveness of viewing the AR presentation if no model home were available (see Table 4.10).

Subject who are "unfamiliar with floor plans" and their response on Question 3 & 8.

*Figure 4.9 Mean responses of plan familiarity with standard error.*
Table 4.10 Hypothesis 3 Results.

<table>
<thead>
<tr>
<th></th>
<th>Below Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants, N</td>
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</tr>
<tr>
<td>Standard Deviation, $\sigma$</td>
<td>.001</td>
</tr>
<tr>
<td>$t$-value</td>
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</tr>
<tr>
<td>Critical Value</td>
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</tbody>
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4.4 Summary

This chapter detailed the results of the data collected by the online survey. Descriptive statistical analyses were given for each of the survey questions. Also $t$-test results were given for question four against questions three, eight, and nine. The next chapter will discuss these results, future recommendations, and a conclusion.
CHAPTER 5. ANALYSIS AND CONCLUSION

The overall objective for this research was to determine what effect an augmented reality presentation has on consumers’ visual perceptions of a floor plan. This chapter analyzes the results of the previous chapter and interprets how those results meet the main objective. The interpretations of the three hypotheses will be given as well as interpretations of individual survey questions. Recommendations for future studies and applications of this study will be discussed. Finally a conclusion of the overall study will be given.

5.1 Hypothesis 1 Interpretations

The first hypothesis examined participants’ familiarity with plans as it relates to whether they indicated that the AR presentation increased or decreased their overall understanding of the floor plan. Participants who indicated an initial Below Average and Average understanding of the floor plan had a statistically significant increase in understanding the floor plan. Participants indicating initial Above Average understanding did not show statistically significant increase or decrease but the researcher believes this is largely due to the sample size. Only two participants answered Above Average with regard to plan familiarity. As most home buyers are not accustomed to looking at floor plans the high number of Below Average and Average responses is not unexpected.

Of all the participants surveyed, the majority (87%) reported an increase in understanding the floor plan. To strengthen the results of question 9, the researcher distinguished the increase by familiarity level to ensure each had a significant increase. The results of this hypothesis suggest that regardless of a person’s familiarity with floor plans, an AR presentation will increase their understanding.
Survey results indicate that AR presentations could help reduce the level of spatial ability needed for a customer to understand a plan. Future research could examine the extent to which this understanding is increased. Two groups of participants with low familiarity with plans could be studied. One group would study a typical 2D floor plan and answer questions about the plan. The second group would view the same floor plan as an augmented reality presentation and answer the same questions. Comparing the results would give researchers insight on what information is better presented in an AR format.

5.2 Hypothesis 2 Interpretations

The second hypothesis examined only participants with Below Average familiarity with plans. It compared viewing the AR presentation to walking a model home with regard to understanding the home sufficiently to make a good buying decision. The similarity of viewing the AR presentation compared to walking a home was statistically significant for these participants. This implies that even if a customer is not familiar with looking at plans, they believe they could make an informed decision about buying the home from the AR presentation alone.

The majority of all participants (82%) indicated that the AR presentation was similar to actually walking the home. The impact of these results would help support the researcher’s claim that AR presentations could help reduce the number of model homes required for residential communities. Constructing fewer model homes would be a substantial cost savings to the builder.

5.3 Hypothesis 3 Interpretations

Hypothesis three examined the effectiveness of viewing an AR presentation for participants with Below Average plan familiarity if no model home was available. This hypothesis was tested to support hypothesis two and the claim that the use of AR technology could reduce the number of model homes a company needs to build. The results were statistically significant. Participants with Below Average familiarity with
plans indicated that the AR presentation was effective if no model was available. All study participants indicated that the AR presentation would be an effective way to view a home if no model was available.

5.4 Additional Survey Interpretations

Of all the participants surveyed, 100% answered that the AR presentation helped them better visualize themselves in the home. The participants were given only the option of Yes or No as a response for this question. Given its straightforward nature, it was unnecessary to divide this question into a Likert scale.

