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The Intuitive House

An Interactive Qualifying Project Report
submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfillment of the requirements for the
Degree of Bachelor of Science
by

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Abstract

This report describes our "intuitive house", a house where every room is located precisely where expected, and where every light switch is in a logical location. It does this by relying upon what people's expectations are on objects, by designing simply, yet intuitively.

This involved the study of how people relate to their environment through architecture, interior design, and psychology. From the results of our research we created a home based on people's perceptions and understanding of the world around them.

Executive Summary

The goal of this project is to design a house in which the design incurs minimal cognition or thinking time on the inhabitants. This project seeks to design an intuitive house, and follows through the steps of researching psychology and house design, conducting surveys to clarify research, designing the house, and testing the house design.

Literature Review

Through the literature review, the project team acquainted itself with the psychological aspects in residential dwellings as they relate to the architecture and interior design. During the psychology review, the areas of perception, cognition, experiences, aesthetics, and technology were covered. Perception relates how a person gains a basic understanding the environment through basic information sources. The five basic sources of information result from the orientation, haptic (touch), taste/smell, auditory, and visual systems. Cognition is the higher level of thinking used to solve problems when basic perception fails, such as a door with an ambiguous mechanism to open it; this project is attempting to minimize the level of cognition required of house occupants. Experience is what a person falls back too when perception and cognition fail; this is when a person draws from past experience with similar devices to hypothesize the operation of a newly encountered device. Aesthetics is a sore point in design when it renders perception, cognition, and experience useless. A common example at hotels and public buildings is glass doors with hidden hinges and pull bars on both sides; people may have no cues or know no precedence as to which side to push or pull on. The design might be visually appealing but may need signs indicating "Push" and "Pull", which are only useful for English speakers. Technology can also interfere with design when, simply stated, too many features are available to confuse or distract the user. In instances such as video cassette recorders (VCRs), advanced features like timed recording and channel restrictions are hidden behind panels such that only the basic functions of play, stop and rewind are initially presented. Lastly, The Book of Norman touches on the aspects of visibility, conceptual models, mapping, mental models, and

feedback as principles of good design.

Through the architectural and interior design literature reviews, the project team explored basics of house construction and interior decorating. The architectural material covers the physical construction of things like footings, walls, doors, and windows, and it then touches on prevalent attitudes towards architectural intuitive design. Interior design discusses how lighting, colors, and room arrangements influence occupants. Lighting may be either artificial or natural, and may vary depending on purpose such as illuminating high traffic areas or adjusting the perceived size of a room. Color has an important emotional impact on occupants; bright warm colors encourage positive feelings, while cooler shades are soothing. Also, colors may influence perceived room size by using bright colors to bring walls closer and pastels to drift walls further away. Room arrangement relates lighting, color, and furniture to room functionality and touches on living rooms, dining rooms, kitchens, bedrooms, bathrooms, and studies.

Survey

A survey is conducted to refine ideas brought up during research. The survey is comprised of three question types: demographical, theoretical, and personal preference. The demographic questions assist in evaluating the survey audience such as field of study, class year, and gender (survey subjects were students). Theoretical questions aided in evaluating theories such things as door knob and light switch mechanics, and preference questions search for patterns in people's expectations of a house. Through the survey analysis, the question results are reviewed and statistically analyzed, and then a second survey is conducted to further clarify ambiguous findings. Of particular interest in survey results, pocket style doors were preferred for closets, and logical room grouping by floor was observed such as sleeping quarters on the second floor and utilities in the basement. Also knobs that turn clockwise to open were preferred on doors, and there was the least preference for windows to face North instead of East, West, or South.

Design

House design is completed in three sections: floor plan, interior design, and exterior

design. The floor plan started with the idea of grouping rooms to floors by general purpose. A room's purpose is one of living, sleeping, or utilities. Rooms for living are relatively public and include the kitchen, foyer, dining room, and the living room; they are placed on the first floor. Sleeping rooms are more private and include the bedrooms, master bathroom, and linen closet; these are on the second floor. Utilities encompass washing machines, water heaters, and air conditioning equipment and are located in the basement. Next, rooms were located based on orientation to the sun. Bedrooms are located on the house's northern side to limit direct sunlight, the living room is at the center of the house on the south side for light throughout the day, and the kitchen is in the east in hopes of morning sunlight waking up early feeders.

Interior design covers floors, walls, ceilings, windows, doors, and appliances. Based on room function, different floors coverings were used: the kitchen and bathrooms have tiles, the dining room, hallway, and stairs have wood, and the living room and bedrooms have carpeting. Many windows are located on the south wall to increase the perceived space of the living room, and fewer windows are on the northern walls to reduce chill from colder northern winds. To aid in differentiation, different styles of doors and door mechanisms are used. Closet doors are pocket style and other doors are hinged; exterior doors are differentiated from other doors by having door handles instead of knobs. Also, several appliances are recommended to furnish the house such as a refrigerator, dishwasher, and microwave. Lastly, services like electricity, water, and sewage and method of access via wire, pipe, or conduit are discussed for each room.

The exterior design briefly discusses the surrounding land for the house and issues such as lot size and landscaping. Minimum lot size is determined by specific building codes in the construction area, but for the purposes of this project, $8000ft^2$ is determined by satisfying physical constraints like house and driveway dimensions as well as by approximate psychological needs. Within the lot, zones are defined to outline recommendations for landscaping with shrubs and trees and well as for vehicle safety at the driveway and road.

Conclusions

The typical house is often designed by an architect in conjunction with what the buyer wishes. A good example is one of the author's homes, where the kitchen, living room, and dining

room are located on the second floor of the house, the bedrooms on the first floor, and the entrance located in a middle floor between the two. People entering the house became instantly confused as to where rooms were located.

The question arises, what does this house feature that is not common in every other house? It has doors, windows, and floors like every other house. The features of this house lie in the intent behind the design, not necessarily anything physically obvious. Our research and study is of what is required to design an intuitive house. Our design is not necessarily the only intuitive house, nor does it suggest that there are no other intuitive homes. Design features unique to this house include the use of different doors to signal the purpose of the room behind them. Most homes contain a varied mishmash of doors; their type selected to suit the dimensions of the house or the room. For the example of closets, sliding or folding doors are typically utilized for long shallow closets, pocket doors are utilized in areas where hallways are shallow, and regular doors are utilized pretty much wherever people feel necessary. Our research showed that sliding doors are associated with closets, therefore by constantly making all closet doors sliding, users of the house will be able to identify the utility of the room behind the door without actually opening the door.

Other symbols associated with door and their contents were the concept of putting a crescent moon on bathroom doors. This concept is unique, since bathroom doors are typically unmarked in homes. The house is designed to be easily navigable for first time users. The house also incorporates appliances that are intuitive. These devices follow Norman's model of design.

There are plenty of other features designed within the house included in the report that enhance the intuitiveness of the house. The research to generate this home is simply a building block of intuitive design. It shows that homes are not random apparitions, designed at solely the whims of the owner, but that there is a conscious system behind its design.

Authorship

All project members took part in the design and writing of this project. In the literature review, Karin Blank researched psychology, Adam Hoffman researched interior design, and David Holl researched Architecture. For the surveys, all team members contributed to the question pool and data analysis, Karin wrote the design rationale, Adam contributed the images and diagrams, and David acquired the population sample and handled the web presentation. David also wrote the CGI scripts to handle web survey data. During design, all team members collaborated in creating floor plans and interior design. Adam created the diagrams of the floor plan and the 3D model. Karin performed a cost analysis of the house. In the written portion, Karin focused on the house floor plan, Adam wrote about the interior design, and David covered the services and exterior design.

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Introduction

Our world is not an intuitive one. We encounter numerous puzzles every day, whether it is navigating through a new building or trying to open a childproof cap on a medicine bottle. It is not intuitive because we are creative creatures – we strive for originality in our designs, to make objects better and bigger than before. Sometimes we succeed and people have no trouble integrating a new item into their lives. And sometimes we do not, and the item remains on the shelf, best left forgotten.

Unintuitive design is as common as intuitive design. Unintuitive items include doors that have pull handles when they have to be pushed, computers with on/off switches placed next to the button for the CD-ROM, and stairs that are not all the same height. All these items will cause human error and require additional learning in order to use without making mistakes. All are typical items that the fix is obvious, yet that does not prevent the mistakes from continually being made.

Particularly at home, non-intuitive design can be a real annoyance. When you enter a house through the front door and immediately end up in a bathroom, you have to wonder what the designer of the house was thinking. Or when you find windows at waist level in your shower, you worry about what was on the architect's mind. Granted, these concepts are somewhat absurd, but homes are sometimes designed without taking into account that the design will make life harder on the occupants. For example, generally speaking, one expects to find the front door of a house on the ground level. As shown in figure 1, this design is not always prevalent. (Gifford, 208)

Figure 1 - Unintuitive Design (Gifford, 208)

There are reasons for creating a design that is unintuitive. Aesthetics may warrant the staircase leading to the front door, but that is based on personal taste (or lack thereof). One may build an unintuitive house simply for ease of construction; it might be easier to build a house that does not bother with making the design intuitive. Safety may also be a concern; while it may make more sense for an exterior door to open outwards, this would expose the hinges of the door to outdoor conditions such as rain, ice, and burglars. These other concerns do not necessarily preclude intuitive home design. We believe that it is possible to make an intuitive house without sacrificing ease of construction, safety, or even aesthetics.

The term "intuitive house" is not one that can go without definition. It is not necessarily a person's ideal house, a building that can only exist in a person's unique imagination. Nor is it some farcical technological zoo in which every human need is served by an electronic invention. It is the "every man's" house and at the same time it is not. It is the house in which every door opens the direction you expect it to, and where every light switch is in a logical location. The place demands no instruction manual, no learning curve, and no frustrations of any sort. It does this by relying upon what people's expectations are on objects, by designing simply, yet intuitively.

The task of intuitive home design demanded that our group do considerable research. These areas of research included architecture, interior design, and psychology. The reasoning behind this is simple: we needed to know how to structurally engineer a house, what should go in the house, and the psychology in its design. The focus in our research was how these different

aspects could affect our goals and how we needed to take them into consideration during the design process. Our house needed to be low maintenance, feature intuitive devices, and take all of the former aspects into consideration as well.

In designing our house, there were many variables we needed to take into consideration, the first and foremost being who will live in the house? Upon much deliberation we decided that its occupants would be two adults, no children. Although this is not quite the "average" family, we deemed this necessary to ensure consistency within the project. Objects that feature an unintuitive design, like medicine caps, covers on electric outlets, drawers specifically hard to open, and gates in front of stairs, are done for the sake of a child's safety. To design with these aspects in mind would sacrifice the integrity of the project.

An improperly designed home can create a great deal of confusion and irritation in the residents. A house might be designed for ease of construction but might not contribute to ease of use. This project attempts to design from the other direction. Making things easy for people is the first concern. Thus, this project presents an alternative theory of design, which has the potential to change the way homes are built.

Our general procedure included 4 phases of research, survey, design and post-design testing. We each took a specific knowledge area of "intuitive home design" and searched through libraries and online sources. The specific areas we divided the research into are psychology, architecture and interior design.

After our initial research, we composed a survey and presented it to students of the WPI community. This survey allowed us the opportunity to clarify our understanding from research and test hypotheses formed during research. Next we composed a few intuitive home designs. The designs were completed with the help of computer-aided modeling and reflected our best ideas towards the goal of an intuitive living environment as defined in this project. In the final stage, we presented our designs to a few individuals to gather feedback. The feedback we sought includes qualitative data on which ideas people enjoyed or disliked and their overall impression of how our ideas fit together into a single home design.

The intuitive home is presented as a set of floor plans for a house, along with pictures taken from a 3D-computer model for the house created using 3D Studio Max 2.0. The rendered model of the house acts as a virtual tour of the building, including architectural and interior design considerations. Along with the model is a written description of the house and each room. Every detail chosen will be pointed out and justified in the written portion.

Literature Review

Psychology

Design is a basic element of our lives. Whether we open a door, pick up a pencil, or walk into a new building, we are all susceptible to the whims of its creator. If the creator believes the design focus to be visual appeal as opposed to utility, they can fail to consider things such as perception and cognition that would allow a human to use the item without difficulty. Or, in an attempt to improve it, it is so withdrawn from previous designs that it baffles people. What follows in this section is a discussion of the elements of design and human psychology – what it is that affects how people use things in their everyday life.

To approach this task one must first understand the basic elements of how humans interact with their environment. Of course there are physical elements to consider: our world of design would be very different if we had wheels instead of legs or could see only in the infrared spectrum. But these are "low level" operational items; there is in fact a much higher level we can relate to that takes into account a broader aspect of human interaction. This is psychology, but in particular, the aspects of cognition and perception. Although these systems could deceptively be considered similar, they are in fact two different steps in using an object. For the sake of simplicity we will define these here. Perception is the "recognition and interpretation of sensory stimuli based chiefly on memory" (American Heritage Dictionary). Cognition is "that which comes to be known, as through perception, reasoning, or intuition; knowledge" (American Heritage Dictionary).

Perception

Perception is a person's basic means of understanding their environment. Its five basic sources of information come from the orientation, haptic, taste/smell, auditory, and visual systems. The orientation system is how people are able to retain their bearings and know the difference between right side up and upside-down. It makes use of our understanding of how our

joints move (kinesthesia), the force of gravity, touch, as well as information from our other systems of perception.

The haptic system is our sense of touch, what sorts of feedback objects give us when we handle them. It is a very important stimulus, but often under-appreciated compared to visual stimuli. For example, a smooth doorknob, although visually appealing, can make it very difficult to open a door. The haptic system also has an effect on a much more subtle level. Temperature is an aspect that is often ignored. Although different temperature levels will often annoy us in our homes, designers rarely take that into consideration and create a place that can be evenly heated or cooled. (Bartley, 56)

The taste-smell system is another one that has a subtle effect upon how people perceive their environment. A bad smell is often associated with a bad experience, the smell of food may stimulate our digestive system, or other smells may make us more alert.

The auditory system is our basic source of feedback. When people do something, they frequently expect it to make a noise, and if it does not will often find the device dysfunctional. An example of this an attempt to create a soundless typewriter. Although it functioned to the same specifications of a normal typewriter, users rated it poorly. They reported multiple complaints, including that the keys had to be pressed much harder (Norman). This indicated that the users were using the sound of the keys to figure out if they were pressing hard enough. Without the audio feedback, they could not tell, and therefore pressed harder.

One element that can hinder our ability to process auditory information is reverberation, or how sound bounces off of the objects around it (such as walls). Studies have shown that a properly noise treated room will provide a condition in which a person's speech is heard with greater clarity. Noise treated rooms also decrease the nearness of outside noise. Although the noise enters the room, it will not have a medium off of which to echo. This therefore decreases the effect upon the user of the room and reduces stress. (Bartley, 183)

The last and most important system is visual. It is the most essential element of design and perception, and will be discussed in a variety of ways throughout these sections.

Cognition

Perception is the initial influence when we first come in contact with something. When we come to a door, we will perceive that the door has a handle, and therefore must be pulled. However, it is not always that easy, and sometimes objects are designed in such a way that we must step back and consider their design. This is where cognition comes into play, when our perception alone fails and we must step up to a higher level of thinking. There are times that cognition should and should not be used. Cognition should be used when encountering new objects or objects that are complex, e.g. computers. Cognition should not be used when encountering everyday things. A door should not require concentration upon what technique needs to be used to operate it; this is something that should be natural and intuitive. The same is true for light switches; one should not encounter a panel of eight switches that gives no clues as to what each switch operates. For items that require some elements of cognition, there are some relatively simple ways to make these items more intuitive. Devices like text or pictures are first step towards this, as well as logical order and grouping of buttons on a device.

Experience and Bias

Another element to analyze during a device's construction is the content of a user's past experience. Past experience dictates expectations from a device; things such as interface features, and an expected result. Even though a device may exceed the designs of the original, it still may fail because it does something in such a way that it is un-interpretable for the uneducated user. For example, let's take the concept of an automatic door that has a lock based on voice recognition. Such a door would be very useful, should a person have their hands full, but would be very cryptic to a first time user. Imagine walking to a door that has no handle, no lock, no evident way of opening the door. How is one to open it? The typically user would probably push on it, kick it, and leave it with a general air of frustration. New is not always better.

Another example of this is would be QWERTY verses Dvorak keyboards. QWERTY keyboards were designed at the time of typewriters. Problems with the internal architecture of the keyboard dictated the creation of the QWERTY key set – it was designed to specifically slow the typist down. Now in the time of computers and digital keyboards, such mechanisms are no

longer necessary, so new key sets were designed with the purpose of speeding the typist up. In particular is the Dvorak keyboard. One would think that the QWERTY keyboard would have quickly faded away in the light of this new key set, yet it is not so. This is because most typists had (and still have) primary experience with QWERTY. To transfer over to the other key set requires much frustration and relearning of patterns that are instinctual to the typist. For companies to retrain their typists for a slight increase in speed proved too great an expense. (Norman, 145)

There are, however, ways to overcome the bias towards prior experience. One very good example is the huge differences in interface between Microsoft Windows 3.1 and Windows 95. Despite the fact that the interface for Windows 95 was proven to be easier to use and quicker to learn by new users, it was met with much resentment by the advanced users who were adept at the old interface. So how is it that Microsoft was able to overcome this resentment? The rewards for upgrading to the new operating system were greater than those for staying with the old. Users were willing to sacrifice the benefits of familiarity for the new features and increases in speed offered by Windows 95. This is very much unlike the Dvorak and QWERTY situation since the benefits of converting to Dvorak were very small. Perhaps if the Dvorak system had generated great increases in speed it would have been met more openly.

A standard fall back for all devices is to simply maintain constancy with users' prior experience. The metric system is a more intuitive system than the English measurement system, yet most devices retain the older measurement system. Sometimes what is better for the user is not better for profits. Consistency is also good for situations that might not necessarily be intuitive. A good example of this is computer software. By having applications maintain consistency, once a user has learned one program, they are generally able to apply this knowledge towards another program because of the consistency in interfaces.

Experience also dictates what sort of response we should get from objects, also known as feedback. Lack of feedback will alert the user something has not gone right, such as a missing click from a door that has failed to latch. Removing feedback that a user expects from a device will often cause confusion for the user. Sound is one of the most prominent types of feedback. It

helps people tell if a device is active, if it's working right, or just bring general awareness to an object. The feedback sound gives, although disruptive to an environment, is difficult to replace with something such as an indicator light. In Norman's Psychology of Everyday Things he describes a hotel he stayed at once which had an invisible ventilation system. There was no evidence that the system existed, ventilation was taken care of through invisible holes in the ceiling as opposed to grates, and the system itself was soundless. When it came time to activate the fan in the bathroom the only probable button seemed to only activate a light that would remain on for five minutes. What the author was told, upon leaving the hotel, was that the light was an indicator that the fan was on. Even though the designer of the ventilation system had taken into consideration that the user would need feedback to indicate that the system was working, he did not take into consideration that the user had preconceived notions of what sort of feedback a fan should provide.

Aesthetics verses Design

Aesthetics verses design, which is the greater evil? Should an object look good or be designed well? Or can both be accomplished? A good example of poor design is a door that requires a "push" or "pull" sign to prevent confusion. These doors are typically examples of good aesthetics; they usually look good, and are frequently considered "elegant." It was these kinds of doors that spawned the idea for this project after one of its authors spent a summer working in a building with "elegant" glass doors. They had both a handle and a push bar on each side of the door so they could mirror each other through the glass. Needless to say, upon approaching a door, it was impossible to tell if it should be pushed or pulled. Memorization and trial-and-error were the sole ways to navigate these doors.

An example of the advantage of design is the Seattle and Los Angeles federal building designs. In this situation, the Los Angeles building was designed by an architect, while the other was designed by its workers. When studies were done comparing the two at a later date, it was shown that the workers in the Seattle building were more productive and more content in their new building. In Los Angeles, there was no recorded difference. In this situation better design actually improved productivity, although it did not win any awards for aesthetics. (Norman, 153)

A good resource for items of poor design is the images by Jacques Carelman and his *Catalog of Unfindable Objects*. It includes images of coffeepots with handles under the spouts, bicycles with uneven wheels or two misfacing chairs, and pre-knotted handkerchiefs. (Carleman)

Technology and Design

Technology has many disadvantages when it comes to intuitive design. It is not typically designed for the "every day user", comes with thick manuals (which alone make something unintuitive), and the engineers (opposed to a practiced designer) usually design its interface. There are two things that tend to proliferate in technology – the tendency for things to have too many features, and the tendency for these features to be hidden. Consider the typical modern VCR. It probably has dozens of features that are never used, such as the nefarious digital clock, except by more advanced users. These functions are not obvious looking at the VCR; most of them cannot be accessed without the remote. Furthermore, these features are probably not obvious on the remote either, and require pushing a button to access a menu that will appear on the screen. Once there, one can select from the myriad of items.

However, it is worth noting that anyone can use the basic features of a VCR without considerable technology experience. The key to this is, ironically that the advanced features are *hidden*. This allows a simpler interface design on the front of the device as well as on the remote. Woe to the novice who wants to use the advanced features and must sit there, remote in hand, to decipher the manual. Woe as well to those who lose their remote and discover that they cannot access their advanced features anymore. Despite many of its inherent problems, the VCR is a fairly good example of how technology can play upon some aspects of design. By separating the two types of controls it follows the cognitive model of grouping features by function. The device also accounts for prior experience, since the initial models of VCRs did not have the additional features available as current ones do, yet they still have the same buttons on in front. This applies as well to the general buttons on the VCR. Instead of generating new names or symbols, the manufactures relied upon the fact that most people will have prior experience with tape recorders and would be able to apply that knowledge to the VCR.

The Book of Norman

In the book *The Psychology of Everyday Things*, the author divides the principles of good design into several aspects of consideration. These aspects are visibility, conceptual models, mapping, mental models, and feedback. These are all tightly linked to models for design that have been discussed prior to this section.

Visibility is an important aspect of design. A feature in a device that is not visible is instantly unintuitive. An example of this is most complicated telephone systems. Instead of creating specific buttons for these features the creators instead relied upon the pre-existing numerical buttons and arbitrary sequences to enable features.

Part of visibility, as well, is natural design. This is based on people's instincts. Natural design provides subliminal clues as the use of an object. By providing the proper contextual clues for an object, human perception will allow a person to use an item without even thinking about it. Doors typically incorporate natural design. An example of natural design is a pen that works best when held a certain way. Creating grips on the pen placed in a way a user is supposed to grab it encourages that action.

Another important aspect of design is the use of conceptual models. Conceptual models limit the user's interaction with an object – the "trying to fit a square peg in a round hole" effect. If the peg has a round end and a square end, the user instantly knows which end is supposed to go into the hole. Conceptual models fit with how a user relates to objects in the world and how they believe they work. If an item does not fit a user's conceptual model (such as if the round end is really supposed to go into the square hole), it suddenly becomes very difficult to use.

