Product Design Report

Utilis Simia

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ENGR 152

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Customer Research

As engineers, we are seeking to find useful solutions to regular problems that every average college student might encounter during their daily routine. We set out to find such problems through interviews with real students and market research to determine if there is a need for a solution to such problems. What you will find below is information about our target demographic, interview results, and design specifications on what types of products we could build. You will also see some market research pertaining to preexisting solutions and some of their strengths and weaknesses. In this section, we discovered that the target customers (College Students) would use any of the following products on a daily basis:

- Paper organizer
- Automatic glasses cleaner
- Motion activated desk lamp/light

We also discovered that college students will have limited budgets, so an ideal selling price would be somewhere between $30 and $45.

Customer Identification

Our target customers fit these characteristics:

- **Age:** 18-21
- **Gender:** Male / Female
- **Location:** George Fox dorms
- **Income:** Broke college student
- **Social class / Occupation:** Middle class college student
- **Education:** High school / College education
- **Frequency of product use:** Daily

- **Type of product use:** Smart products, intuitive products, useful products

Customer Interviews

Our first interview was with Tyler Colvin. He is a full-time student and a part-time employee at Fred Meyers. He has several pain points concerning his dorm. These points include organizing his homework, people forgetting to grab their laundry out of the washer and dryer, and not having enough light in his dorm in the mornings. He says that he wouldn't pay more than $40 for a product that would satisfy these pain points. Some of the key features that he suggested were that it be heat resistant, non-obstructive, and have a pastel color scheme.

After we interviewed Tyler, we interviewed Elijah DeJong. He is also a full-time college student, and he works part-time at 3D Plastics, a manufacturing company in Newberg. Some of Elijah's pain points were staying on task when working on homework, the bathrooms being unsanitary, and, like Tyler, not having enough light to see in the morning. Some of the key features that he suggested were that it must not keep him up at night, and it should have audible feedback to user inputs. His budget for a smart device that could remedy his pains is $55.

Lastly, Josiah Adams would like a cool device that can do fun things. He has a $75 budget, but he will probably only pay that much if the device is really cool. He struggles with organizing his papers from school, and also struggles with seeing in the dark. This is a big issue because he is terrified of the dark. His roommate says this is a big problem, as they have to keep the lights on way too late. Josiah placed an emphasis on a cool product interface that includes LEDs, potentially an LCD screen. For colors, he likes tri-color schemes such as stripes/lines.

Design Specifications

Customer design goals	Engineering design goals
Heat resistant	Can withstand 110 deg F
Priority Good looking housing	9/10 people say it isn't ugly
Can put anywhere	Doesn't tip over on flat surfaces, can be wall mounted
Small/not obstructive	10x10x5 inches or less
Pastel color scheme	Pastel color scheme
Priority Cool lights and noises	At least 3 lights and 1 sound
$75 budget	$75 max
Must be school appropriate	Professor Chris says it's ok
Priority Has to not keep him up at night	Not passively audible
Durable, doesn't break easily	Stress test all components
Multiple uses	3+ different functions
Easy to clean/dust/doesn't get dirty	No weird cracks, doesn't make a mess
Cause mass destruction & serve diabolical needs	Easily does tasks, parent tested
Helps with organizing papers	Some way to organize/manage papers
Likes tricolor scheme	Has 3 different colors
Struggles with seeing in the dark/ is terrified of the dark	Lights that can be used to see at night
Priority Digital interface with LEDs	2+ LEDs, LCD screen

MARKET RESEARCH

After doing research on what is available in the market, there aren't any wall-powered motion-activated lights that are really "smart". There also aren't any smart paper organizers. Glasses cleaners are usually ultrasonic, so most of them have some smart element to them. When we create our product, we want to utilize the microcontroller to perform multiple functions based on a variety of inputs. Based on all of this, we estimate that buyers would want to pay around $30 - $45 for the type of smart product we would like to design.

ECONOMICS

FACTS ABOUT INDUSTRY

We consider a smart product to be a product that has some form of input, computation, and output. They also should be able to perform automated tasks with simple human interaction. There doesn't seem to be a very big category of "smart" products by our definition in the market that we're looking into. Most products of these devices just do one task, and that's it. Since there are really no smart products in the market we are looking to create a product in, there isn't any market data to analyze. Interviews and surveys can only get us so far. The only real way to test the market on these products is to create them and see if they sell.

In terms of smart home devices, with more and more people trying to break away from tech, it seems like the market is neither growing nor shrinking. Consumers definitely prefer consistently performing products, so the more reliable something is, the better. Product trends really just seem to be focusing on cheaper manufacturing, which means that competitors are potentially taking design shortcuts. We think there is plenty of potential for a multi-use "smart" product that utilizes technology without connecting to the internet and violating privacy.

As stated in the market research, there aren't any products in these spaces that can multitask, however, there are products that clean glasses, and table/desk mounted motion activated lights. Most products satisfy our price range of $30-$75. One thing that isn't common is tricolor paint schemes and multi-function LCD displays. It’s undetermined whether or not the competitor’s products make noises based on the user input.

Competitor 1

This is the competitor to our motion activated desk lamp:

AUVON Plug-in LED Motion Sensor Night Light

This motion activated night light is very cheap. Reviews state it works well, but some complain of inconsistency.

Strengths:

- Cheap
- Simple
- Easy to use

Weaknesses:

- Takes up outlet space
- Not bright enough for some people

Basic objectives:

- Lights up as people walk past

- Variable brightness (2 modes)

Target demographic:

- Teenagers/adults, people who have hallways

Product Cost: $20 for 4 ($5 each)

Quality of product:

- Based on reviews, it is decent quality. Not sure on durability because we don't have one to test.

Competitor 2

iSonic® Digital Ultrasonic Cleaner Model CDS100

This ultrasonic glasses cleaner is priced in the middle of the market. We picked this one as a competitor because visually it looks very good.

Strengths:

- Cleans glasses well
- Also cleans jewelry

Weaknesses:

- Uses cleaning solution/water, can't spill it into cracks in the machine.
- Takes a bit to set up

Basic objectives:

- Clean glasses/jewelry using ultrasonic technology

Target demographic:

- People with glasses and nice jewelry
- Older people

Product cost: $56.00

Quality of product:

- The quality seems pretty good, except for the fact that you can easily spill water into cracks in the top of the cleaner, potentially frying the circuitry inside. This makes the product seem not well thought out.