The participants did not believe that the AR presentation aided in demonstrating the builder’s craftsmanship. Of all the participants surveyed more than half (52%) neither agreed nor disagreed with the relevant question. These results may be an effect of how the question was worded. The question was “Do you agree or disagree that the AR presentation aids in demonstrating the craftsmanship of the builder?” More clearly expressing the question could include some examples of what craftsmanship means. If parentheses with examples such as trim or moldings were included, the participants might have responded differently to this question.

When asked if they would be interested in using this type of technology from home, more than half (57%) of the participants responded they would not. This result is largely due to participant demographics. The sales agent who administered the presentation and survey noted that participation was limited to those with an interest in computers. Some would decline to participate stating “I’m not a computer person.” Future research could be targeted to home buyers 20-40 years of age where computer use is more common. The sales agent also reported that the AR presentation was very popular with other realtors of this younger age group.

The majority of participants (82%) responded that the AR presentation helped them better visualize kitchen layouts, bathrooms, or other tight spaces. This question was asked since these are typical problem areas for most home buyers. A residential builder already utilizing 3D modeling with software like Revit could quickly produce 3D models of just the kitchen or bathroom.
5.5 Future Research and Applications

Another reason for this research was to establish a baseline for the use of augmented reality as a tool for residential builders. Participants’ initial opinions were collected and analyzed, and demonstrate that an AR presentation can be a valuable tool for selling homes. To strengthen these initial findings this study could be repeated for a longer duration and a larger sampling size. While there were sufficient participants for effective statistical analysis, larger samples could reinforce the results. Results could be further enhanced if this study was conducted with regard to several different model homes of various price ranges. Participant demographics should also be analyzed in future studies.

Logistically it was not possible for participants to take the survey without viewing a majority of the model home. Future research could also analyze results of those viewing the AR presentation that have not already toured the model home against those which have already toured the model home. These results would show a stronger analyst of whether or not the AR increased the understand of the plan prior to actually viewing the model home.

A cost analysis could be conducted to examine the savings a residential builder could expect by implementing AR presentations compared to building multiple model homes. The expenses associated with a model home can total over several hundred thousand dollars. These expenses include the lot, construction, staffing, furniture, and utilities. Once AR software is purchased, the only reoccurring expense would be the salary of the modeler. The researcher does not feel that AR presentations should completely replace model homes, but could be used to reduce the total number needed to be built.

As a student, the researcher is interested in the effect of AR on student learning. A future study in a classroom environment could follow closely the study outlined in Hypothesis 1. Students could be divided into groups, one using AR and the other not, and asked questions about a model to gauge which group has a better understanding. This could be very helpful where students need to visualize but are not use to using computer
aided design software. The AR-media’s applications are simple to use for demonstration purposes.

The researcher purposely chose to use commercially-available software to make AR implementation seamless for a residential builder. Google SketchUp is free and the AR-media plug-in is relatively inexpensive. A builder could easily use AR-media’s newest software which is an iPad or iPhone application. Sales agents could be given markers for all homes available in a given neighborhood. Using an iPhone or iPad they could show customers the various homes. In addition, builders could host the models and their correlating markers on a server providing links to the AR-media application. Even though the results of this study indicated that participants were not interested in using this technology at home, it is the researcher’s opinion that its use would grow in popularity among potential customers more comfortable with computers. Another possibility would be to post the markers on for sale signs placed on a vacant lot. Customers could then use their iPhone or iPad to view the models. Having this on-site demonstration could lead to more customers scheduling to meet with a sales agent.

5.6 Conclusions

While augmented reality is a relatively new technology its use within residential building companies could have significant benefits. At the start of this research it was predicted that an AR presentation would increase consumer understanding of a given floor plan. AR presentations, such as the one in this study, could be used to minimize the number of model homes required or when model homes are not available. In addition, companies could decrease expenses by using AR not only as a marketing tool but also as an initial design tool.

