

Title: Reusable Canister Cleaner Final Report

Submitted To: Dr. Stephanie Walkup

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Abstract Introduction

Around campus, most Villanova students carry several types of reusable bottles. Reusable water bottles serve as a sustainable alternative to plastic bottles, helping the school to reduce excess plastic waste and follow their sustainability plan, “to establish an ethos of sustainable living” that is at the core of Villanova. Therefore, in promoting the use of reusable bottles to make a more sustainable school, it is imperative that the University provides the infrastructure to clean these products.

Cleanliness for drinking is vital to our health, a key part in our education at Villanova University. Other cleaning areas, such as bathroom sinks, cannot wash reusable bottles due to their shallow depth, so only lids can be washed. To get real data on this problem, each person in our group surveyed five students on campus to create a survey pool of 25. The questions they were asked were: “Do you carry a reusable water bottle?”, “How frequently do you use it?”, “When is the last time you cleaned it?”, and “How frequently do you clean it?”. We found that 80% of them, which is 20 people, frequently carry and use reusable water bottles. Among those 20, 30% of them regularly clean their bottle, which is only 6 people. This argues it is too difficult and time consuming to clean reusable bottles. This is extremely problematic, not just for convenience purposes, but also in terms of sanitation and health. A study by Water Filter Guru (1) found that on average, reusable water bottles contain 20,800,000 CFUs (Colony-Forming Units), which estimates how many living microbes and bacteria are present. Their research also found that among the Gen Z population, our generation tends to clean their water bottles least often. Only 16% of those surveyed said they only clean their bottle a few times per month, supporting Water Filter Guru (1)’s research. Given these statistics and information, our group found it necessary to solve this problem by creating an efficient and effective water bottle cleaner at Villanova. By doing this, we hope to promote a cleaner, more efficient, and more sustainable campus.

Problem Statement

There is no existing system for efficiently cleaning reusable water bottles on campus. Sinks are ineffective and too shallow to fit bottles underneath to clean, and systems offered by companies are quite large and expensive. Without an efficient cleaning system, this promotes uncleanness and the use of other water canisters, such as plastic water bottles, which are harmful to the environment. At all dorms, buildings, and public areas, reusable bottle cleaning stations should be implemented around campus.

Requirements and Limitations

Since the water bottle cleaner is being designed for college students to easily use in their residence halls and other buildings around campus, it must be compact. We would ideally like to limit it to a 2-foot-wide by 3-foot-tall by 1-foot-deep space (this can be subject to change) to ensure that it is not in the way of other dorm necessities. Additionally, because we are designing this cleaner to project water into the bottles from underneath, it requires a location accessible to both water and power. The system design must require minimal maintenance to avoid

counterproductivity. Otherwise, students would resort to using other methods to clean their water bottles, or not clean them at all. Moreover, the cleaning process should take no longer than 10-15 seconds and involve no more than two moving parts (just the student holding the bottle) for enhanced feasibility. Our design will not include a place to clean the bottle lid/straw because these can be easily detached from the water bottle and fit under dorm sinks to clean manually. Finally, because we would like to have at least one of these cleaners per dorm floor, it must be cost-efficient to ensure that multiple can be built within a reasonable budget. They also must be installed during the months of May-August, so the construction will not be a hindrance to student life.

Ideation and Refinement

Idea 1

Our first idea (Figure 1) was to have two separate cleaning mechanisms on the product – one that dispensed soap and water for sterilization, and another that dispensed just clean water for rinsing.



Figure 1 – Cleaning device with two devices

We thought this would be a productive way for students to clean their water bottles that would take minimal time. Students would be able to determine how much soap and water they want to use based on how dirty their bottle is. This design could be installed in dorm hallways next to the water fill stations and would not take up too much space because it fits our size constraints. It is also not very large, so it could be installed between the months of May-August when students are not on campus. We decided this remains a viable option for our final design and wanted to further analyze it.

Idea 2

Our second idea (Figure 2) was to have a separate soap dispenser and a milk shake-like apparatus for cleaning.