Competitor 3

Ballucci 5 Tier Adjustable File Organizer Shelve

The Ballucci File Organizer holds papers in 5 different sections. It isn't a "smart" device at all, but it was designed the best in our opinion. There isn't really a section in the market that makes smart file/paper organizers.

Strengths:

- Simple, clean design
- Large storage compartments
- Solid looking construction

Weaknesses:

- Must be constructed
- Heavy

Basic objectives:

- Holds papers/files in an easy-to-access manner
- Looks good in a variety of different offices and desks

Target demographic:

- People with a desk
- Individuals with lots of papers

Product cost: $34

Quality of product:

- Reviews say strong, robust construction, some people complain of random stains, missing stickers to cover screw heads.

After researching the competition and analyzing consumer feedback, one common theme all competitors fail to address is that none of the products they make can do multiple things. They are all unitaskers that do their thing acceptably, with nothing that really stands out from the rest of the market except for looks and price. Products such as the motion detecting light had a limited light variability, and the ultrasonic cleaner had a crack where water could easily get in and fry components. As aspiring engineers in the George Fox program, we plan to use our engineering skills to thoughtfully design a product with the consumer's experience in mind.

Pricing

The cost of a device containing an Arduino sets the minimum price at $28. Once it contains parts like LCD screens, buttons, motors, a 3D printed/laser cut acrylic chassis, and other sensors, the cost to produce could be around $45. This is not including manufacturing hours and machine costs. Since this is just a prototype, we expect that the final product will not need an Arduino based microcontroller, instead, we could make custom PCBs for our product. Since custom PCBs can be made for much cheaper and can be created in bulk, this should bring the cost of each unit down by at least $20. If we want to turn a profit, we will need to sell the

product for about 20% more than the manufacturing price. The existing products in this space are much cheaper than our product will be. This has several reasons; they use cheaper materials, mass production, and minimal user interface. In order to make our product be profitable, we will need to find ways to minimize expensive electronic components and get the most out of our raw materials.

There aren't very many similar products to what we want to make on the market right now, so the pricing doesn't have to be competitive. Consumer interest really just depends on how helpful/interesting the device is. Since our target demographic is college students who might not have much money to spend, we want to do our best to keep prices low.

Design Challenge

The goal of our product is to build a device that contains a useful night light, glasses cleaner, and a way to help organize papers. Our target audience is college students living in dorms who have a busy life. This product appeals to our target demographic because it helps out in easy and useful ways without being too much of a hassle.

Business Model

Our company plans to build and sell Utilis Simia, the perfect desktop companion. Utilis Simia has several functions, it will act as a desk light, a glasses lens cleaner, and a paper organizer. Because it serves so many functions, we think that a lot of college students will find this product useful. Although there isn’t a large market for these types of products, we believe that there is demand. All of the people we interviewed said that they have trouble organizing papers. In addition, all of the people we interviewed said that they would like an easier way to clean their glasses. Of all of these interviewees, 67% of them said that they have trouble seeing in the morning.

If we were to manufacture and sell a product that solves all of these problems, we think it would be a huge success. In terms of making the products, we plan to build the product in house. This should bring down manufacturing costs quite a bit because we aren't outsourcing any of the work. This also means that we will have better quality control, because there will be no third party manufacturing and labor. On the other hand, this means that each product will take longer to produce, so we will have to price them higher to make up for the time to build.

On our final product (not our prototype), we expect chassis material costs to be around $10 per unit. Electronics in each unit will be around $20. For assembly time, most of the parts will be manufactured by machines instead of human labor, so we will be able to minimize man-hours on each unit. We expect there will be about 1 - 2 man hours per unit once an efficient assembly line is established. The total cost comes out to around $45 per unit. In order to maintain profitability, we will want to sell the products at about 20% more than the cost to manufacture. This will leave the final price of the product at $54.00. Although our product is more expensive than other devices on the market, we think that because of its multifunctionality it will be worth more to college students.

Conceptual Exploration

Problem Statement

Many college students run into inconveniences in their dorm rooms. These inconveniences add up, and no matter how small they are, students end up feeling more frustrated and exhausted than they should. Our goal is to build a product that can help simplify a student's life in the dorm by solving often-overlooked issues in a quick and efficient way.

Our product is unique compared to others because it will be modular. Modular designs that interface well with each other take up far less space than separate things, helping reduce

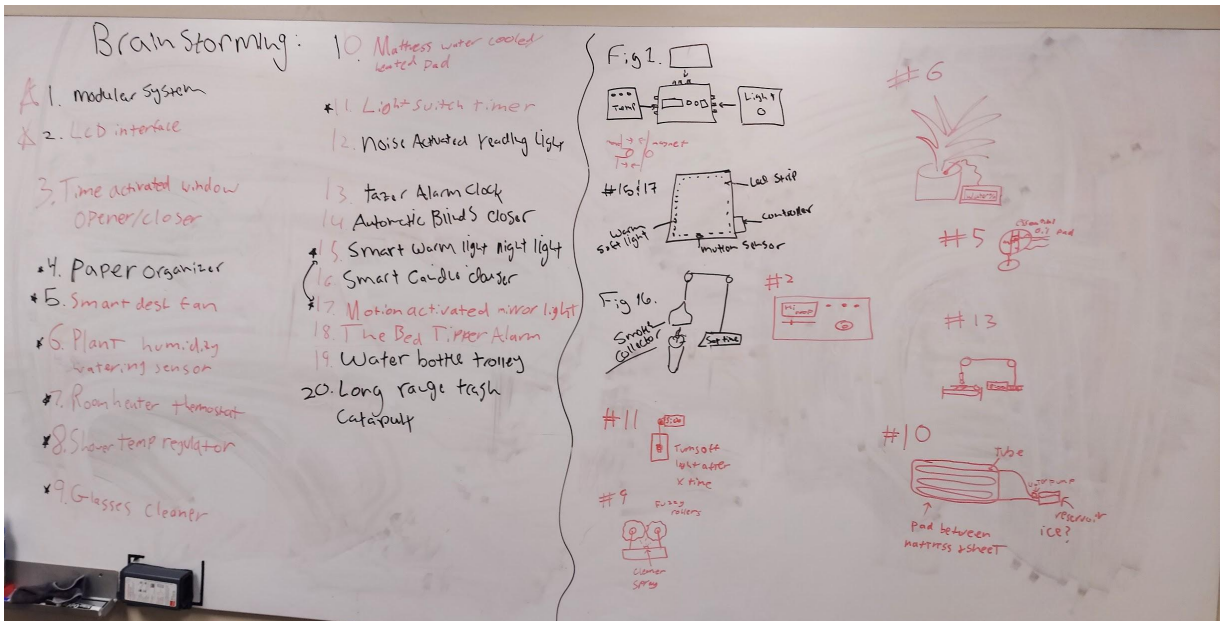
the clutter that can often be found in dorms. We also want to put an emphasis on designing and building things well, much different from current competitors on the market that are just trying to turn a profit.