The survey used for this research accomplished the main goal of developing a baseline of consumer opinion on an AR presentation. The statistical results of the data show a very favorable response to the AR presentation. Also the results have demonstrated that viewers of an AR presentation have an increased understanding of the floor plan.
Future studies can expand upon the research conducted by increasing the length of data collection time. This study covered a two-month time period. Creating additional models and AR presentations in various locations could further validate the results of this study.
REFERENCES
REFERENCES


APPENDIX
Appendix A Bill Clark Homes permissions
I give permission to April Lutheran to conduct her study on augmented reality in one of my sales models with my clients.

Sincerely,

Heath Clark
Area Manager
Bill Clark Homes Wilmington, LLC.
Appendix B IRB Approval & Forms
To: PATRICK CONNOLLY  
KNOY 323  
From: JEANNIE DICLEMEN TI, Chair  
Social Sciences IRB  
Date: 12/05/2011  
Committee Action: Exemption Granted  
IRB Action Date: 12/05/2011  
IRB Protocol #: 111101  
Study Title: Augmented Reality Presentation Study  

The above referenced protocol is considered exempt after review by the Institutional Review Board pursuant to Federal regulations, 45 CFR Part 46.102(f)(2).  

If you wish to revise or amend the protocol, please submit a new exemption request. Please refer to our guidance "Minor Changes Not Requiring Review" on our website. Please contact our office if you have any questions.  

We wish you good luck with your work. Please retain copy of this letter for your records.  

Below is a list of best practices that you should be aware of and keep in mind when conducting your research.  

Category 1  
- Written permission from preschools, primary and/or secondary schools should be obtained prior to the investigator engaging in research, such as recruitment and conducting research procedures. If the written permission was not submitted with the protocol at the time of IRB review (e.g., the school would not issue the letter without proof of IRB approval), the investigator must submit the written permission to the IRB office immediately upon receipt from the school. This is an Institutional requirement.  

Categories 2 and 3  
- Surveys and data collection instruments should note that only participants 18 years of age and over are eligible to participate in the research, state that participation is voluntary and that any questions may be skipped, and include the investigators name and contact information.  
- Investigators should explain to participants the amount of time required to participate. Additionally, they should explain to participants how confidentiality will be maintained or if it will not be maintained.  
- When conducting focus group research, investigators cannot guarantee that all participants in the focus group will maintain the confidentiality of other group participants. The investigators should make participants aware of the potential for breach of confidentiality.  
- Written permission from businesses, preschools, primary and/or secondary schools should be obtained prior to the investigator engaging in research, such as recruitment and conducting research procedures. If the written
permission was not submitted with the protocol at the time of IRB review (e.g., the school would not issue the letter without proof of IRB approval), the investigator must submit the written permission to the IRB office immediately upon receipt from the school. This is an institutional requirement.

Category B
- Surveys and data collection instruments should note that participation is voluntary.
- Surveys and data collection instruments should note that participants may skip any questions.
- When testing foods which are highly allergenic (e.g., peanuts, milk, etc.) investigators should disclose the possibility of a reaction to potential subjects.

General
- To recruit from Purdue University classrooms, the instructor and all others associated with conduct of the course (e.g., teaching assistants) must not be present during announcement of the research opportunity or any recruitment activity. This may be accomplished by announcing, in advance, that class will either start later than usual or end earlier than usual so this activity may occur. It should be emphasized that attendance at the announcement and recruitment are voluntary and the student’s attendance and enrollment decision will not be known by those administering the course.
- When conducting human subjects research at non-Purdue colleges and universities, investigators are urged to contact that institution’s IRB to determine requirements for conducting research at that institution.
- When conducting human subjects research in places of business, investigators must obtain written permission from an appropriate authority from the business prior to engaging in research activities such as recruitment or conducting study procedures. This is an institutional requirement.
Revised 8/11

RESEARCH EXEMPTION REQUEST
(Category 2 or 3)
Purdue University
Institutional Review Board

Exemptions under Title 45 CFR §46.101
(b)(2) exempts research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless:
(i) Information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and
(ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

(b)(3) exempts research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if:
(i) The human subjects are elected or appointed public officials or candidates for public office; or
(ii) federal statute(s) require(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

PLEASE BE AWARE that you cannot begin the project until you have received notification that the exemption has been granted.