The mapping aspect takes into account the relationship between things. This follows the model of grouping like objects together. This also includes the concept that switches should correspond to how an object operates. Consider the typical dimmer switch for a lamp. It is round, needs to be turned to raise or lower the light level, and pushed to turn off. There is no real mapping between turning right and left to raise or lower the light. A more natural mapping would be a sideways dial where rotating up would correspond to an increase in light and the inverse would do the opposite.

The final aspect discussed is feedback, which is sending the user information about what action has been actually done.

There are also several other major considerations in design based on understanding how something will be used, called the "Stages of Execution". These are the steps that a person goes through in order to accomplish a task. The stages of execution are as follows: the goal, intentions, the action sequence, and the execution. The goal is relatively straightforward – what does a person intend to accomplish and what will this require? Objects should meet a person's goals without many hassles if they are to be considered intuitive. The next step is the intention – through what means should the goals be accomplished? The next phase is the action sequence, which includes the actual planning of accomplishing the goals. The final phase is the execution, or carrying out the action sequence. These two steps are most important, for it is here where the failure of the device can take place.

It is also worth mentioning specifically the seven design questions that Norman hold valuable in asking to determine the function of the device. These are:

Can you...

1. Tell what actions are possible?
2. Tell if the system is in a desired state?
3. Determine mapping from intention to physical movement?
4. Determine mapping from system state to interpretation
5. Tell what state the system is in?
6. Perform the action?
7. Determine the function of the device?

Architecture

Design Questions

Before designing a house, there are a couple of important questions to address. First of all, who will live there?

Inhabitants

The way in which inhabitants affect a home's structure, functionality and personality is largely based on a few key aspects:

1. How many people? Is the design for 4 people, or for 300? Expected occupancy may dramatically affect everything from the number of bedrooms & bathrooms to the size of hallways and plumbing pipes.

2. What kind of people? Are we designing a college fraternity house, a retirement home, or a place for a family with 6 school-aged children? This question determines the kinds of rooms and locations of rooms relative to each other. For the example of small fraternity, maybe you only need several bedrooms, a bathroom, a kitchen, common area, and closet. For a home to relax in your later years, you may want 2 bedrooms, a study or library, a bathroom, a kitchen, a dining room.

3. Are there special needs? If this is for a couple that wishes to telecommute, they may need a quiet office space. Suppose the house is for Star Trek fanatics, they may need separate exhibition rooms for their artwork and collectibles. For a far-fetched idea, what if this is a home for a royal family? The house may need security data lines through the foundation, "bullet proof" windows and walls, and a basement to store supplies and double as bomb shelter.

For this project, we wanted to create a home for smaller, working families with few or no children. These people may have busy schedules and may not wish to devote much energy towards regular stress or maintenance.

Location

The next major consideration is where the house will be built? We have a few issues to address here as well.

Terrain

Out of terrain, there are a number of possible issues to deal with such as soil type, topography, and water. Having sandy soil may require a "full pad" (see below) for a foundation,

and solid/rocky ground may allow the use of multiple smaller pads with support posts on each. Also if the house is to be on a slope or hillside, different rooms may be located at different elevations even if the home is to have one floor. Finally, if the house is close to the water table, that may prevent having a basement. Or if the house is to be built partially over a brook or small waterfall, the entire building structure may deserve serious structural engineering such as one of Frank Lloyd Wright's houses, Fallingwater. (Curtis, 310)

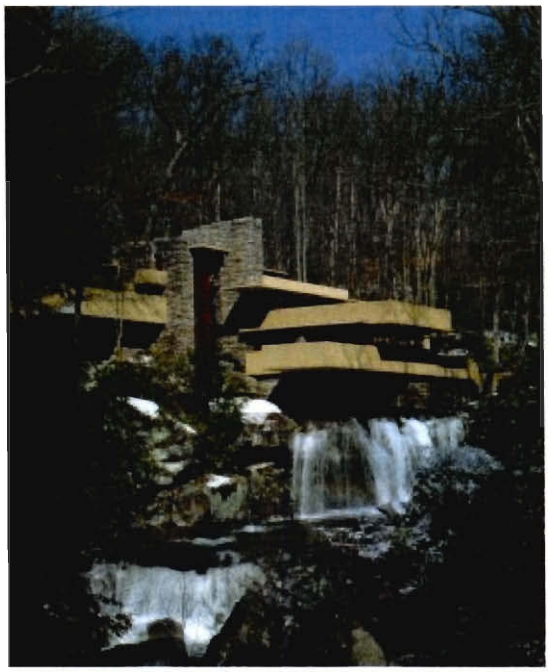

Figure 2 - Fallingwater, a house by Frank Lloyd Wright (Curtis, 310)

Climate

How hot is the area? How much sun does it receive? Also, where does the wind blow from in each season and how humid is it? In very warm climates, the house may need high ceilings to let heat rise away from inhabitants; cooler climate houses may need lower ceilings to keep warmth closer. Perhaps many windows will need to face in one particular direction to maximize light in the winter. The roof could also be extended in that particular direction as well to enhance shade in the summer. Perhaps in an area of strong cold winds, a house needs to minimize exposed area on the coldest sides.

City Proximity

Depending on how close to a city a home may be constructed, there may be other considerations to take into account. Instead of using distances to define "city proximity", the four areas to take note of are urban, suburban, semi-rural, and rural. Such 'building areas' may point out limitations to architectural freedom like local building codes (Worcester) or indicate the need for a leach field, water well, or other special needs. The following table summarizes cost, public services, and "architectural freedom" of the areas:

Table 1 - Building areas in relation to neighboring cities

Area	Cost	Services/Resources	Architectural Freedom
Urban	$/ft^2 high building costs & taxes	Public transportation water/sewage Fire/Police	Limited
Suburban	$/front ft at street medium-high costs & taxes	public transportation water/sewage Fire/Police	Limited
Semi-rural	$/acre @ "living space premiums" Moderate costs & taxes	water/sewage Fire/Police	Unlimited
Rural	$/acre low building costs & taxes	Few natural resources	Unlimited

Basic Construction

In building a house, construction may be broken down into the components of footings, roof, floor, walls, doors and windows. (Roberts, 62)

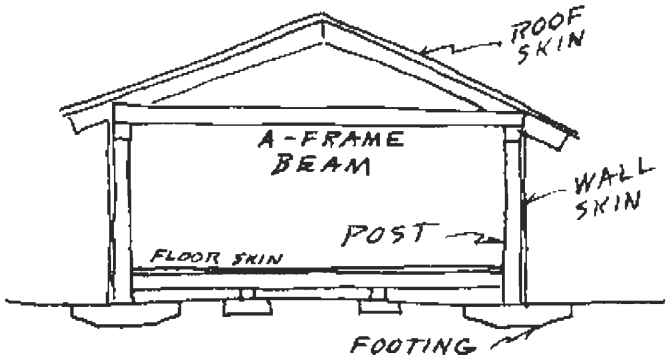

Figure 3 - The major components of a house (Roberts, 62)

Footings

The ground beneath a house may not be firm and often tends to shift around depending on the *loading*. Ground loading refers to how much weight is exerted on the ground per amount of area. As a rule of thumb, a house should exert less than 1000 lbs./sq. ft in order to not "drift in the dirt". There are 4 major design strategies for a house's foundation (or footing).

1. The *full pad* is a single reinforced cement slab that "floats" the whole house. Full pads present the greatest surface area to the ground and therefore provide the best ground loading (lowest weigh/area). They are very nice for preventing uneven settling on unstable ground but do require a plastic film underneath to prevent soaking up ground moisture. (Roberts, 126)

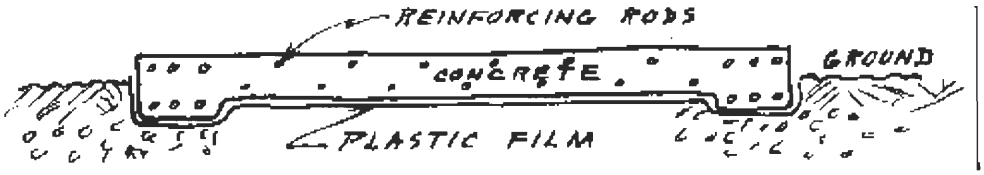

Figure 4 - A full pad made of reinforced concrete and a plastic liner (Roberts, 66)

2. Using a smaller *pad per post* is less expensive than a full pad and is not as likely to stay permanently wet from absorbed moisture. Each pad supporting a major post of the house should be large enough to limit ground loading to 1000 lbs./sq. foot, and then smaller pads may be used for floor joists about the middle of the house. (Roberts, 127)

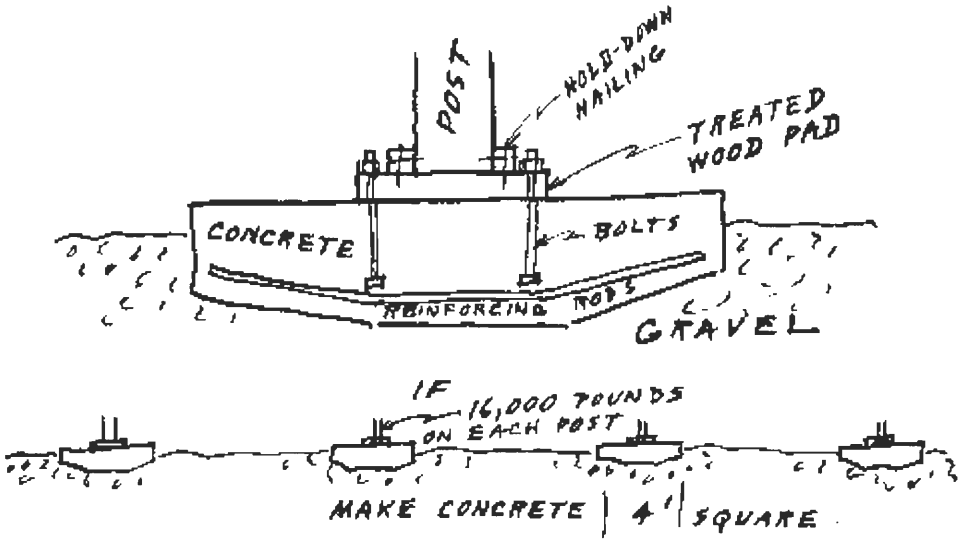

Figure 5 - Small pad construction and placement. (Roberts, 127)

3. *Wall footing* provides the least surface area to support a house and therefore has the worst ground loading. It is commonly used in homes with basements and often lacks a sub-footing to aid in spreading load to a larger area. However, if wall footing must be used, it should consist of reinforced concrete and not stone or cement block to resist sagging and crumbling. (Roberts, 128-9)

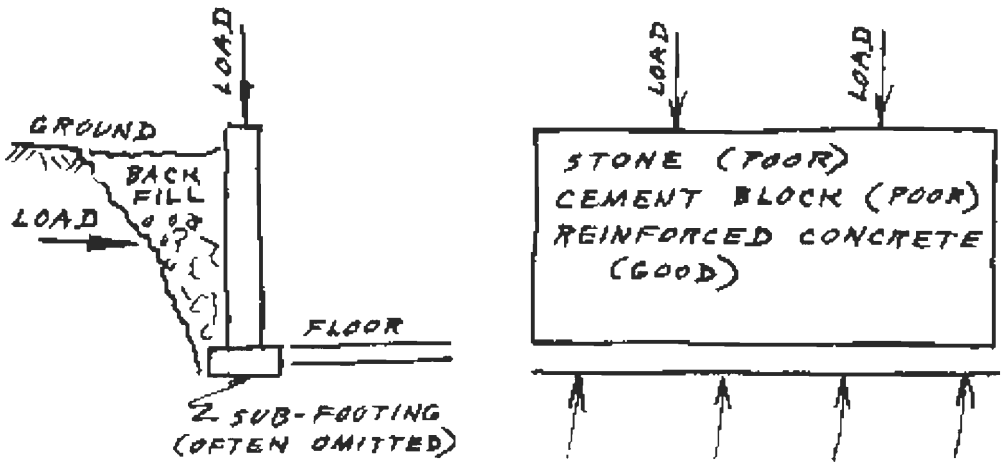

Figure 6 - Wall footing with sub-footing to properly distribute weight. (Roberts, 128)

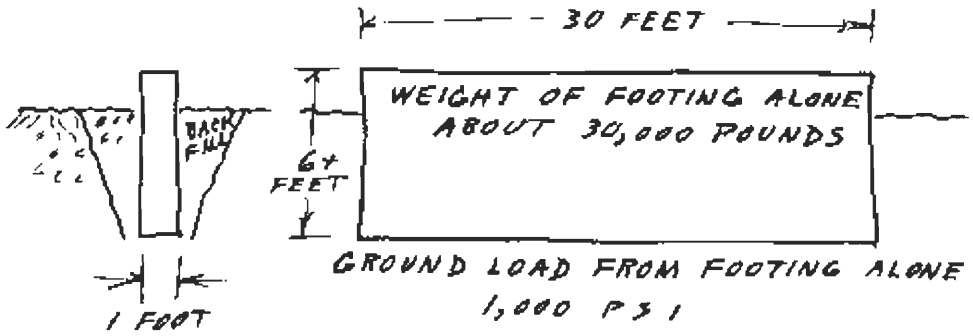

Figure 7 - Weight loading of wall footings without sub-footing. (Roberts, 129)

4. Using *posts* for a footing is the least expensive and most adaptable to varying ground and soil types. They often consist of chemically treated timbers, but "cast-in-place" reinforced concrete posts may also be used. Posts differ from the other forms of footing in that their ground loading is not only determined by vertical surface area. Instead, most of the strength comes from the surrounding ground pressing against the sides of the posts. (Roberts, 130)

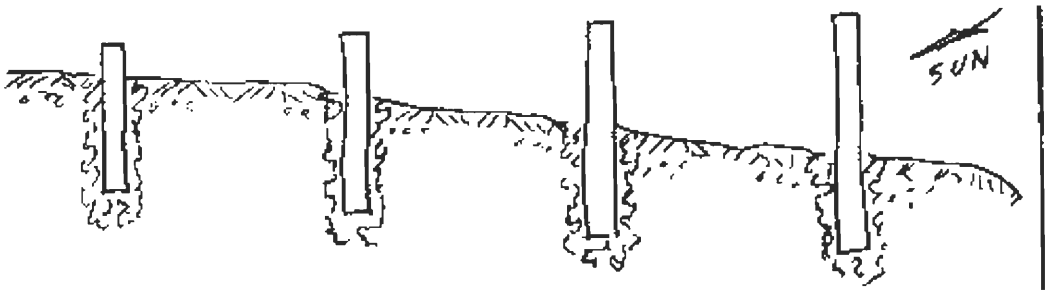

Figure 8 - Post footing formed with wooden posts set in concrete. (Roberts, 130)

Roof

The most important aspect of a roof is its slope. The measure for slope is called pitch, and pitch is the number of inches of rise for each horizontal foot. One inch of rise per foot is 1-pitch, and six inches of rise per foot is 6-pitch. A 45 degree angle roof is 12 inches per foot, or 12-pitch, and a flat roof is 0-pitch. There are 3 factors to deciding the pitch of a roof:

1. Area

   A small pitch does not increase area much, but large pitch can. (e.g.: 12-pitch increases

area by 1.414 times)

2. Construction cost per square foot

   A pitch less than 3 does not lend itself as easily to better structural designs such as A frames and will require thicker, heavier beams to support the same weight. At above 3-pitch, the beams and boards can be smaller but lengths begin to raise sharply thereby increasing cost and weight again. Construction cost is lowest at approximately 3-pitch. (Roberts, 53)

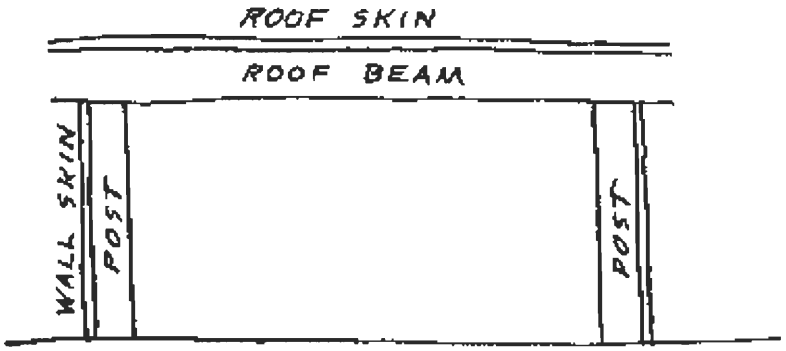

Figure 9 - Flat roofs require extra thick support beams (Roberts, 53)

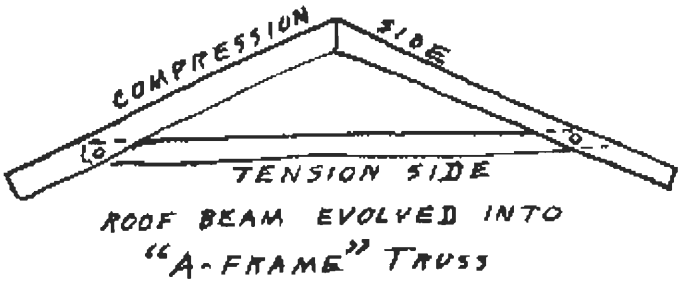

Figure 10 - Roofs based on A-frames may use smaller beams, because they distribute load better. (Roberts, 53)

3. Weather surface cost per square foot.

   For weather surfaces, lower pitches require better quality surfaces to keep water out. However, when the pitch is too high, both area and labor costs increase dramatically. (The carpenters will have trouble standing on the roof.) (Roberts, 135)

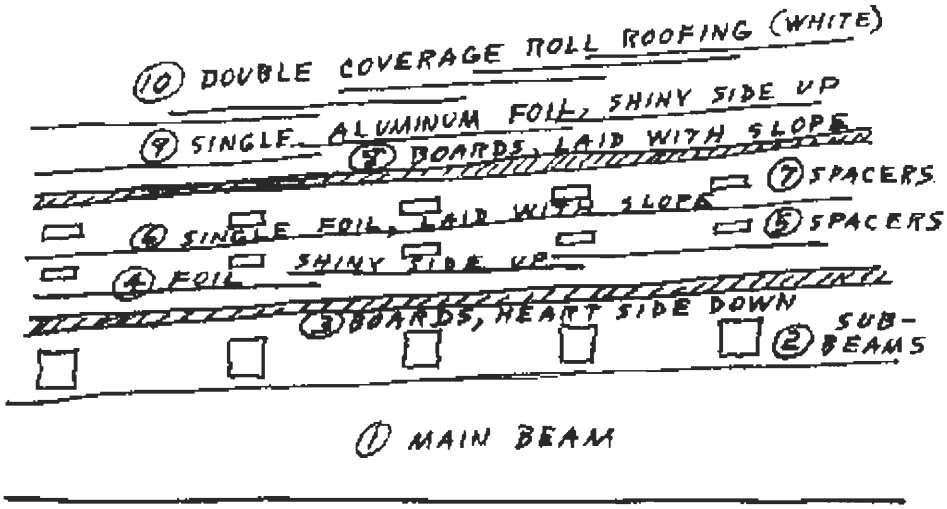

Figure 11 - Cross-section of a roof illustrating the various layers for support and insulation. (Roberts, 135)

1. Main beams - Main beams determine the overall pitch and span of the roof. The posts that main beams sit upon are not shown here.

2. Sub-beams - Sub-beams provide more strength to the roof helping to distribute weight loads.

3. Boards - Boards run with the slope of the roof and contribute to the strength of the beams.

4. Foil - This aluminum foil should be put down shiny side up, in a style similar to shingles (see diagram), and runs the length of the roof. The layer helps keep a house's heat in.

5. Spacers - One-inch spacers create an air gap that acts as conductive insulation.

6. Single foil - This foil is shiny side up and runs with the slope of the roof. It helps keep heat outside of the building.

7. Spacers - These spacers are set directly above the sub-beams and other spacers. This stiffens the roof by adding to the effective thickness of the sub-beams.

8. Boards - These boards are laid with the roof's slope and form the outer. They can be of lower quality than the ceiling because they are not visible to the inside or outside of the

house.

9. Single foil - One more layer of aluminum foil runs the length of the roof and is the main moisture barrier aside from the roll roofing.

10. Double coverage roll roofing - Roll roofing should be laid down with at least half its width overlapping. The color should be as light as possible to reduce heat absorption from the sun.

Floor

The floor needs to be the strongest part of a house. At most, a roof only needs to carry 2 carpenters working, but floors support furniture, grand pianos, boisterous guests and the washer and dryer in the laundry room. Affixing beams to the footing posts starts off floor construction. (Roberts, 140) Next, a layer of insulation board and double-sided aluminum foil go down to offer thermal protection from the ground. If pipes need to run through the floor, spacers should come next on the foil. On top of the spacers, or foil if spacers were not used, sub-beams run perpendicular to the underlying beams, and plywood or a nice hard wood completes the structural floor. If the nice hard wood floor is not desired, floor finishes are available commercially. If the finish is carpeting, a foam pad put down before the carpet gives a softer feeling to feet.

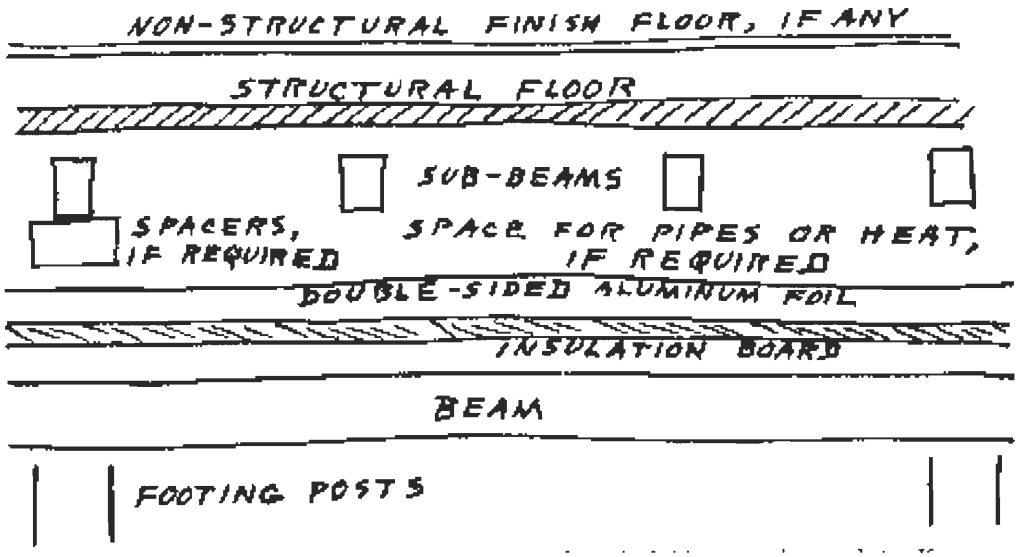

Figure 12 - Cross-section of a floor illustrating the various layers for support and insulation. (Roberts, 135)

Outside Walls

Easy to maintain outer walls have very little detail to them. As shown in the following figure, the inside starts with the floor-to-ceiling posts spaced a standard 16 inches apart. (Roberts, 141) The next layer consists of vertical boards nailed at the ceiling and floor with the wood's heart side in. Aluminum foil gets tacked on next, laid out horizontal and overlapping. Then, battens should be nailed on; they are small, 2-3 inch wide and one-inch thick pieces of wood placed horizontally every two feet. One more layer of aluminum foil traps an inch of dead air with the battens and first foil layer. Finally, one-inch thick vertical battens and outer boarding are added on to trap another layer of dead air and set the dew point at the second foil layer.