Users would interact with our product through an easy to use array of knobs, buttons, and LCD screens. Since our focus is making a product for the consumer, we want it to be fun to use, not a chore. Since we don't quite know what we are building yet, we just know the electrical and mechanical components could vary from motors to LEDs, Arduinos, potentiometers, LCD screens, solenoids, temperature sensors, and more.

The main competitive advantage of our product is its focus on benefiting the consumer. Currently, it seems as if companies just try to sell the cheapest thing possible for them to make a profit, while our goal is a quality smart device. Because of this, one projected weakness is going to be cost. We can try to keep costs down by constructing things out of affordable parts and utilizing the resources we have in the maker hub.

As we don't quite know what we are building yet, we don't yet know what the difficulty level of our product will be. We expect it to be somewhere on the higher end unless there is a really cool concept that we really want to do.

Brainstorming



Conceptual Design Development

1. Smart Paper Organizer: The Smart Paper Organizer would allow students to store their papers and homework in one place. Using Arduino technology, papers would be automatically kept track of. Our design will definitely need to be further developed, as the “vault” method is slow and logistically challenging.

2. Air Freshener Fan: The Air Freshener Fan consists of an efficient blower and an essential oil pad that can be customized to make your room smell like anything you want. The smart software would enable the user to quickly define oscillating limits as well as set a time limit. Since we expect this fan to consume a lot of power, we want to try and figure out a reliable long-term power supply.

3. Semi-Automatic Glasses Cleaner: Everyone with glasses has had a problem with the lenses getting smudged, and the frustration of cleaning them eventually gives way to defeat. Twin cleansing rollers and an onboard lens cleaning solution tank provides a quick one-stop solution to fingerprints and smears. This design would require multiple motors, so getting specialized ones would help a lot.

4. Light Switch Timer: The light switch timer is a smart device that will make a much more convenient and useful light switch for your dorm room. Some of the main functions are a full UI system with an LCD display to set times to turn the light off / on and be able to remotely turn the light off. This system has several digital inputs, an analog input, and a motor output. This device will be easy to install and doesn't damage the wall or the light. The final product might have some cost, but actually manufacturing this could be affordable.

5. Shower Temperature Regulator: The Shower Temperature Regulator is a device that will primarily function to adjust and regulate the temperature of your shower as you enjoy a good wash. Some key features include a temperature probe, a motor to adjust the handle, and a functional UI with LCD to set the temperature. This idea checks all our constraints and requirements, including several digital and analog inputs as well as outputs.

6. Room Heater Thermostat: After interviewing students, we started to notice that a lot of students had issues with the heaters in the dorms being hard to control the knobs. These heaters use unlabeled and hard-to-use knobs on the front of them. This thermostat will hopefully help to let the user more accurately set the temperature in the room. The user will enter a temperature using the potentiometer knob and the

thermostat will automatically turn the knob on the heater to reach that temperature. The user interface will consist of a 0-9 dial pad for control. There will be a temperature sensor also being used to more accurately control the temperature in the room.

7. Automatic Window Opener / Closer: Another temperature control related issue in the dorms is in the summer. Students are not allowed to have AC units in their dorms, so the only way to cool down their dorm rooms in the summer is to open the window. Opening the window also makes the rooms less stuffy. But it is annoying to be opening and closing the windows all day so that the room doesn't get too cold and doesn't get too stuffy. This product will hopefully help with this issue. This automatic window controller will use either a temperature sensor or a timer to tell when to open and close the window. The user will be able to select which mode they want it to be in with the 2 buttons and potentiometer dial on the front of the controller.

8. Motion Activated Mirror Light: This product will function with the purpose of aiding dorm living students to function well in the dark without disturbing their roommate by turning on the full light in their room. The Motion Activated Mirror Light is a smart LED strip that will go around your dorm mirror and light up with a soft light that can be turned on and off with a button. There is also a button that turns on and off the motion sensor function in case you don't want it to turn on based on motion. The Ultrasonic sensor will detect motion in front of the mirror and turn on automatically when you need to see yourself in the dark.

9. Automatic window blinds opener / closer: Some students expressed annoyance with needing to close their blinds at night for privacy and then open them again in the morning for light. This is the problem that this product aims to solve. This automatic

window blinds controller will open and close the blinds using either a photoresistor or a timer. The user will be able to select between a daytime mode where it will open the blinds in the daytime and close them during nighttime, or timer mode, where the blinds will open and close at specific times during the day.