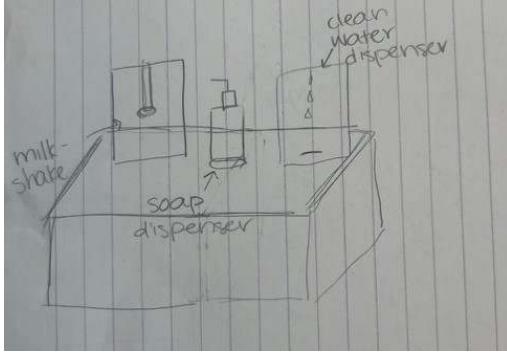


Figure 2 – Device with “milkshake” cleaner

This idea would not work because it had too many moving parts, and having a milk shake-like cleaner could be messy and lead to water spraying everywhere. Additionally, looking at how many different pieces it has, we think it would take up too much space and not fit within our dimension constraints. We also decided the product should be one in which the water bottle is cleaned upside down to minimize spillage and maximize efficiency. Therefore, we ruled this idea out as it cannot be considered as a potential final design.

Idea 3

Our third idea (Figure 3) was a handheld water bottle cleaner with multiple functions in one system.

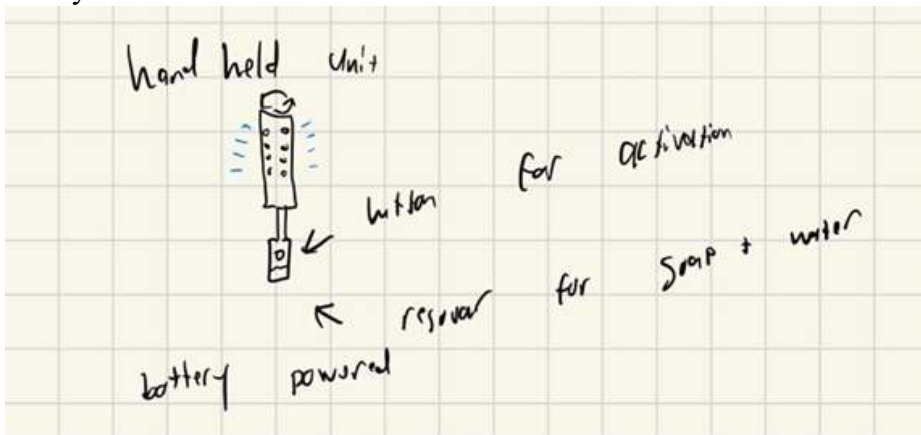


Figure 3 – Handheld device

We liked this idea because it is portable, which is good for Villanova students who are always on the move. It would also be cost-effective and easy to use with minimal moving parts. Additionally, because it is handheld, it easily fits within our size constraints, and we do not have to worry about installation timing because facilities do not need to install a system in dorms or hallways. Because of its ease to meet our requirements, this remains a possibility for our final design.

Idea 4

Our fourth idea (Figure 4) combined a water bottle cleaner with a water fountain.

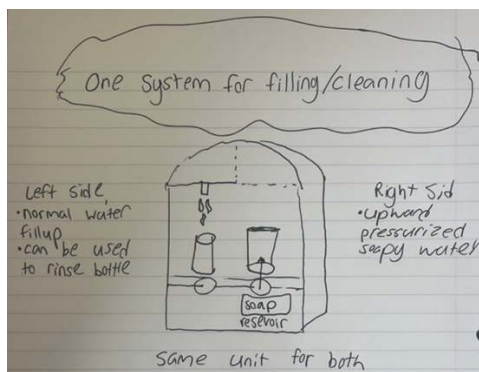


Figure 4 – Device that installs in water fountain as one unit.

For this design, students could use the water fountain aspect to either rinse out their bottle or fill it up with water. Although this kills two birds with one stone, we decided it would be best to keep the water fountains and water bottle cleaners separate to avoid traffic if one student wanted to fill up their bottle with water and another wanted to clean their bottle. Part of our restrictions is efficiency and ease in cleaning, which prompted us to rule this design out as a possible final design.

Idea 5

Our fifth idea (Figure 5) was one in which the cleaner was designed like the others to be one system that sprays water; however, the bottle would be upright the entire time.