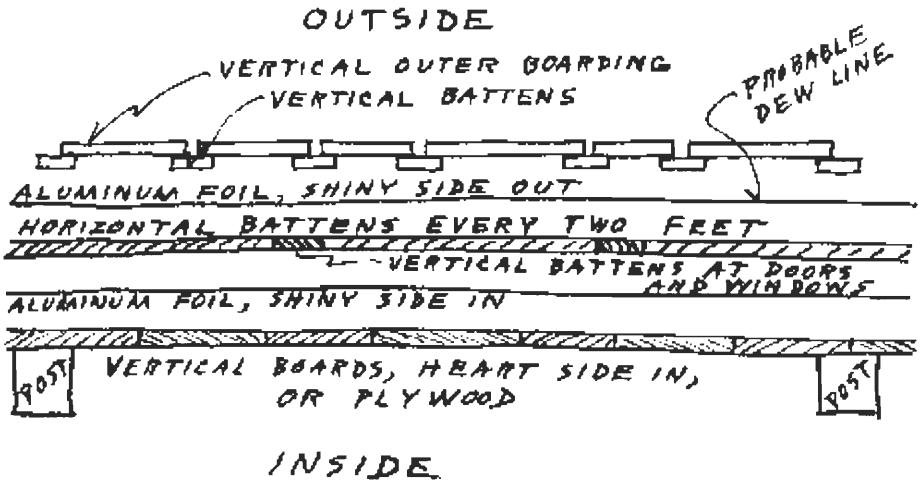

Figure 13 - Cross-section of an outside wall. (Roberts, 141)

Inside Walls

Unlike outside walls, inner walls do not protect a home's family from weather and strange people; they provide acoustic and visual insulation between the people. Inner walls do not support the roof, so they do not need strength. At a minimum, these walls need only consist of two surfaces, with spreaders or spacers, and optionally, some acoustic insulation. (Roberts, 153) Two inch by four-inch studs placed every 16 inches often acts as the spacers between the surfaces. Also, keeping one or two walls unnoticeably off square in each room dampens acoustic reflections and reduces ear strain. (Roberts, 48-9)

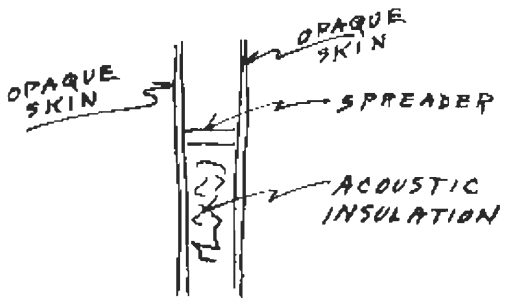

Figure 14 - Cross-section of an inside wall. (Roberts, 153)

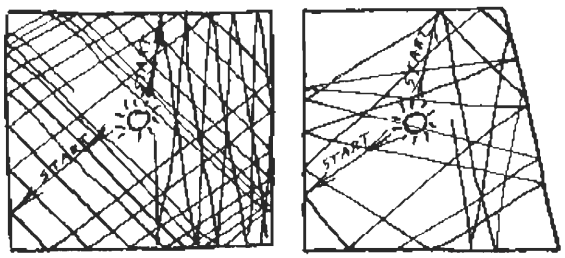

Figure 15 - In the room on the left, a loud sound such as a firecracker or angry word occurs and is echoed back to the source many times. The room on the right does not have the same annoyance. (Roberts, 48)

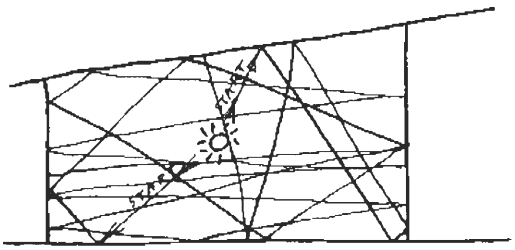

Figure 16 - A tilted ceiling in a room is another means to deform the path of reflected noise. (Roberts, 49)

Doors

The next figure illustrates the fitting of ordinary doors; there is not much to doors aside from width, direction and fire resistance. (Roberts, 143) For width, doors should be wide enough to permit 36-inch wide furniture; 42 inches is a good figure if available. For safety, doors should not open into confined spaces such as hallways, and an outward opening front door should be seriously considered. Some building codes require main doors to open outward at least in public buildings to allow easy evacuation for fire. Outward opening front doors also deter bugs that are resting on it and thwart intruders from getting their foot in the door. On the note of fire safety, doors should not be hollow, but instead made of solid plywood, or preferably, fire-resistant material.

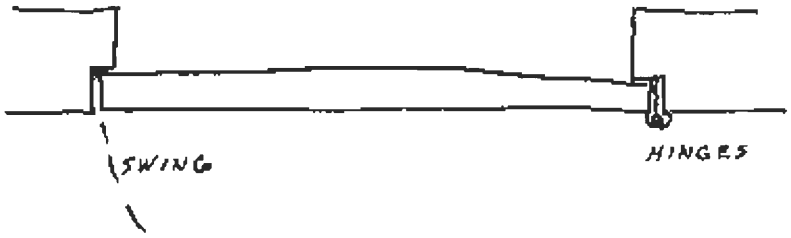

Figure 17 - The detailed operation of a door. (Roberts, 143)

Windows

Conventional windows are created by forming a frame in a wall and purchasing pre-built windows complete with opening mechanisms. However, better windows may be obtained with less effort than forming the tight fit frame. The carpenter's window is built directly in the wall by first creating a frame and then holding the glass in place with half by five-eights-inch wide strips. (Roberts, 146) Also, tilting the top of the glass outward reduces glare, reduces the amount of windowsill on the inside to collect dirt, and makes it harder for dirt to get on the hard-to-clean outside of the window.

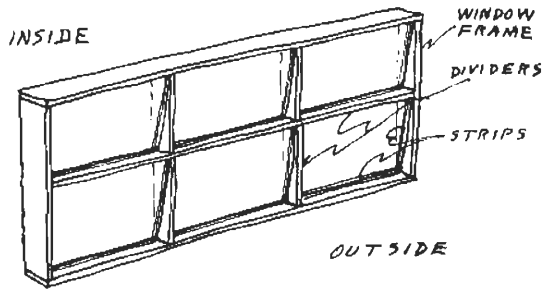

Figure 18 - An array of carpenter's windows illustrating basic window components. (Roberts, 146)

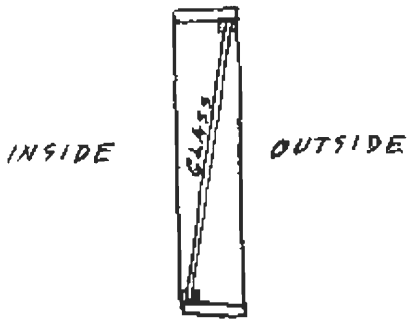

Figure 19 - With outward tilted windows, there's less windowsill on the inside to collect dust, and dirt does not cling as easily to the outside of the glass. (Roberts, 66)

Intuitive Thought in Architecture

All buildings strive for some compatibility with people, not just living quarters. "People compatibility" can be viewed as how well a structure's occupants interact with it. As people relating to buildings, we sometimes find ourselves pushing on doors that should be pulled, fidgeting with light switches to brighten rooms, and tracking in mud at the entries of our homes. In the grand scale of life, we accept these as daily nuisances. However, these "nuisances" are indications a building may not be intuitive; the building may not be fully compatible with our problem solving mechanisms, thereby increasing daily chance error. A popular annoying example is the use of "pull handles" on push-open doors.

There has been thorough effort into examining architectural design processes, and though there are a number of theories and praxes, the decisions behind "people compatible" design are largely innate to each of us. (Lang 66) If we were asked to sketch a small room for one person to sleep in, the room will not be 7 feet long by 3 feet wide to barely accommodate one *Homo sapiens* laying on its back unless we were used to living in pup tents. This is an example of "environmental tolerance" in that, even though we only need a specific amount of space to sleep, most of us feel uncomfortable about sleeping in a coffin. (Sommer, 19) Rather than designing to fit the function of a room, architects should design for this tolerance to further the quest for intuitive living areas and people compatibility. (Broadbent, 143)

During design, there is seldom conscious thought for an intuitive final product. Strategies

for intuitive design are considered a default feature in all structures and to create an unintuitive product is annoyance. Instead of focusing on intuitive thought, there is typically emphasis on function or aesthetics, and intuition is a "given" for most circumstances. And even when behavioral and architectural theory is specifically sought after, the application is then a commercial structure such as an office building where maximizing efficiency and profit is paramount. Therefore, there is an overall lack of information on implementations seeking intuitive, private, residential living quarters such as houses.

Interior Design

Interior design is an art form and must be very specific to each house and the rooms within a house. It determines a house's orientation and layout. When choosing a design, it is important to consider what function each room will hold. Also, one should make sure that the design of any one room in a house does not contrast with any of the others, especially any directly adjacent room. Important factors to take into consideration are lighting, color scheme, and the layout of the room.

Intuition

When it comes to interior design, intuition is an assumption. While an important consideration in interior design is aesthetics, the most major concern of an interior decorator is functionality. Intuitive design is found at the core of interior design and is so fundamental that designers do not even bother to mention intuition. They simply assume with their "rule of thumb" that if a house is easy to use, it is designed properly.

Interior Design and Architecture

For the most part, interior design takes a given house with a given layout and architecture and adds decor on top of it. However, this may not be the best idea in terms of intuitive design. Most of this decoration is done to hide the structure of the house. Generally, it is assumed that the structure is not aesthetically pleasing and needs to be hidden. As an alternative, one could design a house such that the structure itself is decoration. Using good looking materials, like wood, can also contribute to the decor of a house. Wood generally has a warm color, which will

help make a room feel cozy. If at least some of the house is made with decorative structural materials, decoration may not be an issue. Also, in considering economy, decorating a house can be quite expensive, while using good looking structural materials is relatively cost efficient. (Roberts, 51-6)

Lighting

The first thing to consider is a room's lighting. Lighting is important because the amount of light a room gets affects the colors one chooses and the way the room should be arranged. First, it is necessary to determine how much natural light a room will receive and the type. This depends on how many windows a room has and their cardinal direction. In the Northern Hemisphere, South or West facing windows will mainly receive the warm colored afternoon sun, but not as bright as the cool, morning sunlight that North and east facing windows receive. For some rooms, the type of light received can conflict with the purpose of the room. For example, a bedroom with many east-facing windows will be very bright in the mornings, making it uncomfortable to sleep late without very heavy drapes.

Electric lighting should be sufficient enough to fully light the room at night. A room with few or no windows will require effective electric lights during the day, as well. There are three basic types of room lighting: ambient, utility, and task. Ambient light is the bare minimum for navigating through a room at night. It should light whole areas enough for their general purpose. A dinner table, for example, is best suited with an overhead light that illuminates the whole table and people at the table. Utility lighting is brighter, more direct, and should be added in areas of high traffic where accidents could occur. For instance, a stairway should be lit well enough that one could see where stairs start and end. Task lighting is direct light to assist one in doing work; a couch or chair for reading should have a bright direct light, which should be placed such that it does not cast shadows on one's work or reading material. (Wissinger, 214-5)

In most cases, lights should be positioned such that one does not actually see the light bulb. Placing lights high and directing them at the ceiling can create Ambient light. Utility lighting can be done with ceiling mounted lights with frosted crowns or covers to protect one's eyes. Task lighting uses shades or reflected light to brightly illuminate an area without exposing

the bulb directly to one's vision.

Color

The color scheme is very important and specific to the purpose of a room. Colors can affect mood and perception of a room. Also, since colors can affect perception of neighboring colors that, it is important that a house's color scheme works as a whole as well as on a room-by-room basis. One should keep in mind that colors are just reflected light, and thus are dependent on the type of light in a room. Therefore, room colors need to be chosen to fit the lighting conditions.

Colors are associated with a temperature. Reds, yellows, and oranges are considered warmer, while blues, greens, and grays are cooler colors. The temperature of a color can affect the perceived temperature of a room. A blue room may actually seem colder than a red room at the same actual temperature. Also, the type of lighting in a room greatly affects the color of the room. These effects are additive, so if that blue room gets only northern sunlight, the room will seem even colder. In addition, if the room is lit with fluorescent light, colors will seem pale and cool, further lowering the perceived temperature. Cool light can be balanced by painting a room with warm hues. (Halse, 40; Wissinger, 37-8)

The color of a room can impart a mood on the room. One's emotions may be partly related to the colors perceives. Warmer and deeper colors tend to be stimulating, while cooler shades and pastels are soothing. Colors will often be associated with places where one sees the color outside. For example, a sky blue tends to be somewhat soothing. Yellow suggests the energy of the sun and while stimulating, it can also become irritating. (Wissinger, 39)

In addition to affecting mood and temperature, color can affect the perceived size of a room. Pale colors will make a room seem larger. Walls will appear to be farther away, and furniture will seem smaller. Bright colors have the opposite effect; a room painted with dark walls will seem smaller than it actually is. (Wissinger, 38-9)

The effects of color on perception can be used to make rooms more comfortable and livable. For example, a child's playroom can be painted with bright warm colors to stimulate the

child and make them happy. Conversely, the child's bedroom should be decorated with soothing cooler colors to allow the child to sleep better. A room that has a low ceiling can be made more comfortable if the ceiling is painted in a pale off-white. A room with a great deal of open space can be brought down to size with bright or dark colored walls and ceiling. An odd shaped room can be made to seem less disproportionate by painting the long walls darker than the short walls. (Bartley, 13-5)

Room Arrangement

After choosing a light and color scheme for a room, one must arrange the room to fit its purpose. One must keep in mind that rooms are made for people to use and should be arranged to maximize ease of use. It does not make sense to put a bed in front of a closet door, even if that door is rarely used. The dimensions and features of a room must be taken into account when arranging furniture. Also, if specific items are usually used only in one room, it makes sense to allow storage for those items in that room. Rooms generally can serve several purposes; they should be specialized enough to perform a common purpose well, but dynamic enough to handle other purposes.

Living Room

The living room, as the name implies, is the center of life for a house. It is where people will generally spend most of their active time. Generally, a living room should be located in a central area in the house, allowing people to get to the room easily from any other part of the house. It is typically a high traffic area. One walks through the living room on the way from the bedroom to the bathroom or kitchen or dining room. The living room is also a likely place where one entertains guests.

As the most commonly used room, it should feel spacious and open. Lights that point at the walls instead of the ceiling can make the room seem larger, as can large windows, high ceilings, and pale colors. Lighting for a living room should be bright for ease of navigation. Additionally, there should be at least one place where task lighting is available for reading. The living room should have enough room and furniture to comfortably seat at least as many people as live in the house plus a few guests. There must also be enough room at entrances and between

furniture for people to move through at ease. Storage is an important consideration too. The living room should have shelves enough to store books or games that might be used in the living room. If there is an entertainment center, there should be ample room for videos, CDs and other associated items, and seating should be oriented so as to give every seat a good view. (Wissinger, 71-7)

Dining Room

The basic dining room needs only a table with chairs. It is sensible to have the dining room located near to the kitchen, so that one does not need to carry food very far. Also, some amount of storage space could be added to put utensils and dining ware near the table. Since the dining room is a place for eating food, the surfaces should be made of easy to clean materials; a carpet is not a good idea in a dining room, but hardwood floors, tile, or linoleum work well. The table should be big enough for each member of the household and a few guests to sit comfortably. Lighting for the room is usually set in an overhead fixture. Bright light is not necessary for eating, but the dining room can also be used for other purposes, and a dimmer switch allows for better lighting when needed. Often, a dining room is a part of the living room or kitchen. In these cases, it should still be distinctly different, but should blend in well with the other room. (Wissinger, 82-86)

Kitchen

The kitchen is mainly a room of utility. It is the place where one gets and prepares food and may include a dining area. It is important that the kitchen be a relatively low traffic area. Putting a kitchen in an area where people constantly pass through is convenient for getting snacks or drinks, but invites disaster when someone is cooking.

To increase effectiveness, kitchens utilize the theory of a work triangle. The work triangle is the distance between the stove, sink, and refrigerator, the three most common used appliances when one is cooking. This distance should be between twelve and twenty-one feet, divided evenly between the three. Shorter distances will make a kitchen feel cramped, while longer distances will require more walking and thus more work for the cook.

Kitchens require plenty of counter space that is resistant to heat, as an area to set hot pots,

and that is easy to clean, as a place where foodstuff is bound to fall. Also there should be enough cabinet space to store utensils, cooking-ware, and food. For safety's sake, there should be an exhaust fan over the stove to draw off smoke and an easily accessible fire extinguisher near the stove. (Wissinger, 90-4)

Bedroom

The bedroom is generally only used for sleeping, dressing, and sometimes reading. As such, there should be little in the room that does not relate to these activities. Thus, the only furniture necessary in a bedroom is the bed, dressers for clothes, a mirror, night tables, and possibly a bookshelf or two. A spacious closet is usually a good thing, as well. It is imperative that a bedroom is located in an area that does not get noisy. One should be able to sleep even if there is activity elsewhere in the house. Thus a bedroom is commonly not placed directly adjacent to a living room or dining room. Bedrooms can be relatively small rooms, which can add to the peacefulness of the room. In general, warm or dark colors make a bedroom a better place for sleeping. Many windows can be a problem with a bedroom as windows detract from a bedroom's privacy and allow light and noise in from outdoors. Beds should be placed away from windows, such that direct sunlight does not fall upon them. Lighting in a bedroom should be mainly task lighting. A few directional desk lamps make reading easy. Ambient light can be relatively dim, provided by a lamp or a sconce. If the bedroom is shared, lights should be arranged such that one occupant can do things without disturbing the other. (Wissinger, 136-41)

Bathroom

The bathroom, like the kitchen, is an area of utility, not exorbitance. Bathrooms should be located as close to the bedrooms as possible. They should have enough room to go, shower, shave, and dress, but not too much more. There needs to be a toilet, bathtub with showerhead, sink, mirror, and usually a medicine cabinet in a full bathroom. As this is a place where water can be splashed around a lot, surfaces should be water and slip resistant. There should also be something to grab hold of to prevent one from slipping. Other safety features include a good exhaust fan to remove excess steam and ground fault interrupt circuits, which can shut off automatically before water causes a short circuit. Lighting in the bathroom should be bright to

prevent accidents, and to provide a truer view in the mirror. Windows are not an important aspect of the bathroom so to preserve privacy, windows should be small or have heavy curtains. (Wissinger, 148-52)

Study/ Office

The study generally consists of a desk or two with some writing space and a computer. There should be plenty of room for storing paper files, discs, CD's, and other work, which should also be easily accessible from the desk(s). A U-shaped or L-shaped layout is good for keeping important things close by. Lighting is very important in a study; task lighting is necessary to make working easier on the eyes. Glare can make a computer monitor very difficult to use, so the desk with a computer on it should face away from windows. (Wissinger, 126-31)

Closets

Closets should be located near to rooms where they will be useful. A linen closet should be located near bedrooms and the bathroom. Coat closets should be found near outside doors. Utility closets should be in out of the way places, such as under the stairs. Also, any bedroom should have its own closet.

Wiring

For any room, wiring can be a real problem. Electric outlets and telephone jacks are usually located low on walls and can often be blocked by furniture. It is important that there are enough outlets so that while some may be blocked, others are still accessible. Lighting fixtures will need electricity too, though they may be hardwired into the house circuit out of sight (as opposed to using an outlet). Phone jacks and cable jacks should be placed in every place where they could be useful. Any room, excepting the bathroom and closets, will need a phone jack and also a place to put a phone. Cable jacks should be placed in the living room and possibly in bedrooms.

Procedure

Worcester Polytechnic Institute's Interactive Qualifying Project is designed to integrate the social sciences with technology. This project, "The Intuitive Home", fits within that description, as it combines topics in social science, intuition and perception, with topics in technology, house design. Intuition is an aspect of psychology – it is how people relate to their world at a subconscious level. A house is an aspect of technology – it is the science of building and design.

To accomplish our goals, the project was divided into 4 major phases: research, survey, design, and test. During the research phase of our project, we each targeted one area of either psychology, architecture, or interior design, and then we scavenged through the surrounding libraries and online resources. Our goal in research was for each of us to become a specialist in a specific area and share our findings with the project team. After the research was complete, we tested our understanding of the material with a survey against a sample of the WPI community and then analyzed the survey results to note correlations, discrepancies, and possibilities for "intuitive home design".

At the conclusion of our survey, we proceeded with designing the house with a few sub-tasks: brainstorming, house design, and landscaping & interior design. During brainstorming, we incorporated our research and survey findings into a list of "intuitive possibilities" and sought ways of implementing these in the completed home. During this time we began designing the floor plan and then worked into the landscaping around the house and the interior design of individual rooms. When the home designs had been created, we tested the models with presentations to selected individuals to gain feedback. With this feedback, we made a few slight alterations.

The data for our project was retrieved from two primary sources, research and the survey. Through research we obtained the background information, including understanding the materials that go into a house, what kind of furnishings a house needs, and how a house influences people. Through this we gained an image of how humans relate with their

environment. The next step was to formulate theories based on the information obtained. How would a person react in a certain situation? What is the general population's personal preference on something? These are all questions we hoped to answer in our survey.

Survey Design Rationale

There were many elements to consider in designing this project's survey including purpose, goal achievement, potential setbacks, and audience. The survey's purpose is to aid the research behind our IQP. It is also important to be aware of potential biases and strive for optimal sampling in data results.

During the process of writing the literature review, we concluded there was a great deal of essential information that could not be found in books. There were also a number of items that, although we considered them common sense, we had no scientific basis to back them. Therefore this survey had a two-fold purpose: to help clarify issues unanswered by the literature review, and to provide a "truth" behind some of our theories. The questions are mainly multiple choice and include demographics, theory, personal preference, and testing various design concepts. Our survey also included a brief introduction. The introduction informs the user of the purpose of the IQP, as well as instructions as to how to regard the questions in the test. We asked the user to imagine a "typical" house to deter people from describing their current or ideal home, neither of which are likely intuitive.

Demographically questions are necessary for any survey. They help during analysis to search for any patterns. We included four questions of this type: major, year of graduation, gender, and writing hand. Writing hand preference provides insight into twisting and turning objects. Using statistical analysis, demographics may be correlated with survey responses to identify trends and irregularities.

Theoretical questions are intended to support our theories and cover questions regarding: direction of turning a knob, flipping a switch up or down to activate a light, and direction a door opens. In these questions we already have conceptual answers but have little evidence or literature to verify against. They are intended to show that our theories have an existing basis.