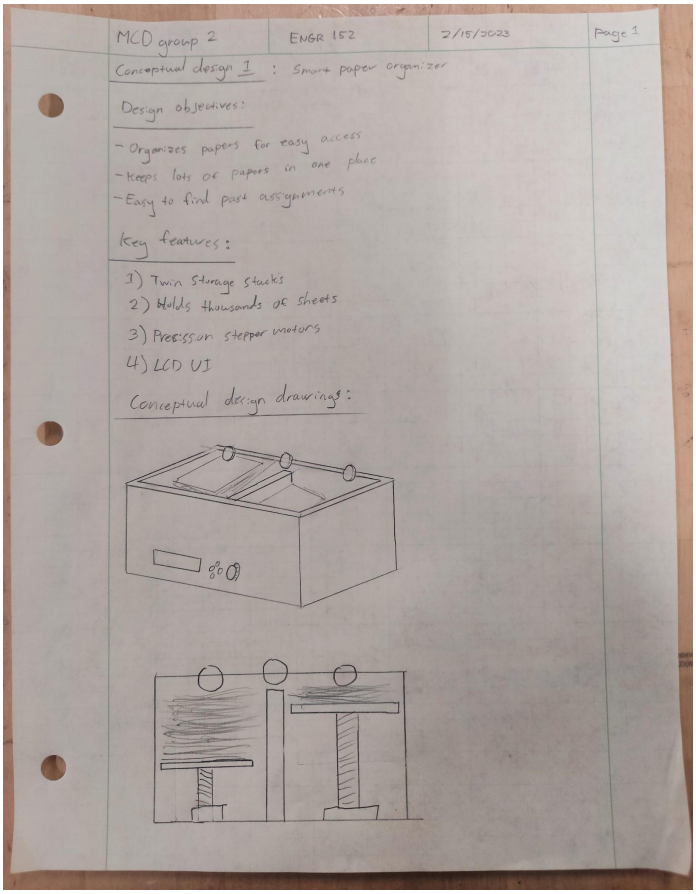
10. Plant humidity watering sensor: Remembering to water a plant is something that a lot of people have trouble with. This product will sense when the water content in the soil is low and water it for you so that the soil stays moist. The device will use a fork sensor in the soil to detect when the water content is low and it will use a servo connected to a sprayer nozzle to spray the ground with water. The user will be able to set the frequency of the spraying as well as the minimum water content in the soil.

Conceptual Designs

These designs have a good balance between being a good smart product that also isn't overly ambitious. The designs we want to expand upon are the Smart Paper Organizer, The Shower Temperature Regulator, and the Automatic Window Blinds Opener/Closer.

Design 1 – Paper Organizer

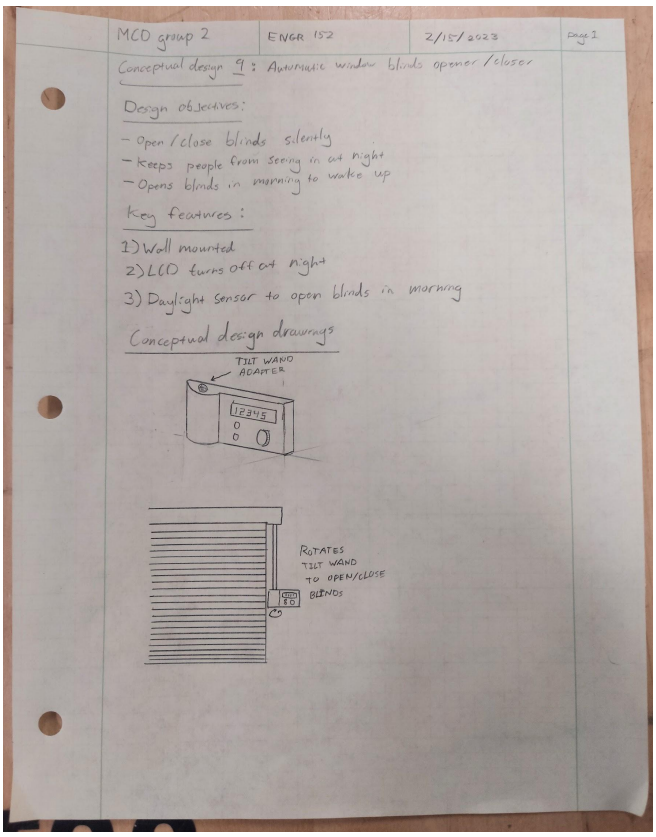
This paper organizer could not only hold hundreds of pages, but it will also keep track of them individually. Featuring dual stepper motor actuated platforms, an LCD screen, and a laser-cut chassis, this vault would enable the user to name each page and then later recall them.



This version of the paper organizer would require a lot of coding, but the versatility would enable it to be a one-stop dump for all of a college student's needs. However, because of the complex design and high-tech materials, this version of the paper organizer could easily cost over $50.

Design 2 – Window Blinds Controller

This is the automatic window blinds controller. Several college students we talked to have an issue with privacy at night. They want the blinds open when they wake up, but they don't want people looking in while they sleep. This device will open and close your blinds

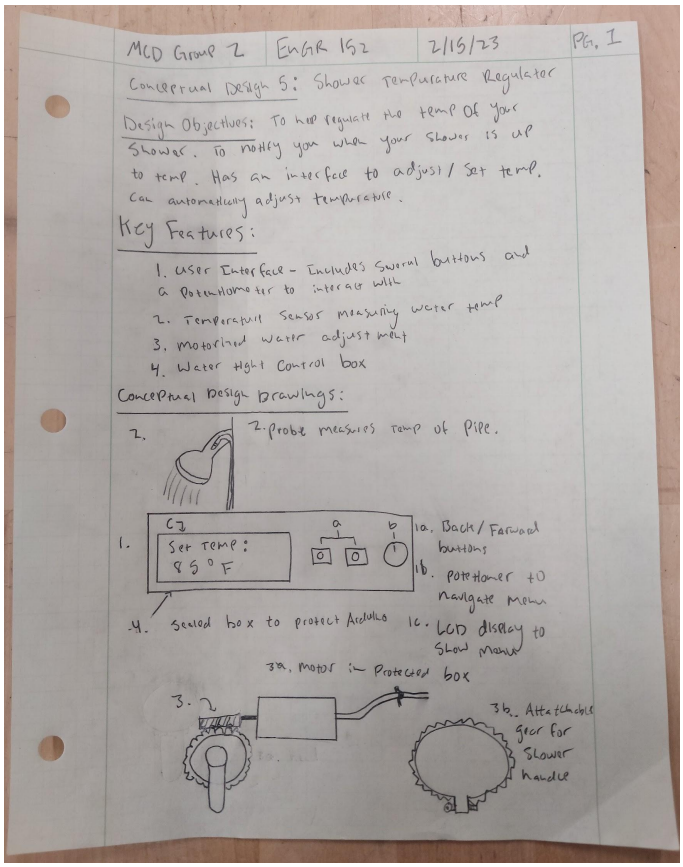


automatically. You can either set a certain time to open or close the blinds or set them to open when daylight becomes present. The interface consists of 2 buttons and a dial. The dial will be to scroll through menu options such as the time to open blinds or what light level to open the blinds at. The two buttons to the left of the dial will be used as 'select' and 'back' buttons to further navigate through the menus.