1. Check one of the following:
   □ This submission replaces a previous exemption, IRB Ref.#
   ☑ This is a new study

2. Project Title:
   Augmented Reality presentation study

3. Anticipated Funding Source:

4. Principal Investigator [See Policy on Eligibility to serve as a Principal Investigator for Research Involving Human Subjects]:
   Patrick Connelly, Professor, Computer Graphics Technology, Knoy, 765-496-3943, connollp@purdue.edu
   Name, Title, Department, Building, Phone, Fax, E-mail address

5. Co-Investigators and key personnel [See Education Policy for Conducting Human Subjects Research]:
   April Lutheran, Graduate Student, Computer Graphics Technology, Knoy, 252-258-7185, aluthera@purdue.edu
   Name, Title, Department, Building, Phone, Fax, E-mail address

6. Consultants [See Education Policy for Conducting Human Subjects Research]:
   Brad Norris, Sales Agent, 910-988-4888, 910-523-5597, bradnorris.oib@gmail.com
   Name, Title, Department, Building, Phone, Fax, E-mail address

7. Anticipated Duration of Study: Please indicate when this project will end. Estimate how long it will

1
take to transcribe audio and/or video tapes if used, and when they will be destroyed.

Project END Date:  February 29, 2012

Participant Population

8. Expected Age Range

Check all that apply:
☐ <18 (for public observation only when researchers do not interact with subjects)
☒ 18-64
☒ 65 and older

9. Describe location of subjects during research data collection

Check all that apply:
☐ Purdue University, specify campus:
☐ Elementary/Secondary Schools, specify:
☐ Community Center, specify:
☐ Other University Campus, specify:
☐ Subject’s Home, specify:
☐ International Location, specify:
☒ Other location, specify: Model home for Bill Clark Homes LLC, Wilmington

Summary of Activities

(use lay language, do not cut and paste from or refer to grant or abstract)

10. Briefly state your research question.

What effect does an augmented reality presentation have on consumers’ visual perception of a floor plan?

11. Describe the tasks subjects will be asked to perform (e.g., frequency and duration of procedures, psychological tests, educational tests, and experiments; including screening, intervention, follow-up etc. Reminder: No sensitive information can be sought under exempt guidelines.) Attach all surveys, instruments, interview questions, focus group questions, etc.

The participants will be shown an augmented reality presentation then asked to take a web hosted survey. See attachments.

12. How will the data be recorded?

☐ Written Notes
☐ Audio
Compensation

13. Will you give subjects gifts, payments, compensation, reimbursement, services, or extra credit?
   ☑ YES
   ☑ NO
   If yes, please explain:

Recruitment

14. Check all that apply:
   ☐ The subjects are elected or appointed public officials or candidates for public office.
      If the above applies, for what office is your subject population a candidate, or if the subject population currently holds a public office for which they were elected or appointed, provide the title(s) of the office:

   ☐ Federal statute(s) require(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter (45 CFR §46.101(b)(3)(ii)).
      If the above applies, what federal statute(s) require(s) confidentiality?

   ☑ None of the above applies

15. Describe the recruitment process to be used:
   Home buyers that come to tour the model home will be asked if they are willing to participate in the study.
   Attach a copy of any and all recruitment materials to be used (i.e. advertisements, bulletin board notices, e-mails, letters, phone scripts, or URLs.)

16. Explain who will approach potential subjects to take part in the research study and what will be done, if anything, to protect individuals' privacy in this process:
   The sales agent for the model home will give the potential subjects a link to a survey to take after viewing the presentation.

17. Is contact information for your subject population publicly available?
   ☑ YES
   ☑ NO
   If no, describe your permissible access to this population (or include written documentation for the cooperation/permission from the holder or custodian of the records):
18. Is contact information for your subject population chosen from records?

☐ YES
☒ NO

If yes, what type of records?
☐ Medical
☐ Educational
☐ Employment
☐ Other, specify:

Who controls the permissible access for the use of the records?