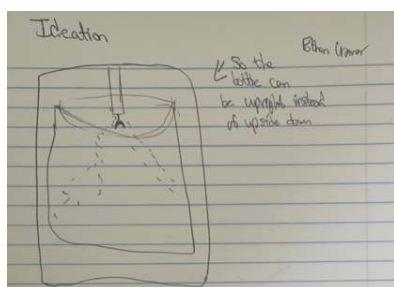


Figure 5 – Device with upright cleaner

As said before, the design on the top with an upright layout would lead to drainage issues and is just a little bit more difficult to maneuver, and this design does not include some form of a soap dispenser, so it would not clean the water bottles as effectively as we would like. Additionally, this design could spray water everywhere and make a mess, which takes away from the function we are trying to perform, which is clean water bottles as easily, quickly, and mess-free as possible.

Idea 6

Our final idea (Figure 6) was a system with one spout that shoots water to clean the bottle upside down and is designed as a single mechanism with multiple functions and a button that serves as a soap dispenser. Water comes out when the user presses their bottle down on the apparatus, soap comes out when they hold the button down simultaneously, and when the shield is down it keeps the water from spraying the surrounding area.

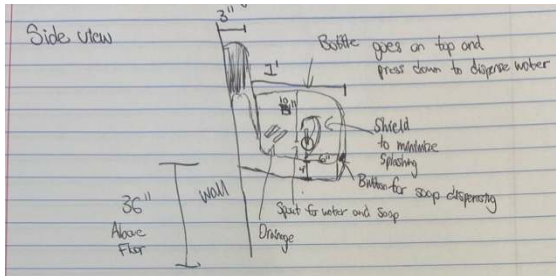


Figure 6 – One system with a shield and button for soap

We found that this would be a very simple and efficient way to solve our problem and people with a space to clean their water bottles effectively. It also considers each of our design constraints, staying within our size dimensions and including a shield to prevent water spraying everywhere and making a mess. Also, given that this product must be installed between the months of May and August, we believe that only having one main mechanism would make installation easier and quicker so that it can be done within the time constraint.

Ultimately, we the three final potential design options that still fit our identifies constraints and were viable for our final product. These ideas were figures 1, 3, and 6.

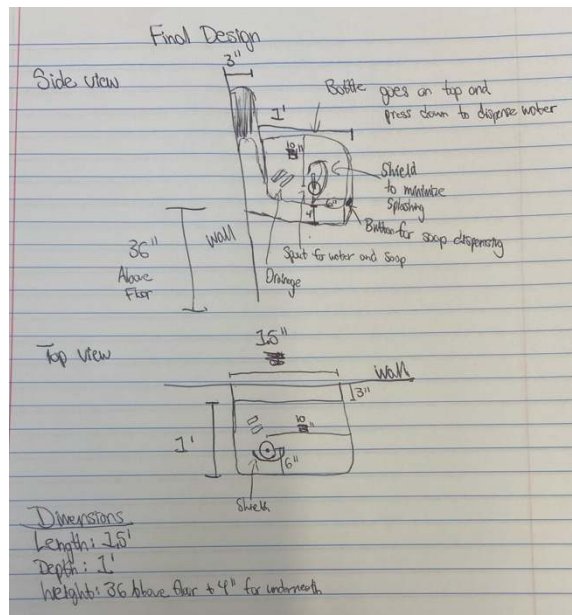
Analysis of Potential Design Options

Decision Matrix Water Bottle Cleaner		Alternatives		
		Two separate mechanisms in one unit	Handheld Water Bottle Cleaner	Spout cleaning bottle (on bottom) with button for soap/water
Analysis Criteria	Max Score	Score 0->5	Score 0->5	Score 0->3
No more than (2x1x3)				
Compactness Within it's Location	3	1	3	3
Location (Accessible to water)	3	3	2	3
Cost-Efficient	2	2	2	2
Complexity of Moving Parts	2	1	1	2
Within 10-15 Seconds of Run Time	2	1	2	2
Function	3	3	3	3
Human Factors (Ergonomics)	3	3	2	3
Product Market	2	2	2	2
Physical Specification	2	1	2	2
Durability/Longevity	3	2	1	3
Economic Factors	3	2	2	2
TOTAL	28	21	22	27