The front plate of this design will be 3d printed, while the back plate will be either laser cut acrylic or sheet metal. The major electronic components will consist of 2 buttons, a potentiometer, a servo motor and driver, a photoresistor, an LCD display, and, of course, an Arduino microcontroller. The design will open and close the blinds by turning the tilt wand with the servo motor. The estimated cost for this product (not including the microcontroller) is about $35.

Design 3 – Shower Temperature Regulator

The Shower Temperature regulator is going to be a smart device that solves several problems that often happen to everyone while in the shower. Sometimes certain showers don't have the best heat control (dorm showers) and users have to try and fiddle with the handle to get the right temperature that they want. This device uses a temperature sensor attached to the head of the shower and a motor connected to the handle to read and adjust the temperature of the water. The idea is to allow the user to set a temperature that they want, and the motor will turn the faucet to reach it. There is going to be a user interface that uses an LCD display, two buttons, and a potentiometer to move through a menu-like system and set temperature. This will make it much easier for the user to set the temperature that they want in an intuitive way.



Another issue that showers often have is when the hot water starts getting used by another device like a washing machine or another shower, the temperature in your shower will start going down and you have to turn the temperature up again to match what you were at before. This device will automatically do this for you. As the temperature goes down, it will sense the change and automatically turn the temp up to try and compensate for this. The most significant cost will be from the Arduino, but the temperature sensor and motor will also add cost. The system also needs a box that is water tight, and some manufactured plastic gears. To

find the approximate cost, we added up all the electronics and about 250g of 3d printed material. The cost is around $30.19 plus the cost of an Arduino Uno of $27.

Conceptual Design Comparison

Team Lambda Weighted Decision Matrix							
Customer Requirement	**Priority (out of 10)**	**Design 1 - Paper organizer**		**Design 2 - WIndow blind controller**		**Design 3 - Shower temp controller**	
		Score (out of 3)	**Total**	**Score (out of 3)**	**Total**	**Score (out of 3)**	**Total**
Cost	4	2	8	3	12	1	4
Ease of Install	7	3	21	3	21	1	7
Efficiency	9	2	18	3	27	3	27
Running Costs	1	3	3	2	2	3	3
Quality	10	1	10	3	30	3	30
Feasibility	5	2	10	3	15	2	10
Ease of Maintenance	2	2	4	2	4	2	4
Safety	6	3	18	2	12	3	18
Efficient Power Management	3	3	9	1	3	3	9
Expansion Capacity	8	3	24	1	8	1	8
	TOTALS:		125		134		120

The design that scored the most in the decision matrix was the window blinds controller. This design was the best in several categories, including feasibility, cost, and ease of install. Although it did not score as well in power management due to it being always on, and not scoring well in expansion capacity due to it being a small, wall-mounted design, it is still a solid design. This design would specifically cater to people who like extra privacy in their dorms,

either during the night, or when they are not at their dorms. One possible flaw with this design is that it could inhibit the manual use of the tilt wand on the blinds.

The second place went to the paper organizer. We believe that this design, if done right, could be much more versatile and appeal to more college students. But the hardest part about this is creating a good, effective, and reliable design that will not jam or clog. This design will also be quite a bit more expensive than the window blinds opener because of the sheer amount of material needed to make a box that can hold 2 stacks of paper. This Idea is also significantly less feasible, because creating a matrix of every document and keeping track of every location is going to be very intense for an Arduino.

The design with the most points in our decision matrix is the Window Blind Controller. It would run off of both consumer and environmental inputs to regulate natural light and privacy in indoor spaces, and will greatly benefit individuals with dorms that are near walkways. This concept outperformed our other proposed designs, especially in cost, quality, ease of installation, and efficiency because we expect to easily be able to tackle this product.

The second best design was the Paper Organizer. Although cool and useful, the Paper Organizer would be much more difficult to successfully execute. Combined with quality worries and feasibility, we decided to knock it out of the final decision. One big advantage that the Paper Organizer has over the Window Blind Controller is that all college students could use one, regardless of dorm location. The Shower Temperature Controller would also be a very cool project, but the cost and ease of installation are big factors for a consumer product, and it places very low in both of those categories.

Final Design

The product will continue to be developed in the following sections.

In Google Drive create the following:

1. "MCD 4" folder in the team's "Maker's Competition Online Submission" folder where this document will be turned in.
2. "Drawing Package 4" sub-folder within the "MCD 4" folder.
3. Copy the ENGR 152 Detailed Program Design Template and upload to the "MCD 4" folder when completed.

Complete the following pages of the Drawing Package:

1. *Updated* Title Page
2. *Updated* Table of Standard Electrical Symbols
3. *Updated* Mechanical Overview
4. *Updated* Electrical Overview
5. ***All*** Mechanical Details Drawings
6. ***All*** Wiring Details Drawings
7. **Use the Drawing Package Template to format them!**
8. Upload all drawings into the "Drawing Package 4" folder for grading. **Make sure they are saved in .pdf format for grading purposes.**

(Delete all instructions before submitting).

Detailed Design Choice

Our group chose Design 2 which was the Window Blinds Controller. In the Product Specifications Decision Matrix from MCD 2, the Window Blinds Controller was the product with the highest score at 134. The reason why we chose this design over the other two conceptual designs is because it is the cheapest out of the three designs, it is very easy to install, it's high

quality, and is more efficient than the other two designs. Our Window Blinds Controller meets 5 customers requirements.

1: Good looking. Our controller will have a sharp looking rectangular shape with a corner shaved off it and the side panels will be made out of wood.

2: Cool lights. The inside of our controller will be embedded with LED lights to make it glow.