The third type of question, personal preference, is a search for a logical pattern of people's expectations in a home. Part of intuitive design is meeting these expectations, providing no surprises for the average user. If we find a pattern in results, we can implement these into the design. However, a lack of pattern will not hinder us; it will give us freedom in our designs. These questions are a dominant part of the survey and include:

1. cardinal direction of windows
2. type of windows
3. analog versus digital thermostat
4. knob/handle/push plates for doors
5. closet door types
6. house shape
7. if the house has a basement, attic, or deck
8. the number of floors
9. what rooms are contained on each floor
10. color preference according to room function

The last type of question tests preliminary intuitive designs. Accompanying each house plan are scales of intuitiveness and attractiveness, as well as a comment box to note suggestions and ideas. With these sections, we tested our ideas and fished for new concepts. With the intuitiveness rating, we were searching for feedback on the logic of the design. The aesthetics rating is not of primary importance; however it is a minor concern. Although we wish the house to have a pleasant appearance, intuitiveness will not be sacrificed for "looks".

Accounting for potential biases is important in survey design. Poor question wording, question order, or answer order can create these biases. Improper wording can lead people towards certain answers. Wording can also confuse the question, thereby generating invalid data.

In order to prevent this, each question must be carefully read over and its implications discussed. In improving clarity, it is also important to ensure that the original meaning of the question is retained.

The second element regards the order of questions and answers. It is important for these to have a degree of randomness in them. This is less so for the questions than it is the answers. Since the survey is multiple choice, the order of the questions could be suggestive to the user. For the web based version of the survey this is fixed by randomizing the answers in all multiple-choice questions. The questions themselves are randomized as well but to a lesser degree since some questions follow a logical progression. Questions are randomized selectively - caution is required to prevent any sort of confusion. An example of question randomization is the final part of the survey, which inquires into models of intuitive homes. It is important to randomize this factor in order to prevent a bias based on their impression of the first plan they come across.

The final stage of a survey regards the means of getting people to take it. This approach could be to put a table out wait for people to take it, to put it on the web, or to hijack a professor's class and make them take it. All of these have potential biases. The problem with the table or the web is that specific people are inclined to be involved in these types. In the situation with the class, a bias occurs because a specific group of people is interested in the activity. All of these limit the randomness of population selected it. Therefore, we decided that a combined effort of these would help generate better results. In the first situation, the survey was forced upon a class. This helped prevent a non-response bias, a bias caused by people deciding not to take the survey. This gap causes a sampling error and invalidates the data. A non-response bias removes a portion of the population that is needed to get accurate results. If a non-response bias exists, it is similar to purposefully eliminating sections of the population. In the second situation, a modified survey was put on the web. A low percentage of users asked actually took the survey, but the results were comparable to those from the paper survey.

Survey Analysis

Aside from gathering information from our research and the survey, it is also important to analyze the data. In the case of research there is no true method outside of simply filtering out

what information could be used and which could not. In the situation of our survey, we analyzed the information for any irregularities or patterns. We also had to decide what data is valid.

Analysis of Class Survey Results

The surveying process consisted of two parts - a web based survey and a class based survey. Because of changes made to the web based survey, it is necessary to analyze those results separately. The following is a statistical analysis of the class sampling. The class was a Social Science class, chosen because it would be unlikely to favor any major at WPI. 45 people took the survey.

Table 2 - Demographics

Gender	**# of people (out of 45)**	**Percentage***	**WPI Percentage**
Female	11	24%	22%
Male	34	76%	78%
Class	# of people (out of 45)	**Percentage***	**WPI Percentage**
Class: 2000	10	22%	
Class: 2001	13	28%	
Class: 2002	9	20%	26%
Class: 2003	10	22%	
Class: 2004	2	4%	
Class: Unidentified	1	2%	
Major	**# of people (out of 45)**	**Percentage***	**WPI Percentage**
Biology/Biotechnology	8	18%	11%
Chemical Engineering	2	4%	7%

Civil Engineering	2	4%	7%
Chemistry	1	2%	8%
Computer Science	13	29%	17%
Electrical Engineering	6	13%	16%
Humanities	1	2%	.3%
Mechanical Engineering	7	16%	20%
Management	2	4%	4%
Social Science	2	4%	.1%
Undeclared	1	2%	.4%
Handedness	**# of people (out of 45)**	**Percentage***	**World Statistics**
Right Handed	41	91%	89%
Left Handed	4	9%	11%

**Due to rounding, the sum of the percentages may not equal 100*

In regards to gender, our survey presents a group very close to the sample available at the university. Year of graduation also reflects WPI's distribution, in accordance to our typical 4-year program. The handedness data is also statistically correct.

In majors, however, the sampling is not as representative as WPI's typical population. In particular, a large number of computer science majors make a large percentage of the class, compared to the popularity of the major at WPI. There could be multiple reasons for this, however one of the most likely is that the time schedule of the class corresponds better to the time schedule existing for Computer Science classes than for other majors. Another reason could be that cognitive psychology appeals more to Computer Science majors than others do, but that is for another study to determine.

Survey Questions

For many of the questions, answers were very clear cut, giving strong enough evidence that the question does not need to be repeated on the web survey. Others were harder to judge, so a χ^2 test was run on them. A χ^2 test tells the probability of a null hypothesis that states the expected results for a question. In this case, the null hypothesis states that the results are due to random chance, and thus assume equal numbers of responses for each answer to a question. Data is considered statistically significant if the null hypothesis is less than 5% probable. If the probability is higher than five percent, the results should be rejected as random chance. In these cases, the questions will be repeated in the web survey. Also in the web survey will be questions that will be reworded or that are used to demonstrate general trends as opposed specific data.

Table 3 - Does your bedroom door open in or out of the room?

In	43	96%
Out	2	5%
Total – 45		

For this question the majority of people answered "in". This is most likely because having doors open into a room is regarded as an industry standard and therefore very common.

Table 4 - Do you flip the light switch up or down to turn on the light?

Up	43	96%
Down	2	5%
Total – 45		

For this question, the majority of people answered "up", indicating that most people expect that when they flip a light switch up, it should go on, down, it should go off. From this result we can assume that people associate "up" with activation, and therefore will be able to apply it to other situations as well.

Table 5 - Do you turn the doorknob clockwise or counterclockwise?

Clockwise	37	82%
Counter Clockwise	7	16%
Total – 44		

A large number of people answered "clockwise" to this question. A number of people commented that "the side of the door matters", since the doorknob will be on either the right or the left side of the door depending on how it's approached. However, this is not relevant since how the doorknob is turned is dependent on which hand is used. It is much more difficult to twist a doorknob counterclockwise with the right hand than the left. This is why the "handedness" question was asked - to establish if there was a relationship between a person's dominant hand and the way they use a door. Of the four left-handed people in the class, all of them answered clockwise to this question, which allows us to tentatively establish that there is no relationship. From this question we can establish that people perceive that doorknobs (and perhaps other knobs as well) should be turned clockwise to be used.

Table 6 - What type of closet doors do you prefer?

Folding	6	14.0%	
Hinge	8	18.6%	
Pocket	17	39.5%	
Sliding	12	27.9%	χ^2 Test
Total – 43			p = .087
Opens out	14	32.6%	χ^2 Test
Opens to side	29	67.4%	p = 0.022

Overall, people seemed to prefer pocket doors for a closet. Of the four types of doors offered, pocket doors seem to be the most convenient, as they do not get in the way of anything when opening or closing and do not take up much space. Sliding doors, which

operate in a similar manner, were the second favorite. However, a χ^2 test reveals that this data is not statistically significant. Thus, the data was regrouped into doors that open outwards (hinge and folding) vs. doors that open to the side (sliding and pocket). This reveals a distinct preference for side opening doors.

Table 7 - Is your thermostat analog (mechanical) or digital (electronic)?

Analog	26	57.8%	
Digital	19	42.2%	χ^2 Test
Total – 45			p = .297

Though the majority of the class chose analog thermostats, the difference is not large enough to judge conclusively one way or the other. The wording of the question may add a bias, as it may seem to ask which type the survey-taker *currently* uses. This question will be reworded and included with the web-based survey.

Table 8 - What do you prefer on a door?

handle	11	24.4%	
knob	30	66.7%	
push	3	6.7%	
voice	1	2.2%	χ^2 Test
Total – 45			p < .001

The vast majority preferred knobs on doors. Though this may be due to the fact that knobs are currently the most commonly used of the three choices offered, there is enough support for knobs to rule out the other choices. One student offered an interesting idea: voice operated doors. This would be most convenient, but would be hardest to implement and would run into errors of speech recognition.

Table 9 - What is the first room you enter after walking through the front door?

Foyer	19	43.2%	
Living	15	34.1%	
Kitchen	6	13.6%	
Other	4	9.1%	χ^2 Test
Total – 44			p = .03

Because we left this as an open-ended question, the responses varied greatly. People suggested mudrooms, coatrooms, and hallways, family rooms and dining rooms. We decided that for ease of analysis, we would group these together as foyers and living rooms, which seemed to be the overall preference. The χ^2 test shows the data to be significant, but since the results for this question are not entirely clear, this question will have to be reworded. In the web survey, subjects will be given a number of choices, rather than a blank space.

Table 10 - Does your house have a basement? Does your house have an attic?

Basement			Attic		
No	4	9.1%	No	8	17.8%
Yes	40	90.9%	Yes	37	82.2%
Total – 44			Total – 45		

A very obvious majority had basements and attics in their houses. These results only demonstrate trends in building and not whether attics and basements are intuitive. The questions were worded so as to ask whether the survey taker's own house has a basement or attic. These questions will be reworded and asked again in the web survey.

Table 11 - How many floors do you have in your house (not including an attic or basement)?

One	3	6.7%
Two	32	71.1%
Three	10	22.2%
Total – 45		

Most people preferred to have a two-floor house. This makes some amount of sense, as separating the house into two floors allows for logical grouping of rooms. Unfortunately, the wording of this question leads people to respond with information about their current house, not the ideal house they were asked to imagine.

Table 12 - Where would you locate these things?

	Bedrooms		Water heater		Washer/dryer		Bathrooms		Kitchen		Dining		Living	
One	14	31.1%	2	4.4%	17	37.8%	27	60.0%	40	88.9%	39	86.7%	38	84.4%
Two	39	86.7%	3	6.7%	2	4.4%	28	62.2%	5	11.1%	4	8.9%	6	13.3%
Three	8	17.8%	-	0.0%	1	2.2%	11	24.4%	2	4.4%	3	6.7%	2	4.4%
Base	5	11.1%	39	86.7%	25	55.6%	6	13.3%	-	0.0%	-	0.0%	-	0.0%
Attic	2	4.4%	1	2.2%	-	0.0%	1	2.2%	-	0.0%	-	0.0%	-	0.0%
Total – 45														

This question shows some interesting trends in room placement. First of all, that the third floor is not particularly popular exhibits once again that a two-floor house is the preference. Secondly, there are some very distinct trends in room grouping. Kitchens, dining rooms, and living rooms are grouped together and are preferred to be on the first

floor. Bedrooms are found more often on the second floor. The basement serves as a good place to store a water heater, washer and dryer, though washers and dryers could be placed on the first floor instead. Bathrooms are generally expected on both the second and first floor. It should be noted that the numbers given do not add up to the total. This is because a good number of people chose more than one floor for any given room. Each choice was counted in the numerical analysis to fully demonstrate trends in room location.

Table 13 - Does the house have a deck?

Yes	38	84%
No	7	16%
Total – 45		

In this question, the majority indicated a desire to have a deck on the house. Perhaps this is a perceived feature of an "intuitive home" or maybe this is a trend of what people believe to be "popular" in purchasing a new home.

Table 14 - From a top-down (bird's-eye) view, what shape of house do you prefer?

Rectangle	33	73%
Square	4	9%
Circle	1	2%
Other	7	16%
Total – 45		

From this data, 3 in 4 people appear to prefer a house with a rectangular shape versus squares, circles, or other geometric layouts. This is most likely due to the influence of

most houses being rectangular.

Table 15 - When you walk into each of these rooms, what colors are the walls?

	Red	Green	Blue	White	Brown	Yellow	Black	Light/Pastel	Medium/?	Dark/Deep
Bathroom	2 4%	2 4%	12 27%	18 40%	0 0%	2 4%	0 0%	28 62%	16 36%	1 2%
Bedroom	1 2%	7 16%	15 33%	13 29%	1 2%	1 2%	1 2%	16 36%	17 38%	12 27%
Kitchen	4 9%	1 2%	2 4%	21 47%	0 0%	8 18%	1 2%	23 51%	18 40%	4 9%
Study	3 7%	7 16%	4 9%	9 20%	12 27%	3 7%	0 0%	9 20%	16 36%	20 44%
Hallway	1 2%	0 0%	3 7%	23 51%	5 11%	2 4%	0 0%	21 47%	18 40%	6 13%

With this data set, it is important to note the room color responses do not add to 100% due to people giving multiple responses. For restrooms, people seem to prefer white or blue and medium to light shades; the same may also be said for bedrooms, except, there is a tendency for medium and darker shades as well. The survey responses also indicate a desire for white and light shades in kitchens and hallways. The study is a different situation where individuals indicated preferences for white as well as darker shades of brown and green. This may be due to possible associations between dark green and wood finishes with perceived "intellectual sophistication" in today's society.

Table 16 - What style of windows do you prefer?

Crank	12	27%	
Double Hung	25	56%	
Sliding	8	18%	
Picture	0	0%	χ^2 Test
Total – 45			p <

	.001

From this data, more than half indicated they prefer double hung windows and a quarter indicated crank windows. The preference for double hung is most likely due to double hung windows being the predominant style in New England, and crank windows are being installed in newer homes. It is noted there is no interest in fixed "picture" windows, and surprisingly little interest in sliding windows.

Table 17 - Which direction would you like most windows to face?

West	13	27.1%	
South	11	22.9%	
North	6	12.5%	
East	13	27.1%	
Other	5	10.4%	χ^2 Test
Total - 48			p = .187

Collectively, people appear to like windows on all sides of their homes except for North. This may be due to the northern faces of buildings here being colder in this hemisphere. The χ^2 test shows low statistical significance, so the results may be due to random chance.

Table 18 - Which house was ugly and which was useful?

Answer	Ease of Use		Aesthetics		Correlation
	Average	Standard Deviation	Average	Standard Deviation	
House A	2.35	0.99	3.1	1.00	0.49
House B	2.6	1.10	2.9	1.00	0.7
House C	2.7	1.30	2.7	1.00	0.7

This question was to test the theory behind several of our designs. House A and house B are both two-story homes with similar design - their primary difference is in the location of the rooms. They were designed to test how different levels of complexity can influence the results. In house A, simplicity was key in the first floor with few rooms and simple design. In house B having the front door enter by the staircase as well as several other rooms created a layer of abstraction.

House C was designed to contrast the other two with its one floor design. It also was designed to test the effectiveness of logical grouping on one floor. Logical grouping, or putting like rooms near each other, was accomplished in the other two houses by putting the rooms of rest on the second floor and other "living" rooms on the first floor. In house C, the design grouped the "rest" rooms to one side and the "living" rooms to the other.

We surveyed general opinion on "intuitiveness" and aesthetics of the three house plans; here, lower scores are better. In general, the house "A" was perceived as easiest to use but ugly. House C, on the other hand, was better looking, but hardest to use. However, statistical analysis does not show that much correlation between ease of use and aesthetics. The useful data from this question came mainly in the form of comments and suggestions, which may be implemented in further designs.

Analysis of Web Survey Results

Only 37 out of 200 (18.5%) people responded on the web based survey. The results were very similar to the first survey except for a few questions.

Table 19 - Is the thermostat analog (mechanical) or digital (electronic)? (Web)

analog	13	35%
digital	24	65%
Total - 37		

This time, the majority chose digital thermostats. The difference from the original survey may be due to the question rewording, or it may be due to how the survey was presented - electronically. The electronic survey may have appealed to the "sort" of people that would also prefer digital thermostats.

Table 20 - What is the first room you enter after walking through the front door? (Web)

foyer	28	78%
living	7	19%
kitchen	1	3%
Total - 36		

Here, there is the same order of preference as in the first survey where people preferred foyers. Though now with fixed responses, the foyers are rated much higher, 78%.

Table 21 - Please evaluate the following house plans in terms of aesthetics and "ease of use". (Web)

Answer	Ease of Use		Aesthetics		Correlation
	Average	Standard Deviation	Average	Standard Deviation	
House A	2.39	1.05	2.73	1.35	0.67
House B	2.44	1.11	2.97	0.97	0.42

House C	2.51	1.17	2.70	1.05	0.69

The house evaluation question differs in ranking from the first survey. Now House C is ranked as easiest to use, and House A is hardest. And House B is the most aesthetically pleasing while House C is least pleasing. The results from both surveys are very close; this question may not give much reliable data.

From our results, a number of things can be extrapolated. These include:

- The demographics are statistically representative of WPI's student population.
- Handedness does not effect operation of doors or lights.
- Doors to rooms open into the room.
- "Up" is linked to activation (such as the light switch).
- Counterclockwise is associated with activation (such as the door).
- Sliding doors signal a closet.
- Analog and digital devices are preferred equally.
- Knobs are preferred on doors.
- People expect to enter a house through the foyer.
- Homes are expected to have an attic and a basement.
- Homes are expected to have two floors.
- Bedrooms are on the second floor.
- Utilities are in the basement.
- Bathrooms are on both the first and second floor.
- Kitchen, dining room, and living room are all on the first floor.
- There is nothing in the attic.
- Houses are expected to have decks.
- Houses are rectangular in shape.
- White is a favored room color.

- Double Hung windows are preferred
- Logical grouping of rooms, to be affective, is accomplished via several floors
- Simplicity is key to making the house more intuitive

House Design

What is an intuitive home? Is it only a place where everything can be found? Anyone can live in a house for thirty years and know where everything is, however that does not make the house intuitive. Intuitive is the ability to approach something and to be able to instantly utilize it, without ever having seen it before. Because of this, intuitiveness of the house is not applicable to long term residents since *any* device can be learned, given an appropriate amount of time and training. Someone who has lived in a hedge maze for thirty years may be comfortable navigating around it, however most guests to this home would be instantly baffled.

In approaching the task of laying out an intuitive house, it was necessary to organize a basic design concept. The original concept for this house was that a person could step into it, and know in an instant where everything is because the house was design to fit the average person's perceptions of what a house's layout is. However, because people have different perceptions of what a house is like, it is necessary to use a slightly different concept for design. This basic concept was that a person new to the house would be able to establish the location of all the rooms quickly upon entering. There are two key parts to meeting this goal - visibility and the results of the survey.

Visibility is related to intuitiveness because it decreases learning time. Visibility is the attempt to make the location of rooms and their purpose obvious at a glance. It is accomplished by having rooms as open as possible. An example of visibility would be not to have a door to the dining room, in order for someone to see what the room was by just walking past it. A counter-example would be a hallway with many doors and the purpose of each room being hidden unless a person opened the door or had memorized the location of each room. Doors are typically used to hide things, an item to be avoided in this house design. For rooms with closed doors, such as bathrooms, bedrooms, and closets, clues must be placed in order for a person to tell what is

behind the doors. For example, sliding doors are associated with closets, and are therefore used to signal closets.

The second key part is the results of the survey, primarily the section concerning room location. Through the survey we can help utilize one of the items of intuitive design - fulfilling general user expectations. By using this information, we know already how many floors our house should have, and on what floors the rooms should be located. It also tells us that sliding doors, no matter the type, are the clues for closets. From this we can logically group the different components of the house into three areas: a "living area", a "sleeping area", and a "utilities area". These groups are arranged according to the floors first, second, and basement, respectively.

Although the survey specified that people expected an attic in the house, we decided against including one in the design. The primary reasoning behind this was that, although it was expected, the use for it could not be validated since few responses put any rooms in the attic. Therefor to add an attic to the house would simply add a layer of abstraction to the design. Access to the typical attic is another complexity since most are reached by trapdoors in ceilings, often hidden away in closets.

Indicating the absence of the attic is accomplished by having the ceiling be the sloped inside of the roof. This acts as a simple visual clue. The absence of the attic also is a positive effect towards the design of the house. People are typically more pleased with high ceilings, which are generated with its removal. Material expenses are cut back, since there is no need to add an extra ceiling. This also permits taller windows on the southern side of the house, allowing extra sunshine in during the winter, which in turn would provide more heat to the house.

Another example of a house design choice that contradicts survey results is the use of the sliding windows instead of the popular double hung windows. It was concluded that one type of window was not necessarily more intuitive. Double hung windows most likely appeared more popular since they are a common item New England homes. The group concluded that they were consistently more difficult to open than other styles of windows and could be complicated with items such as counter weights. Crank windows were ruled out because, despite them being easy to open, with more parts they are prone to mechanical failure. Sliding windows, the windows

added to the house, were chosen because they are consistently easy to open and have few parts, so they are unlikely to suffer mechanical failure. They also offer greater airflow than other styles. This type of window is coupled with a picture window, to allow the sliding action.

In the design of the house, it was decided to follow Norman's concept of logical grouping. This philosophy is to group like items. This concept had been considered prior to the survey and it surprising how well the results corresponded. This house was divided into three logical groups: public places, private places, and utilities. Public places include the living room, dining room, and kitchen. They are places that guests are likely to frequent, but also places that serve as recreation for the tenants. Private places are areas of rest, and are not likely to be on display for guests. They include the bedrooms and the main bathroom. Utilities include items such as air heating, water heating, and laundry equipment. They are items that would waste potential living space, and therefore are stored in an area of the house that is not conventionally used. Some of them also rely on an external source (water, for example) that comes in via the ground, thereby making it logical for the corresponding devices to be located there.

Room Locations

Entrance

The location of the entrance was an important decision in this house. An entrance in an improper area could severely hinder the intent of the house. In the house design, possible positions of entrance were either the living room or the hallway. The advantage of having it in the living room would be that most of the house could be seen from there, thereby increasing the number of rooms seen on the first impression. However, the dining room and kitchen are not visible from there - for the user to see them, they would have to explore. Therefore, by having the entrance at the beginning of the hall, it acts as a guide for the users.

Kitchen

The kitchen is visible immediately upon entrance to the house. There is no door to the kitchen, instead a wide entranceway to the room. This allows for maximum visibility of the entire room. The pantry is placed in the right-hand corner of the room, where it can be seen easily from the entrance. The pantry also utilizes a pocket door, to signal that it is a place of

storage.

Dining Room

The dining room is located logically across from the kitchen. There is no door to the room either, and it too is completely visible from the entrance.

Living Room

The living room is slightly visible from the entrance, and is accessible from a short walk down the hall. It is here where the second floor recedes, allowing for tall ceilings and large windows. This construction aids not only with heating and lighting for the house, but also allows a complete view of all the rooms on the second floor. From the living room the deck is accessible and can be seen through glass doors.

Guest Bathroom

Since guests will be primarily entertained on the first floor, it is pertinent that the guest bathroom be located there. Of the three rooms the guest would be located at, the living room and the dining room are the most likely. Therefore the room is visible from both the dining room and the living room. Its location towards the middle of the house also coincides with the bathroom upstairs, simplifying plumbing. That location also allows easy access from anywhere on the first floor by the tenants. The door is marked with the symbol of a crescent moon, an artifact often found on outhouses.