We concluded that Figures 1, 3 and 6 were the most viable options for our final design. We used our design restraints/limitations and overarching goal to compare our other options. Although we favored the idea of having both water and soap dispensed from our system like in Figure 1, we decided that it would be more productive, cost-effective, and efficient to combine these processes into one apparatus instead of having separate ones. This way, it would keep the water and soap constrained to one process and limit the possible mess that could be caused when moving the water bottle from the first device to the next. Additionally, we decided that Figure 3 did not fit our requirements because our goal was to install a system in dormitory hallways, and this design demonstrated an individual device that each student would have to purchase. While this seemed to be convenient, we wanted our solution to be easily accessible for everyone on campus, so we ultimately decided against this idea. However, we did like the idea that this design was only one mechanism, and all functions were on one piece, so we knew we wanted to choose a final design that had one part that performs multiple functions, because it is the most efficient kind of design. Ultimately, we decided to choose our sixth idea from the ideation and refinement as our final design. We found that this design was a combination of the best aspects of our other two designs that we were deciding between. It has a fixed design like in Figure 1 which allows it to be used by students living in a dorm, rather than every individual needing their own. It also makes it easier for maintenance to service. Its simpler design means that it should be more robust and have a longer lifespan, and its fixed nature also allows for the potential of excess water to be recycled in other systems of the building. The waste created by this device could be grey water, and thus still very practical for other systems in and around the building, like a sprinkler system or water for toilets. All these factors make our market for the product more business focused,

unlike the handheld device in Figure 3, which is more individual. We also combined the soap and water to dispense together, similar to the device in Figure 3 and different from the device in Figure 1, which simplifies the user experience and human involvement.

Final Design

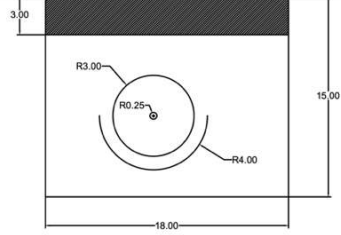


The final idea was taken with inspiration from the first idea, the spout that projects water to clean the bottle from underneath when pressed down, and the third idea, in which was designed as a single spraying system with multiple functions (both water and soap, operated by push button).

We decided this would be the most simple and efficient way to solve our problem and will provide the students on campus with a good space to clean their water bottles. Given that this product must be installed between the months of May and August to avoid hindrance to student life, we believe that only having one main mechanism for both the soap and water would make installation simpler, easier, and quicker, so that it can be done within the time constraint.

Our design is unlike others on the market because of its unique tube-like system for water dispersion. Also, it will be installed close to existing water bottle fill stations without taking up too much space. Some of the products on the market, such as the bottle wash/fill station from Daedalus, would not work to solve our problem because it is too big, and will not fit in a dorm hallway. Daedalus' system is extremely costly, making it hard to implement in numerous locations on Villanova's campus. Originally, we discussed an aspect of the design to clean the lids of the bottles, but we would be deviating from our main problem: the fact that water bottles do not fit under the sink faucets in the bathrooms. Since water bottle lids can fit and be cleaned under sinks, we therefore are no longer concerned with cleaning the lids of the bottles.

Wall



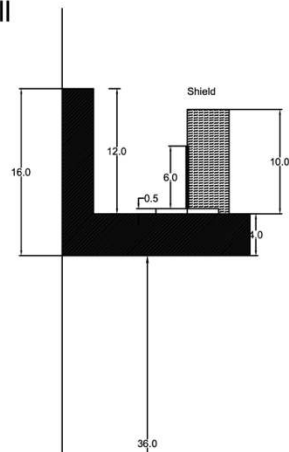
Final Design Top View

Date Created: 10/3/23

Author: Ethan Cramer

Scale: 1:1 in Inches

Wall



Side View Final Design

Date Created: 10/3/23

Author: Ethan Cramer

Scale: 1:1 In Inches

Floor

Conclusions and Recommendations

In conclusion, our design resolves the problem of water bottle uncleanness and promotes health on the Villanova campus. Cleaning our reusable bottles is another step towards an increase in health quality at Villanova. After assessing limitations and requirements, ideating, and refining our unique designs, we concluded with a system that includes the best features of each of our design ideas. Our team believes our final design is cost-efficient, compact, and easily installable throughout campus buildings. After a prototype of this design is initiated, assessed, and confirmed efficient, our design should be implemented across campus. The health and cleanliness on our Villanova campus provides a safer learning atmosphere for all students and maintaining this health is vital to life on the Villanova campus and the level of academic excellence expected here.