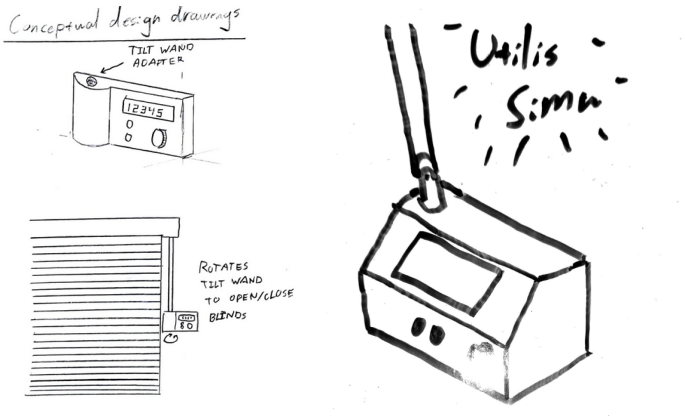
3: Will not keep you up at night. Our controller will not make any noise unless the button is pressed on the front of the box by someone to display noise. The only other place on the controller where it makes noise is in the gears when the motor turns them. The gears in the motor are nearly silent when moving thanks to the motor, so it will definitely be under 30db(the noise of a whisper).

4: cool noises. On the front of our controller box, we will have a button that when pressed, will make some sort of cool noise.

5: Digital interface with LED's. Our LCD will have a 20x4 display with a cool and calm color so it won't be too obnoxious.

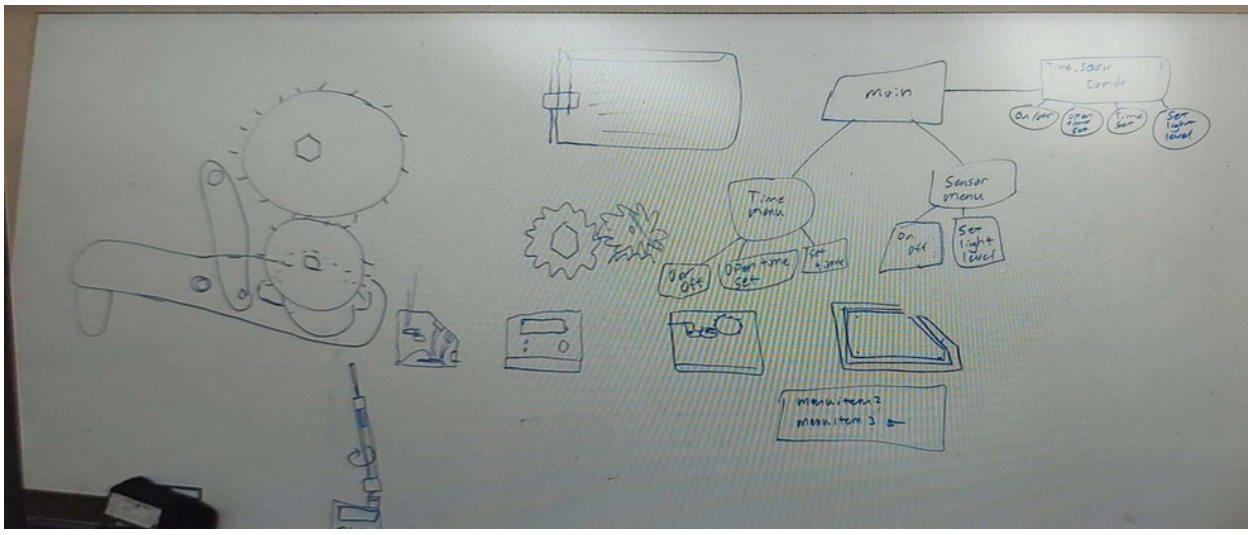
Mechanical Design

Mathematical Analysis



This design's function is to open and close the window blinds based on the time of day. This can be done by either detecting the light outside of the window or by opening it at a certain user-set time. The light sensor is going to be an arbitrary number from 0 -10 based on the resistance of the photoresistor. We will use a map() function to make this conversion from the value received from the photoresistor. As for the clock, we will be using the millis() function to detect whenever a second has passed. There will also be a way for the user to set the time on the device, and with the combination of these two systems, we will be able to accurately keep track of the time and display it.

When designing the part of the product that would actually turn the tilt wand on the blinds, we realized that the basic stepper motor might not have enough power to turn it. To account for this, we decided to use a 3 - 1 gear reduction to give the stepper motor more torque to open and close the blinds. After this, we realized that having the system directly hooked up to the tilt wand would make it so that the blinds could not be manually controlled, and the device could "crash". In order to fix this, we came up with a mechanism (pictured below) that would release the motor from the tilt wand if the user wanted to manually open or close the blinds. This mechanism would also be able to prevent damage to components, because when it is over-torqued, the gear teeth will just click over.