Bedrooms

The bedroom's locations are completely visible from the first floor, due to the balcony. Bedrooms, unfortunately, cannot have an open door to make its intent seen; therefore we rely on the fact that the doors appear different from the others accompanying them on that floor. The doors appear different because they are simply unmarked and contrast the doors intended to be indicators.

Linen Closet

The linen closet is distinguished as such through the use of a pocket door.

Bathroom

The bathroom is marked with a blue crescent moon, which was informally found to be recognized as a signal for a bathroom.

Basement

The location of the basement is easily recognized by the stairs leading below ground level. The stairs are not behind a door, as is common with most houses. They would be harder to find that way. Instead, there is a door at the entrance to the basement to prevent odors from there leaking to the upper levels.

Slant of Roof

The slanted roof of the house is important to note for several reasons. The pitch of the roof is three inches per foot which is not too steep, to prevent inflation in costs. It is also not too flat, to allow adequate drainage for rain and snow. The taller end faces south, allowing the maximum amount of light in for the daylight hours. This permits the sun to actively heat the house. However, to prevent the house from being overly heated in the summer, there is a marked overhang to the roof. This overhang will allow sunlight in during the winter months, when the sun is at its lowest angle. In turn it will shade the house when the sun is at its zenith. The angled roof also provides adequate noise reduction, since sound will deflect off it at an angle. It also meets human psychological needs for space and makes the living area feel more spacious.

Stairs

The stairs are located so that they will be both easily seen and accessed from the first floor. The basement stairs are slightly offset from the main stairs to prevent someone from falling down two sets of stairs. However, they are located in such a way that a person going from the first floor to the basement has minimal detour. It was discussed to place the stairs on top of each other to utilize space more effectively. However, this was not done because it would have hidden the basement stairs from common view. One would not know where the stairs to the basement are without a search.

Walk Through

In order to test the design rationale, the house was subjected to a walkthrough test at which a theoretical new user was walked through the house. We used this to test visibility, and various theories as to how things were located. It conducted using the floor plans and doing a "finger walk through" and asking the questions: What does the user know about the house at a given point? What can the user guess about the house? What is currently hidden from the user? If its hidden, does this hinder the design (and how can it be fixed)?

To start with, the user approaches the house. They recognize that it is two stories and will possibly be able to surmise at this point that the bedrooms are on the second floor, and the kitchen, dining room, and living room are on the first. At this moment, there is no physical indication of a basement, but the user may guess its existence. The user might also conclude, unfortunately, that there is an attic at this point, as well. At this point, the user is not aware of the implicit location of every room, but may be able to divide to at least two logical groups.

The user enters the house. The first thing they see is the coat closet, which is evident by its sliding doors. From the entranceway they already know the location of the kitchen, pantry, dining room, and living room, since these are all clearly visible. At this point, the user has established the location of 4 of 9 rooms, not counting closets.

Halfway down the hall, the user knows the location of the fuse box, stairs for upstairs, stairs for the basement, patio, and a bathroom. They will possibly know that it is the guest bathroom without opening the door, since master baths are associated with bedrooms. At this point, the user is aware of the location of 6 of 9 rooms.

Once they have entered the living room, they have established the location of every room in the house. This is due to the open area above the living room, which permits a view of the entire second floor. Therefore the user needs to cover approximately 15 feet to know the entire layout of the house. This is very different from typical houses that require exploration of the entire building to locate rooms.

Interior Design

The interior design for this house matches a room's function with decorative elements. Each room is lit, colored, and furnished to best suit its purpose and its orientation within the house. Some aspects contribute directly to intuitiveness, such as layout of furniture or cabinets so that things can be easily found. In decisions where intuitiveness has no role, practicality takes a lead role. These contribute indirectly to the goals of the design, such as floor coverings appropriate for the room.

Floors

Carpeting is an area that deals not with intuitiveness, but practicality. Carpeting tends to make a room more comfortable, but it doesn't mix well with bathrooms or food areas. For this reason, we chose to make the first floor out of finished hardwood, which looks nice, is easy to clean, and makes a room feel warmer. In the kitchen and bathrooms, a tiled floor was chosen, as tile is more practical for cleaning and more resistant. On top of the hardwood floor in the living room and bedrooms will bed wall to wall carpeting for comfort as well as provide sound dampening. Areas that will contain finished hardwood include hallways, the dining room, and stairs. Hallways and stairs are high traffic and wood floors will be able to resist wear better than carpeted. The dining room is uncarpeted so it can be cleaned easier, but it not tiled because such floors tend to be very cold.

Walls & Ceiling

Color choice is important for this house because of the subliminal affect of colors on people. Yellow, for example, has been shown to irritate people, where as colors like red is known to make people angry. From the survey we found that in all rooms, except the study, white or lighter shades are the preferred colors. Thus, walls will be painted white in every room. This makes the house overall feel larger, and brightens the rooms. However, it also makes rooms feel a little drab and boring. Thus, to accent the walls, furniture and decorations in the rooms will have some color. In the living room, where the majority of the natural light is warm afternoon sunlight, light blue colored couches and wood grain cabinets and ceiling help to balance the room temperature. In the bedrooms, the wood color of the ceiling will help to balance the cool

northern light from the windows.

Windows

The windows that meet the design goals of the house have to be well-placed and easy to use. For this reason, we chose to make all of the windows sliding or fixed. Sliding windows are easy to use and allow a large amount of light in. Windows have also been placed so as to provide a great amount of light in from outdoors. Because we are using a single slant roof that is exposed to the interior, the South wall will have a very large surface area. For the sake of heating and lighting, the walls are covered with large picture windows. Since the wall faces South, it will receive sunlight all day long, which will help to heat the house in the winter. If dual paned argon filled insulated windows are utilized, heat loss from the house is prevented. These windows prevent convection heat (heat flowing through the air) from leaving the house, but allow radial heat (heat produced from sunlight bouncing off objects) in. Because the sunlight energy gets converted to heat once inside the house, this allows the house to be both heated and insulated from the outdoor elements. In the summer, the roof overhang causes direct sunlight to fall outside the house so as not to overstrain the air conditioner. The view through these windows should be a nice landscape, which can be seen even from the second floor balcony.

Doors

Doors can provide good visual cues to the function of a room. The primary function of doors is to hide unwanted things or to ensure privacy. As such, they need only be placed in rooms that need to be closed off. Only bedrooms, bathrooms, and closets need doors. The kitchen and dining room do not need such separation, so they have large open archways instead.

Doors are an important part of making "hidden" rooms integrated with the intuitive environment. To provide a visual cue to the identity of each room, door types are varied by room type. Closets have pocket doors that slide into the wall, which shown by the survey will distinctly define the room behind them as a closet. To distinguish bathrooms and bedrooms, bathroom doors will have a small crescent shape, the traditional symbol for an outhouse, painted or engraved on them. Informal testing showed that people will recognize this symbol in association with a bathroom.

Another visual cue is air vents. The basement door and the panty door will each have a section of vents on the bottom half to allow airflow. The fuse box door on the first floor is a small, cabinet-like door placed above the air conditioner intake vents. The vents should be associated with utility, and thus will hint at the purpose of the doors.

The final necessity to doors is their knobs/handles. Pocket doors utilize a side handle, to indicate they are made to slide. Inside doors, such as bedroom or bathroom doors, use a standard knob. Outside doors, such as the front door, use a crank handle to signal it's an outside door. Outside of the fact that inside doors will open into rooms, these will also utilize have door jams and clearly visible hinges which act as clues to which way the door opens.

Appliances

While a home may have an entirely intuitive floor plan and the best visual cues, all these efforts are lost if the appliances in the house are impossible to figure out. For this reason, it was necessary to search for examples of intuitive devices to go into the house. These include the oven, stove, dryer, washer, refrigerator, dishwasher, and microwave. They are listed by type, showing brand name and several features about each that make them intuitive.

Gas Stove and Oven - General Electric

Figure 20 - General Electric Stove and Oven

1. Stove settings are in a logical order (low to high).
2. Knobs must be pushed in to turn to prevent accidental gas leakage. This is a good example of the need to make something a little harder to use for the sake of safety.
3. Construction of gas outlet allows only one alignment to guide installation. Also prevents food from falling in.
4. Digital timer is simple and straightforward.
5. Oven light clearly labeled with symbol of a light bulb.

Dryer and Washer - Amana

Figure 21 - Controls for Amana Washer

Figure 22 - Controls for Amana Dryer

1. Color-coded dials match cycles with appropriate fabric settings.
2. Dials click at each option, which provide physical clues that the right setting has been reached.
3. Dials are each labeled clearly with a main label and a smaller label. This accommodates the two different naming standards that are typically found on these devices.

Refrigerator - Maytag

Figure 23 - Maytag refrigerator

1. Temperature controls are lit and very easy to access in front of fridge.
2. Temperature controls use numbers and graphics instead of cryptic letters common to most refrigerators.
3. All shelves can be adjusted by height or removed if necessary
4. Drawers are clearly labeled with intent they are best suited for
5. Vent adjustment on specific drawers is labeled fruit on one end and vegetable on the

other. This way, users do not need to check instructions to find out what setting is best for each type.

6. Ice tray is designed so trays stack and do not stick together

7. Both fridge and freezer have lights both in the back and front of the refrigerator. This is unlike most refrigerators, which have lights only in the back that get obscured by food.

Dishwasher - Whirlpool

Figure 24 - Whirlpool Dishwasher

1. Has simple buttons, which are clearly labeled with dish/pot specific functions.

Microwave - Whirlpool

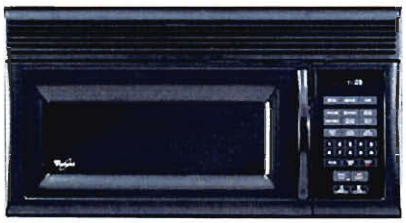

Figure 25 - Whirlpool Microwave

1. Clear distinction between numbers and other buttons

2. Handle on door to indicate how the door opens, unlike buttons which are common to most microwaves

Services

A home of this time period typically allows for services to be easily accessible to inhabitants. This issue by default is not one for intuitive design, but practical design. Basic services include water and gas, but some modern homes include advances like central air conditioning and networking. To keep future expandability in mind, this house will incorporate these services:

- Water
  Piped, clean water is supplied by the local municipality through underground pipes.
- Sewage
  Wastewater will be carried away via underground pipes to the local municipality.
- Gas
  Natural gas is supplied by the local gas company through underground pipes.
- Electricity
  Electricity is supplied by the local electric company through underground wires.
- Telephone
  The local telephone company will supply service via underground wires.
- Central Air Conditioning
  The house will contain air ducts and equipment to heat and cool the air at a single location.
- Television
  Television service may be provided by a cable company or by an inhabitant's antenna or satellite dish. The house will contain coaxial lines to allow central management of television signal distribution.
- Data
  Network service is a very new trend in recent homes. The home will contain wiring for today's prevalent network structure, "100 base T", and allow a central location to manage and connect to other networks like the Internet.
- Other
  Additional wiring conduits will be installed in the house in anticipation of future wiring needs.

Location

Some rooms will need all services, while others may not. Electricity, telephone, data, and other will be available in all rooms including bathrooms and closets, and electricity will also be in hallways and stairwells. In instances where it may not be apropos to have specific services, like telephone and data in bathrooms, the services will be terminated and left inside the wall. The kitchen, dining room, living room, bedrooms, and bathrooms will have air conditioning and television. The kitchen will also have water, sewage, and gas, and bathrooms will have only water and sewage service.

Routing

All of the services will be run from the basement for management except for electricity; electricity will have a second wiring center on the first floor for ease of resetting circuit breakers. Another breaker in the basement will control that area and supply the first floor breaker for the first and second floors. 20-amp electrical service will be available in each room, and all outlets will be able to cut power during ground faults. A ground fault occurs when electricity from an outlet finds a different return path to ground such as a person or animal instead of back through the outlet.

Each service will need a medium to be transported to rooms. Water and sewage will be carried through polyvinyl chloride (PVC) pipe certified for drinking water; one-inch steel pipe will carry gas. Telephone, television, and data services will be run together via one-inch aluminum conduit for electrical noise shielding. Television will use RG59 coaxial cable, and telephone lines will use RJ11 cable supporting 3 lines. Data will use the current proposed Cat-6 cable. The "other" service will be empty one-inch conduit to assist in future expansion. All conduits will have pull strings inside to assist future modifications.

Air conditioning will rely on insulated ducts and a return vent to cycle air between equipment in the basement and the rest of the house. The ducts will have a $\frac{1}{4}ft^2$ cross-section and transport air to floor or wall vents in each room. The return vent in the first floor will contain an electrostatic filter and allow air to return to the heating and cooling equipment of the basement. The electrostatic filter will provide higher air quality than conventional paper filters and be

washable in the dishwasher to eliminate filter replacement costs.

Exterior Design

The surrounding land including driveway, street, and landscaping is also considered part of the house design. However, exterior design is not the focus, and due to limited project time, this is not fully explored.

Lot size

The minimum size of land for this house is 8000ft². To encompass the house, driveway, and lawns, the lot will extend 100ft from the street curb and run 80ft along the street. This is the smallest lot recommended for the house in order to accommodate people's psychological needs for space. Smaller lots are possible, pending on area building codes, however it will defeat some designs behind the house. This includes the large windows in the living room, which heating purpose will be defeated if shaded by the neighbor's home.

Transportation

For design purposes, the street will run east west and will be north of the house. A 10ft wide driveway will extend 59½ft from the street to the deck, and 4ft wide sidewalks will connect the driveway to the deck and front door to aid vehicle loading.

Landscaping

Ideally, some nature such as forest, mountains, or a valley should be visible south of the house. The land directly beneath the house should be generally flat with a slight slope toward the street to direct debris and runoff away from the property. Native trees, shrubs, and grass should be selected for landscaping to reduce maintenance and environmental impact.

Bushes along the house's northern wall and two trees placed in the center of the north and south lawns would aid psychological privacy needs. The trees should be at least 15 feet from the house to reduce property damage due to natural tree growth or fallen trees. Also, inhabitants may add an automated sprinkler system or a small distraction, such as rock garden, to decrease or increase their chores, as they deem appropriate.

For motor-vehicle safety, shrubs and other visual obstructions should be at least 5 feet from the curb. Mailboxes must comply with local residential codes, and if one needs to be located within 5 feet of the street, it should be easy to see around and not resemble a gargantuan salute to the Berlin Wall. This will assist drivers in seeing other cars and pedestrians.

Walkways

Walkways serve purpose outside of keeping people from stepping on the grass. They also serve as tour guides to people unfamiliar with the surroundings. Therefore for this house there are two walkways that lead to the external doors of the house. Imagine a guest being invited to a barbecue and being told to "Just head to the deck when you get there". As they walk up the driveway, they note that there is no deck visible in the front of the house. However, when they reach the corner of the house, they see the path leading around to the back of the house. Being and intuitive house, following that would lead them straight to the deck, avoiding an awkward trip around the wrong side of the house if the walkway was not present.

How is this Home Different from Others?

In many ways, the appearance of this home is not different from others. There are no "new fangled" inventions, nothing to mark it different or spectacularly unique. Walking into it, one may not realize that it is intuitive, very much the same way one does not notice the paint on the wall unless it is cracked. People tend to recognize bad things and annoyances quicker than they are to notice benefits. This is a home that uniquely strives to go unnoticed.

In the introduction to this paper, it is mentioned that this house "...is the "every man's" house and at the same time it is not". The typical house is often designed by an architect in conjunction with what the buyer wishes. This is an excellent example of why homes can be poorly designed, since the central concept they are made from was created by the inexperienced buyer. Architects themselves make many unintuitive decisions due to different priorities. Their priorities may include items such as utility, aesthetics or innovation, but will probably not include intuitiveness. A good example is one of the author's homes, where the kitchen, living room, and dining room are located on the second floor of the house, the bedrooms on the first

floor, and the entrance located in a middle floor between the two. People entering the house became instantly confused as to where rooms were located.

The question arises, what does this house feature that is not common in every other house? It has doors, windows, and floors like every other house. It is not a showcase to technological innovation; there are no flash devices to display. The features of this house lie in the intent behind the design, not necessarily anything physically obvious. Our research and study is of what is required to design an intuitive house. Our design is not necessarily the only intuitive house, nor does it suggest that there are no other intuitive homes. We did not, for example, build a new, never before seen, easier to use door handle. Although a worthy endeavor, it would most likely fail since part of intuition is relying on people's past experiences.

Design features unique to this house include the use of different doors to signal the purpose of the room behind them. Most homes contain a varied mishmash of doors; their type selected to suit the dimensions of the house or the room. For the example of closets, sliding or folding doors are typically utilized for long shallow closets, pocket doors are utilized in areas where hallways are shallow, and regular doors are utilized pretty much wherever people feel necessary. There is no order or intent behind this design. Our research showed that sliding doors are associated with closets, therefore by constantly making all closet doors sliding, users of the house will be able to identify the utility of the room behind the door without actually opening the door.

Other symbols associated with door and their contents were the concept of putting a crescent moon on bathroom doors. This concept is unique, since bathroom doors are typically unmarked in homes. In areas that have bathroom doors marked, such as restaurants, they are typically labeled "restrooms", "Woman"/Gentlemen", with their respective symbols. For a typical house, such labels are gaudy and therefore it was necessary to test another means to symbolize bathroom, the moon.

Some features this house not found in other homes includes logical grouping of the rooms according to their intent and their locations based on expectations from the survey. The house is designed to be easily navigable for first time users. Light switches are designed so that even

when grouped together, the lights that they operate are obvious at a glance. The house also incorporates appliances that are intuitive. These devices follow Norman's model of design.

There are plenty of other features designed within the house included in the report that enhance the intuitiveness of the house. Some of these are typical features in every house, yet this does not make them less intuitive. If these were removed, their absence would be noted. Example of this is the use of a metal box around the circuit breakers to indicate that they are contained in there. This is intuitive because it is a visual cue to the user, however it is a common item in most households.

The research to generate this home is simply a building block of intuitive design. It is intended to show how people think and approach living in their environment. It shows that homes are not random apparitions, designed at solely the whims of the owner, but that there is a conscious system behind its design.

Cost Analysis

An important sideline of this project is the cost of this "intuitive home". In order to accomplish this it was necessary to figure at all the materials that would be built into the home. This includes the number of screws, nails, wallboards, gallons of compound and their respective prices. This required extensive analysis of the design of the home, as well as gathering the prices for each individual piece.

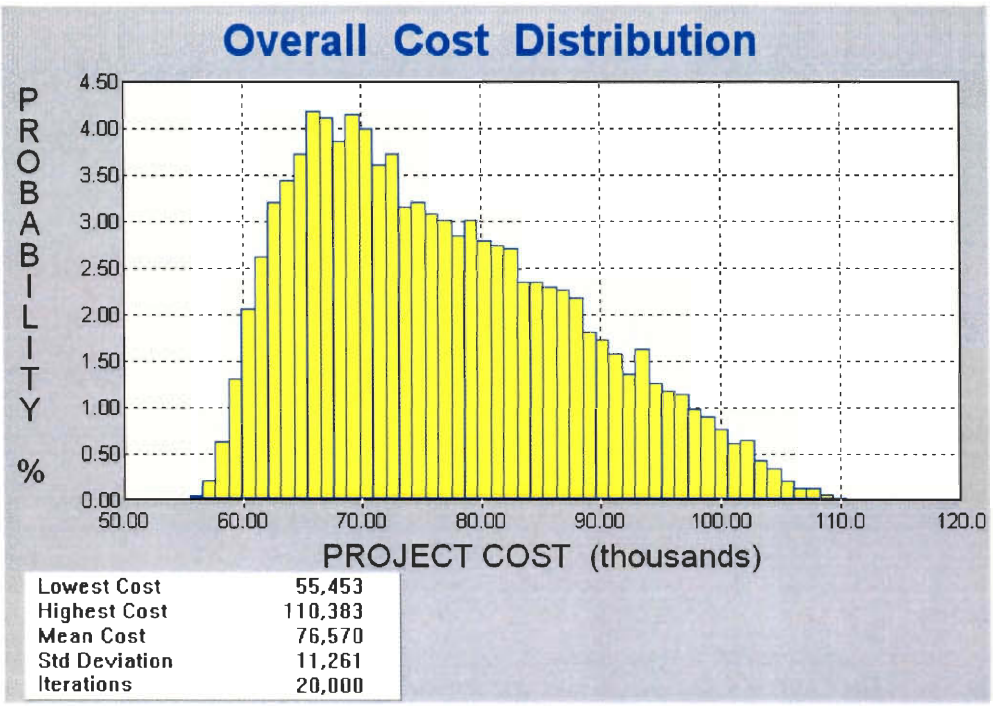

Figure 26 – Probable cost of materials

There are many issues to consider when finding the prices of components. Prices are not static, they can vary because of cost of living, quality of product, or the quantity ordered. For example, price of toilet paper rolls varied between $3.00 to $15.00 depending on if they were plastic or of metal. To over come the price obstacle, it was necessary to use three prices for each

product – the minimum price, the maximum price, and the likely price. Using statistical analysis, the approximate price for the entire house can be determined.

The data indicates that the cost of materials will likely range between 65 to 75 thousand dollars. The absolute minimum the materials could cost is $55,453 dollars; the absolute maximum is $110,383. The mean value is $76,570, however, this cost is not within the higher probability range.

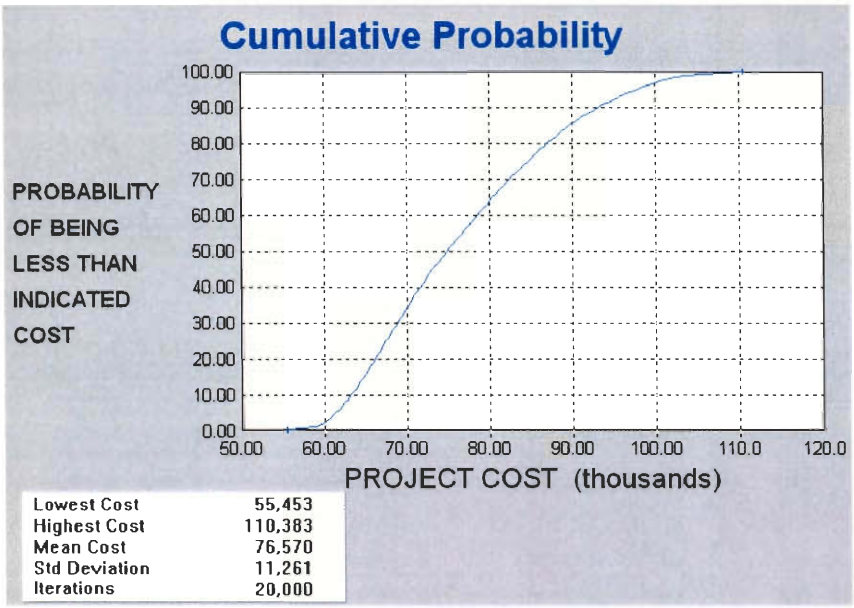

Figure 27 - Probability of being less than indicated cost

The figure to the right indicates the probability of the costs being less that a specific amount. This indicates that in the $70,000 range, the estimated material cost, that there is a 35% chance the cost may be less than amount. However, there is also 65% chance that it may be over that value. Equal probability of a larger or lesser cost occurs at approximately 75%.