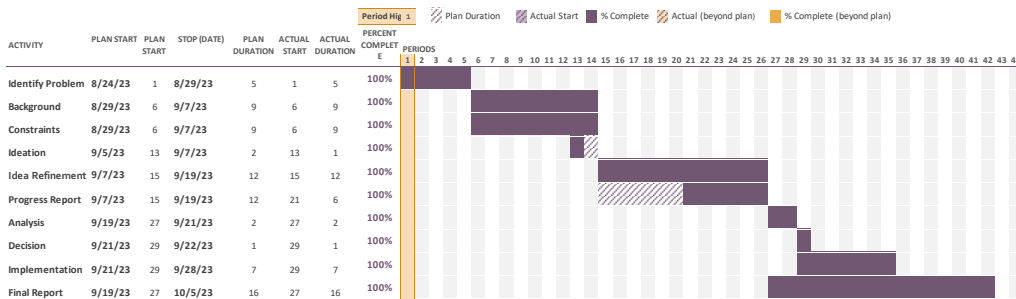
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Appendices

Appendix A - Gantt Chart

Resuable Canister Cleaner



Appendix B - Work Log

8/29/23: People Present: Ethan, Anthony, Dom, Sophie, Tatum

Shared our Topics List 1 with each other and ranked them based on importance and if good idea for project. We have a good solid 3 ideas that we really resonated with, and I think we can make a combination of them to form a really good product to solve our problems. Sophie's problem had the most interest in our group.

8/31/23: People Present: Ethan, Anthony, Dom, Sophie, Tatum

Started working on project proposal after deciding that we are going to solve the problem of a lack of water bottle cleaners around campus and especially in the dorms. Our stakeholders in this problem are everyone that lives/and or studies at Villanova. Keep in mind that people who don't go to Villanova or study here still walk on the path. We talked to Dr. Walkup, and she informed us on how we need to analyze the scope of our ideas, and possible constraints.

After talking to Dr. Walkup, we pivoted our energy to trying to solve the problem of a lack of water bottle cleaners around campus. In terms of constraints, we had to think about the amount of time cleaning a water bottle really takes. Originally, we were thinking somewhere around 15-20 seconds but when counted out, it seemed a long time to hold a bottle on the cleaner. With this in mind, we knocked the time down to 10 seconds with only a second of soap dispensed. This is a good amount of time to activate the soap and give the bottle a good cleaning. Another few constraints we must remember is location, budget, and user-friendliness. For location, these cleaners are essential everywhere on campus, but especially in the dorms, which is where most of the campus' water fountains are at. Having our product next to water bottle fillers will remind students and faculty to clean their water bottles out. A big issue aside from there not being anywhere to clean water bottles, is people forgetting about the action at all. The location of our product will erase this side issue. Additionally, wherever our product is placed on campus, it needs to have access to water. The budget of this product is more of a minor concern for us because the product doesn't require a whole lot of expensive materials and the product is relatively small.

9/5/23: People Present: Ethan, Anthony, Dom, Sophie, Tatum

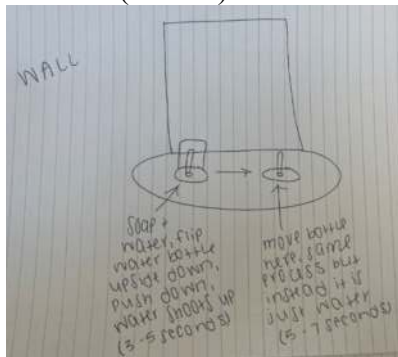
Lecture 4: Learned how to maneuver the Gantt Chart on Excel

Ideating as individuals for a period then come together to share.

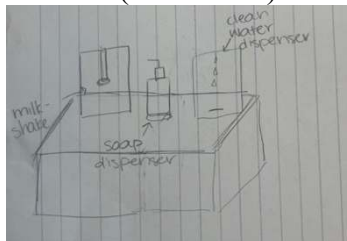
Build or “hitchhike” on each other’s ideas to build more ideas.