Confidentiality

19. Will the data be collected anonymously (without identifiers)?

☒ YES. Skip to end of document.
☐ NO. Describe the identifiers to be collected:

20. Describe provisions that will be taken, if any, to maintain confidentiality of data (i.e. surveys, audio, video, etc.):

21. Estimate how long it will take to transcribe audio and/or video tapes and when they will be destroyed.

22. Will the PI be able to identify subjects (i.e. identifiers, code keys, etc.)?

☐ YES
☐ NO

23. Will identifiable data be made available to anyone other than the PI?

☐ YES
☐ NO

If yes, explain who and why they will have access to the identifiable data:

Conflict of Interest

24. Do the investigators have a significant financial interest in this study?

☐ YES If yes, proceed to question 25.
☒ NO If no, skip to question 26.

25. Have you filed a Conflict of Interest Disclosure Statement (Form C-1)?

☐ YES If yes, proceed to question 26 below.
☒ NO If no, refer to Conflict of Interest: Policies and Management.

26. Do the investigators have any other known conflict of interest in this study?

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YES If yes, please attach an explanation identifying the conflict.
☐ NO

As principal investigator of this study, I assure that the information supplied in this form and attachments are complete and correct. I have read the Researcher Responsibilities and will conduct this research in accordance with these requirements.

Principal Investigator Signature: [Signature] Date: [Date]

Submit this signed form and attachments to the Human Research Protection Program office either via hardcopy or electronically. Forms received without signatures will be returned. A signed form and attachments can be submitted electronically as an email attachment to irb@purdue.edu. If a signed form is submitted electronically, a paper copy need not be submitted.

U.S. Mail Address:
Human Research Protection Program
Purdue University
YONG, Rm. 1032
155 Grant Street,
West Lafayette, IN 47906-2114

Campus Address:
Human Research Protection Program
YONG 10th Floor, Rm. 1032
Need help? Contact HRPP office at 765-494-5942.
Office Hours: M-F 8-11 am 1-5 pm
Appendix C Online Survey
Intro Question

You are requested to participate in research that will be supervised by April Lutheran, on what effect an augmented reality presentation has on consumers' visual perception of a floor plan. This survey should take about 5 to 10 minutes to complete. Participation is voluntary and responses will be kept anonymous. Participation or non-participation will not impact your relationship with Bill Clark Homes.

If you have any questions about the research, please contact April Lutheran via email at a199497@purdue.edu. If you have questions about the treatment of human subjects, contact the IRB Administrator at 507-335-2321.

Please select yes below as your informed consent to participate and that you affirm that you are at least 18 years of age.

Yes  
No

Block 1

Do you feel that the AR presentation helped you better visualize yourself in the rooms?

Yes  
No

Block 2

How does this experience compare to walking through an actual home as it pertains to your ability to understand the home in order to make a good buying decision?

Not at all Similar  Slightly Similar  No Difference  Fairly Similar  Very Similar

Block 3

Would you say your familiarity with reviewing plans is above or below average?

Below Average  Average  Above Average

Block 4

Do you agree or disagree that the AR presentation aids in demonstrating the craftsmanship of the builder?

Strongly Disagree  Disagree  Neither Agree nor Disagree  Agree  Strongly Agree

Block 5

Would you be interested in using this type of technology from your home computer?

Definitely not  Probably not  Don’t know  Probably will  Definitely will

Block 6

Do you feel that viewing an AR presentation helps you better visualize kitchen layouts, bathrooms, or other tight spaces?

Strongly Disagree  Disagree  Neither Agree nor Disagree  Agree  Strongly Agree
Block 7

Would an AR presentation be an effective or ineffective way to view a home if no model was available?

Very Ineffective  Ineffective  Neither Effective nor Ineffective  Effective  Very Effective

Block 8

Did the AR presentation increase or decrease your overall understanding of the floor plan?

Decreased  Somewhat Decreased  No Change  Somewhat Increased  Increased