This data is a summary of the graphical data. Outside of the basic statistics and averages mentioned before, it also contains the confidence and contingency values. Confidence values are based on how close the estimated value is near the minimum. Contingency estimates the chances of something going wrong at a specific values.

The total cost of the home is also dependent on the cost of labor. By researching the prices of labor on homes of similar size and quantity it is possible to determine the approximate total cost for the house. The estimate, calculated from estimated price per square foot, is a total of $260,000. This is relatively average price for a project of this scale, and is comparable to other houses of its size range.

Walkthrough

A few selected people were asked to evaluate the house design in a walkthrough. They were first presented with floor plans to evaluate room layout. Then, they were allowed to navigate through the 3D model of the house. Participants were asked to provide feedback about how intuitive they thought the house was and about any comments or suggestions they may have. Comments and suggestions are as follows:

- "The stairs to the basement should be underneath the other staircase."

We placed the stairs where they were because it puts the essential items in plain view. It is very likely that the stairs to the basement will be used more often than the living room closet, and putting the basement stairs out of the way makes them harder to find. Also, in order to get to the stairs, one would have to cross through the living room in front of anyone in the room.

- "I like where the upstairs bathroom is, but it needs to be a bit bigger."

The bathroom currently takes up as much space as is necessary for its purpose without being too big. Perhaps it makes sense to have extra room in a bathroom to move around, but in this case, it would involve shrinking the deck size.

- "It might get annoying to have to carry your laundry all the way down to the basement to wash it."

The washing machine and dryer are kept in the basement mainly because that is the first place that people would look for them. Thus, without knowing anything about the house, one can assume that the laundry room is in the basement and the bedrooms are upstairs.

- "Gray walls are depressing."

Due to a complication in the 3D rendering program, the plaster walls appeared to be a dull gray color. This was unintentional, as the walls are actually intended to be white.

- "The view from the balcony would be nice."
- "I like the big windows in the living room; they make the room look a lot bigger."

The large windows were designed to add to the spacious feel of the living room, to allow light and heat into the house from the south, and to provide a good view out the back of the house.

- "I want the living room windows to all be the same size, even the fixed ones."

We did not consider that people might like all of the windows to be the same size. There may be a concern that adding more, smaller windows to the wall could lower its structural integrity. As we do not really know about wall structural integrity, we cannot know if this will be a problem without further research.

- "The bathroom needs a small frosted window."

This has been added in the floor plan of the house.

- "There should be another window on the front in the kitchen."

Putting a window on the front would lower the amount of cabinet space in the kitchen and would get in the way of the stove/oven. While it is not totally impossible to add a window here, doing so would not benefit the house too much as it would be a north-facing window.

Generally, responses to the design were positive. People thought that the house would look good and that it had some features that would make it easier to know which rooms are which at a glance. However, out of the seven people we asked, three said that they would not like to live in this house, even if it is intuitive. There was some concern about how safe the house would be for children or the elderly. While the balcony may look nice, it presents the potential for a safety hazard.

Conclusion

Practical Applications

Through a process of intuitive design, the project team created floor plans and a model of a house. This processes simply involved researching what was intuitive. Our method of intuitive design is simple, easy, and has no clear disadvantages. This process could be applied to other designs.

Limitations

The overall cost for this house has been estimated at about $260,000. This price is highly variable, depending on cost of space, materials, and labor. This cost is probably about average for a house of this size. Thus, it appears that an intuitive house does not necessarily cost more than a non-intuitive house. In practice, it may be that the specific needs of this house, such as the single slant roof or the large windows, would cost a good deal more (or less) than anticipated. The actual price difference between this design and a non-intuitive one seems to very low, but a consumer must then individually determine the value of intuitive design.

Though it does not seem to be a likely problem, there may be structural problems with this design. Having the roof as a single slant is less structurally sound than an A-frame roof. Also, since the exterior walls must support the weight of the roof, having large windows may compromise structural integrity. Likely, however, the materials that exist today are sturdy enough to hold themselves up, so structure should not be too much of a problem.

Unfortunately, we were unable to obtain building codes. Thus we cannot know for certain if this design violates any laws regarding wiring, plumbing, structure, etc. We are fairly sure, however, that the house could meet these standards, possibly with only a few alterations.

A major limiting factor of the design is that it is based largely off of data received from the surveys. This data is very likely biased, because the majority of the survey recipients was

from the same general location, was technical oriented students, and had never previously purchased a home. Also, participants may have answered based more on personal preference than on what they felt to be more intuitive. Thus we cannot know if the traits that we determined to be intuitive are based solely on these aspects. Perhaps if we had run this survey in Texas, there would be an overwhelming trend towards one-floor houses with no basements or attics. Also, intuitive features of the house may be more obvious to a person who owns a house. In the end, what this means is that we can only be sure that this house is intuitive for New England technical students who do not own houses.

A common reason for making a non-intuitive house is aesthetics or personal taste. One may feel that it is more important that the house looks good than that the house is easy to use, or perhaps the homeowner actually *likes* the daily challenges that an unintuitive design offers. This design was not made to suit individuals seeking aesthetic goals.

Where do we go from here?

While the design for this house seems to be intuitive, various aspects within the house could use more attention. For example, the design of the kitchen alone could be an entire project. In the kitchen, it is nearly impossible to know at a glance where each item is stored. It may be possible to provide some sort of cues to let the casual observer know which drawer contains the silverware, and which holds the potholders.

Another interesting problem arises with appliances. While we selected appliances that we believed to be somewhat easier to use than their counterparts, these might not be as intuitive as they can be. It would be an interesting project to search in more detail for appliances that lend themselves to easy everyday use, or perhaps to even design new appliances for this purpose.

Concepts used in designing this house could be applied elsewhere as well. Using the same methods we used, one could design an intuitive office building, movie theatre, shopping mall, or torture chamber. Devices could be made intuitive as well. One could research and survey people to find out what is the most intuitive VCR, bicycle, calculator, or shoe.

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Appendices

Intuitive Home Survey

Our IQP is an attempt to design an intuitive house. An intuitive house is not necessarily the home of a person's ideals, nor is it a museum of every elaborate electronic invention. It is a house designed based on psychology – where every door opens in the expected direction and every light switch is in a logical location. The place demands no instruction manual, no learning curve, and no frustrations of any sort. The design relies on what people's expectations are.

In order to create this design, we need to know what people expect. The following questions ask you to imagine a typical house without the typical problems. While taking a "mental walk" through the house, please answer these questions to describe what you imagine.

If you have any questions, comments, or suggestions, feel free to contact us:

- mailto:blankk@wpi.edu
- mailto:hoffman@wpi.edu
- mailto:smyrph@ece.wpi.edu

Major

Year of Graduation

Gender
- Male
- Female

Which hand do you write with?
- Left
- Right

Imagine a typical house...

1. Does the house have a basement?
   - Yes
   - No
2. Does the house have an attic?
   - Yes
   - No
3. How many floors does the house have? (not including an attic or basement)
   - 1 story
   - 2 stories
   - 3 stories

4. Where would you locate these things?

	Basement	1	2	3	Attic
Bedrooms	☐	☐	☐	☐	☐
Water heater	☐	☐	☐	☐	☐
Washing machine/drier	☐	☐	☐	☐	☐
Bathrooms	☐	☐	☐	☐	☐
Kitchen	☐	☐	☐	☐	☐
Living room	☐	☐	☐	☐	☐
Dining room	☐	☐	☐	☐	☐

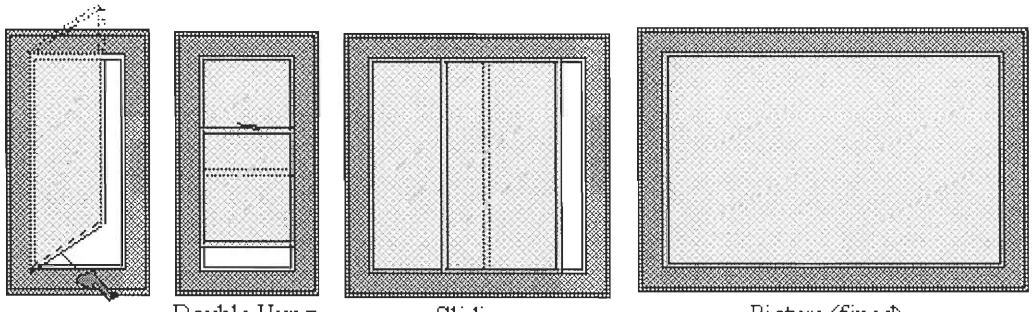
5. From a top-down (birds-eye) view, what shape of house do you prefer?
   - ○ rectangle
   - ○ square
   - ○ circle
   - ○ other ☐

6. Does the house have a deck?
   - ○ Yes
   - ○ No

7. What is the first room you enter after walking through the front door?
   ☐

8. Which direction would you like most windows to face?
   - ○ north
   - ○ south
   - ○ east
   - ○ west

9. What style of windows do you prefer?



○ ○ ○ ○

10. When you walk into each of these rooms, what colors are the walls?

Room	Red	Green	Blue	White	Brown	Yellow	Black
Bathroom	○	○	○	○	○	○	○
Bedroom	○	○	○	○	○	○	○
Kitchen	○	○	○	○	○	○	○
Study	○	○	○	○	○	○	○
Hallway	○	○	○	○	○	○	○

Light/Pastel	Dark/Deep
○	○
○	○
○	○
○	○
○	○

11. Is your thermostat ○ analog (mechanical) or ○ digital (electronic)?

12. What do you prefer on a door?
    - ○ knob
    - ○ handle
    - ○ push plate/pull bar

13. What style of closet doors do you prefer?

○ ○ ○ ○

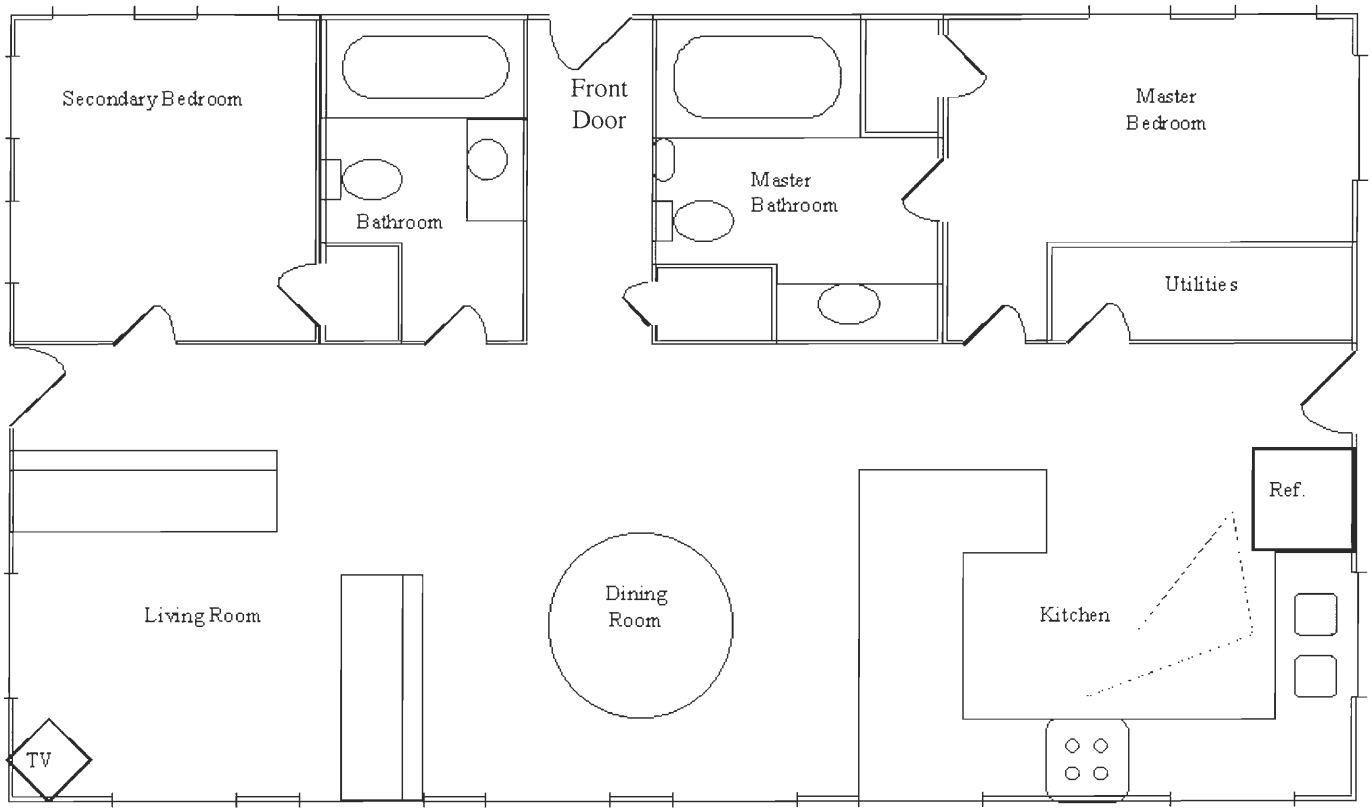
14. When you go to turn the knob on the door, which way do you turn it?
    - ○ clockwise
    - ○ counter-clockwise

15. You walk into a room and flip a switch to turn it on. Do you flip it ○ up or ○ down?

16. Does your bedroom door open ○ in to or ○ out of the room?

17. Please evaluate the following house plans in terms of aesthetics and "ease of use":

Please evaluate the following house design. Pay attention to how easy the house is to use and how visually pleasing the design is.



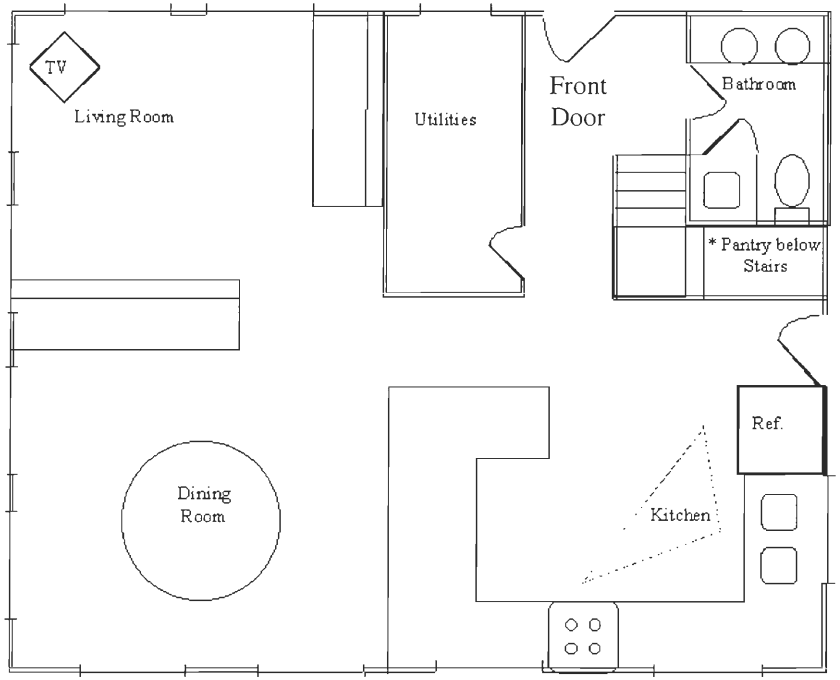
__ 1 (Intuitive) __ 2 __ 3 __ 4 __ 5 (Unintuitive)

__ 1 (Visually Pleasing) __ 2 __ 3 __ 4 __ 5 (Hideous!)

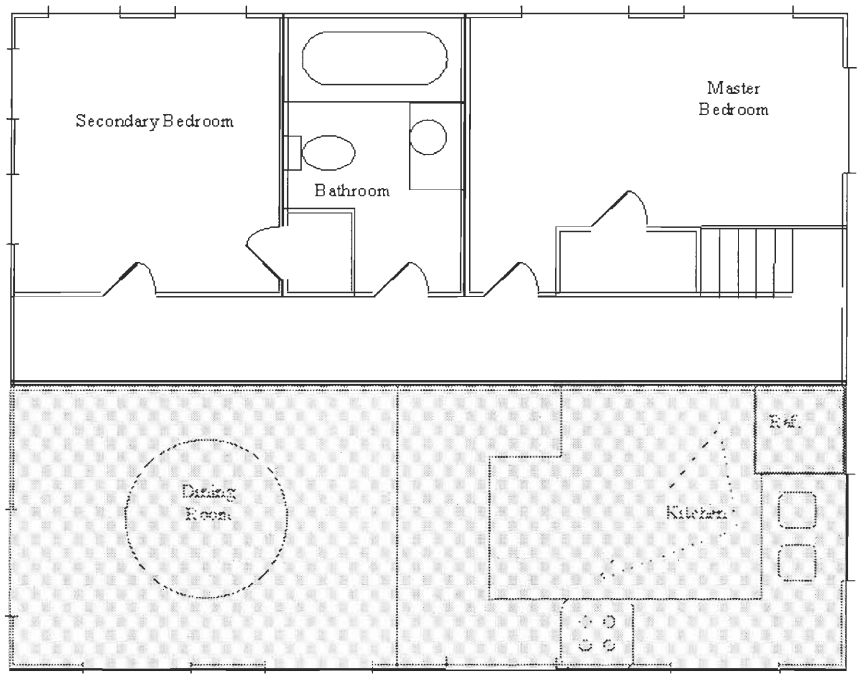
Comments:

Please evaluate the following house design. Pay attention to how easy the house is to use and how visually pleasing the design is.

First Floor



Second Floor



__ 1 (Intuitive) __ 2 __ 3 __ 4 __ 5 (Unintuitive)
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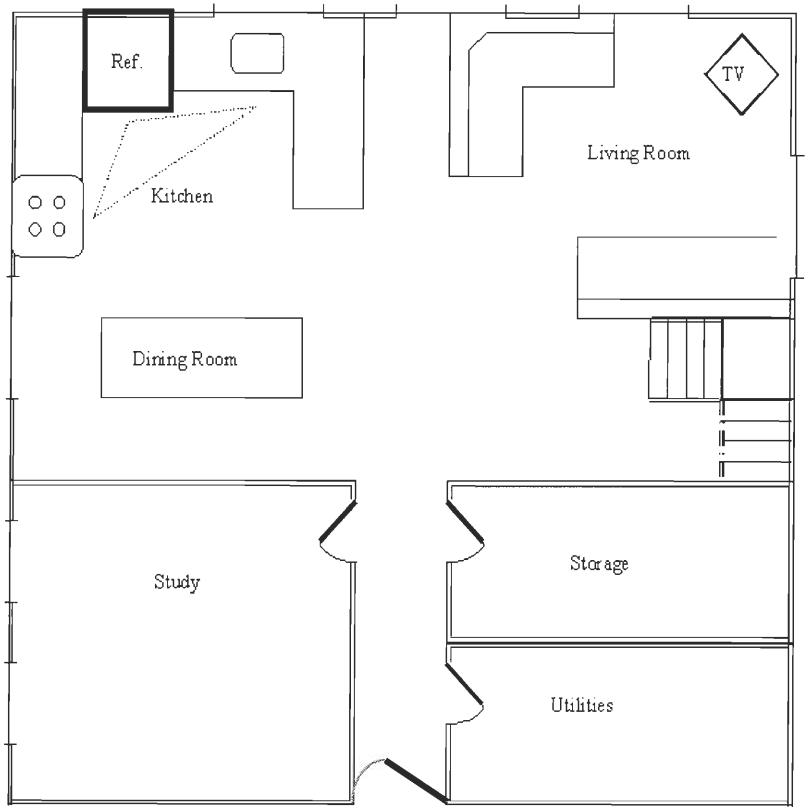
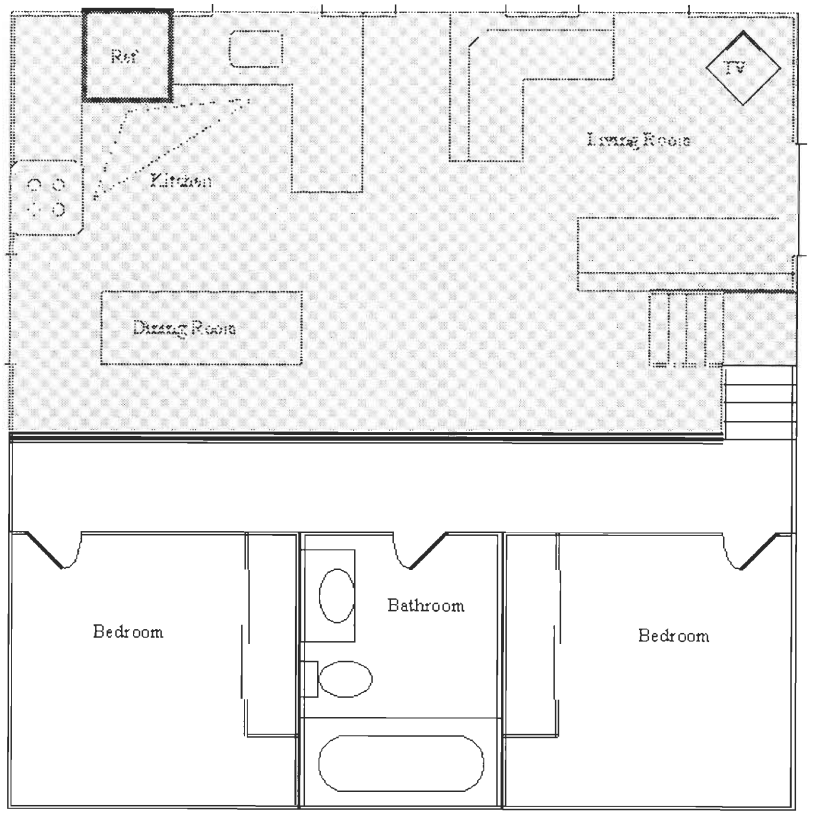
Comments:

Please evaluate the following house design. Pay attention to how easy the house is to use and how visually pleasing the design is.

First Floor



Second Floor



__ 1 (Intuitive) __ 2 __ 3 __ 4 __ 5 (Unintuitive)

__ 1 (Visually Pleasing) __ 2 __ 3 __ 4 __ 5 (Hideous!)

Comments:

Intuitive Home Survey

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- mailto:blankk@wpi.edu
- mailto:hoffman@wpi.edu
- mailto:smyrph@ece.wpi.edu

Major

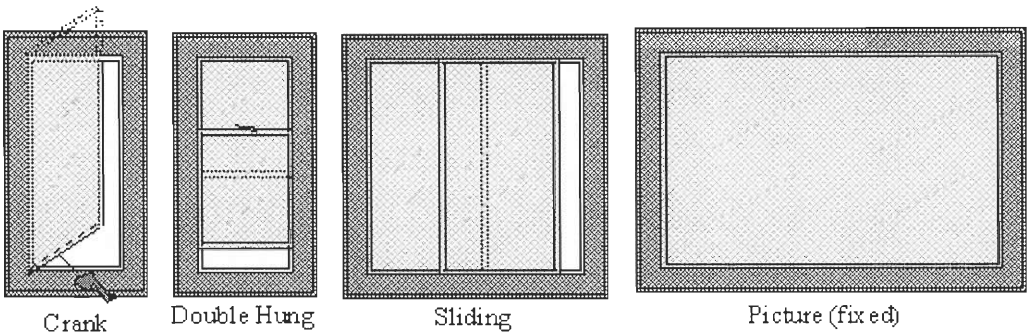
Year of Graduation

Gender
- Male
- Female

Email Address (for prize drawing)

Imagine a typical house...