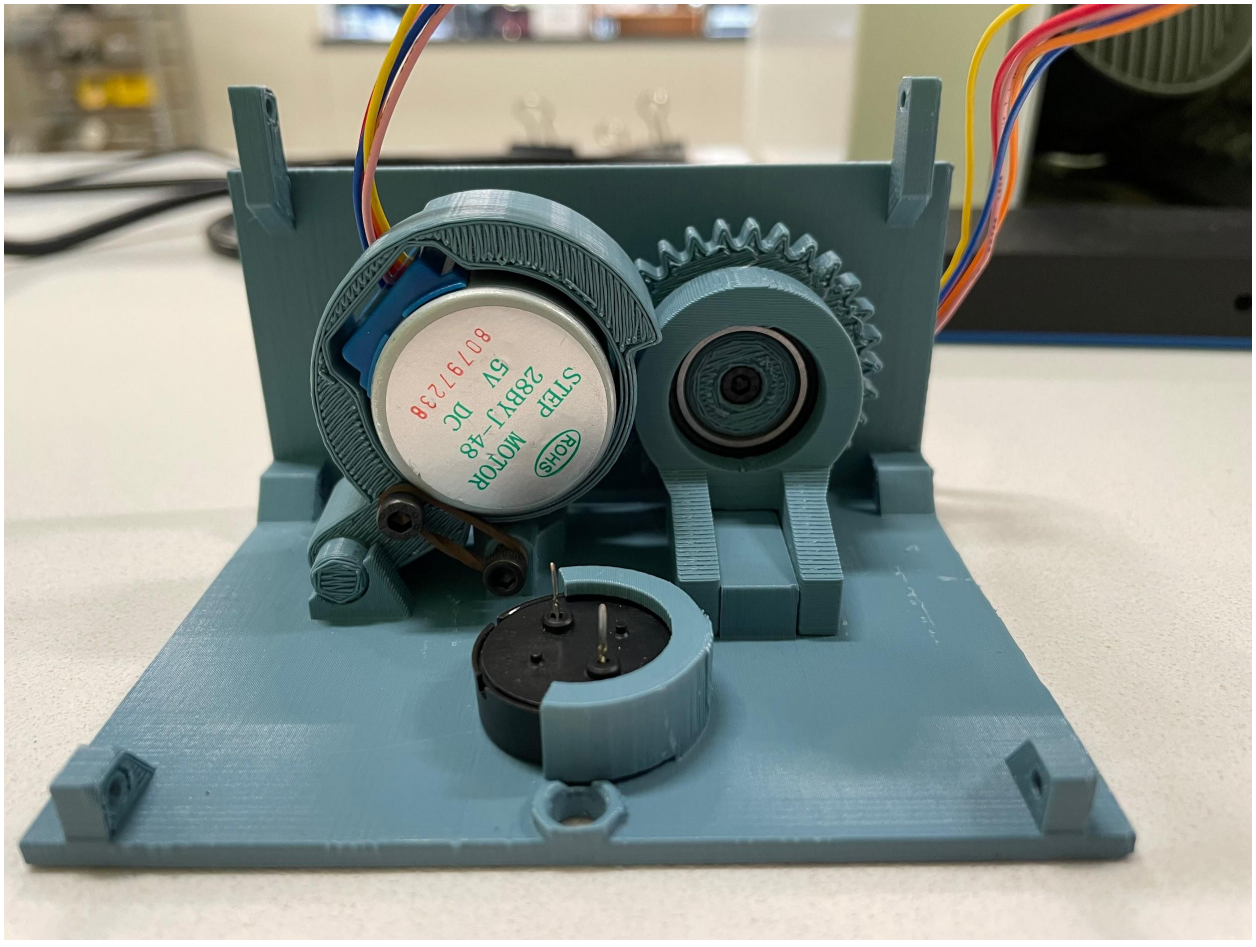


Solid Modeling

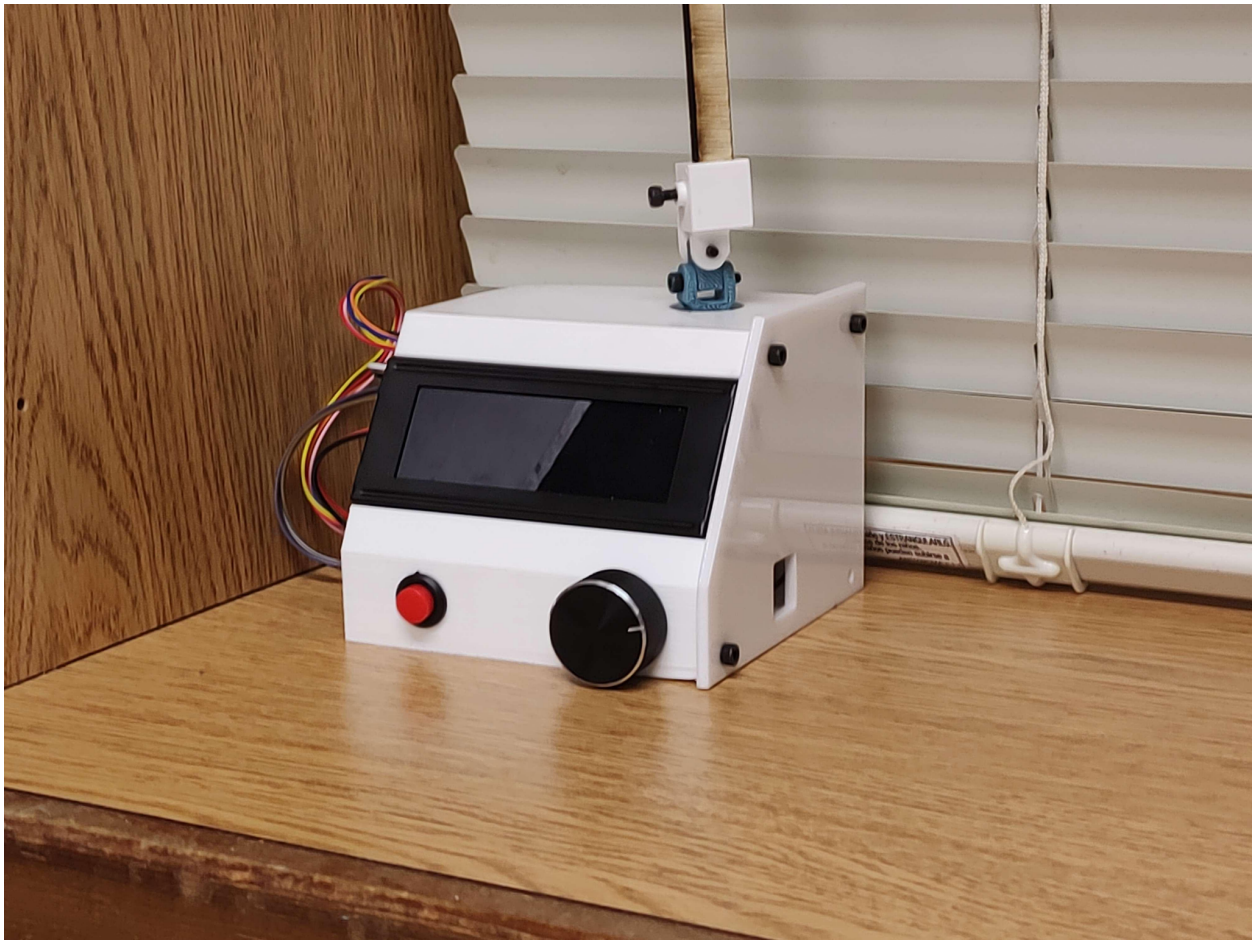
A few major changes made to the design of Utilis Simia involved redoing the stepper mount and the LCD screen mount. Since we wanted to make the device as small as possible, we constrained our width to that of the LCD screen. With no 3D-printed fascia around the LCD and no room for screws, the LCD screen is held in place with slots in the top and bottom halves of the housing. With the stepper mount, the ratcheting lever system was completely redone for a more reliable system that takes advantage of the space we have.