After some time individually to facilitate some potential designs, we came together as a group and shared what we came up with. With some discussion, we all came up with similar ideas but what we think will be most efficient is a system that can be added to current water bottle fillers on campus. With our added part, soap would be added to the dirty bottle and swirled around, then the user can rinse out their bottle with the already installed water bottle filler. This would reduce water usage compared to if we were to have a water source along with our soap source.

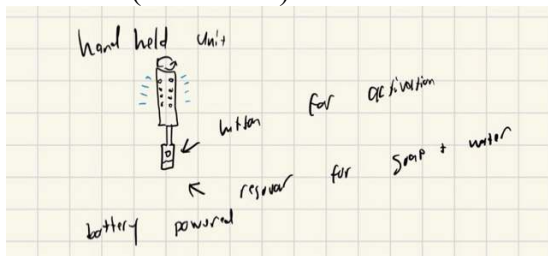
Idea #1: (chosen)



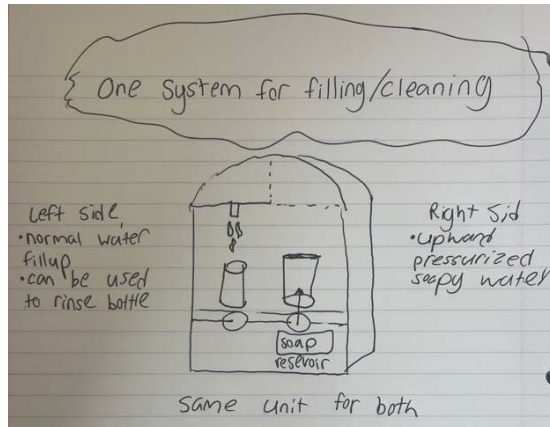
Idea #2: (not chosen)



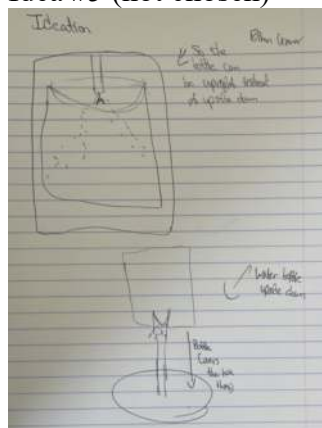
Idea #3: (not chosen)



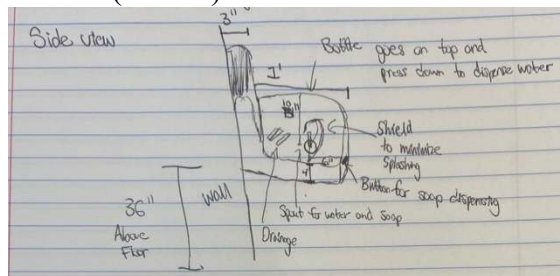
Idea #4: (not chosen)



Idea #5 (not chosen)



Idea #6 (chosen)



9/7/23: People Present: Ethan, Anthony, Dom, Sophie, Tatum

Idea Refinement

- Idea 1
 - Able to be installed in a dorm hallway.
 - Convenient for students to use.
 - Don't have to get an additional water supply.
 - Eco-friendly with less water usage
 - Better cleaning process

- We'd like to refine this idea to make it one mechanism where first the spout emits soap and water, then just water to rinse the bottle out. With both instances, we understand there are multiple moving parts. However, the two separate pieces seem to be more to handle than the parts of the one mechanism with two settings (soap and plain water)
- Idea 2
 - Has multiple moving parts – less convenient/takes longer?
 - Operates with bottle upright – systems with bottle upside down are easier.
 - Upright bottle cleaning system could lead to spilling and be more out of control/messy.
- Idea 3
 - Handheld – fewer moving parts (one singular mechanism)
 - Could be cheaper.
 - Harder to design/doesn't fit well in dorm environment.
 - Harder to maintain.
- Idea 4
 - The design was of a unit that has a bottle filling station and cleaning station for reusable water bottles combined.
 - Do not have to route additional water supplies.
 - Water can be used for both sides, except right side has soap reservoir with connected to the tip to clean the bottle.
 - Implement idea one's cylindrical raised waterspout for the cleaning side.
- Idea 5
 - Like our other designs however the spout design would not be as effective as cleaning bottles.
 - The top design would have drainage issues.
 - Is soap included in the design?
 - Doesn't specify where it would be installed/what it would be installed to
- Idea 6
 - One mechanism with both soap and water
 - Button to dispense soap
 - Shield to prevent water from spraying everywhere