1. What style of windows do you find easiest to use?



2. What is the first room you enter after walking through the front door?
   - Dining Room
   - Foyer
   - Kitchen
   - Living Room

3. Does the house have a basement?
   - ○ Yes
   - ○ No

4. Does the house have an attic?
   - ○ Yes
   - ○ No

5. How many floors does the house have? (not including an attic or basement)
   - ○ 1 story
   - ○ 2 stories
   - ○ 3 stories

6. When you walk into each of these rooms, what colors are the walls?

Room	Red	Green	Blue	White	Brown	Yellow	Black
Bathroom	○	○	○	○	○	○	○
Bedroom	○	○	○	○	○	○	○
Kitchen	○	○	○	○	○	○	○
Study	○	○	○	○	○	○	○
Hallway	○	○	○	○	○	○	○

Light/Pastel	Dark/Deep
○	○
○	○
○	○
○	○
○	○

7. Is the thermostat ○ analog (mechanical) or ○ digital (electronic)?

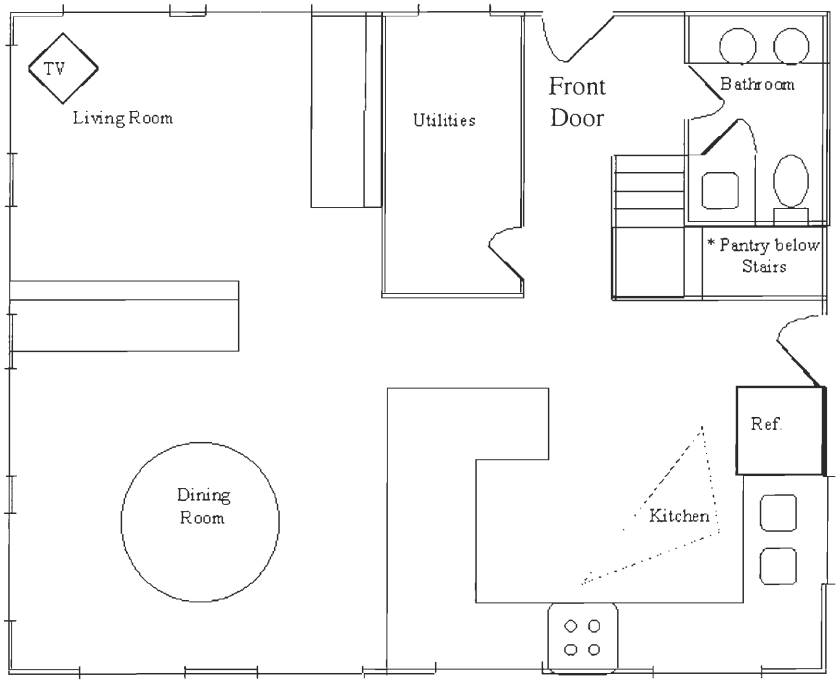
8. What style of closet doors do you prefer?

○ ○ ○ ○

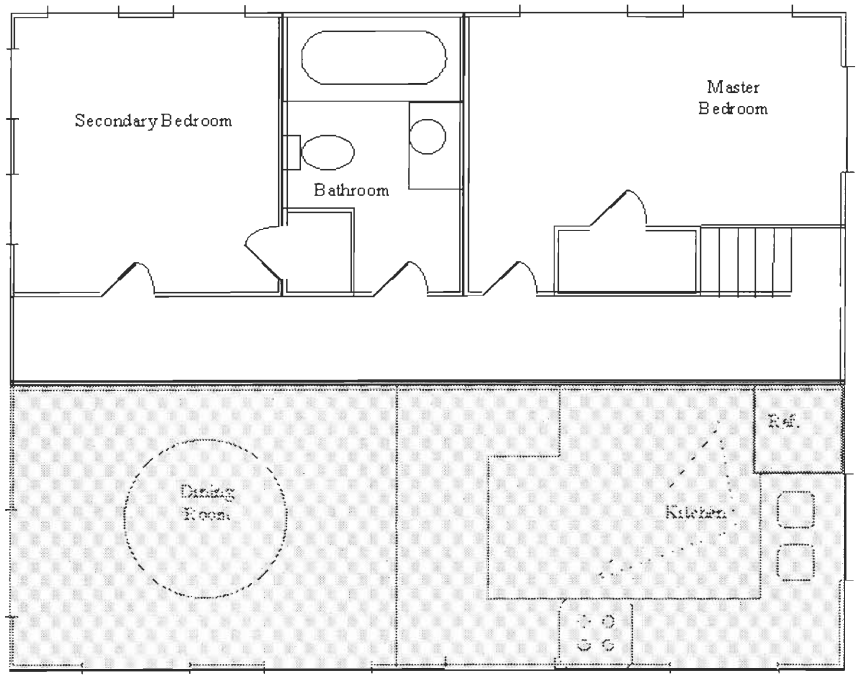
9. Please evaluate the following house plans in terms of aesthetics and "ease of use":

Please evaluate the following house design. Pay attention to how easy the house is to use and how visually pleasing the design is.

First Floor



Second Floor

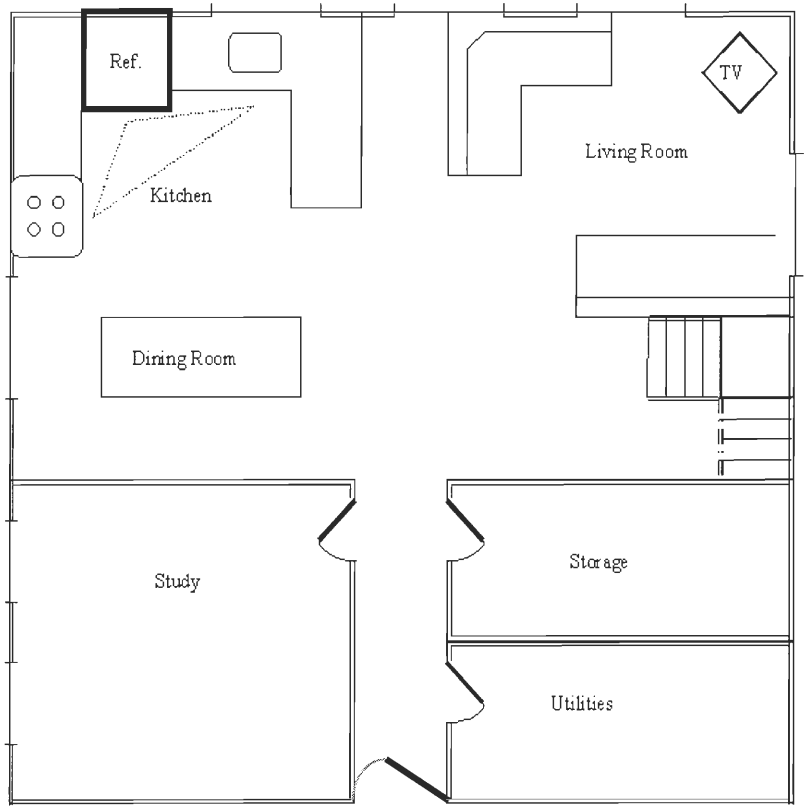


__ 1 (Intuitive) __ 2 __ 3 __ 4 __ 5 (Unintuitive)
__ 1 (Visually Pleasing) __ 2 __ 3 __ 4 __ 5 (Hideous!)

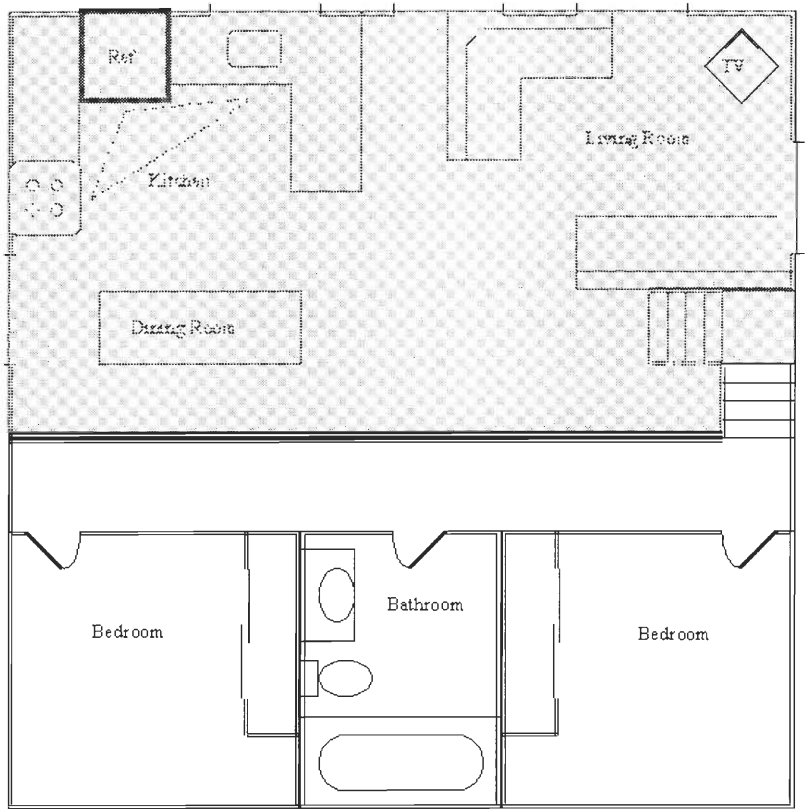
Comments:

Please evaluate the following house design. Pay attention to how easy the house is to use and how visually pleasing the design is.

First Floor



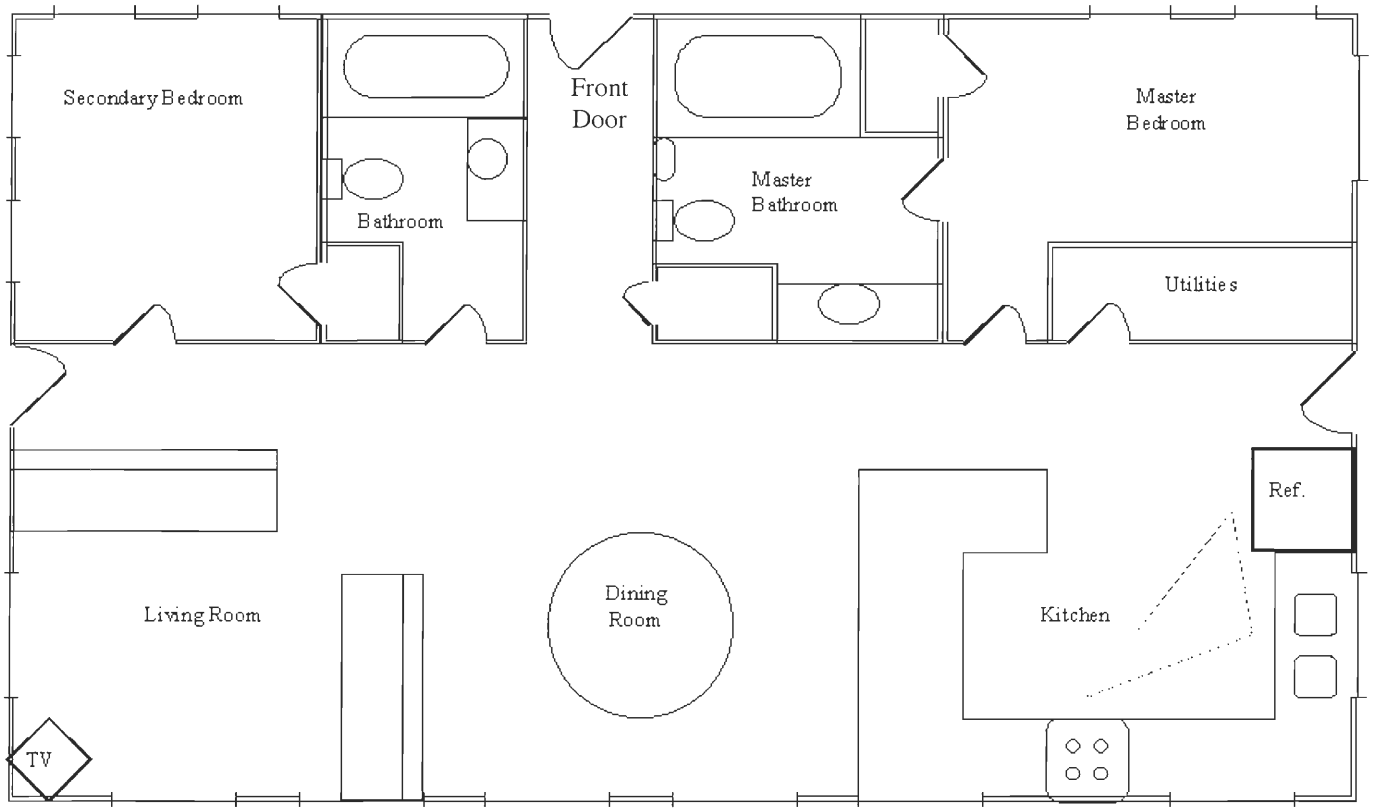
Second Floor



__ 1 (Intuitive) __ 2 __ 3 __ 4 __ 5 (Unintuitive)
__ 1 (Visually Pleasing) __ 2 __ 3 __ 4 __ 5 (Hideous!)

Comments:

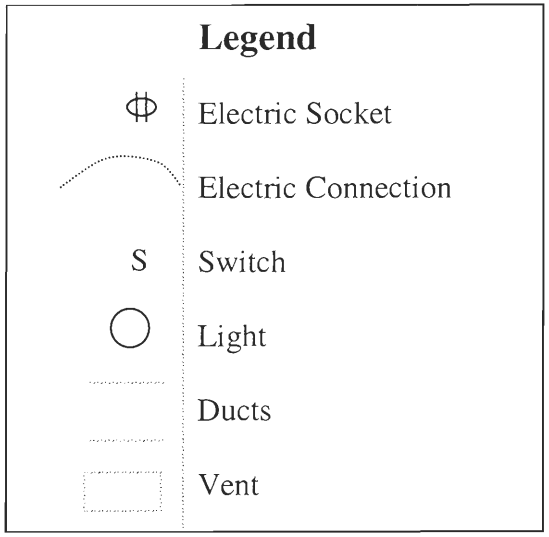
Please evaluate the following house design. Pay attention to how easy the house is to use and how visually pleasing the design is.

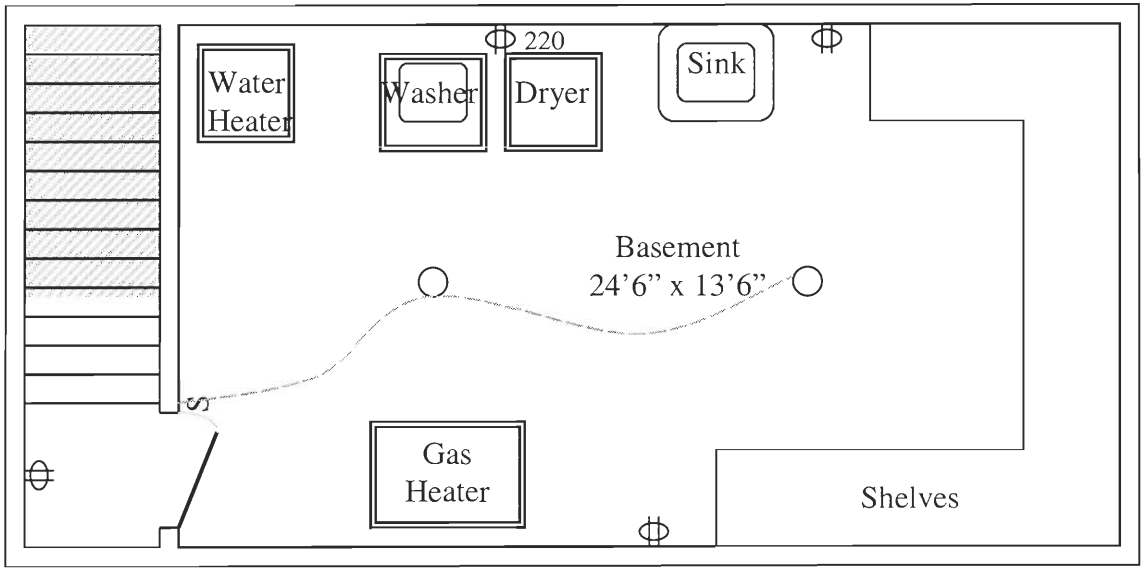


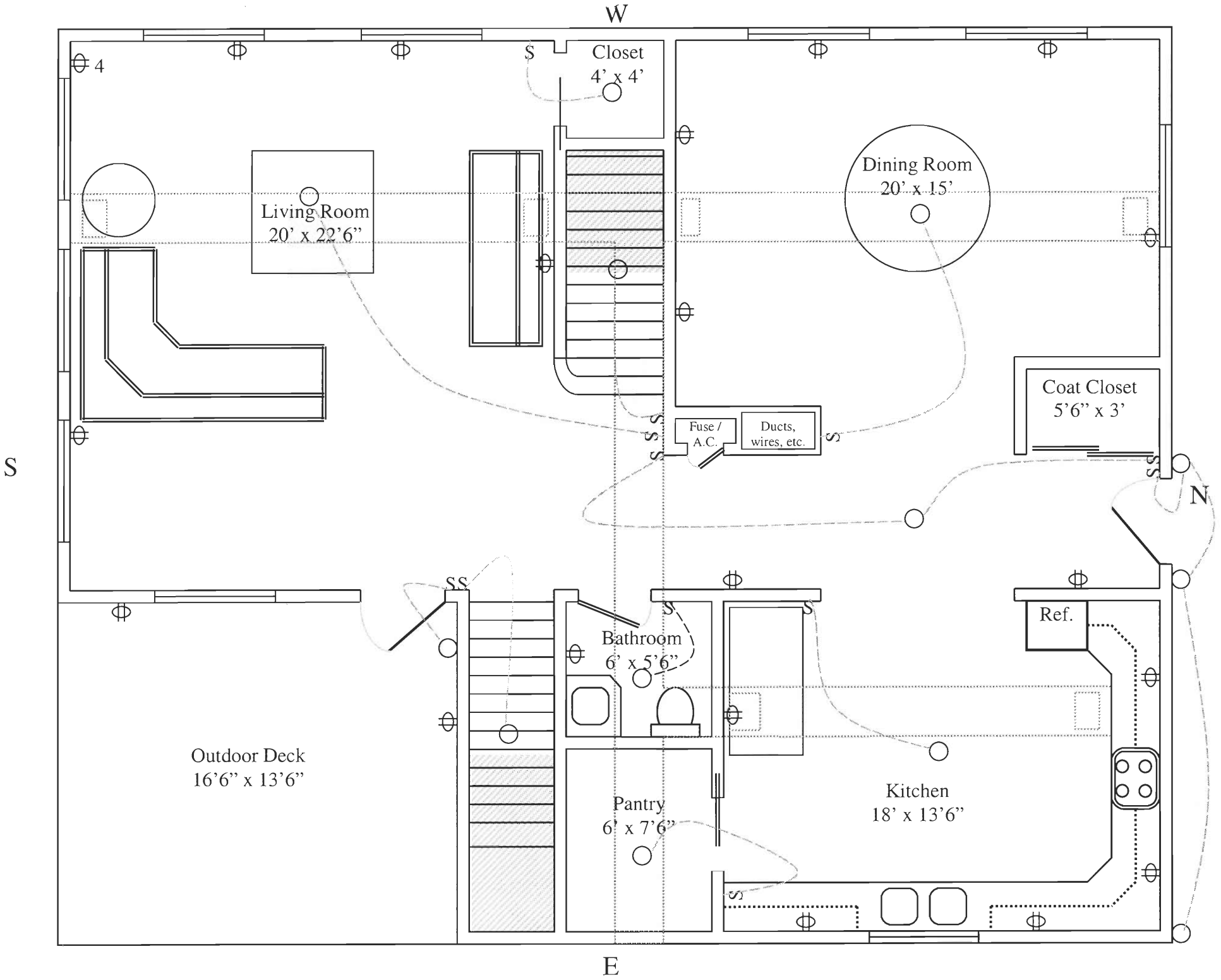
__ 1 (Intuitive) __ 2 __ 3 __ 4 __ 5 (Unintuitive)
__ 1 (Visually Pleasing) __ 2 __ 3 __ 4 __ 5 (Hideous!)