Manufacturing

Previous picture of prototype:



Current picture:



Utilis Simia is currently able to open and close blinds reliably based on user input. The user can navigate the menu to reach different settings, and the ratcheting drivetrain works well to both prevent crashes and make up for inconsistencies from surroundings, and the stepper has plenty of torque to manipulate the blinds when combined with a 3:1 gear ratio.

Unfortunately, the rotary encoders are giving us trouble, as every single one we have has started to act up. With new encoders coming soon, we still have hope for a user-friendly UI. Our back button works well, and user feedback from the piezo is consistent and engaging. The overall physical design is just a 3D print away from being complete.

As for the coding and electronics, we have successfully wired all of the sensors and outputs to the Arduino. We are still working on compacting everything down so that it will fit

inside the assembly without things breaking, but this is just a matter of soldering a few components together and switching out our breadboards for some prototyping boards. Coding is also nearing completion; we have a fully functional menu system with several sub-menus and features. Currently, the user is able to set the bounds of the stepper, open and close the blinds manually, and read the Bible verse of the day on the main menu. The rest of the features, such as light level detection, a clock, and a way to set the time are all complete, and are just a matter of implementation.

Overview of Materials

We decided to add bearings to the design to allow for a smooth operation of the drivetrain from the stepper motor to the output universal joint. Although these added to the cost, they reduce friction in the drivetrain and allow for a more reliable operation. We also made some changes to the materials used, specifically in the side panels. We decided to go with acrylic side panels instead of wooden ones to make the assembly look more uniform with the white 3D-printed body. There were also some other minor changes such as adding another screw to the system and mounting the rotary encoder, but these had very little effect on the overall cost of the product.

Electrical Design

See PDF

Program Design

The main algorithm that we decided to implement was a menu tree system that keeps track of wherever the user is in the tree and will do certain functions depending on where they are. The main menu holds the Verse of the day, Settings menu, Time mode, and Light mode. In each of these, there will be functions that pertain to the category. Some key aspects of the code

outside of this system are the IO control and sensor reading. The user can interact with a back button and a rotary encoder that can scroll and press. This will control the menu, but also directly control a stepper motor when desired. There are functions to celebrate the stepper motor, move between open and closed, and set what time to open or close the blinds. There are more functions yet to be added still, like the time mode and light mode submenu items and functions.

Future Design

Overview

In one **short** paragraph, give a brief introduction overviewing what is discovered in the following sections. (Write this after completing the following sections).

In these sections, we talked about the strengths and weaknesses of this product. These are things that we would either want to focus on, or completely redesign for our final product. We also looked at how well our prototype reached our original goals and satisfied the customer's needs. Lastly, we looked back at our original design and compared it to our final design to see how we have improved and what we have changed.

Design Strengths

When developing this product, there were a few key features to the product that really stood out to us, and that we would like to develop further. One of these features was the one-way drivetrain for the stepper motor. This drivetrain was able to fully close the blinds every time so that the program would never get lost. This system seemed to work perfectly for the 2 week test period. The program never lost where the stepper was and the blind full opened and closed every night. One thing that we would do if we were given more time and funding would be to develop a quieter system to do the same thing. Currently, the gears skipping in the drivetrain make quite a noticeable noise, which might concern customers.

Another thing that we could focus on in further development would be keeping the clock accurate. Currently, since we are referencing the millis() function on the Arduino itself, we are lacking quite a bit of precision in the time. After the 2 week test period, the clock was off by 6 minutes. This isn't bad for a prototype, but if we were to produce and sell this product, we would want to fix this issue.

One last strength that we feel deserves to be mentioned is the menu system that we designed. It made use of our product easy and streamlined for a new user. They could move between various menus and submenus to find relevant features grouped together. In future development, we would like to add more features to the menu tree, and make the code more efficient with fewer lines.

Design Weaknesses

We did find things that worked well with the product, but there were also things that didn't work well which deserve some extra attention. One of these things is the light-sensing functionality. This was an idea that we were originally going to implement as a main feature, but

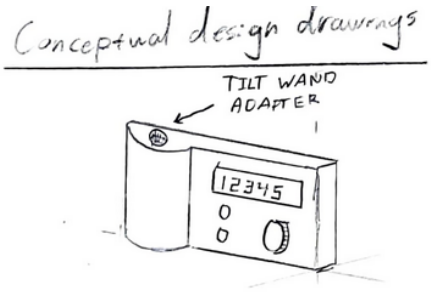
we never got it fully implemented. There were several wiring and coding errors that prevented this from working with the time we had, so given more time and funding, this would be something that we would want to redesign.

Another weakness is the rotary encoder that we used for menu navigation. Whether it was an issue with the code or the hardware, the rotary encoder was not functioning properly. We spent a lot of time trying to optimize the encoder, but it seemed like nothing we did worked. The encoder would constantly skip and go backward for no apparent reason.

Commercialization

If this product were to receive future funding for production and development, there would be some changes that would allow for the shift from prototype to product. The first alteration that would drastically change the total cost of the product would be changing the microcontroller to a custom pcb that has only the features we need it for. We would also change the materials used to be more compatible with mass production, like an injection molded chassis. We would use the money invested in making these changes and further improvements, then build the product, market, and begin shipping through various shipping companies. This would likely take around a year from initial funding to the final product.

Conclusion



Our final MCD project didn't look like our original drawing at all. The product was originally going to be a wall-mounted alarm clock that would have a secondary function to let natural light in when it goes off. We ended up with a device that would be placed on a windowsill and open/close the blinds based on time or light level. When comparing the original drawing to the final product, there are some obvious differences. We think these changes were important, and helped us achieve the customer goals in the most effective and efficient way possible. In terms of functionality, the prototype was very effective at showing the functionality of a product like this, and how useful it can actually be. As a pre-alpha tester, Owen Tonseth said "When it got removed, I was disappointed that there wasn't natural light in the room in the mornings anymore." All in all, the prototype showed the convenience of automating your window blinds, and we understand what we would need to improve before putting them on consumers' windows.