9/12/23: People Present: Ethan, Anthony, Dom, Sophie, Tatum

- Listened to lecture about AutoCAD and learned a beginner's level understanding of the controls
- Now we can design our product in a way that is efficient

9/14/23: People Present: Ethan, Anthony, Dom, Sophie, Tatum

Working on project report with group.... potential survey questioning?

Do you carry a reusable water bottle?

How frequently do you carry it?

When is the last time you cleaned it?

How frequently do you clean it?

9/19/23: People Present: Ethan, Anthony, Dom, Sophie, Tatum

After we submitted the progress report, we discussed design analysis with the group.

- Function:
- Product market: focusing on college campuses but can be extended to all educational and corporate buildings.
- Human Factors: possibly adding a shield of some sort to prevent college students from purposely making a mess, will need someone to refill soap when it runs out, check on it for maintenance (just like they need to check on water fountains)
- Possible wear and tear: hard water build up on the spout, shield cleaning,
- Dr. Walkup talked to us about concerns with usability: how could someone using our product find a way to make a mess or use it wrongly.
- Physical specifications:
- New product design factor: A shield only facing the user.
- Strength: use aluminum (best for stability and price, similar structure to water bottle fill stations), hard plastic for outer covering/shield, pipe for waterspout (aluminum or plastic?)
- Economic Factors: Current water bottle fill stations are \$1000-2500, but our product will be in the \$1000-\$1500 price range. We will be using cost-efficient materials like aluminum rather than stainless steel for the framework. Plastic can be used for the outer shell, prohibiting the public from mangling/seeing the inner system operation.
- Models:
- Physical Specifications: Radius of bottom pressure plate piece: 3" in radius

9/21/23: People Present: Ethan, Anthony, Dom, Sophie, Tatum

What we are doing today: figuring out our three remaining design ideas and analyzing them

Design Analysis

Idea 1: Our final design we all liked.

- a) Function
- b) Human factors (Ergonomic)
- c) Product market
- d) Physical specifications

- e) Strength
- f) Economic factors
- g) Models

Idea 2: Our final design we all liked but with a shield to block a water mess for silly users.

- a) Function
- b) Human factors (Ergonomic)
- c) Product market
- d) Physical specifications
- e) Strength
- f) Economic factors
- g) Models

Idea 3: Our final design but has the mobility to be adjusted for users of all heights.

- a) Function
- b) Human factors (Ergonomic)
- c) Product market
- d) Physical specifications
- e) Strength
- f) Economic factors
- g) Models

9/26/23: People Present: Ethan, Anthony, Dom, Sophie, Tatum

-Dr. Walkup slideshow about design decision process with the decision matrix chart
 - In our progress report, we eliminated too many of our ideas and so we need to add some back, so we have at least 3 potential designs
 Factors we should have in our decision matrix.

- Cleanliness
- Sustainability
- Convenience
- Functionality

Drawings Needed:

Actual Drawing, 4 elevations, with dimensions (only shown once)

Specifications drawing

Assembly Drawing: for how parts used will be put together.

What we have completed this class:

- Made a decision matrix.
- Added four ideas to consider.
- Analyzed some of the ideas in the matrix.
- Added a table of contents to our final report document.
- Fixed our introduction using Dr. Walkup's comments\

9/28/23: People Present: Ethan, Anthony, Dom, Sophie, Tatum

Dr. Walkup introduction on maneuvering through Excel. Tricks and shortcuts to formulas, graphs, and combining table sets into graphs. Used Scatter Plot.

10/3/23: People Present: Ethan, Anthony, Dom, Sophie, Tatum

What we are doing: Finishing up final report, figuring out what to fix with our design elimination process, and completing the AutoCAD drawing portion of the report. Overall finalization of Final Report due Thursday.