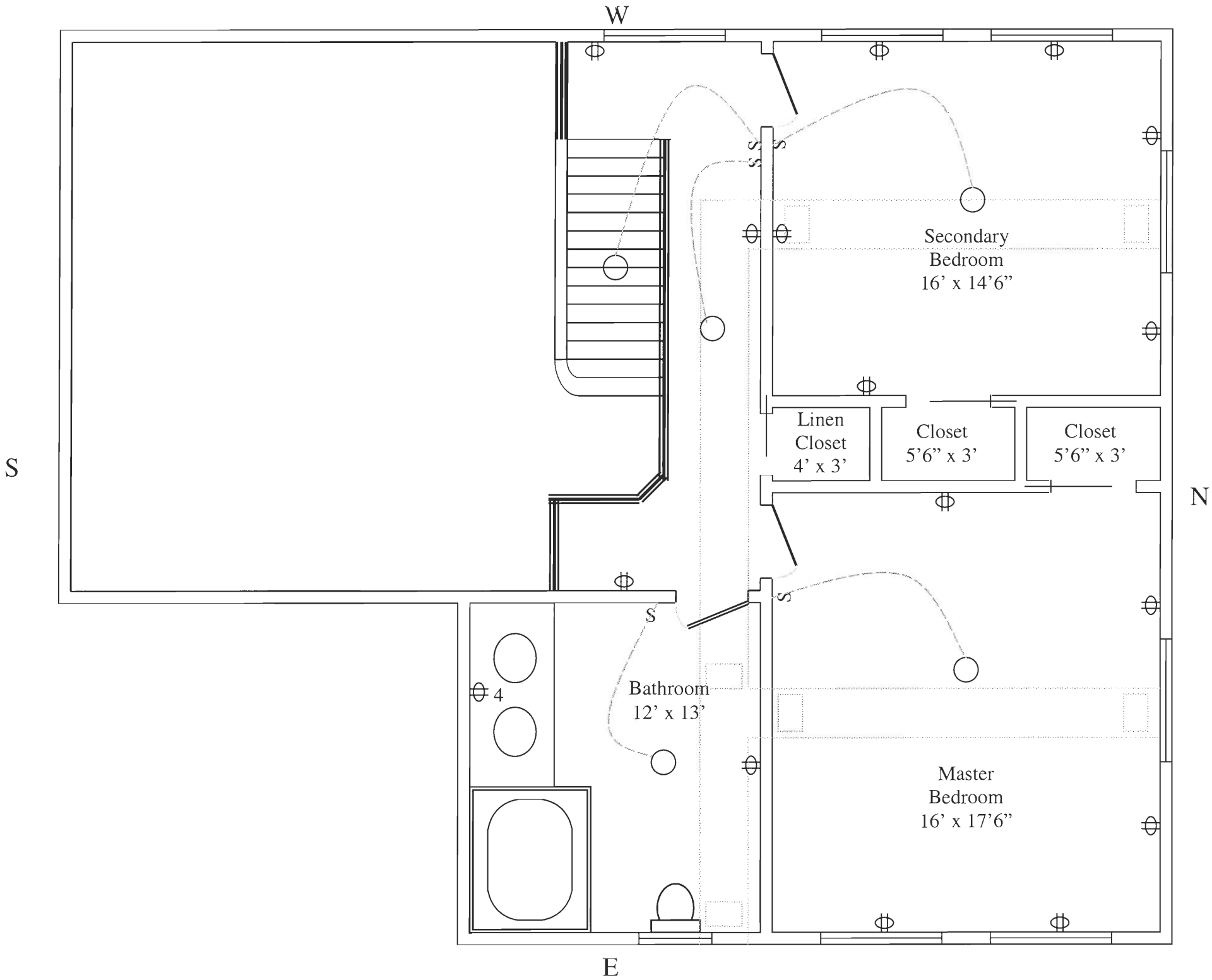
Comments:

Appendix B: Floor Plans

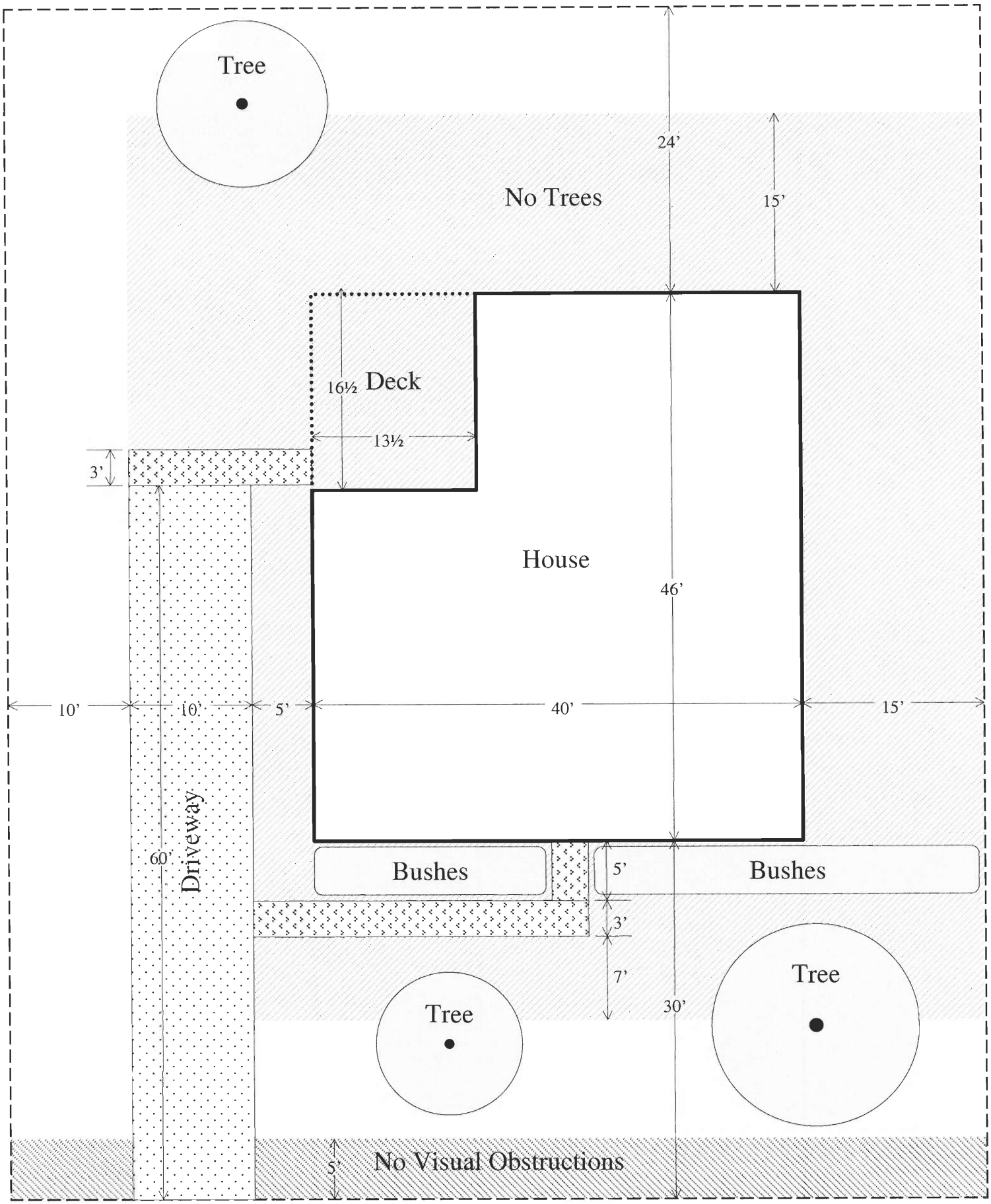




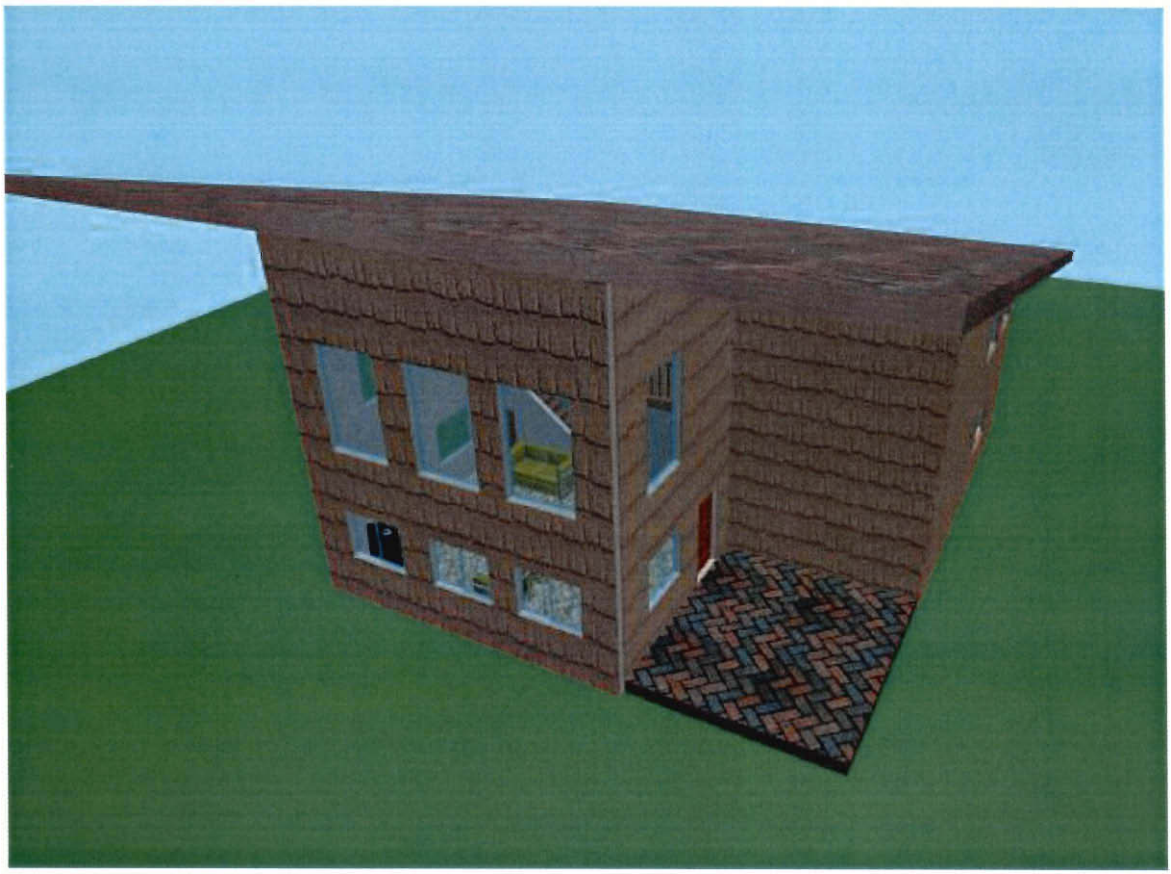

W
S
N
E
4
S
Closet
4' x 4'
Living Room
20' x 22'6"
Dining Room
20' x 15'
Coat Closet
5'6" x 3'
Fuse /
A.C.
Ducts,
wires, etc.
SS
Bathroom
6' x 5'6"
Ref.
Outdoor Deck
16'6" x 13'6"
Pantry
6' x 7'6"
Kitchen
18' x 13'6"


W
S
N
E
Secondary
Bedroom
16’ x 14’6”
Linen
Closet
4’ x 3’
Closet
5’6” x 3’
Closet
5’6” x 3’
Bathroom
12’ x 13’
4
Master
Bedroom
16’ x 17’6”

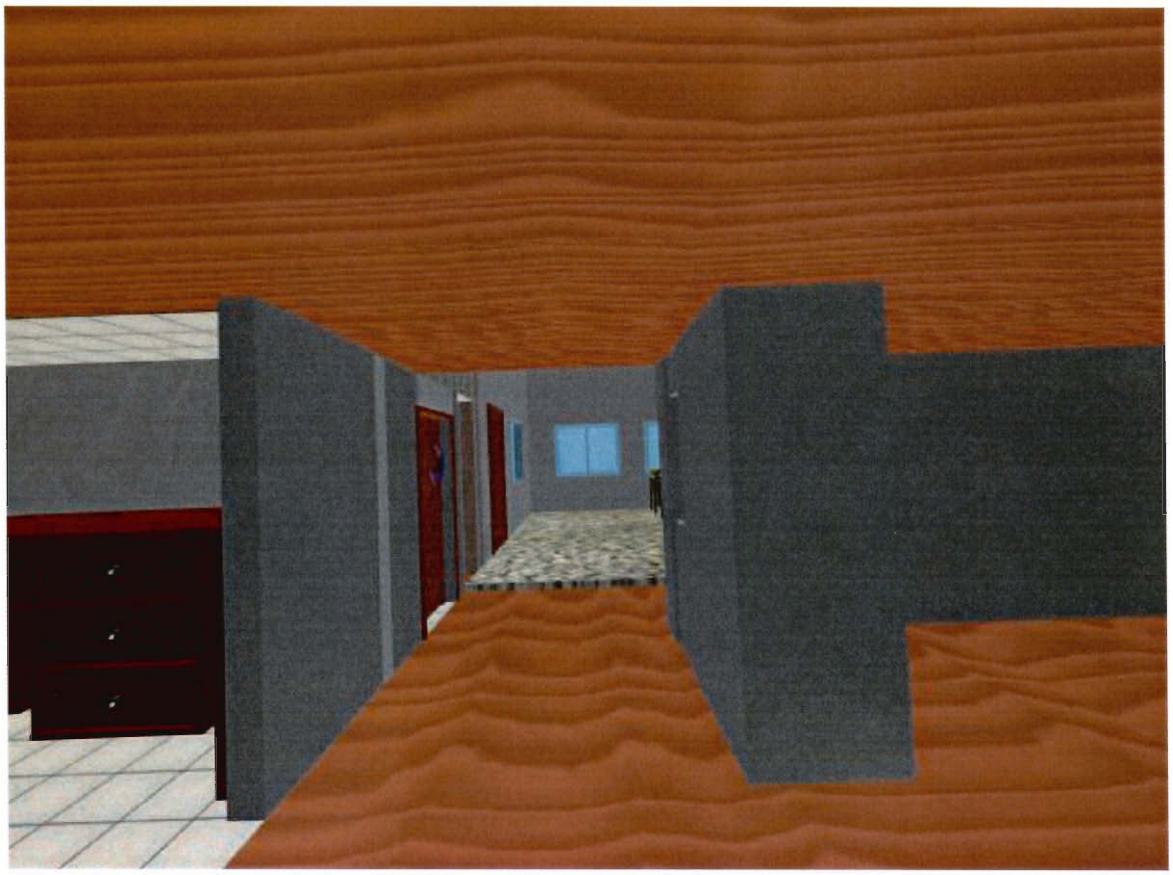
Appendix C: Exterior Plan



Appendix D: 3D Model Pictures

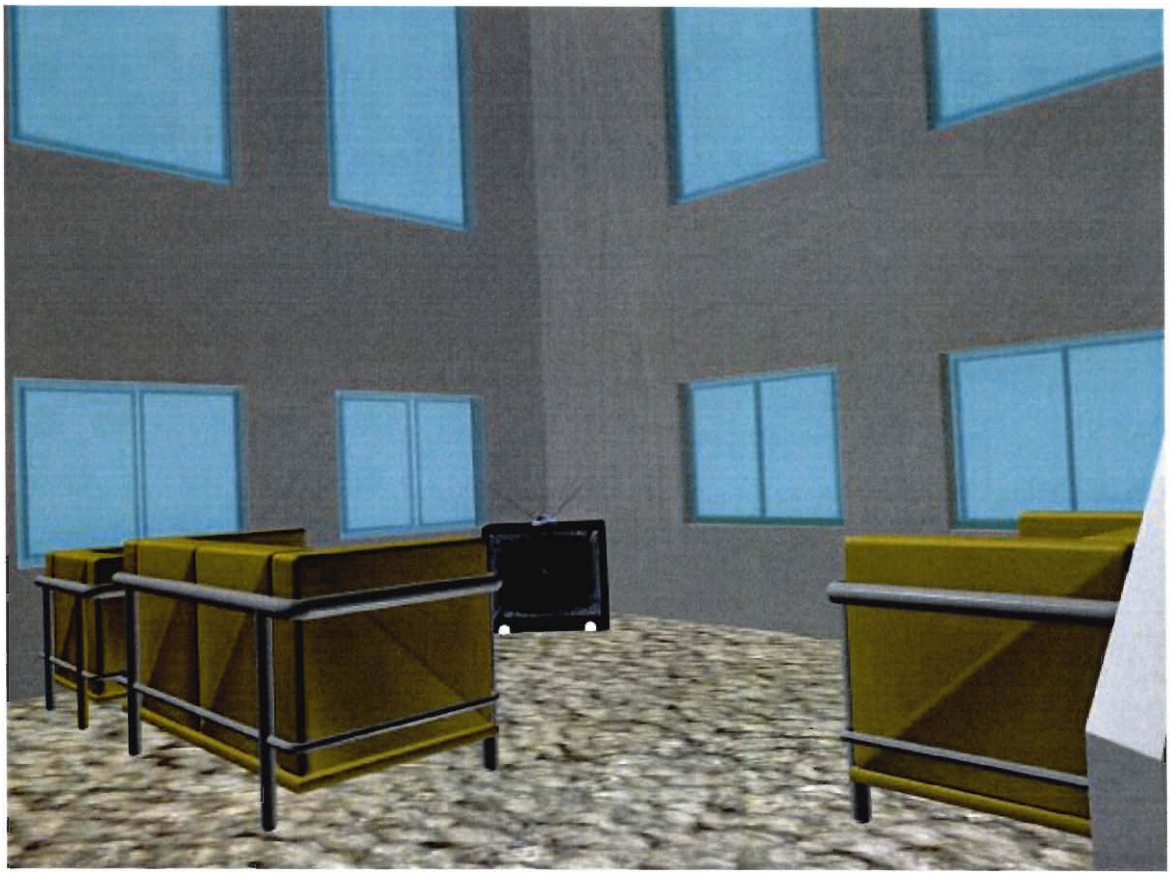


Back View: *This is the South face of the house*



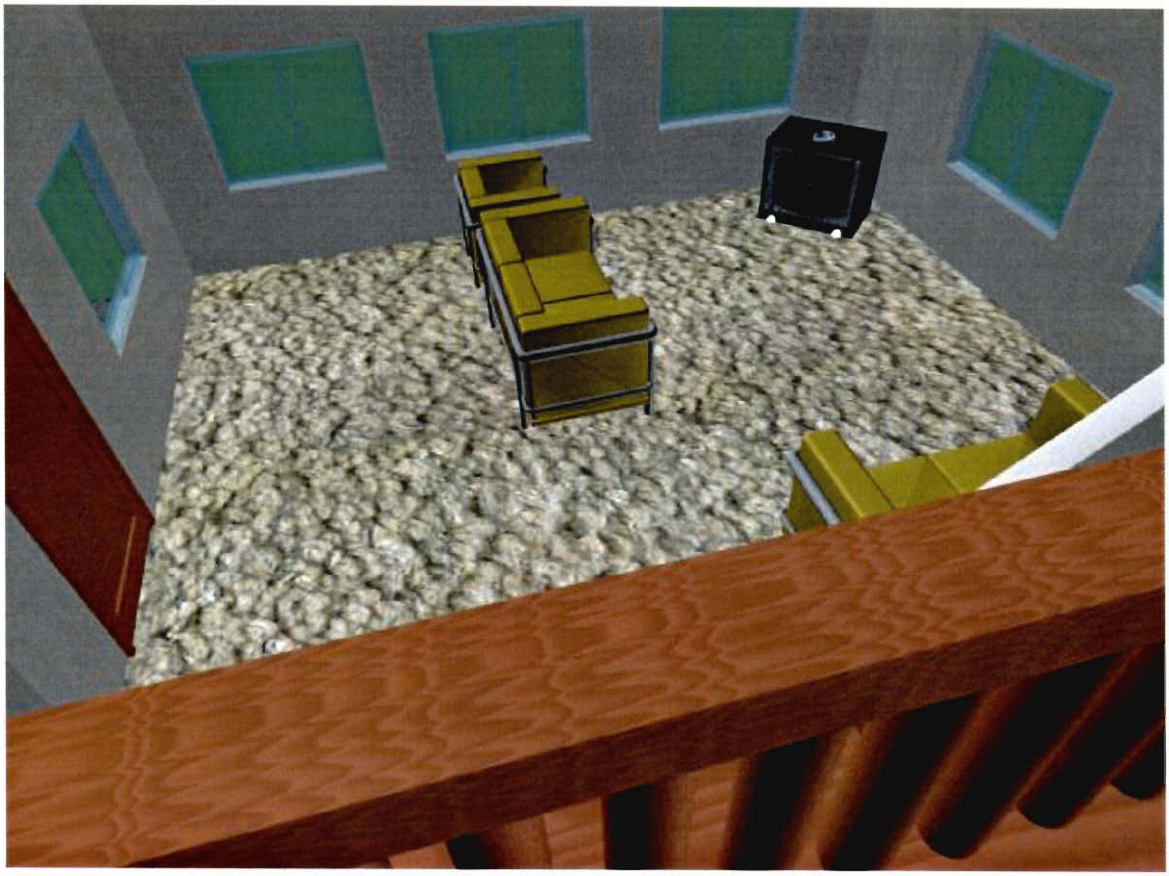
Main hallway: *A view from the front door looking down the main hallway. Upon entering the house, all rooms on the first floor are immediately visible.*

Kitchen: *The kitchen. One can see from this image that there is plenty of counter space and the work triangle is within acceptable ranges.*



Living Room: *A view of the living room.*

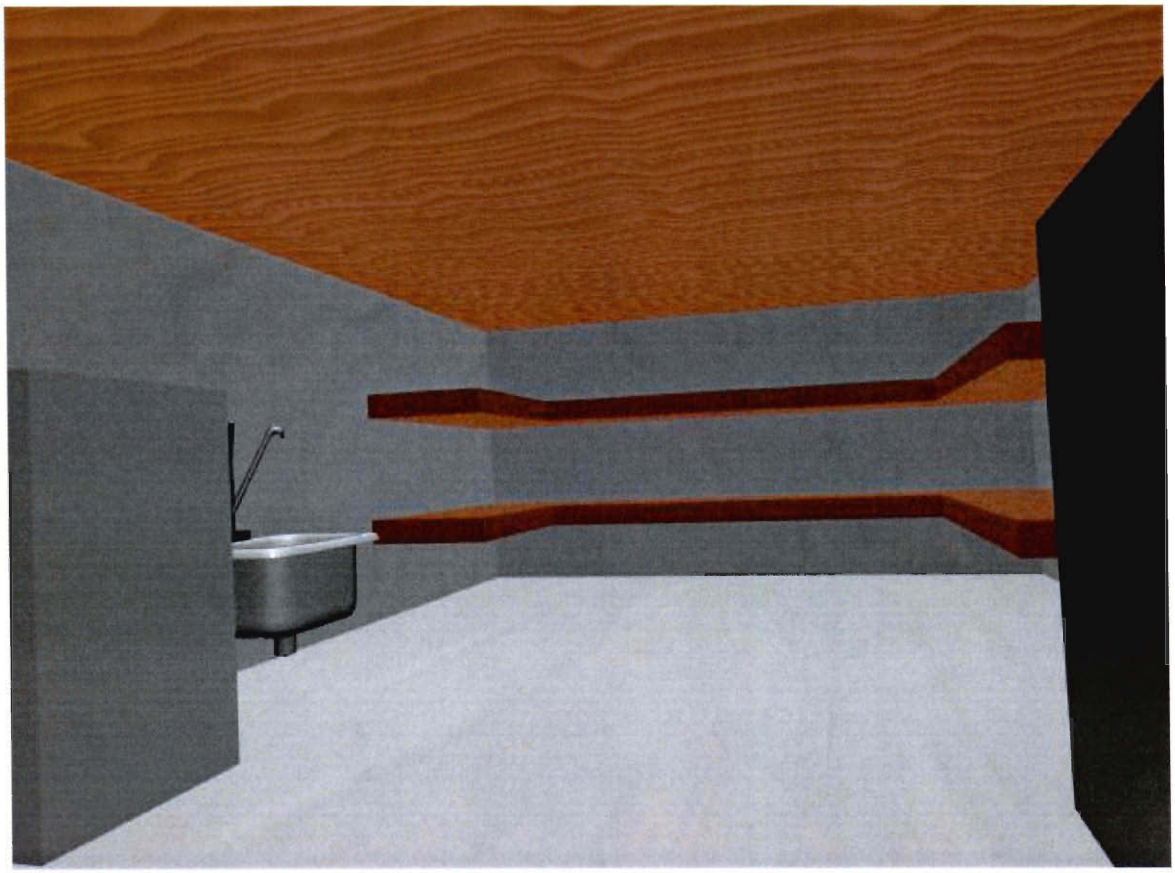
Living Room: *A view from the living room looking at the balcony above. Note the crescent symbol on both bathroom doors.*



Living Room: *A view of the living room from the second floor balcony.*

Bedroom: *The master bedroom.*

Bathroom: *The master bathroom, with tile floor and two sinks. The area under the sinks would be used for storage.*



Basement: *A picture of the basement as seen from the door. The box seen on the left represents the dryer and on the right is the air heater.*